IMPROVEMENT OF QUALITY MANAGEMENT FOR HIGHWAY AND BRIDGE CONSTRUCTION AND MAINTENANCE, PHASE II

MANUAL FOR LOAD RATING OF BRIDGES

2014

Department of Public Works and Highways

Japan International Cooperation Agency

IMPROVEMENT OF QUALITY MANAGEMENT FOR HIGHWAY AND BRIDGE CONSTRUCTION AND MAINTENANCE, PHASE II

MANUAL FOR LOAD RATING OF BRIDGES

3RD EDITION

2014

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

JAPAN INTERNATIONAL COOPERATION AGENCY

Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
Manila

FOREWORD

Bridges along national roads support our country's sustainable economic growth by facilitating the transport of goods and services.

Nonetheless, there are still challenges in ensuring the structural integrity of national bridges. In coming face to face with these formidable tests, the Department of Public Works and Highways has developed supplementary plans to support the ingenious Bridge Management System in the form of this manual.

Truly, this Third Edition of the **Manual for Load Ratings of Bridges** is beneficial in ensuring public safety with its content on supplementary details and guidelines for our engineers in determining load capacity of existing bridges. In doing so, the procedure then helps identify those bridges needing urgent rehabilitation and/or replacement.

This Manual will also help enhance our technical staff's knowledge in computing bridges' load ratings that will eventually avert further deterioration due to overloading.

Our sincerest gratitude to JICA for their technical and funding assistance and the dedicated DPWH personnel who both worked hard in the realization of this Manual.

I enjoin all those concerned to use this as easy reference and proper guide in load ratings of bridges.

ROGELIO L. SINGSON
Secretary

ACKNOWLEDGMENT

The 3rd Edition of MLRB which incorporates the User's Manual of Computer-based Program on Load Rating is one of several manuals improved by the Japan International Cooperation Agency (JICA) with the Department of Public Works and Highways (DPWH) during the implementation of the Technical Cooperation Project for the Improvement of Quality Management for Highways and Bridge Construction and Maintenance, Phase II (2011-2014).

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ABBREVIATIONS

ASM	Allowable Stress Method
AASHTO	American Association of State Highways Transportation Officials
BIM	Bridge Inspection Manual
BMS	Bridge Management System
BOD	Bureau of Design
BRS	Bureau of Research and Standards
CBPLR	Computer-Based Program on Load Rating of Bridges
DEO	District Engineering Office
DPWH	Department of Public Works & Highways
GVW	Gross Vehicle Weight
JICA	Japan International Cooperation Agency
LFM	Load Factor Method
LRFM	Load and Resistant Factor Method
LR	Load Rating
MCEB	Manual for Condition Evaluation Bridges
MLRB	Manual for Load Rating of Bridges
PCBG	Prestressed Concrete Box Girder
PCDG	Prestressed Concrete Deck Girder
PCG	Prestressed Concrete Girder
PWRI	Public Works Research Institute
RA	Republic Act
RC	Reinforce Concrete
RCBG	Reinforce Concrete Box Girder
RCDG	Reinforce Concrete Deck Girder
RCFS	Reinforce Concrete Flat Slab
RCS	Reinforce Concrete Slab
RF	Rating Factor
RO	Regional Office
SIG (NCS)	Steel I-Girders with Non- Composite Concrete Slab
SIG (CCS)	Steel I-Girder with Composite Concrete Slab
SBG	Steel Box Girder
SDG	Steel Deck Girder
SDT	Steel Deck Truss
STT	Steel Through Truss

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Chapter 1

INTRODUCTION

1.1 PURPOSE OF THE MANUAL

The purpose of the Manual for Load Rating of Bridges (MLRB) is to guide and provide the Department of Public Works and Highways (DPWH) and others with uniformity in the procedures and policies for determining the load capacity and load rating of existing bridges.

In any event, this Manual should not overrule sound engineering judgment.

1.2 SCOPE OF THE MANUAL

This Manual has been prepared to provide the DPWH with a load rating process consistent with the objectives of the DPWH Bridge Management System. The Manual is focused on load rating (or load capacity determination) procedures with a section on engineering and in-depth inspection of existing bridges. A section is devoted to provide examples in performing load rating calculations.

Chapter 1 provides the necessary background and information on load rating of bridges including rating considerations, procedures and methodology. In order to assess the existing capacity of bridge components or attributes, it is necessary to determine the existing condition of these members using more detailed inspection and condition evaluation. A discussion on engineering and in-depth inspection and condition evaluation of bridge components is presented in Chapter 2. Chapter 3 deals with the process and procedure of load rating including loadings used for load rating, rating guidelines, load posting and reporting. Computer-based Program on load rating is presented in Chapter 4. Examples for load rating calculations are presented in Chapter 5.

The provisions of this Manual apply to all conventional concrete and steel highway bridge structures in accordance with the DPWH Design Guidelines and the AASHTO Standards. Special bridges and bridges other than highway bridges may need special provisions not covered in this Manual. General guidance is given in this Manual but more complex procedures must be used to determine actual load rating.

This Manual is prepared with reference to the following:

- Bridge Management System - Bridge Inspection Manual (Referred to as BMS-BIM), Department of Public Works and Highways, January 2004.
- Bridge Inspection Manual (Draft), (PWRI Text No. 2651) Public Works Research Institute, Ministry of Construction in Japan, July 1988. (Referred to as BIM-PWRI)
- Manual for Condition Evaluation of Bridges, 2nd Ed. (Referred to as MCEB), American Association of State Highway and Transportation Officials, 2000.
- Design Guidelines, Criteria and Standards - Bridge Design, DPWH & JICA, March 2004.
- Standard Specifications for Highway Bridges, 17th Ed., AASHTO, 2002.
- An Approach to Inspection and Condition Evaluation of Bridges (Referred to as AICEB), JICA, DPWH & KEI, November 2003.

- Revision of Bridge Management System – Bridge Inspection Manual (Referred to as Rev BMS-BIM), Department of Public Works and Highways, December 2007.
- Bridge Engineering Inspection Manual, DPWH and JICA, 2014

For all matters not covered by this Manual, the current DPWH and AASHTO Specifications and Standards should be used as a guide. However, if bridge member behavior is not consistent with the controlling specifications, such deviations based on the known behavior of the member may be used but should be fully documented.

1.3 THE DPWH BMS - BRIDGE INSPECTION MANUAL

The *Bridge Management System (BMS)* was established by the DPWH to provide a computer based system for the management of Philippine national bridges. The function of the BMS is to provide the DPWH with a "comprehensive and sustainable bridge inspection program to provide sufficiently accurate, consistent and timely information to planners and maintenance personnel for all bridges which are part of the national road network, utilizing computer applications being procured by DPWH".

Under the BMS system, a *Bridge Inspection Manual* is prepared "to provide bridge inspectors and others with guidelines and procedures to undertake effective bridge inspections".

The Bridge Inspection Manual contains standardized bridge inspection procedures and requirements for all types of bridge inspections undertaken by the DPWH and is intended to be utilized as a training guide and reference manual for the DPWH bridge inspectors. This will ensure that consistent inspection reports are delivered from all bridge inspections.

The 2004 BMS-Bridge Inspection Manual was revised in 2007 reducing the inspection types from seven (7) to five (5) types to avoid overlapping activities and simplify the required actions. The 2007 Revised BMS-Bridge Inspection Manual which focuses on the detailed procedures for condition survey and rating, will provide a clear definition on how to assess bridge condition using a more specific defect measurement guidelines and a bridge condition rating card.

1.3.1 Bridge Inspection Types

The revised BMS - Bridge Inspection Manual (2007) focuses on five major Bridge Inspection Types to assess bridge conditions based on defects or damages, as listed in Table 1.3-1. The Inspection Types are categorized into:

- Scheduled Inspection – required to be undertaken on a set of frequency to provide data for DPWH functions, and
- Non-scheduled Inspection – undertaken only when required because of the addition of new bridges or due to calamities.

Bridge Inspection Types 1 is essentially a visual inspection, without requiring specialty in bridge engineering, to check for obvious defects and ensure that regular planned maintenance is being properly undertaken.

Bridge Inspection Type 2 or Condition Inspection will monitor and rate the condition of bridges that becomes a basis for identifying maintenance needs, forecasting future bridge intervention requirements and estimating funding requirements.

Bridge Inspection Type 3 or Engineering Inspection is undertaken as follow-up to bridge Condition Inspection when attribute defects are in condition state 2 or 3 in any primary component/attribute or in any secondary component that has a detrimental effect on the structural performance of the bridge. This will provide information for future design of the required major maintenance works.

Bridge Inspection Type 4 or Emergency Inspection is undertaken in response to calamities. This will confirm bridge safety following a calamity or determine the necessary work to ensure safety and restore the bridge function.

Bridge Inspection Type 5 or Inventory Bridge Inspection is an initial inspection performed to obtain inventory data on bridges.

Table 1.3-1 Bridge Inspection Types and Responsibility

TYPE	NAME	FREQUENCY	PURPOSE	RESPONSIBILITY
SCHEDULED BRIDGE INSPECTIONS				
1	Routine	Monthly	- Scheduling of routine maintenance, check on bridge condition to ensure the safety of bridges - To detect defects of bridges at an early stage	DEO
2	Condition	Annual	- To obtain condition data on and major maintenance needs of the bridge for operation of the BMS - To assess and rate condition of the structure	DEO/RO
NON-SCHEDULED BRIDGE INSPECTIONS				
3	Engineering	As Required	- To investigate the major maintenance needs of defective bridge identified by a condition inspection or other inspection - To evaluate the needs for improvement works - To decide on appropriate countermeasure - To determine the safe load capacity of the bridge - To monitor progress of any damage - To test and evaluate strength or quality of materials - To evaluate structural strength and seismic vulnerability	DEO / RO / BOD / BRS / BMS Team and other Entities
4	Emergency	As Required	- To determine emergency work to bridges after occurrence of calamities, ensure safety of bridges - To obtain damage information to evaluate necessity of urgent repairs - To determine severity of structural damage to bridges - To confirm safety of bridges and vehicular traffic - To evaluate structural strength	DEO/RO
5	Inventory	As Required	- To obtain/update bridge inventory data for the RBIA and the BMS	DEO/RO

NOTES: RO - Regional Office; BOD - Bureau of Design; DEO - District Engineering Office; BRS - Bureau of Research and Standards

Although the above inspections can identify defects or damages with condition ratings for the bridge attributes, its primary objective is to prepare maintenance needs with corresponding estimated costs for funding requirements. Moreover, the manual does not provide a basis for determining the safe load capacity of the bridge and the need for load posting. In this regard, this Manual will supplement the BMS-BIM with a guide for load rating of existing bridges and recommends load posting when necessary.

1.3.2 Condition Rating of Bridge Attributes

The 2007 revised BMS - Bridge Inspection Manual enumerates and describes common material defects or damages of bridge components/attributes (referred to as members in this manual) with corresponding condition state criteria. Although the condition evaluation state of bridge components/elements depends on many factors, the bridge attributes condition states are developed using the evaluation rating, as presented in Table 1.3-2.

As seen in Table 1.3-2, the Condition States are rated from 0 to 3 with 0 being the good condition state of the attribute. Although maintenance actions are recommended for each condition state, load posting is not mentioned as an alternative option for the action.

It should be noted that bridges exhibiting progressive or advanced stage of deterioration or damage should be checked thoroughly as to the safe load capacity and load posted, if necessary.

Table 1.3-2 Bridge Attribute Condition States

CONDITION STATE	DESCRIPTION	ACTION
0 (Good)	Attribute is in good condition with little or no deterioration.	No action required
1 (Fair)	Attribute shows deterioration of a minor nature to the primary supporting material and is showing first signs of being affected.	Major maintenance is required within 10 years
2* (Poor)	Attribute shows advancing deterioration and loss of protection to the supporting material, minor loss of section	Major maintenance is required within 2 years
3* (Bad)	Attribute shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress	Immediate major maintenance is required

*When Condition State is 2 or 3, a follow-up inspection (Engineering Inspection) is conducted to provide more information on the degree of deterioration or damage which will be used to determine the necessary maintenance requirements or intervention. At this stage, the bridge stability may be affected so that determination of the safe load capacity of the bridge is needed. The vehicle live load that will be allowed to pass through the bridge may have to be limited when the load capacity is reduced from the original design live load. This Manual will provide the necessary guide in performing load capacity determination and load rating.

1.3.3 When to Perform Load Rating

The need to perform Load Rating calculations for the bridge is indicated in Table 1.3-3. As shown in Table 1.3-3, it is not necessary to perform Load Rating of bridges under Inspection Types 1 and 2. However, recommendations to perform load rating calculations can be specified at these inspection stages if certain bridge conditions require load capacity reevaluation.

The following condition requires load rating evaluation:

- ☞ When the structural configuration was changed from the one originally intended by design (e.g. changes in support conditions, changes in structural members, etc.),
- ☞ When the dead load condition was modified due to repair, rehabilitation, or other reasons,
- ☞ When the bridge use or function is modified,
- ☞ When the overall condition of bridge is poor or bad, or
- ☞ When engineering judgment requires a need for safe load capacity reevaluation.

Since Engineering Inspection is performed when Overall Condition of bridge is poor or bad, it will be necessary to perform load rating to determine the safe load capacity of the bridge prior to maintenance or restoration works. This will ensure public safety and prevent loss of structure.

Table 1.3-3 Bridge Load Rating Schedule

INSPECTION		LOAD RATING	REMARKS
TYPE	**NAME**		
1	Routine	Not Performed	Load Rating calculation is not necessary since the objective is to identify maintenance needs. *Recommendation for the need for Load Rating is given at this stage.
2	Condition		
3	Engineering	Performed when Overall Condition is poor or bad	Since Overall Condition is poor or bad which may affect bridge stability, the safe load capacity of the bridge should be verified.
4	Emergency	Performed when Overall Condition is poor or bad	If the bridge Overall Condition is poor or bad after an emergency or a calamity, Load Rating should be performed.
5	Inventory	Performed when Required by DPWH	This initial investigation may require verification of the safe load capacity of the bridge in order to determine its initial Load Rating.

Load Rating calculations shall be performed during an Emergency Inspection when the Condition State of any attribute is 2 or more.

For bridges designed prior to current design requirements, load rating evaluation is needed to check its safe load capacity. This is usually done during the Inventory Inspection to obtain or update bridge inventory data.

1.4 LOAD CARRYING CAPACITY OF BRIDGES

The load-carrying capacity is defined below, as stated in the "*Maintenance and Management of Roadways and Bridges, AASHTO 1999*".

Each bridge has an estimated capability to carry a certain total load limit. A bridge is designed for a specific load, and there is an estimated load at which the bridge is expected to fail (ultimate strength load). The ratio of the two loads is the factor of safety estimated to exist in the bridge.

$$\textbf{Factor of Safety} = \frac{\textbf{(Estimated Failure Load)}}{\textbf{(Design Load)}}$$

The "capacity" of a bridge is the sum total of the various loads that a bridge can safely carry in its existing condition or state. The various loads on a bridge may include the following:

- ***Dead Load:***

This is defined as the load from the weight of the beams and deck and all of the structure above the piers and abutments upon which the vehicular and pedestrian traffic weight is supported. Some elements of the bridge included in the dead load are as follows:

- Wearing courses.
- Structural decks.
- Structural members.
- Curbs, sidewalks, railings, and fencing.
- Utility pipes, conduits, lighting masts, and traffic signal hardware.

The dead load may be significantly altered by the removal or addition of such elements during the bridge maintenance process, thereby reducing (or increasing) the bridge capacity to carry a specified live load. When considering the foundation support of the bridge, the piers (and the footings, if piers are supported by footing rather than piles) must be included in the dead load. That is, at whatever level within a bridge structure the capacity is estimated, all elements of the structure permanently in place are included in the dead load.

- ***Live Load:***

Live load includes the weight of vehicles, pedestrians, and other traffic. Highway loadings used in establishing load-carrying capacity will be the standard DPWH (or AASHTO) vehicle loadings or the DPWH legal loads.

- ***Impact Load:***

Impact Loads are dynamic loads resulting from vertical acceleration of vehicles. It is estimated as a percentage of the live load according to the approved bridge design and analysis process.

- ***Wind Load:***

Pressure on the beams, trusses, and other parts of the bridge exposed to steady or buffeting wind gusts. Sometimes this loading is significant for tall bridges and may require a detailed engineering analysis to determine its effect. The total effect of wind load depends upon the expected maximum wind velocity, the vertical area of all bridge members in the side profile, and the shape of the section (using drag coefficient).

- ***Longitudinal Forces:***

Through acceleration and braking, traffic moving across a bridge can generate forces parallel to the centerline or longitudinal axis of the bridge. Such forces are often estimated to be 5% of the estimated live load.

- ***Thermal Forces:***

Changes in temperatures create stresses and strains due to the thermal expansion and contraction of bridge materials.

- ***Earth Pressures:***

This includes soil pressure on abutments and other components of the bridge against which any significant depth of earth fill rests. Additional pressure can build up if weep holes (drainage openings) become clogged and do not drain the hydrostatic pressure.

- ***Stream Forces:***

Bridge piers must resist horizontal loads caused by water flowing around them. During flood flow, this pressure can significantly increase. Allowing debris to build up against a pier during flooding greatly increases this pressure.

- ***Earthquake Forces:***

Bridges in earthquake zones are subject to potential vibration loadings from any direction that the geologic earth crust plates may move during an earthquake tremor.

Bridge capacity defines the capability of the bridge to carry the load from the above various forces. However, in the load rating calculations to determine the safe live load capacity of bridges, it is not necessary to include all the above loadings which will be discussed in the next sections.

1.5 LOAD RATING CONSIDERATIONS

Bridge load rating provides a basis for determining the safe load capacity of the bridge. Such load rating requires engineering judgment in determining the rating value that will be used to assess the bridge soundness and safe use by establishing the safe load capacity of the members. Bridge load rating calculations will be based on the information of the most recent inspection indicating the present condition of the bridge, including changes in structural condition due to repairs and rehabilitation, dead load and member deterioration.
As part of every inspection cycle, bridge load ratings should be reviewed and updated to reflect any relevant changes in condition or dead load noted during the inspection.

The Manual will provide two load rating methods for the Operating and Inventory Levels: (1) the *Allowable Stress Method* which is especially useful for comparison with past practices, and (2) the *Load Factor Method* which is based on multiples of the actual load.

1.5.1 Assumptions

The safe load capacity of a bridge is based on existing structural condition. To maintain this capacity, it is assumed that the bridge is subjected to competent inspections as often as the existing conditions of the structures require, and that sound judgment will be exercised in determining an appropriate safety margin.

1.5.2 Substructure Consideration

It is a matter of good engineering sense to ensure that the calculated safe load capacity can be supported by the existing substructure elements. Careful attention should then be given to all elements of substructure for evidence of instability that will affect its load-carrying capacity. All available information including as-built plans should be checked to ensure that the substructure have at least the capacity of the lowest rated superstructure member. If no information is available, the engineer should judge the adequacy of substructure based on observations of its condition and performance over time.

1.5.3 Safety Criteria

In general, the safety factors to be used shall be taken from this Manual. However, certain cases where judgment must be exercised in evaluating a structure, safety factors may be adjusted based on site and/or structure conditions as recorded in the most recent inspection report. All data used in the determination of safety factors should be fully documented.

1.5.4 Nonredundant Structures

Nonredundant structures are critical components whose failure would be expected to result in the collapse of the bridge. Such bridge components may exist that could become critical to load capacity calculations. Careful consideration shall be given to nonredundant bridge component during load rating of the bridge.

1.6 LOAD RATING PROCEDURE

The flowchart is presented in Figure 1.6-1. For bridges with complete maintenance and inspection records and information, the load rating will consider the present condition of the bridge members. However, when the bridge data are not available, field survey and presumption of original design is necessary. Reconstruction of as-built plans may have to be done using the data gathered from field survey and measurements. In cases where field measurement is difficult to perform, presumption of original design will have to be performed by back analysis using the original requirements of the code used during the design of the bridge.

※ The process of load rating begins after bridge inspections and condition evaluation with the need to perform load rating calculations decided based on the actual condition of the bridge components or attributes. The decision to perform load rating calculations is discussed in Section 1.3.3. When load rating calculation is not necessary, usual bridge maintenance and inspection procedure is conducted and the results documented and forwarded to the DPWH BMS Unit for recording and filing.

※ Load rating calculations become necessary when:

- ☑ the condition states of the bridge attributes or components warrants determination of a safe load capacity, or
- ☑ when changes in the original bridge structural system or configuration was observed during the inspection, including changes in geometry or dead load condition.

※ Data collection and in-depth inspection (Engineering Inspection) is then conducted to obtain enough information that will be used for load rating. Data includes As-Built Construction Drawings, Bridge Inventory, Inspection Reports, Testing Results, Surveys, etc.

※ Structural modeling and analysis is then performed, with necessary sketches and calculations on how the structure was modeled, assumptions, load calculations and derivations, computer software documentation and sources of information.

Dead load shall be modeled as accurately as possible. Member conditions including damages and defects may or may not be reflected in the structural model to determine redistribution of forces in the structural system (this will be left to the discretion of the rater if the analysis model warrants the use of existing member condition including deformation and changes in support conditions to determine a more accurate force distribution). However, member section damages and defects shall be reflected in calculating member capacity or resistance.

Load rating vehicle shall be applied to determine the live load effects and demand on the bridge (see Section 3.4 for the rating vehicles).

Load ratings are then evaluated at two levels – the *Inventory Level* and the *Operating Level*. The methods that can be used for load rating evaluation include the allowable stress, the load factor, and the load and resistance factor methods. The results of the load rating evaluation will indicate the present allowable live load and the maximum permissible live load of the bridge. The details of these load rating methods are presented in Chapter 3.

※ A Load Rating Report (see Section 3.13) shall be prepared to document the load rating calculations.

※ When Load Posting the bridge is necessary, it shall be made by the Responsible Official of the DPWH.

※ All Reports and Documents shall then be forwarded to the BMS Unit for recording and filing.

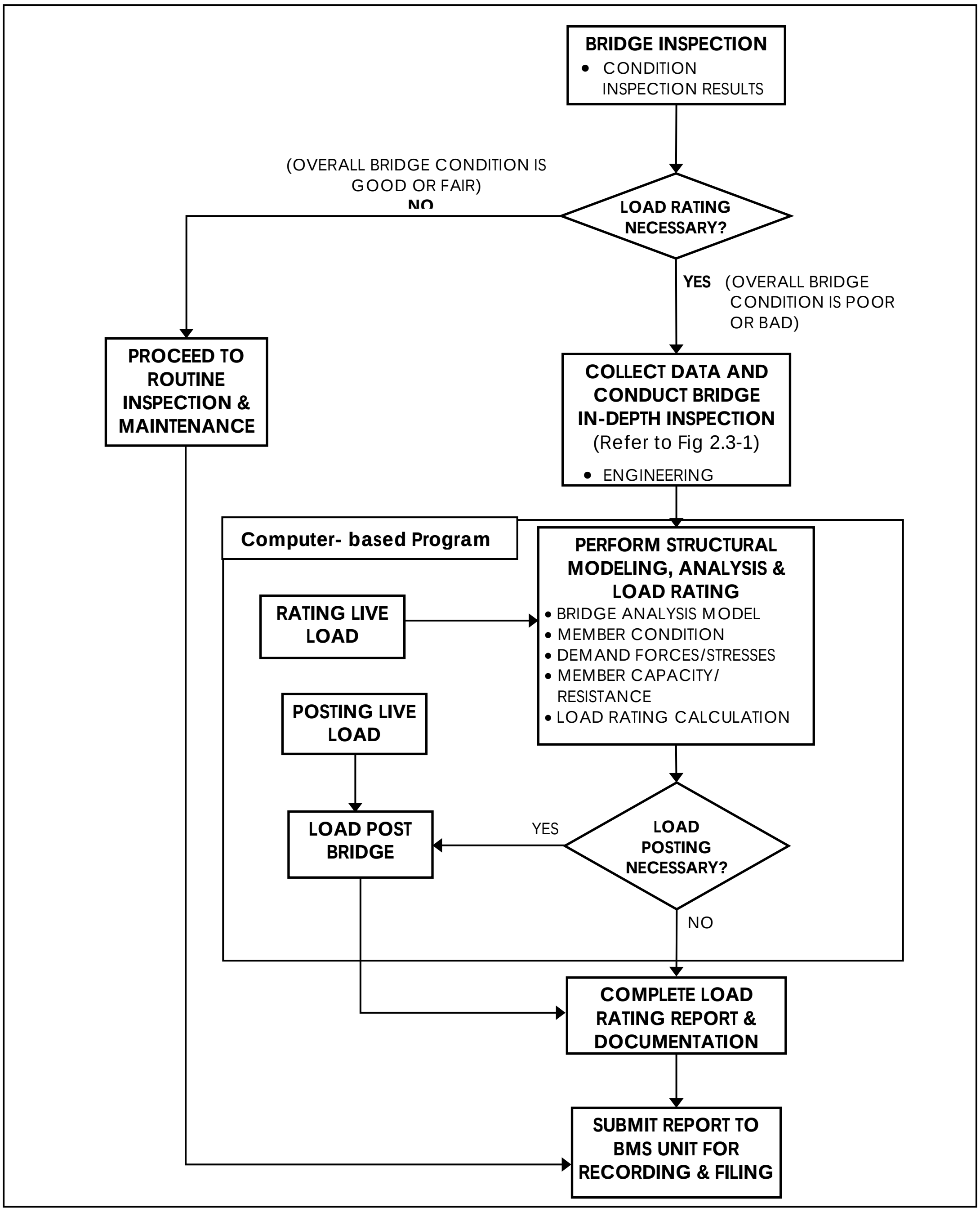


Figure 1.6-1 Flowchart of Load Rating Procedure

Chapter 2

ENGINEERING AND IN-DEPTH INSPECTION FOR LOAD RATING

2.1 INTRODUCTION

The 2007 Revised Bridge Management System - Bridge Inspection Manual (BMS-BIM) describes in detail the general processes and procedures of bridge Inspection Types 2 and 3. It also provides a more comprehensive damage or defect assessment through a more definite condition rating criteria.

In order to perform bridge load rating, it is necessary to get as much information as possible on the actual condition of bridge attributes and components. These data will be used to prepare structural analysis model that will reflect the existing conditions of the major components of the bridge including geometry, damages, defects, support conditions, etc. Such information can be obtained by an engineering inspection or in-depth inspection.

The in-depth inspection of the bridge will be considered as equivalent to the Engineering Inspection, Type 3 of the revised BMS-BIM. The method of inspection discussed in this Chapter shall be a supplement to the Engineering Inspection (Type 3) described in the revised 2007 BMS-BIM. Refer to the DPWH-JICA Bridge Engineering Inspection Manual developed by the Technical Cooperation Project on Improvement of Quality Management for Highway and Bridge Construction and Maintenance, Phase II, in 2011-2014.

2.2 CONSIDERATIONS FOR IN-DEPTH INSPECTION

An Engineering or In-Depth Inspection is a close-up, hands-on inspection of one or more members above or below the water level, usually *performed as a follow-up inspection to the Routine, Condition or Emergency Inspection to better pinpoint any deficiency(ies) found*.

Traffic safety management signs/devices and special equipment, such as under-bridge inspection equipment, staging and workboats, should be provided when needed. When appropriate, or when necessary to ascertain the existence or extent of deficiencies or damages, non-destructive field tests and/or other material tests may need to be performed.

The inspection shall include load rating to assess the residual capacity of the member/s, depending on the extent of damage or deterioration. Non-destructive field tests and/or other material tests may be performed, if necessary.

The following points should be kept in mind in conducting the in-depth inspection:

i) During the in-depth inspection, bridge components and elements evaluated to be Condition State “3” in the initial inspection and require urgent rehabilitation, shall be made a priority due to the urgent nature of damages. The inspection is normally carried out after conducting a temporary emergency repair of the damaged component or element. However, the need for a permanent measure for repair, rehabilitation or reconstruction of the bridge will be decided after a more detailed and thorough investigation is done under the in-depth inspection stage.

ii) For bridge components and elements evaluated to be Condition State "2 or 3" in the initial inspection, the in-depth inspection shall be conducted to provide data for judgment on the cause, scale and progress of damages. This survey will then become the basis for judging whether the bridge rehabilitation work is needed or not.

iii) For damages found to have a progressive tendency, the inspection shall be continued to confirm the progress of damage for a certain period of time.

2.3 PROCEDURE FOR IN-DEPTH INSPECTION

The purpose of the in-depth inspection is to get necessary information to:

- judge the need for improvement works,
- determine the safe load capacity of the bridge, and
- decide an adequate improvement method.

The flowchart of in-depth Inspection procedure for load rating is shown in Figure 2.3-1, where the need for the survey is based on the initial Condition Inspection assessment. Desk survey is then performed to analyze and estimate the cause of damage and clarify the objectives and the inspection items of the in-depth Inspection to be conducted.

During the desk survey, reference is made to the as-built plans, bridge records and inspection reports previously conducted. It is important to note the previous damages observed and the repair or rehabilitation conducted so that the inspectors will be guided as to the present condition of the bridge.

The key to an effective, safe performance of any bridge inspection is proper advance planning and preparation. The inspection plan should be developed based on a review of the Bridge Record and may require a pre-inspection site visit. It is advisable for the inspector to confer with the DPWH District or Regional Offices regarding the bridges to be inspected since they are more familiar with the bridge and may point out peculiarities which may not be apparent at the time of inspection.

As much as possible, the bridge inspection should be scheduled at the time of the year which offers the most suitable conditions for thorough inspections. Substructures of bridges over streams are best inspected at times of low water and structures requiring high climbing should be inspected during seasons when high winds or extremes of temperature are not prevalent.

Bridge inspection equipment consists of those items used for access and those used for actual inspection tasks. The methods and equipment used to gain access to bridge members include ladders, power lift vehicles, power lift staging, rigging and scaffolds, boats, and assisted free climbing.

In planning the inspection, a pre-inspection site visit by the Team Leader will be helpful. If plans are available, the pre-inspection should be done with plans in hand to allow preliminary verification of the structure configuration and details.

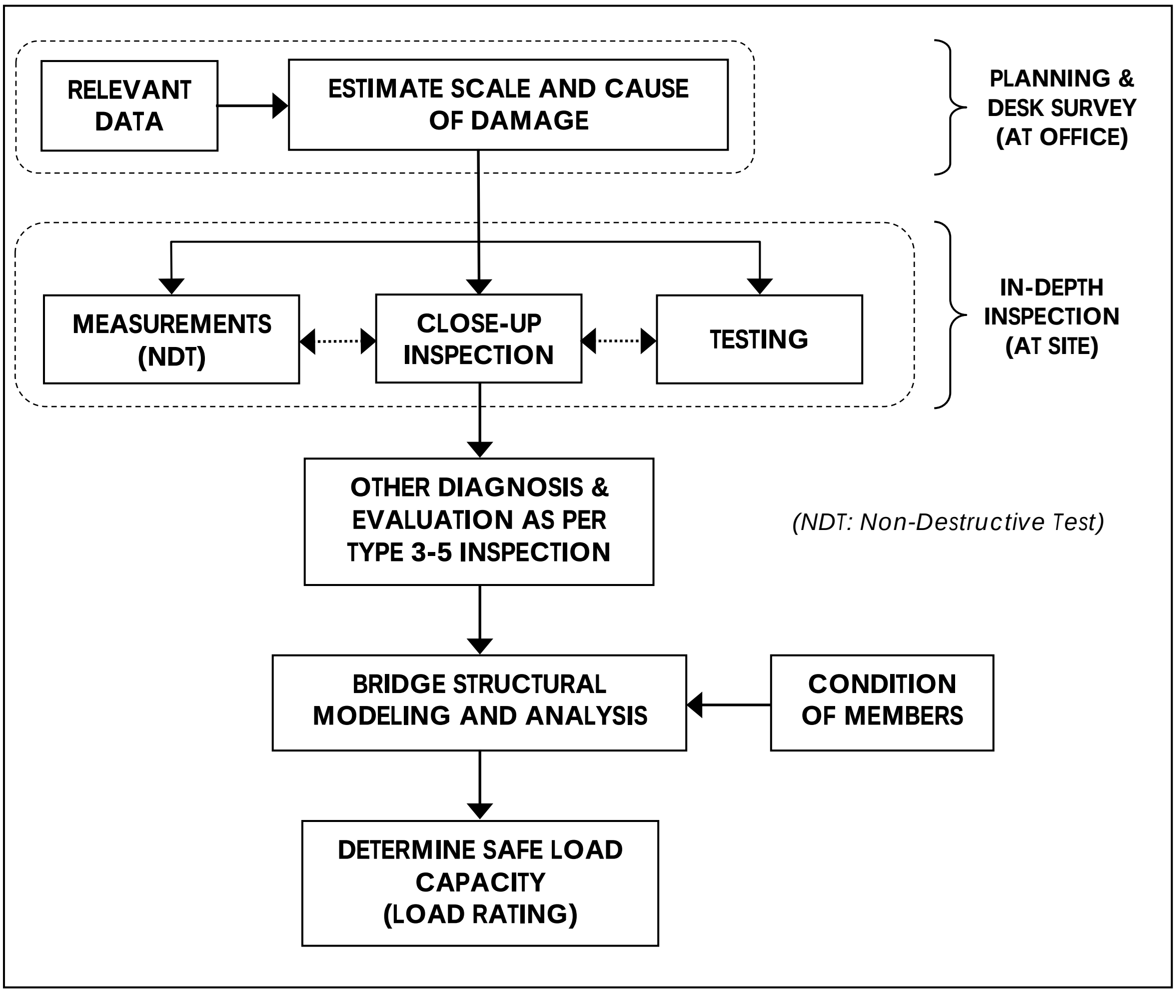


Figure 2.3-1 Flowchart of In-Depth Inspection Procedure for Load Rating

The pre-inspection should determine the following points:

☑ site access – availability and means of,

☑ areas of potential concern which will:

- require close attention during subsequent inspections, and
- form the basis for decisions on timing, weather conditions, traffic controls, and utility protections.

The in-depth Inspection shall then be conducted after all preparatory works have been conducted including:

(a) review of all relevant data and information through desk survey activities,

(b) specification of inspection items and establishment of clear objectives of the survey, and

(c) identification and estimation of the cause and extent of damages by analysis of the following relevant materials:

i. damage location,

ii. design, construction and inspection records of members,

iii. damage records of members or elements caused by earthquake, fire, flood, etc., and

iv. similar cases of damage including rehabilitation/repair.

In conducting the in-depth inspection, it is necessary to prepare an inspection guide showing the bridge components and elements to be inspected. Every joint and element of the bridge shall be given a node number and name using symbols or abbreviations to easily identify the joint and the element.

To simplify damage identification, symbols similar to those shown in Figure 2.3-2 can be used during inspection.

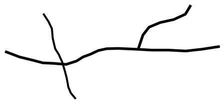
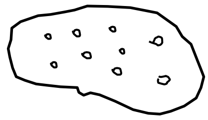
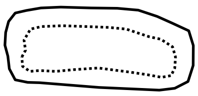
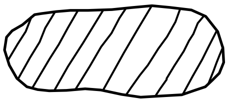
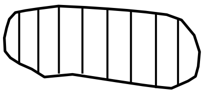
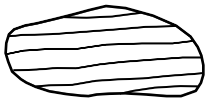
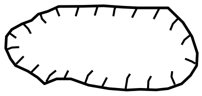
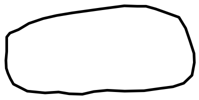
Damage Type	Symbol	Damage Type	Symbol
Crack		Honeycomb/Void	
Spalling		Rutting/Erosion	
Exposed Rebar		Water Leakage	
Efflorescence		Others	

Figure 2.3-2 Damage Symbols

2.4 CAUSES OF DEFECTS AND DAMAGES IN BRIDGE STRUCTURES

In order to properly inspect a bridge, the inspector must be able to recognize the various defects, damages or deterioration in bridge members and its components. It will be more helpful if the inspector knows the causes of such defects and damages and how to inspect them. This section will briefly discuss some of the common defects and damages of bridge components and their causes. Additional discussion on material defects can be found in the BMS-BIM. Refer also to Appendix I for the inspection points on damage-prone members.

The causes of bridge damages may be almost always in conjunction with many factors, making it difficult to specify the causes of such damages. In this section, there are five (5) major factors or causes of damages which can be classified as to either External or Internal factors as presented on Table 2.4-1.

In estimating the causes of damages, it will be necessary to consult with engineers with sufficient experience in structural damage assessment. In some cases, high engineering judgment may be required to estimate the cause and extent of damages.

2.4.1 External Forces

Bridge members and components, once constructed, are always exposed to external forces causing internal stresses to the members which, when the strength or capacity is exceeded, may cause permanent damages.

Table 2.4-1 Factors Causing Damages

External Factors
(a) External Forces
(1) repeated loads such as overloaded vehicle
(2) increase in dead loads
(3) vehicle/vessel collisions
(4) support settlement (uneven pressure)
(5) scour / erosion (by floods, heavy rains during typhoon)
(6) loads by earthquakes
(7) fire
(b) Environmental Factors
(8) change in temperature/drying shrinkage
(9) salt damage
(10) exposure to aggressive chemicals (acid attack)
(11) growth of vegetation on small spaces (e.g. cracks)

Internal Factors
(c) Material Deterioration
(12) alkali-silica reaction
(13) carbonation
(14) poor quality
(d) Fabrication / Construction Faults
(15) fabrication / construction faults
(16) poor waterproof / drainage facility
(e) Structural Factors
(15) structural deficiency

Figure 2.4-1 illustrates some common external factors that may cause permanent damage to the bridge and its components. However, in relation to load rating of bridges, bridge inspection should focus on the damages to superstructures caused by increase in dead load, overloaded vehicles, vessel/vehicle collision and fire. Such defects and damages lead to decrease in carrying capacity of the section or member being rated.

In some instances, bridges may be exposed to fire caused by accidents. Depending on the degree and duration of fire exposure, bridge components may be severely damaged and becomes unsafe for public use. Figure 2.4-2 illustrates damage to concrete structures caused by fire. Similarly, extreme temperature due to fire causes loss of tensile and compressive capacity for steel structures causing bridge members to become unstable.

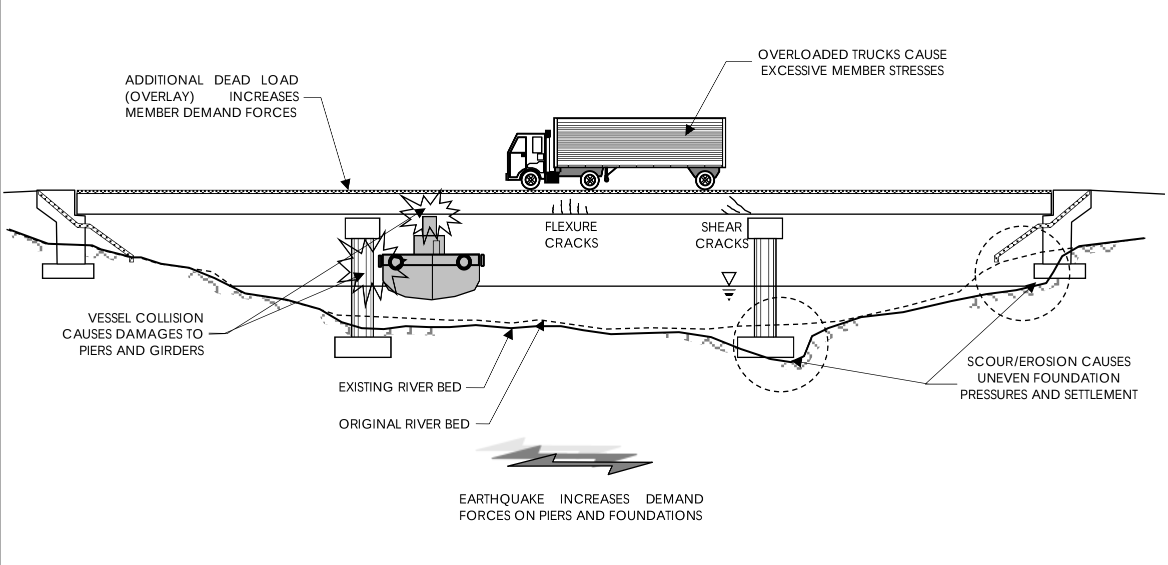
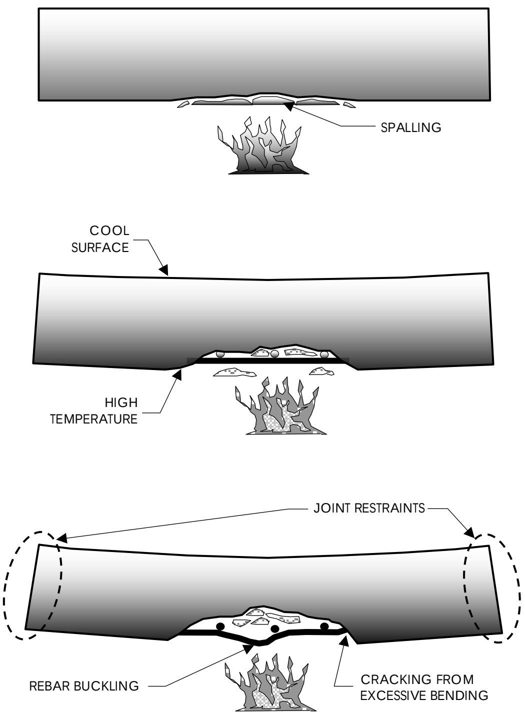


Figure 2.4-1 External Factors Causing Damages to Bridge



Fire causes uneven volume changes in concrete members resulting to distortion, cracking and disintegration. Spalling occurs due to rapidly expanding concrete surface.

Extreme heat causes aggregates to expand. While moisture turns rapidly into steam, concrete begins to disintegrate with localized bursting of small pieces of concrete. Cement mortar turns to quicklime at 400 °C causing further concrete disintegration. Concrete spalling exposes reinforcing bars.

The exposed reinforcing bars begins to expand more rapidly than the surrounding concrete causing buckling and loss of bond to adjacent concrete where the reinforcement is fully encased.

Figure 2.4-2 Damage by Fire

2.4.2 Environmental Factors

Drying Shrinkage and Change in Temperature

Drying shrinkage and temperature change involves changes in concrete volume. On exposure to atmosphere, concrete loses some of its original water through evaporation and shrinks. If the member is restrained from moving, shrinkage stresses build-up that may exceed concrete tensile strength and cause shrinkage cracking (see Figure 2.4-3). However, changes in concrete length or volume varies with the moisture content - i.e. concrete that dries out will shrink and concrete that becomes moist will expand.

Similarly, changes in temperature of the concrete structure relates to volume change. If the temperature varies within the member, e.g. temperature gradient, this causes some section of the member to expand more than the other section resulting to an upward or downward movement of the member (see Figure 2.4-4). If the structural member is restrained, stress build-up occurs and can be very significant and may result to tension cracks, shear cracks and buckling.

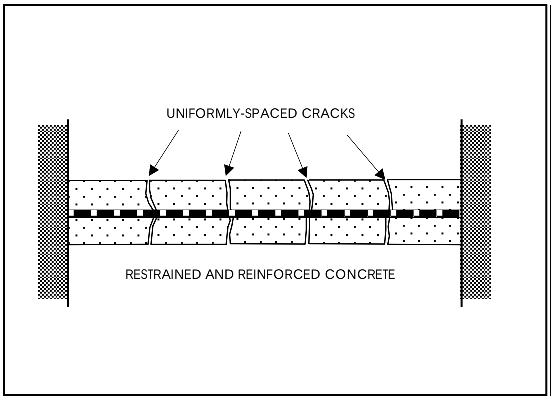


Figure 2.4-3 Drying Shrinkage

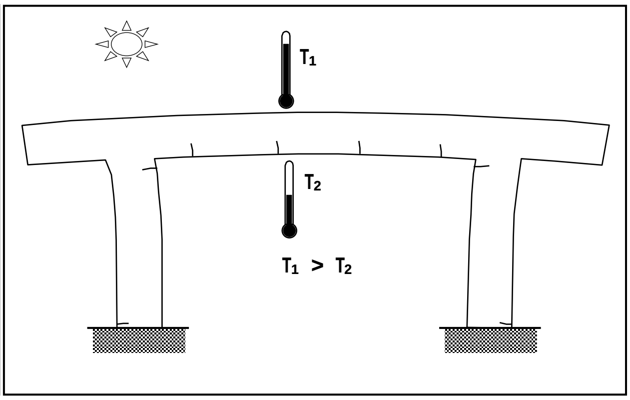


Figure 2.4-4 Temperature Change

Salt Damage

Chlorides can be introduced into the concrete when it comes into contact with the environment containing chlorides such as sea water and aggregates with chlorides or introduced deliberately as an accelerator. Penetration of chlorides usually starts from the surface and moves inward with time. Eventually, the chlorides in contact with the reinforcing bars will cause corrosion when moisture and oxygen are present. As the rust build up in the reinforcement, tensile forces generated by the expansion of the oxide cause concrete to crack and delaminate. When cracking and delamination progress, accelerated corrosion takes place because of easy access of corrosive salts, oxygen and moisture. Figure 2.4-5 illustrates the damage due to salt penetration.

Defects of this nature cause section loss in reinforcing bars, thus decreasing the section capacity against external forces.

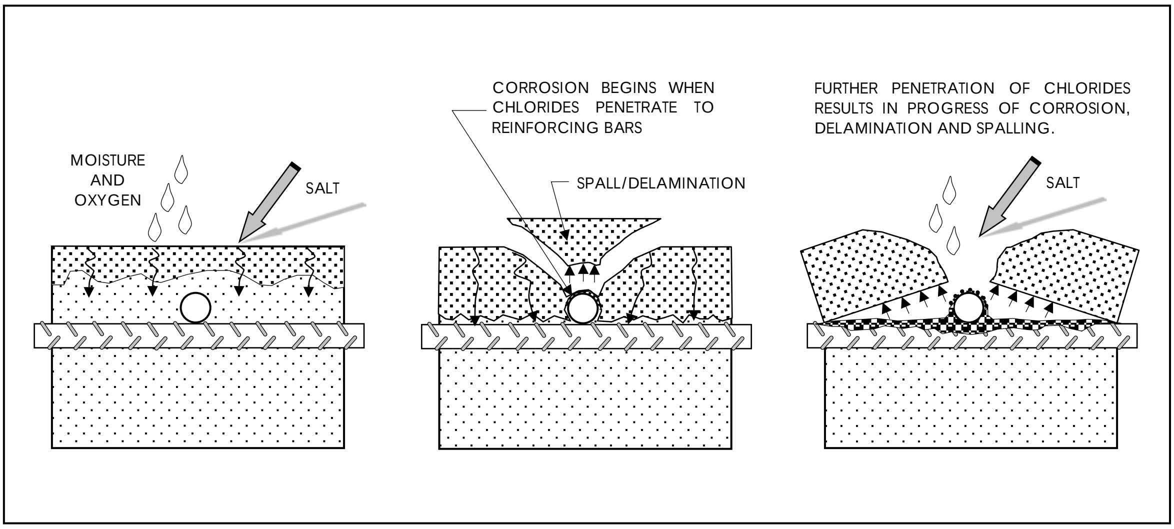


Figure 2.4-5 Damage Due to Salt Penetration

As discussed above, intrusion of chemicals including chlorides eliminates reinforcing bar protection due to concrete alkalinity. This enables water and oxygen to attack the reinforcing steel, forming iron oxides (commonly referred to as rust). Corrosion, as an electrochemical process, increases the metal volume as iron is oxidized into rust and easily occupies a volume of up to 10 times of the corroded steel it replaces. The expansive volume creates internal pressure that causes the concrete to yield producing wider cracks, delamination and spalling. Early development of corrosion can be observed as rust stains on the surface of concrete before spalling occur.

Accelerated corrosion will occur if the pH (alkalinity) is lowered (Figure 2.4-6) or if aggressive chemicals (acidic) are introduced into the concrete. Again, structural capacity of concrete member is affected by reinforcing bar corrosion and cracking of the surrounding concrete (Figure 2.4-7).

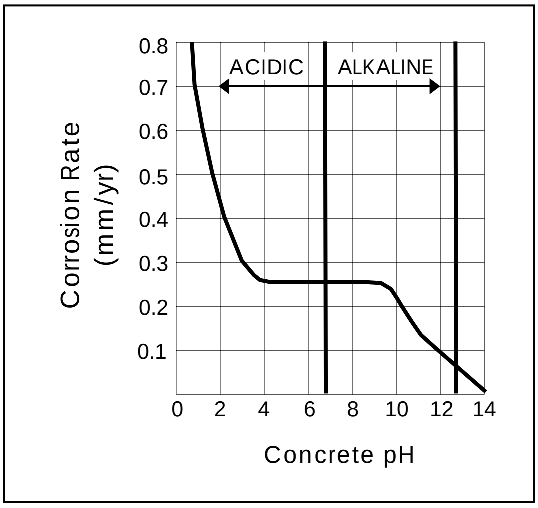


Figure 2.4-6 Concrete pH and Corrosion Rate

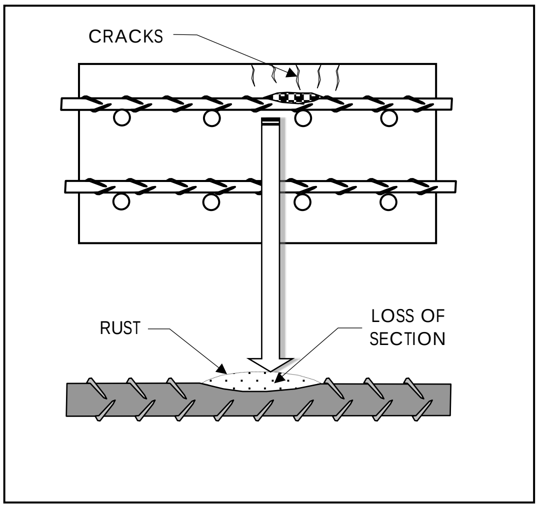


Figure 2.4-7 Rebar Loss of Section

Exposure to Aggressive Chemicals (Acid Attack)

Certain aggressive chemicals in solution (including inorganic acids, organic acids, alkaline solutions, salt solutions, etc.) will attack various constituents of concrete. Such chemicals, in reaction with concrete constituents, may greatly damage the concrete member in contact and reduce its strength considerably.

Acid attack on concrete leads to a reaction between the acid and the calcium hydroxide of the hydrated Portland cement. The reaction produces water soluble calcium compounds, which are leached away leading to concrete disintegration (see Figure 2.4-8). However, it should be noted that certain acids dissolves aggregates in the form of limestone or dolomitic aggregates.

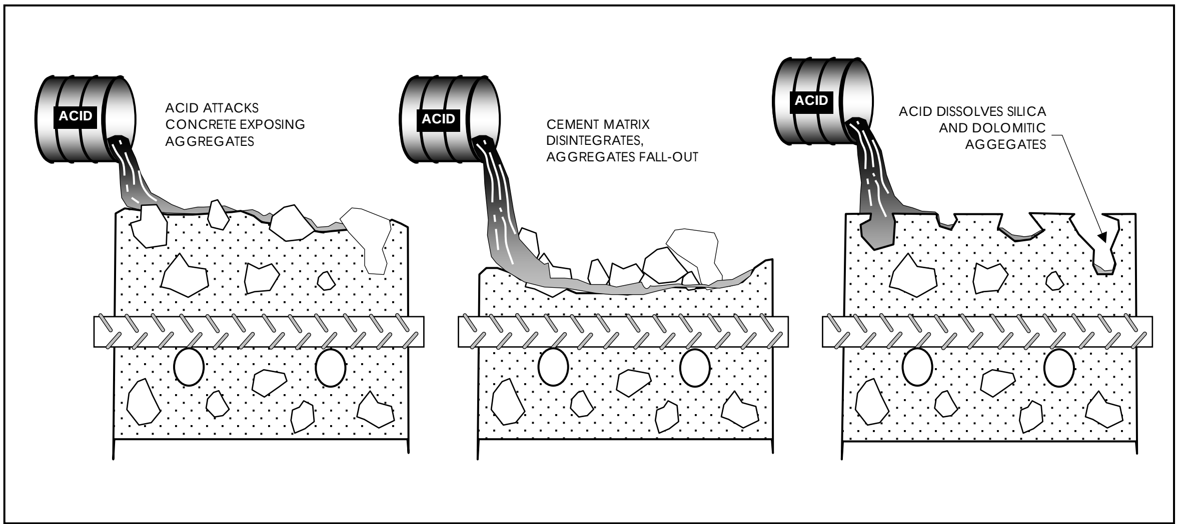


Figure 2.4-8 Concrete Reaction to Acid Attack

2.4.3 Material Deterioration

Alkali-Silica Reaction (ASR)

Alkali-silica reaction, although slow by nature, may create expansion and severe cracking of concrete structure and pavement. In this type of reaction, certain aggregates such as reactive forms of silica react with potassium, sodium, and calcium hydroxide from cement and form a gel around the reacting aggregates. When the gel around the aggregate is exposed to moisture, it expands and creates forces that cause tension cracks around the aggregate. Concrete undergoing alkali-silica reactions exhibits signs of surface map cracking on the exposed surfaces. Once cracking has formed, more moisture penetrates the concrete and accelerates the alkali-silica reaction.

Figure 2.4-9 illustrates the mechanism of alkali-silica reaction.

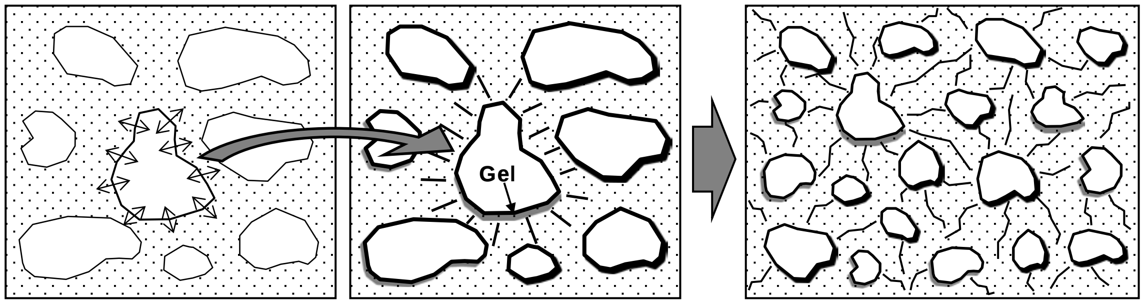


Figure 2.4-9 Mechanism for Alkali-Silica Reactions

Carbonation

Carbonation of concrete is a reaction between acidic gases in the atmosphere and the products of cement hydration. Carbon dioxide penetrates into the pores of concrete by diffusion and reacts with the calcium hydroxide dissolved in the pore water. As a result, the alkalinity of concrete is reduced to a value that lowers the passive protection of the reinforcing steel and makes it susceptible to corrosion. When the environment is acidic or mildly alkaline (loss of passive protection layer), corrosion sets in if moisture and oxygen gains access into concrete. Carbonation in good quality concrete is slow and it will not occur when concrete is constantly under water.

Figure 2.4-10 illustrates the process of carbonation.

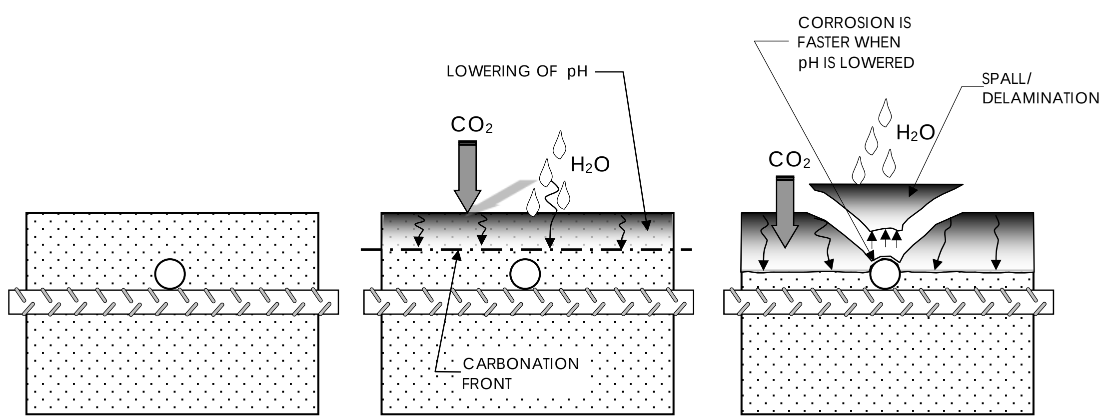


Figure 2.4-10 Process of Carbonation in Concrete

2.4.4 Construction Faults

Honeycomb

Honeycombs are voids left in concrete due to failure of mortar to effectively fill the spaces among coarse aggregate particles during construction. In some cases, as seen in Figure 2.4-11, honeycombs are caused by improper vibration during concrete placement, resulting in the segregation of the coarse aggregates from the fine aggregates and cement paste. In most cases, honeycombs are the result of insufficient vibration especially during hot temperature, where the entire concrete mix does not physically reach the form surface. *Rock pockets* are generally severe conditions of honeycombs where excessive volume of aggregate is found.

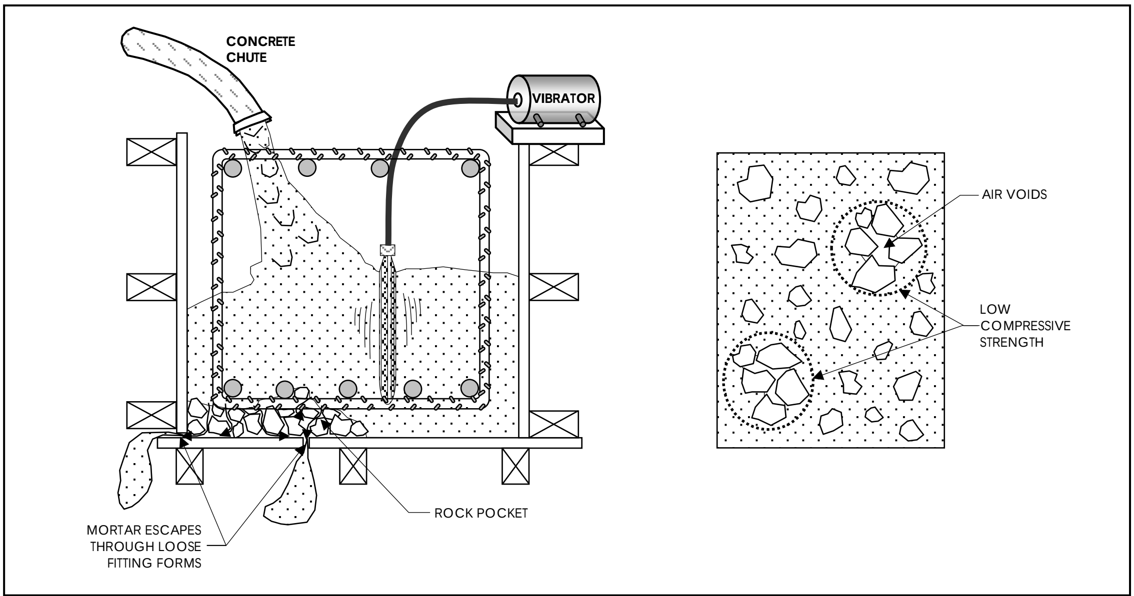


Figure 2.4-11 Honeycombs, Rock Pockets and Air Voids

Honeycombs, rock pockets and air voids reduce the effective areas of the concrete and when located in compressive zones, reduce the capacity of the member. Inspectors should take note of such areas and include in the report so that rating engineers (for Load Rating) can properly assess the section capacity.

Segregation

Concrete segregation results to non-uniform distribution of its constituents. The problem is attributed to high slump mixes, incorrect methods of handling concrete and over-vibration. Segregation causes the upper surface of concrete to have excessive paste and fines, which may also possess high water-cement ratio, while the lower part contains mostly coarse aggregates (see Figure 2.4-12). The resultant concrete will lack consistency and acceptable durability.

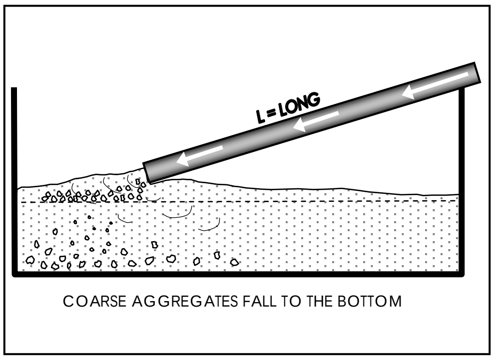


Figure 2.4-12 Concrete Segregation

2.5 VISUAL INSPECTION

The visual inspection of bridge attributes and components play a major role in identifying critical damages in the bridge structure during an in-depth inspection. When performing the visual inspection, the damage types of bridge attributes and components are identified and evaluated as to the degree of defect or damage. The Condition State of the attribute is then evaluated as per BMS-BIM depending on the degree or severity of the defect and the damage.

The visual inspection items shall include the primary and secondary members of the bridge. Table 2.5-1 presents the items to be observed in the field while Table 2.5-2 shows the inspection and examination contents.

Table 2.5-1 Items to be Observed in the Field

	Members			Inspection Items
Primary Members	Super-Structure	Steel	Main Girder, Cross Beam Stringer, Truss Chord, Steel Deck	Corrosion, Cracks, Looseness and Missing Member, Break/Rupture, Painting Deterioration, Deformation, Abnormal Vibration, Missing Bolts and Rivets.
		Concrete	Main Girder	Cracks, Spalling, Exposed Rebars, Free Lime, Fracture, Honeycombs, Discoloration/Deterioration, Movement/ Inclination/Settlement/Displacement
			Slab	Cracks, Spalling, Exposed Rebars, Free Lime, Fracture, Honeycombs, Chipping-off, Damage of Joint, Leakage.
	Sub-Structure	Concrete	Abutment Pier	Cracks, Spalling, Exposed Rebars, Free Lime, Honeycombs, Wearing, Discoloration, Water Leakage, Loss of Member
		Foundation		Settlement, Movement, Inclination, Scour
	Bearing	Steel Bearing		Corrosion, Cracks, Loosening, Falling, Failure, Discoloration, Deformation, Settlement, Movement, Inclination
		Rubber Bearing		Discoloration, Water Leakage, Deformation, Failure
		Mortar		Cracks, Failure
		Anchor Bolt		Corrosion Damage, Cracks, Loosening, Falling, Failure, Deformation
	Unseating Prevention System	Steel	Restrainer Cable / Bar, Anchor Bar	Corrosion, Missing Bolts
		Concrete	Shear Block	Cracks, Spalling, Exposed Rebars, Free Lime, Fracture, Honeycombs, Discoloration
Secondary Members	Lateral Bracing	Steel		Corrosion, Cracks, Looseness and Missing Member, Break/Rupture, Painting Deterioration, Deformation, Abnormal Vibration, Missing Bolts and Rivets.
		Concrete	Intermediate and End Diaphragm	Cracks, Spalling, Exposed Rebars, Free Lime, Fracture, Honeycombs, Discoloration
	Sway Bracing	Steel		Corrosion, Cracks, Looseness and Missing Member, Break/Rupture, Painting Deterioration, Deformation, Abnormal Vibration, Missing Bolts and Rivets.
	Railing	Steel		Corrosion, Cracks, Looseness and Missing Member, Break/Rupture, Painting Deterioration, Deformation, Abnormal Vibration, Missing Bolts and Rivets.
		Concrete		Cracks, Spalling, Exposed Rebars, Free Lime, Honeycombs, Wearing, Discoloration, Leakage, Loss of Member
	Median Strip Curbstone	Concrete		Cracks, Spalling, Exposed Rebars, Free Lime, Fracture, Honeycombs, Discoloration
	Curb and Gutter	Concrete		Cracks, Spalling, Corrosion Damage, Free Lime, Honeycombs, Fracture
	Pavement	Asphalt		Potholes, Cracks, Rutting, Leakage
	Expansion Joint	Steel		Corrosion, Cracks, Loosening, Falling, Failure, Abnormal Opening, Abnormal Sound, Deformation, Water Leakage
		Rubber		Failure, Abnormal Opening, Abnormal Sound, Deformation, Loss of Member, Water Leakage
	Drainage Facility			Corrosion, Cracks, Loosening, Falling, Failure, Discoloration, Leakage, Deformation, Loss of Member.
	Lighting			Corrosion, Cracks, Loosening, Falling, Failure, Painting Deterioration, Deformation, Loss of Member.

Table 2.5-2 Inspection and Examination Contents

Examination Contents		Inspection and Test Method	Examination Items
Steel	Cracks	Penetrant test	Present Condition
Steel	Corrosion	Visual inspection	Present Condition
Concrete	Cracks, Honeycombs, Reinforcement Corrosion	Photograph of damaged portions.	Present Condition
Concrete	Measurement of section	Measurement tape	Construction condition
Concrete	Crack width and crack length	Cracks scale and measurement tape.	Cracks
Concrete	Compressive strength	Schmidt hammer test,	Quality of Concrete

2.6 DAMAGE-PRONE MEMBERS

Some members or elements of the bridge structure where stresses are concentrated are relatively easily damaged compared with other attributes. Such members shall be the main focus of inspection and check point. These members are referred to as damage-prone members and presented in Appendix I, together with the common types of damages, for reference.

2.7 DAMAGE RATING AND CONDITION STATES

2.7.1 Member Damage and Condition

In performing bridge load rating, it is important to note the present condition state or degree of damage and defects of bridge members. Such condition will become the basis for determining the remaining capacity of a structural member.

Appendix B of the Revised 2007 BMS – Bridge Inspection Manual presents some common damages observed on site for existing bridges.

Damages and defects found in bridge components and members, including cracks, holes, loss of steel section due to corrosion, rebar corrosion, missing members and bolts, deformation, etc., affect the load carrying capacity of the bridge. Therefore, proper measurements and evaluation of such damages and defects are very important to reflect the actual condition of the member for bridge structural modeling and section capacity determination.

The Bridge Inspector should note the type of damage or defect, location, its scale and extent of coverage. For example, concrete cracks (bending and shear cracks) should be mapped indicating its width and depth of penetration; loss of section due to steel member corrosion should be assessed and recorded; degree of member deformation that could affect its strength should also be noted. These defects or damages will become the basis in determining the remaining section capacities.

2.7.2 Urgent Temporary Countermeasures

In the interest of public and traffic safety, certain conditions of the bridge necessitate undertaking *temporary countermeasures (repairs or structural strengthening)* on the damaged or defective component/element of the bridge. *Such urgent temporary countermeasures shall be done prior to any repair or rehabilitation and does not warrant any load rating evaluation.* The following conditions require urgent temporary countermeasures:

1) Possibility of collapse of the bridge is anticipated due to the significant damages of superstructure and substructure,
2) Possibility of falling of pedestrians or vehicles is anticipated due to fracture or section loss of railings,
3) Possibility of driving accident is anticipated due to tire blowout caused by severely deformed expansion joints, loss of expansion joints or due to undulating pavement,
4) Drop of concrete segments from curb, railing and slab deck is highly anticipated to harm pedestrians or vehicles passing under the bridge.
5) Possibility of bridge falling down is anticipated due to damaged or loss of fall-down prevention devices or abnormal movement of a girder.
6) Possibility of road surface caving in is anticipated due to heavily damaged slab deck.
7) Abnormal noise from a girder or inspection facilities is adversely affecting nearby residents.

Chapter 3

LOAD RATING

This Chapter discusses the general principles, policies and guidelines on Load Rating of Bridges. The methodology is based on the AASHTO Manual for Condition Evaluation of Bridges (MCEB).

3.1 LOAD RATING PRINCIPLES

In general, the resistance (R) of a structural member (also called attribute) should be greater than the demand (Q) as follows:

Resistance (R) $\geq$ Demand (ΣQ)

or in Equation form,

$$R \geq Q_D + Q_L + \Sigma Q_I \qquad [3.1\text{-}1]$$

where: R is the member resistance or capacity,
ΣQ is the effect of all loads,
Q_D is the effect of dead load,
Q_L is the effect of live load, and
ΣQ_I is the effect of load i.

In the bridge evaluation process, the maximum allowable live load need to be determined and by rearranging Equation [3.1-1], the maximum allowable live load becomes:

$$Q_L \leq R - \{ Q_D + \Sigma Q_I \} \qquad [3.1\text{-}2]$$

It then becomes a question of whether a fully loaded vehicle (Rating Vehicle) can be allowed on the bridge or not, or what portion of the rating vehicle can be allowed on the bridge. The portion of the rating vehicle will be given by the ratio between the available capacity for live load effect and the effect of the rating vehicle. This ratio is called the ***Rating Factor (RF)*** as defined by:

$$RF = \frac{\text{Available Capacity for Live Load Effect}}{\text{Rating Vehicle Load Demand}} = \frac{R - \{ Q_D + \Sigma Q_I \}}{Q_L} \qquad [3.1\text{-}3]$$

Simplifying the above equation to AASHTO MCEB form with **$\Sigma Q_I = 0$** (see Section 3.4 for loading consideration) gives,

$$RF = \frac{R - Q_D}{Q_L} = \frac{R - A_1 D}{A_2 L(1+I)} \qquad [3.1\text{-}4]$$

where: RF = is the rating factor for live-load carrying capacity. The rating factor multiplied by the rating vehicle in metric tons gives the rating of the structure.

R = is the resistance or capacity of the member.
Q_D = $A_1 D$
Q_L = $A_2 L(1+I)$
D = is the dead load effect on the member. For composite members, the dead load effect on the non-composite section and the dead load effect on the composite section need to be evaluated when the Allowable Stress method is used.
L = is the live load effect on the member.
I = is the impact factor to be used with the live load effect.
A_1 = γ_D = is factor for dead loads.
A_2 = γ_L = is the factor for live load.

The "load effect" in the preceding equation is the applied loads on the member. Typical load effects are axial force, vertical shear force, bending moment, axial stress, shear stress and bending stresses. Once the load effect to be evaluated is selected, the "capacity" of a member to resist such a load effect may be determined.

When the rating factor is equals to or greater than one, the bridge is capable of carrying the rating vehicle. On the other hand, when the rating factor is less than one, the bridge may be overstressed while carrying the rating vehicle.

The Rating Factor (RF) may be used to determine the rating of the bridge member in metric tons as follows:

Load Rating = Rating Factor x Rating Vehicle Weight

or in Equation form,

$$LR = RF \bullet W \qquad [3.1\text{-}5]$$

where: LR = is the bridge member load rating in metric tons.
W = is the weight (in metric tons) of nominal truck used in determining the live load effect (L)

The rating of the bridge is controlled by the member with the lowest rating in metric tons.

The effects of dead and live loads are the only two principal loads considered in the evaluation process. *However, impact should be added to the live load used for the rating.*

3.2 LOAD RATING METHOD

Although the basic concept of load rating evaluation is the same, there are three methods commonly used to check the capacity of the members, namely, the Allowable Stress Method (ASM), the Load Factor Method (LFM) and the Load and Resistance Factor Method (LRFM). However, in this Manual, only the allowable stress method and the load factor method are recommended as the load rating methods.

3.2.1 The Allowable Stress Method (ASM)

The *Allowable Stress (or the Working Stress) Method* constitutes a traditional specification to provide structural safety. The actual loadings are combined to produce a maximum stress in a member which is not to exceed the allowable or working stress. The allowable or working stress is found by taking the limiting stress of the material and applying an appropriate factor of safety.

In this method, the capacity of a member is based on the rating level evaluated: Inventory Level-Allowable Stress or the Operating Level-Allowable Stress.

The Rating Factor (RF) under this method is calculated as:

$$\mathbf{RF} = \frac{\mathbf{R - A_1 D}}{\mathbf{A_2\,L(1+I)}} = \frac{\mathbf{R - D}}{\mathbf{L(1+I)}} \qquad [3.2\text{-}1]$$

where $A_1 = 1.0$
$A_2 = 1.0$

Rewriting the above formula in terms of flexural and shear stress,

For moment stresses, $$RF = \frac{\sigma_b - \sigma_{DL}}{\sigma_{(LL+I)}} \qquad [3.2\text{-}2]$$

For shear stresses, $$RF = \frac{\tau_v - \tau_{DL}}{\tau_{(LL+I)}} \qquad [3.2\text{-}3]$$

where σ_b : allowable stress in flexure
σ_{DL} : flexural stress due to dead load
$\sigma_{(LL+I)}$: flexural stress due to live load and impact
τ_v : allowable stress in shear
τ_{DL} : shear stress due to dead load
$\tau_{(LL+I)}$: shear stress due to live load and impact

Note: σ_{DL} and τ_{DL} should include superimposed dead load effects (see Example 3 of Appendix III)

3.2.2 The Load Factor Method (LFM)

The *Load Factor Method* is based on analyzing a structure subject to multiples of the actual loads (factored loads). Different factors are applied to each type of load which reflects the uncertainty inherent in the load calculations. The rating is determined such that the effect of the factored loads does not exceed the strength of the member.

The nominal capacity of structural steel, reinforced concrete and prestressed concrete should be the same as specified in the load factor design of the DPWH Design Guidelines.

The Rating Factor (RF) under this method is calculated as:

$$RF = \frac{\phi R_n - \gamma_D D}{\gamma_L L(1+I)} \quad [3.2\text{-}4]$$

where ϕR_n : is the nominal resistance or capacity

γ_D, γ_L : is the dead and live load factors

γ_D = 1.3

γ_L = 2.17 (Inventory Level)

γ_L = 1.3 (Operating Level)

γ_L = 2.17 (Posting Level)

Rewriting the above formula in terms of moment and shear forces,

For moment forces, $$RF = \frac{M_U - \gamma_D M_{DL}}{\gamma_L M_{(LL+I)}} \quad [3.2\text{-}5]$$

For shear forces, $$RF = \frac{V_U - \gamma_D V_{DL}}{\gamma_L V_{(LL+I)}} \quad [3.2\text{-}6]$$

where M_U : $= \phi M_n$, moment strength or capacity

M_{DL} : moment due to dead load

$M_{(LL+I)}$: moment due to live load and impact

V_U : $= \phi V_n$, shear strength or capacity

V_{DL} : shear due to dead load

$V_{(LL+I)}$: shear due to live load and impact

ϕ : 0.90 for flexure (bending) and 0.85 for shear

Note: M_{DL} and V_{DL} should include superimposed dead load effects (see Example 3 of Appendix III)

For the basic load rating evaluation, the analysis can be simplified by assuming that a similar rating vehicle will occupy all the possible lanes to produce the maximum effect on the structure. This assumption will allow us to use the AASHTO live-load distribution factor approach.

During the structural evaluation for load rating, the location and type of critical failure mode should be first identified – such critical areas and sections differ depending on the structural system and the physical condition of the bridge members.

The determination of structural failure modes for bridge rating depends on the load rating method used, as shown in Table 3.2-1.

Table 3.2-1 Failure Criteria for Structures

RATING METHOD	FAILURE CRITERIA	REMARKS
Allowable Stress	• When a portion of a structural member is stressed beyond the allowable stress, the structure is considered failed	• Serviceability and strength is assured using this method since structural member never reaches yield • Normally, deflections and vibration are always satisfied under this method
Load Factor	• Failure occurs at two limit states: 1. Serviceability limit state – when the structure reaches its maximum allowable serviceability limit, and 2. Ultimate strength limit state – when the member reaches its ultimate capacity	• In load factor method, satisfying one limit state does not guarantee satisfaction of the other limit state • Both serviceability and strength criteria need to be checked • When estimating operating rating, serviceability need not be checked

Typical shear and flexural failure modes for simple concrete and steel bridges are shown in Figure 3.2-1 and Figure 3.2-2.

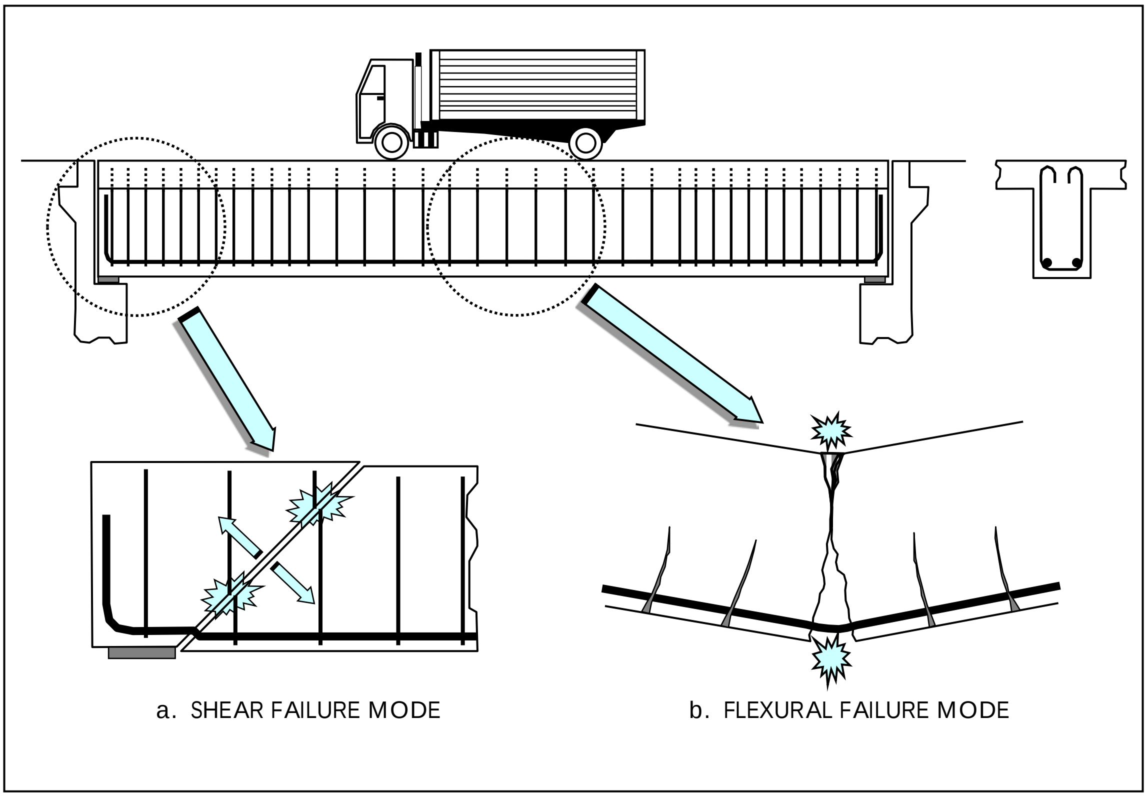


Figure 3.2-1 Typical Shear and Flexure Failure Modes for Concrete Bridges

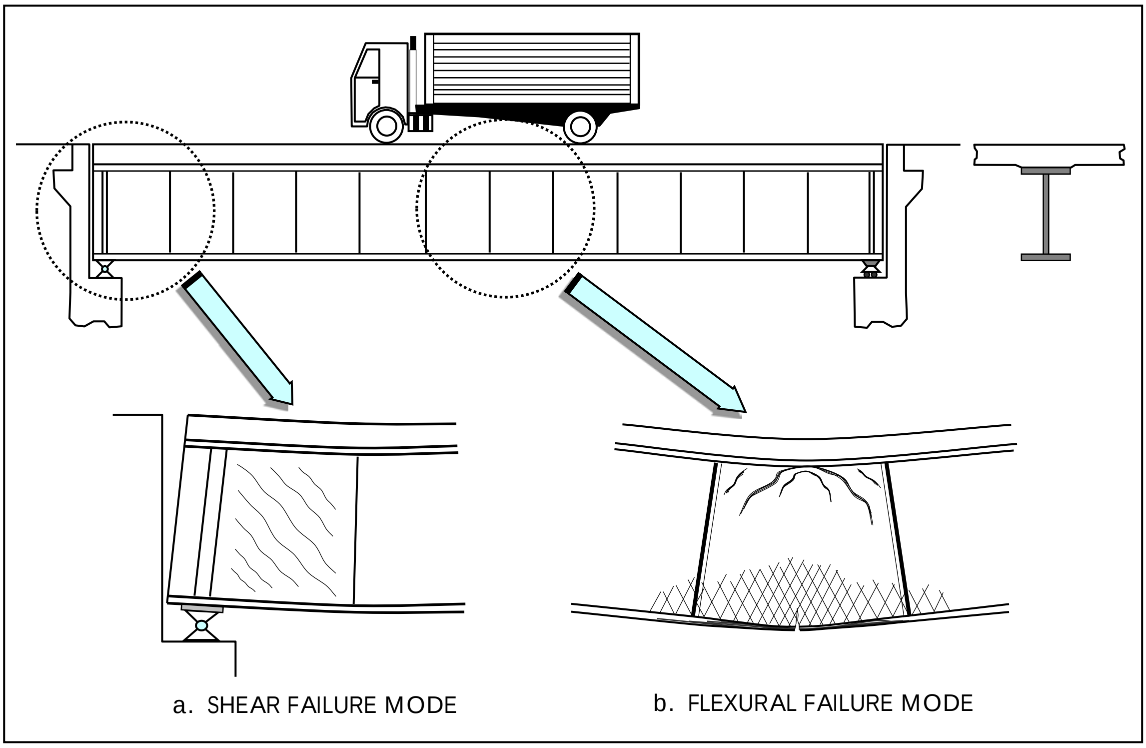


Figure 3.2-2 Typical Shear and Flexure Failure Modes for Steel Bridges

3.3 LOAD RATING LEVELS

There are two levels of rating to which a bridge should be load rated - the Inventory and the Operating Levels.

3.3.1 Inventory Level (To be used for Load Posting)

The life of the bridge depends on the fatigue life or serviceability limits of the bridge materials. Higher frequent loading and unloading may affect the fatigue or serviceability of the bridge components and the bridge life itself. Therefore, in order to maintain the bridge for a longer period, the live-load carrying capacity available for frequently passing vehicle needs to be estimated at service level. This process is then referred to as the **Inventory Rating**.

The Inventory rating level generally corresponds to the **customary design level** of stress but reflects the existing bridge and material condition with regard to deterioration and loss of section. This rating level allows comparison with the capacity for new structures.

*The Inventory Rating Level results in a **live load that can be safely carried by an existing bridge for an indefinite period of time**.*

3.3.2 Operating Level (To be used for Permit Loading)

Although very heavy but less frequent vehicles may affect the fatigue life or serviceability of a bridge, bridges can however be allowed to carry **less frequent vehicles** with higher loads than usual. This process of evaluating such load capacity is referred to as the **Operating Rating**.

Load rating based on the Operating rating level reflects the **absolute maximum permissible live load that can be safely carried by the bridge**. *Allowing unlimited number of vehicles to use the bridge at the Operating Level may shorten the life of the bridge*.

However, extraordinary heavy vehicles or trucks (within the bridge operating level) can only be allowed to pass the bridge structure after complying with the conditions stipulated in the permit to travel.

3.4 LOADINGS

3.4.1 Dead Load (DL)

- Dead load effects should be computed in accordance with the conditions existing at the time of analysis. The minimum unit weight of materials to be used in computing the dead load should be in accordance with the current DPWH design guidelines. Care should be observed in taking the dimensions of the different bridge members and components.
- For composite members, the portion of the dead load acting on the non-composite section and the portion acting on the composite section should be determined.
- Care should be exercised in estimating the weight of concrete decks since significant variations of deck thickness have been found, particularly on older bridges.
- The approximate overlay thickness should be measured at the time of inspection.
- Assumptions for members of unknown geometry should be done based on experience and engineering judgment. Back calculations may be necessary to determine the missing dimensions.

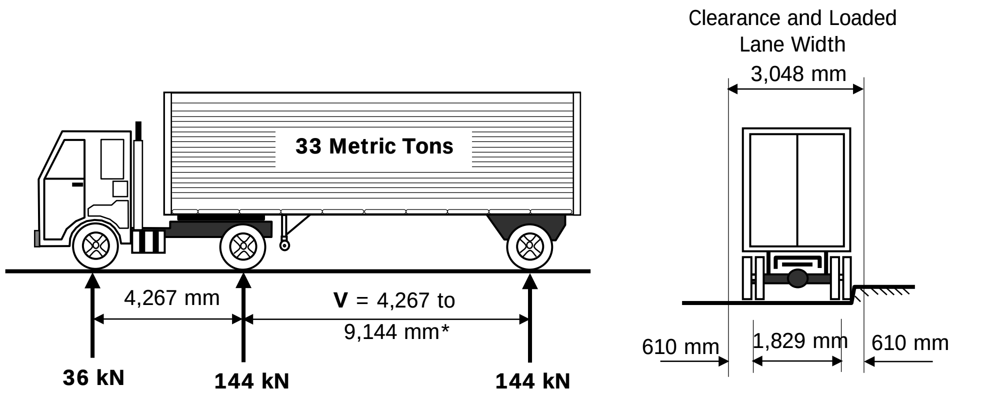
3.4.2 Rating Live Load (LL)

The live load to be used in the basic rating equation is the MS18 (HS20-44) truck or its equivalent lane loading in accordance with the DPWH Design Guidelines, as shown in Figure 3.4-1.

Although the DPWH Design Guidelines Section 3.2.4 “Highway Loads” specify the minimum design loading to be the MS18 loading or the Alternate Military loading (which results to bigger design loads at shorter spans), only the MS18 vehicle loading will be used for load rating in this manual.

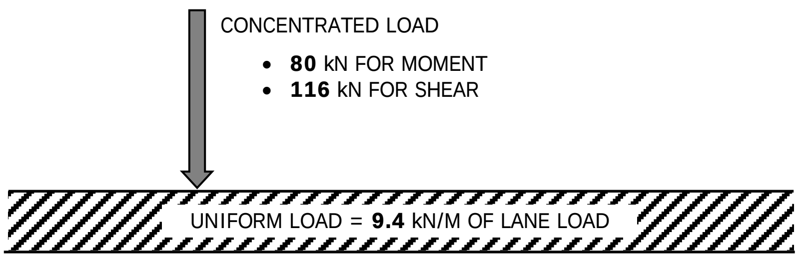
Moreover, the DPWH Design Guidelines Section 3.2.4.6 requires checking the bridge capacity against the demands of the *Permit Design Load* with an increase in the allowable design stresses or the use of a live load factor equivalent to one(1).

A comparison of the design live loads under the DPWH Design Guidelines is presented in Appendix IV of this Manual.



NOTES: 1. *VARIABLE SPACING V = 4.267M TO 9.144M TO BE USED IS THAT WHICH PRODUCES MAXIMUM STRESSES.
2. FOR TIMBER FLOORS OR ORTHOTROPIC STEEL DECKS (EXCLUDING TRANSVERSE BEAMS) FOR MS18 LOADING, ONE AXLE LOAD OF 108kN OR TWO AXLE LOADS OF 72kN EACH, SPACED AT 1.22M APART (WHICHEVER PRODUCES THE GREATER STRESS) MAY BE USED, INSTEAD OF THE 144kN AXLE SHOWN.

(a) Standard MS18 Truck Load (HS20-44)



(b) Standard MS18 Lane Load

Figure 3.4-1 Rating Live Load

3.4.3 Posting Live Loads

The live load to be used in the rating equation for posting considerations should be any of the typical legal loads shown in Figure 3.4-2. For spans over 60m in length, the selected legal load should be spaced with 9m clear distance between vehicles to simulate a train of vehicles in one lane and a single vehicle load should be applied in the adjacent lane(s).

3.4.4 Wheel Loads (Deck)

In general, stresses in the deck do not control the load rating except in special cases; however, the wheel loads and the calculation of bending moments in the deck should be in accordance with the current DPWH Design Guidelines.

3.4.5 Truck Loads and Number of Traffic Lanes

The live or moving loads to be applied on the deck for determining the load rating is the Standard MS18 (Metric units) or HS20-44 (US units) loading. The number of traffic lanes to be loaded and the transverse placement of wheel lines shall be in accordance with the current DPWH Design Guidelines and the following table.

Table 3.4-1 Roadway Width and Number of Traffic Lanes

Roadway Width	Number of Design Traffic Lanes	Remarks
5.4m to 6.0m (18ft to 20ft)	2	Each lane equal to one-half the roadway width
Less than 5.4m (18ft)	1	Equal to roadway width
☞ When conditions of traffic movements and volumes warrant it, fewer traffic lanes than specified by DPWH Design Guidelines may be used.		

3.4.6 Lane Loads

Standard MS (HS) Lane Loads, as specified in the current DPWH Design Guidelines, may be used for all spans where it will result in load effects greater than those produced by the standard MS18 trucks.

3.4.7 Sidewalk Loading

Sidewalk loadings used in calculations for safe load capacity ratings should be the probable maximum loads anticipated. Such load varies with site conditions and requires an engineering judgment but in no case will it be more than the value given in the DPWH Design Guidelines.

The Operating level rating should consider full truck and sidewalk loading acting simultaneously on the bridge.

3.4.8 Live Load Effects

- Live load moments in longitudinal stringers and girders may be calculated using 2D or 3D analytical model of the bridge or using the moment table in Appendix III for live load moments produced by the rating and posting loads.
- Live load moments in the intermediate and end floor beams of trusses and through girders may be calculated by statics using simple models and considering the transfer of wheel loads from the stringers to these members.
- Live loads in truss members can be calculated by using influence lines for maximum shears and moments or using design aids or tables for trusses. A 2D or 3D analytical truss model may be used to calculate truss member demand forces. Care should be taken when the structure or panels are too short to permit the entire load to be on the structure with the load positioned to produce the maximum shear or moment.

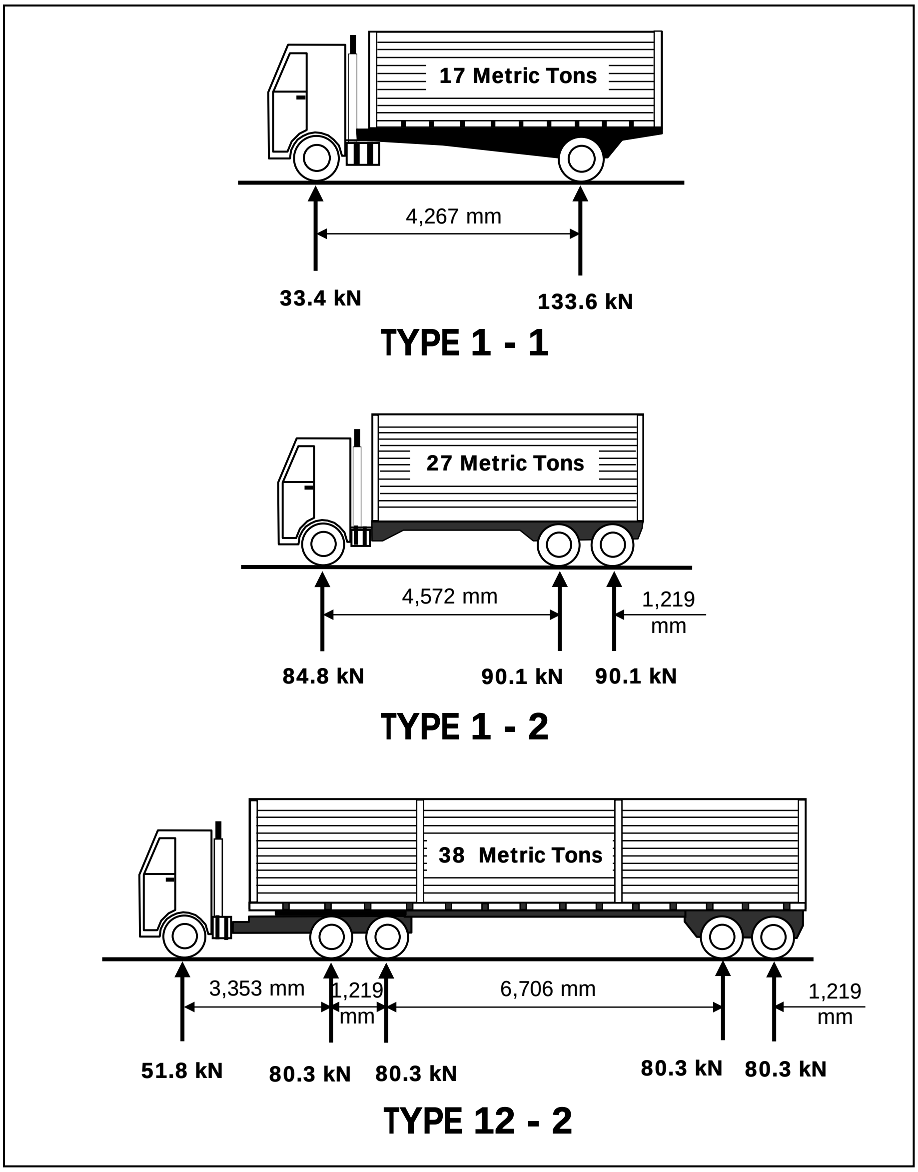


Figure 3.4-2 Typical Legal Loads Used for Load Posting

3.4.9 Distribution of Loads

The fraction of live load transferred to a single member will be selected in accordance with the current DPWH Design Guidelines. The values represent a possible combination of diverse circumstances.

Other methods can be used including field measured values, analytically calculated values or those derived from advanced structural analysis using the properties of the existing structures. Loadings should be placed in positions causing the maximum response in the components being evaluated.

3.4.10 Impact

Impact should be added to live load used for rating based on the current DPWH or AASHTO recommendations. Reduction in impact values can be made for bridges when conditions of alignment, enforced speed posting, and similar situations require a vehicle to substantially reduce speed in crossing the structure.

3.4.11 Deflection

Basically, live load deflection limitations should not be considered in load rating.

3.4.12 Loads That Can Be Neglected in Load Rating

Since the occurrence of extreme values during the relatively short-duration live - loading is extremely small, the following load effects should not be considered in load ratings:

- Longitudinal Loads,
- Environmental Loads,
- Wind Loads,
- Earthquake Loads,
- Thermal Loads, and
- Loads Due to Stream Flow

3.5 MATERIAL PROPERTIES AND NOMINAL RESISTANCE OR CAPACITY (R)

The nominal capacity or resistance to be used in the rating equation depends on the structural materials, the rating method and the rating level used. *AASHTO Manual for Condition Evaluation of Bridges (MCEB), 2nd Ed., 2000*, provides nominal capacities for Allowable Stress and Load Factor methods in Articles 6.6.2 and 6.6.3.

For all bridge components and elements, the material properties used for the rating shall be based on the material grade or design stresses, as specified in the plans or design drawings. When plans are not available or they do not specify material grade or design stresses, the rating engineer must use proper judgment to determine the appropriate material properties based on the information available. Normally, the decision is based on the year the bridge was constructed.

Table 3.5-1 presents the material properties based on the year of construction as given in the AASHTO MCEB. The material property table is based on the predominant grades of materials as recommended by AASHTO and adopted in the Philippines during the early design of bridges.

After making a thorough investigation into all possible sources of information concerning the bridge structure under rating and the rating engineer is still unable to determine the grade of material used or the year of construction, then a conservative estimate of the construction year should be made. The material properties in Table 3.5-1 shall then be used to determine the material properties for the rating.

3.5.1 Capacity under Allowable Stress Method

In the Allowable Stress Method, the resistance or capacity of a member is based on the rating level evaluated:

- Inventory Level - Allowable Stress, or
- Operating Level - Allowable Stress

The properties used for determining the allowable stress capacity for different materials is given in Table 3.5-1 or those found in the DPWH Design Guidelines or the AASHTO Design Specifications. For convenience, the table provides, where appropriate, the Inventory, Operating, Posting and yield stress values. Allowable stress and strength formulas should be those provided in the AASHTO MCEB, DPWH Design Guidelines or the AASHTO Design Specifications.

Table 3.5-1 Material Properties Used When Actual Grade of Material is Unknown

MATERIAL	YEAR OF CONSTRUCTION	Fy or F'c (MPa)	ALLOWABLE STRESS RATINGS		
			INVENTORY (MPa)	OPERATING (MPa)	POSTING (MPa)
Structural Steel *Bending (Compression/ Tension)*			0.55 Fy	0.75Fy	0.55 Fy
	Prior to 1905	179.3	96.5	134.4	96.5
	1905 to 1936	206.8	110.3	155.1	110.3
	1936 to 1963	227.5	124.1	168.9	124.1
	After 1963	248.2	137.9	186.2	137.9
Structural Steel *Web Shear*				0.45Fy	
	Prior to 1905	179.3	58.6	79.3	58.6
	1905 to 1936	206.8	65.5	93.1	65.5
	1936 to 1963	227.5	75.8	103.4	75.8
	After 1963	248.2	82.7	110.3	82.7
Reinforcing Steel *Tension*	Prior to 1954	227.5	124.1	172.4	124.1
	After 1954	275.8	137.9	193.1	137.9
	Grade 50	344.7	137.9	224.1	137.9
	Grade 60	413.7	165.5	248.2	165.5
Concrete *Bending*	Prior to 1959	17.2	6.9	10.3	6.9
	After 1959	20.7	8.3	13.1	8.3
	1977 to 1981	27.6*	11.0	16.5	11.0
	After 1981	31.0*	12.4	18.6	12.4

* For prestressed concrete

Prestressed Concrete and Steel Strands	Based on actual grade or material used (Refer to Section 6.6.6.3 of the AASHTO MCEB)

Timber	Based on actual grade or material used (Refer to Chapter 6 of the ASEP NSCP 2001)	1.33 x Inventory	Same as Inventory

When situations arise that are not covered by the specifications, then rational strength of material formulae should be used consistent with data and plans verified in the field investigation. Deviations from the above specifications should be fully documented.

When the bridge materials or construction are unknown, the allowable stresses should be fixed by the rating engineer, based on field investigations and/or material testing conducted and should be substituted for the basic stresses given herein.

Moreover, for *prestressed concrete members*, the allowable stress rating equations shall be:

For Inventory Rating:

a. Concrete Tension $$RF = \frac{\frac{1}{2}\sqrt{f'_c} - (F_d + F_p + F_s)}{F_l} \quad [3.5\text{-}1]$$

b. Concrete Compression $$RF = \frac{0.6\, f'_c - (F_d + F_p + F_s)}{F_l} \quad [3.5\text{-}2]$$

c. Concrete Compression $$RF = \frac{0.4\, f'_c - \frac{1}{2}(F_d + F_p + F_s)}{F_l} \quad [3.5\text{-}3]$$

d. Prestressing Steel Tension $$RF = \frac{0.8\, f^*_y - (F_d + F_p + F_s)}{F_l} \quad [3.5\text{-}4]$$

For Operating Rating:

a. Prestressing Steel Tension $$RF = \frac{0.9\, f^*_y - (F_d + F_p + F_s)}{F_l} \quad [3.5\text{-}5]$$

where

RF	:	rating factor
f'_c	:	concrete compressive strength
$\frac{1}{2}\sqrt{f'_c}$	:	allowable concrete tensile stress; use $\frac{1}{4}\sqrt{f'_c}$ for corrosive exposure condition
F_d	:	unfactored dead load stress
F_p	:	unfactored stress due to prestress after all loses
F_s	:	unfactored stress due to secondary prestress forces
F_l	:	unfactored live load stress including impact
f^*_y	:	prestressing steel yield stress

3.5.2 Capacity under Load Factor Method

The nominal capacity of the structural steel, reinforced concrete and prestressed concrete should be the same as specified in the load factor sections of the current DPWH Design Guidelines or the current AASHTO Design Specifications. Nominal strength calculations should take into consideration the observable effects of deterioration, such as loss of concrete or steel-sectional area, loss of composite action or corrosion.

❑ Structural Steel

The yield stresses used for determining load ratings should depend on the type of steel used in the structural member. When specifications of the steel are not available, yield strengths should be taken from the applicable “Year of Construction” column of Table 3.5-1. The capacity of structural steel members should be based on the load factor requirements of the DPWH Design Guidelines.

Allowable fatigue strength should be checked based on the current AASHTO Design Specifications.

❑ Reinforced Concrete

The capacity of concrete members should be based on the strength requirements stated in the DPWH Design Guideline. The area of tension steel at yield to be used in computing the ultimate moment capacity of flexural members should not exceed that available in the section or 75 percent of the reinforcement required for balanced conditions.

❑ Prestressed Concrete

The load rating of prestress concrete members at both the Inventory and Operating Level, should be established in accordance with the strength requirements, including the minimum reinforcement requirements, of the DPWH Design Guidelines. In situations of unusual design with wide dispersion of tendons, the Operating rating might further be controlled by stresses not to exceed 0.90 of the yield point stress in the prestressing steel nearest the extreme tension fiber of the member.

Live loads shall be limited to preserve the relationship between the nominal moment capacity (ϕM_n) and the cracking moment (M_{cr}), as prescribed for new design. This necessitates an adjustment to the value of ϕM_n, used in the flexural strength rating equation. Thus, when $\phi M_n < 1.2\ M_{cr}$, the nominal moment capacity becomes $(k)(\phi)(M_n)$, with $k = \phi M_n / 1.2\ M_{cr}$.

The strength rating equation for prestressed concrete shall be:

<u>For Inventory Rating</u>:

Flexural and Shear Strength, $$RF = \frac{\phi R_n - (1.3D + S)}{2.17L\ (1 + I)} \qquad [3.5\text{-}6]$$

<u>For Operating Rating</u>:

Flexural and Shear Strength, $$RF = \frac{\phi R_n - (1.3D + S)}{1.3L\ (1 + I)} \qquad [3.5\text{-}7]$$

where
- ϕR_n : nominal section strength (Moment - ϕM_n; Shear - ϕV_n)
- D : unfactored dead load moment or shear
- S : unfactored prestress secondary moment or shear
- L : unfactored live load moment or shear
- I : impact factor

3.5.3 Conditions of Bridge Structural Members

In the load rating analysis and section nominal capacity or resistance determination, the following factors should be considered to obtain a more realistic assessment of the actual bridge performance and structural behavior:

- ☑ The condition and extent of deterioration of structural components of the bridge should be considered in the computation of the dead load and live load effects when stress is chosen as the evaluation approach and for capacity when force or moment is chosen for use in the basic rating equation.

- ☑ The rating for load-carrying capacity should be based on the most recent field investigation considering all physical features that will affect the structural integrity of the bridge. Adequate data should be taken for damaged or deteriorated sections for proper evaluation in the analysis.

- ☑ Size, number and relative locations of bolts and rivets through tension members should be determined and recorded to determine the net sectional area.

- ☑ Misalignments, bends, or kinks in compression members should be measured carefully as these control its load-carrying capacity.

- ☑ Connections, especially compression members should be checked carefully for eccentricities that should be considered in the structural analysis.

- ☑ Cracks found on concrete members shall be noted and its effect in reducing member capacity or resistance and stiffness shall be considered as follows:

  - Bending Cracks: *Effective Section Properties* shall be calculated using the original section less the effects of cracks. This effective section property shall be used in the analysis model of the bridge structure.

    Section Capacity or Resistance shall be calculated considering crack width and effects on steel reinforcements. When steel reinforcements are severely corroded, consider the loss of section and use the remaining steel cross-section in calculating member capacity.

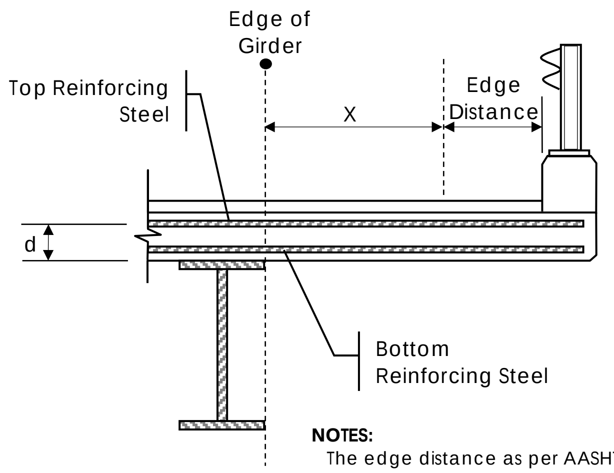
  - Shear Cracks: Concrete shear resistance shall be calculated based on the extent of shear cracks on the section. Basically, concrete shear capacity shall be neglected on members with shear cracks extending to more than half the depth of the member; in this case, consider only the shear resistance contribution of reinforcing steel.

- ☑ The capacity or resistance and section properties of steel member with cracks or severe corrosion shall be calculated based on the effective cross-section of the members. The effective area of members to be used in the calculations shall be the gross area less the portion that has deteriorated due to cracks, decay or corrosion.

3.6 RATING BRIDGE DECKS

Reinforced concrete decks supported by longitudinal girders with main reinforcement perpendicular to traffic shall be rated according to this section.

- This section covers deck slabs continuous over three or more supports. The slab must be supported by longitudinal girders or stringers with the main slab reinforcement perpendicular to the girders or for deck slab skews less than or equal to 20º. (Deck slab skew is defined as the deviation in degrees of the main reinforcement bars from perpendicular to the girders. The main reinforcement bars may have a different skew than the bridge structure.)
- When design plans are available, use the applicable concrete strength and steel yield stress or use the values in Table 3.5-1 (Year Construction - Allowable Bending Stress Table) for the appropriate year of construction.
- When plans are not available for a concrete deck, and the deck shows no sign of failure, then the assignment of rating values will not be required. However, if the condition of the deck indicates probable failure, then rating values shall be calculated and assigned. The rating engineer shall indicate on the rating summary sheet that plans are not available for the deck.
- All other types of bridge decks shall be rated in compliance with the applicable guidelines within this Manual and the current DPWH and AASHTO Codes.



NOTES:
The edge distance as per AASHTO is equal to 300mm.
If "**X**" is greater than "**d**" then consider rating the overhang.

- Usually, deck overhangs at the exterior girder do not control the slab rating. However, the rating engineer should use judgment in determining if the overhang should be rated. A criteria that may be used is: Rate the cantilever portion of the concrete bridge deck if the wheel load can be applied outside the exterior girder by a distance equal to or greater than the distance from the bottom of the slab to the centerline of the top reinforcement, as shown below.
- For reinforced concrete slabs with main reinforcement parallel to traffic, load rating shall be done in accordance with the guidelines for reinforced concrete structures.

3.7 RATING REINFORCED CONCRETE GIRDER BRIDGES

This section covers the rating of reinforced concrete girders and slabs reinforced longitudinally. The types of bridges covered by this section include:

- RCBG - Reinforced Concrete Box Girder (Simple and Continuous)
- RCS - Reinforced Concrete Slab (Simple and Continuous)
- RCDG - Reinforced Concrete Deck Girder (Simple and Continuous)

3.7.1 General

- Computer software used for load rating shall be approved by BOD, DPWH.
- Concrete girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The analysis output results can then be supplemented with hand calculations to consider any of these influences, as necessary. However, the rating engineer may perform a more refined analysis including all geometric and material considerations using advanced analytical tools and methods.
- Bridges shall be rated using Allowable Stress or Load Factor Method.
- When plans are available, use the minimum yield strength values given in the plans; otherwise, values given in Table 3.5-1 shall be used for the applicable year of construction. If the condition of the girder indicates that full strength should not be used, the rating should be used as appropriate.
- Moment rating shall be performed at standard critical sections (i.e. ½ span lengths for simply supported structures or at points of maximum negative and positive moments for continuous structures), any controlling rebar cut-off section, or any section that shows signs of distress or deterioration.
- Shear rating shall also be performed at critical sections (i.e. at "d" distance from support, points of maximum shears, etc.), any section with change in shear reinforcement, or any section that shows signs of distress or deterioration.
- Rating of cast-in-place box girder bridges can be simplified by separating out the boxes into I - shapes and rate as a typical interior and exterior girder. Dead loads and live loads shall be applied as appropriate.

3.7.2 Girders Requiring Rating

- *Interior Girders* - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, differences in loads, moments, concrete strength and/or reinforcing, condition of member, etc.
- *Exterior Girders* - An exterior girder shall be rated under the following conditions:
    1. When the section used for the exterior girder is different than the section used for an interior girder.
    2. When the overhang is greater than S/2.
    3. When the plans indicate that the curb and floor slab were poured monolithically, the live load distribution factor for the exterior girder shall be calculated and compared to the live load distribution factor for the interior girders. If the live load distribution factor for the exterior girder is equal to or greater than 75% of the live load distribution factor for the interior girders, the exterior girder shall be rated.
    4. When the loading condition or the demand forces varies with that of the interior girders.
    5. When the existing condition of the exterior girder shows signs of distress or deterioration that could affect the safety of the public.
    6. When the rating engineer determines the rating would be advantageous in analyzing the overall condition of the structure.

3.7.3 Calculations

- A set of calculations shall be submitted with each rating. These calculations shall include:
    - ☑ Derivations for dead loads,
    - ☑ Derivations for live loads and distribution factors, and
    - ☑ Any other calculations or assumptions used for rating.
- Dead Loads
    1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 50N.
    2. Dead loads applied after a cast-in-place concrete deck has cured shall be distributed equally to all girders and, when applicable, treated as composite dead loads. Examples include asphalt, curbs, sidewalks, railing, etc.
    3. Use 250N/m^2 for the unit weight of formworks that has remained in place in the superstructure. An example is closed cell construction, such as cast-in-place concrete box girder.
    4. Dead loads applied before a cast-in-place concrete deck has cured shall be distributed to the applicable individual supporting girders and treated as non-composite loads. Examples of this type of dead load are deck slabs, girders, diaphragms, etc. The weight of diaphragms may be treated as point loads or as an equivalent uniform dead load for the span.

5. Dead loads due to utilities shall be considered when it is found to be significant, as per rating engineer's judgment. Application of load due to utilities is left to the rating engineer's discretion.

3.8 RATING PRESTRESSED CONCRETE GIRDER BRIDGES

This section presents the policies and guidelines for rating prestressed girders. The types of girders covered by this section include precast pretensioned girders as follows:

- PCDG - Prestressed Concrete Deck Girder (Simple and Continuous)
- PCBG - Prestressed Concrete Box Girder (Simple and Continuous)
- PCG - Other Prestressed Concrete Girders

3.8.1 General

- Computer software used for load rating shall be approved by BOD, DPWH.
- When rating girders using load factor method, prestressed girders shall not be rated for shear. However, all prestressed girders shall be checked for shear using the appropriate DPWH or AASHTO recommendations.
- The live load distribution factor to be applied to the bridge shall be as prescribed in the current DPWH or AASHTO Design Guidelines and Specifications.
- The rating engineer shall be responsible to determine whether stress-relieved or low relaxation strands were used in the bridge. Such information are normally stated in the plans, but if it is not possible to discern the type of strand used, the rating engineer shall assume stress-relieved strands until 1983 and low-relaxation strands thereafter.
- Prestressed concrete girder bridges with complex geometric alignment, i.e. flared girder bridges or girders with variable overhangs, shall be modeled as simple straight beams on pin or roller supports. The output results can then be supplemented by hand calculations to consider any significant influences, as necessary. However, the rating engineer may perform a more refined analysis including all geometric and material considerations using advanced analytical tools and methods.
- For effective slab widths, the "b" in the equation "12t + b" shall be the width of the top flange of the girder, not the web.

3.8.2 Girders Requiring Rating

- _Interior Girders_ - A rating is required for the critical interior girder. More than one interior girder may require an analysis due to variation in span length, girder size, girder spacing, differences in loads, moments, concrete strength and/or reinforcing, condition of member, etc.
- _Exterior Girders_ - An exterior girder shall be rated under the following conditions:

1. When the section used for the exterior girder is different than the section used for an interior girder.
2. When the overhang is greater than S/2.
3. The exterior girder of a multi-girder bridge should be rated if it does not have a cast-in-place composite slab. For this case, the dead loads due to sidewalks, curbs and railings shall be applied to only the exterior girder.
4. When the loading condition or the demand forces varies with that of the interior girders.
5. When the existing condition of the exterior girder shows signs of distress or deterioration that could affect the safety of the public.
6. When the rating engineer determines the rating would be advantageous in analyzing the overall condition of the structure.

3.8.3 Calculations

The guidelines under this section shall be the same as Section 3.7.3. However, the rating engineer shall indicate whether stress-relieved or low-relaxation strands were used in the rating calculations.

3.8.4 Simple and Continuous Span Bridges

- Simple span prestressed girders shall be rated as simple span members for all loads (i.e. dead loads, superimposed dead loads, live load, etc.). Span length shall be taken as the distance between the centerline of bearing at abutments or supports.
- Simple span prestressed girders made continuous for composite dead loads and live load plus impact, shall be rated as continuous members for these loads. Span lengths shall be taken as the distance from centerline of bearing at the abutment to centerline or pier, and centerline of pier to centerline of pier as applicable.
- The negative moment analysis at centerline of piers shall be based on the Allowable Stress or the Ultimate Strength (Load Factor) Method. The girder's primary negative moment reinforcement and only the top layer of the slab's distribution reinforcement, within the effective slab width, shall be used in the analysis.
- In cases when the compressive strength of simple span prestressed girders made continuous for composite dead loads and live load plus impact changes from span to span, only the girder with the least compressive strength shall be used to model the entire structure.

3.9 RATING STEEL BRIDGES

This section presents the policies and guidelines in rating steel girder bridges. The types of girders covered by this section are:

- SINCS - Steel I-Girder with Non-composite Concrete Slab (Simple and Continuous)

- SICCS - Steel I-Girder with Composite Concrete Slab (Simple and Continuous)
- SBG - Steel Box Girder (Simple and Continuous)
- SDG - Steel Deck Girder (Simple and Continuous)

3.9.1 General

- All steel girders shall be rated using software approved by BOD, DPWH.
- Steel girders with considerable stress/strain effects due to horizontal curvature, skew, temperature, or other influences shall be modeled as simple, straight beams on pin or roller supports. The analysis output results can then be supplemented with hand calculations to consider any of these influences, as necessary. However, the rating engineer may perform a more refined analysis including all geometric and material considerations using advanced analytical tools and methods.
- Bridges shall be rated using Allowable Stress or Load Factor Method.
- Use the minimum design yield strength value (f_y) and the minimum compressive strength (f'c) indicated in the plans. If no data exists, the rating engineer may refer to Table 3.5-1 based on year of construction or actual tests may be performed to determine material strengths.

3.9.2 Girders Requiring Rating

Refer to Section 3.7.2.

Exterior girders on navigable water channels are prone to vessel collisions. The condition of such exterior girder should be checked thoroughly for evidence of collision or damages. If the exterior girder is badly damaged due to collisions or other factors, its capacity for live load as well as dead load should be checked and redistribution of forces to the next interior girder verified carefully. The additional dead load as well as live load redistributed to the next interior girder should be considered in rating the interior girder.

3.9.3 Calculations

Refer to Section 3.7.3.

As mentioned in Section 3.9.2, additional dead loads due to redistribution of forces from a badly damaged exterior girder shall be considered for the adjacent interior girder.

3.10 RATING TRUSS BRIDGES

This section covers the general policies and guidelines for rating truss bridges. Since majority of truss bridges are structural steel, this section covers the necessary details to rate steel truss bridges.

Bridge decks shall be rated in accordance with Section 3.6.

The types of bridges covered by this section include:

- SDT - Steel Deck Truss
- STT - Steel Through Truss

3.10.1 General

- Computer software used for load rating shall be approved by BOD, DPWH.
- Truss bridge rating shall be performed in accordance with this Manual and the DPWH and AASHTO Design Guidelines.
- Members designed by allowable or working stress method shall be rated by the working stress method.
- Structural stringer or floor beams shall be rated using the applicable portions of this Manual.
- When design plans are available with given design stresses, the applicable inventory and operating stresses shall be used. Otherwise, reference is made to the year of construction to determine steel strengths. However, it is possible that the year of construction and the year of steel member fabrication are not coincident when salvaged members are used. In this case, the year of steel fabrication shall be used in determining allowable stresses.
- Truss members and its location shall be clearly identified during load rating in a simple manner in accordance with the BMS-BIM or the AICB Manual.
- Section capacities of steel members shall be in accordance with the current AASHTO MCEB or DPWH Design Guidelines.

3.10.2 Members Requiring Rating

- *Truss Members* - A rating is required for all members that make up a truss. If a truss is symmetrical about its midspan centerline and the member conditions are basically the same, then all members on only one side of the centerline require a rating. A rating is not required for a portal or sway bracing members.
- *Interior Floor Beams* - A rating is required for the critical floor beam. The rater should determine the critical floor beam based on the existing member condition, cross-sectional area, grade, loading condition or any factor that may influence the strength of the member.
- *End Floor Beams* - A rating is required for an end floor beam when the cross-sectional size is different from that used in an interior floor beam or when the existing condition state requires capacity check or evaluation.
- *Interior Stringers* - A rating is required for the critical stringer. The determination of the critical stringer is similar to a critical floor beam.
- *Exterior Stringers* - A rating is required for an exterior stringer when the cross-sectional size is different from that used in an interior stringer or when the existing condition state of the member requires capacity check or evaluation.

3.10.3 Calculations

- A set of calculations shall be submitted with each rating. These calculations shall include:
    - ☑ Analysis model of truss (diagram) with member labels and node numbers,
    - ☑ Derivation for member section properties,
    - ☑ Derivations for dead loads,
    - ☑ Derivations for live loads and distribution factors, and
    - ☑ Any other calculations or assumptions used for rating.
- Live Loads

  Live load distribution factors shall be calculated in accordance with the DPWH Design Guidelines.
- Dead Loads
    1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 50N.
    2. Dead loads supported by stringers and applied after a cast-in-place concrete deck has cured shall be distributed equally to all stringers. Examples include asphalt and curbs.
    3. Dead loads supported by stringers and applied before a cast-in-place concrete deck has cured (or applied when the deck is not cast-in-place concrete) shall be distributed to the applicable individual supporting stringer. Examples include stringer weight and deck, but not necessarily overlay weight.
    4. Dead loads due to utilities shall be considered when it is found to be significant, as per rating engineer's judgment. Application of load due to utilities is left to the rating engineer's discretion.

3.11 RATING BRIDGES WITHOUT PLANS

Bridge inventory requires complete set of as-built drawings and inspection records. However, when records of old or existing bridges are not available, it will be necessary to reconstruct the as-built condition drawings of bridges that will become the basis of bridge inventory, inspection and load rating.

In order to complete and update bridge records and data, available sketches and inventory drawings should be checked and verified on site and changes or repairs and rehabilitation made on the bridge should be reflected on these records. When data on bridge members and components are lacking or measurements and fields tests are difficult, if not impossible to perform, structural drawings shall be reconstructed by "Presumption of Original Design". That is, reconstruction of original design shall be done by back-analysis using the governing design specifications during the time of construction.

In this manner, it will be necessary to know the history of the bridge, its original intended function and load capacity. The year of design or construction will provide valuable information as this will provide the governing design specifications on which bridge details were based.

When load rating will have to be performed for bridges without plans, the following guidelines shall be observed:

[1] When no plans or other documentation for a particular bridge structure is available, its numerical rating shall be determined by a Registered Professional Engineer appointed by DPWH. This rating shall be based on a complete and comprehensive engineering or detail inspection as specified by BMS-BIM, AASHTO MCEB or the AICB Manual. The rating engineer can assign a maximum Inventory Rating of 33 metric tons (using MS18 as the rating vehicle) when the following conditions are met:

→ The bridge has been carrying unrestricted traffic for many years,

→ There are no signs of significant capacity-reducing distress or deterioration,

→ Bridge must exhibit proper proportions and span-to-depth ratios of the main members, indicating that the original design was done by competent engineers,

→ Construction details including slab thickness and reinforcement cover over any exposed reinforcement conform to the specifications current at the time of the estimated construction date, and

→ Appearance shows that construction was done by a competent builder.

[2] When there are signs of capacity-reducing distress or deterioration, an appropriate judgment should be made and an Inventory Rating proportionally less than 33 metric tons shall be given to the bridge structure. The process is the same for operating rating except that the maximum operating rating of 36 metric tons can be assigned.

[3] Load testing of bridge structures to determine load capacity will be permitted where member details are unknown or an accurate loading history unavailable. Allowable postings will be established at 75% of the proof load vehicle. The proof load vehicle shall be as determined by DPWH based on the rating vehicle given at Section 3.4.2 or the posting vehicle presented at Section 3.4.3. Careful planning for load testing shall be done prior to execution so as not to overstress the bridge.

3.12 LOAD POSTING

1. Posting Vehicle Ratings are used to determine the maximum vehicle loads that will be allowed to travel on bridges. The Posting Vehicles are composed of the maximum vehicle loads currently permitted by law. In the Philippines, the Legal Loads are based on the Maximum Allowable Gross Vehicle Weight (GVW) as per Republic Act RA No. 8794 (Table 3.12-1). Consequently, the Posting Ratings are a means for ensuring the safe use of bridges by vehicles that do not exceed the legal loads. However, for the purposes of load posting, the posting vehicles recommended are those shown in Table 3.12-2.

2. In this Manual, ***Load Posting shall be done at the Inventory Level*** to ensure safe live load that can be carried by the bridge for an indefinite period of time. On the other hand, ***Permit Live Load shall be that equivalent to the Operating Level Load Rating***.

3. If a structure rating indicates a need for posting, the DPWH Office responsible for the bridge shall perform load rating/posting analysis following Figure 3.12-1 guidelines and load post the bridge. The BMS Unit shall be informed of any changes in load capacity and load posting of the bridge to update the bridge record and inventory.

4. The following guidelines will be used for load posting:

    - A bridge should be capable of carrying a minimum gross live load weight of 3.0 metric tons at Inventory or Operating Level. Bridges not capable of carrying a minimum gross live load weight of 3.0 metric tons must be closed.

    - A concrete bridge need not be posted for restricted loading when it has been carrying normal traffic for an appreciable length of time and shows no distress.

    - When it becomes necessary to reduce the allowable live loads in order to conform to the capacity of a structure, such reduction should be based on the assumption that each axle load maintains a proportional relation to the total load of the vehicle or vehicle combination.

    - The live load to be used for posting considerations should be any of the typical posting loads shown in Figure 3.4-2 of Section 3.4.3 and Table 3.12-2.

    - When the Inventory Rating value of a structural member is less than 33 metric tons, the structural member shall be rated for the posting vehicles and the results recorded on the Rating Summary Sheet as shown in Figure 3.13-2.

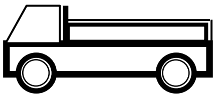
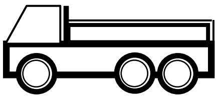
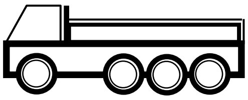
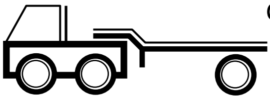
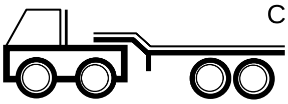
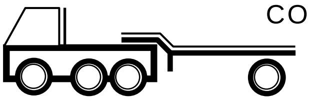
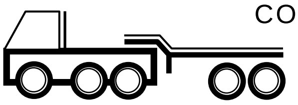
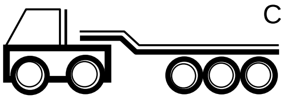
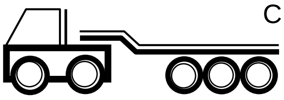
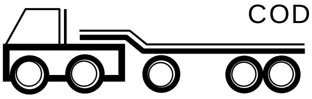
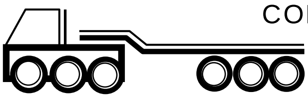
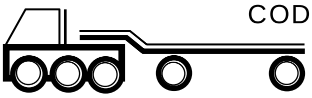
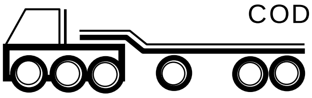
    - However, if the rating engineer feels that a posting analysis would be helpful in assessing the overall condition of a structure whose Inventory Rating is greater than or equal to 33 metric tons, then the posting rating values may be calculated and recorded on the Rating Summary Sheet.

    - *When the posting ratings for bridge members are greater than or equal to 95% of the legal limits (or posting vehicles), the structure can be exempted from posting requirement*. The rating engineer shall then make the determination and fill out the Rating Summary Sheet accordingly.

    - The member or section with the lowest rating factor shall govern the load posting of the bridge. Posting load shall be based on the lowest rating factor calculated.

5. Load Posting Sign shall be as shown in Figure 3.12-3. Basically, three Truck Vehicle Types shall be used for Load Posting as indicated in Table 3.12-2

Table 3.12-1 Maximum Allowable Gross Vehicle Weight (GVW) as per RA No. 8794**

TRUCKS/TRAILERS	DESCRIPTION	MAX. ALLOWABLE GVW (in kgs.)
 CODE 1-1*	TRUCK WITH 2 AXLES (6 WHEELS)	16,880
 CODE 1-2*	TRUCK WITH TANDEM REAR AXLE 3 AXLES (10 WHEELS)	27,250
 CODE 1-3	TRUCK WITH TANDEM REAR AXLE 4 AXLES (14 WHEELS)	29,700
 CODE 11-1	TRUCK SEMI-TRAILER WITH 3 AXLES (10 WHEELS)	30,380
 CODE 11-2	TRUCK SEMI-TRAILER WITH 4 AXLES (14 WHEELS)	30,380
 CODE 12-1	TRUCK SEMI-TRAILER WITH 4 AXLES (14 WHEELS)	30,380
 CODE 12-2*	TRUCK SEMI-TRAILER WITH 5 AXLES (18 WHEELS)	37,800
 CODE 11-3	TRUCK – TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (18 WHEELS)	30,378
 CODE 11-3	TRUCK –TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (14 WHEELS)	30,378
 CODE 11-12	TRUCK –TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (18 WHEELS)	36,900
 CODE 12-3	TRUCK –TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (22 WHEELS)	41,000
 CODE 12-11	TRUCK –TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (18 WHEELS)	37,800
 CODE 12-12	TRUCK –TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (22 WHEELS)	41,000

Note: *Truck CODE 1-1, 1-2 & 12-2 corresponds to the Posting Vehicles (see Table 3.12-2).
**When computing actual load rating use maximum allowable GVW in the amended IRR of RA No. 8794 as shown on page 56.

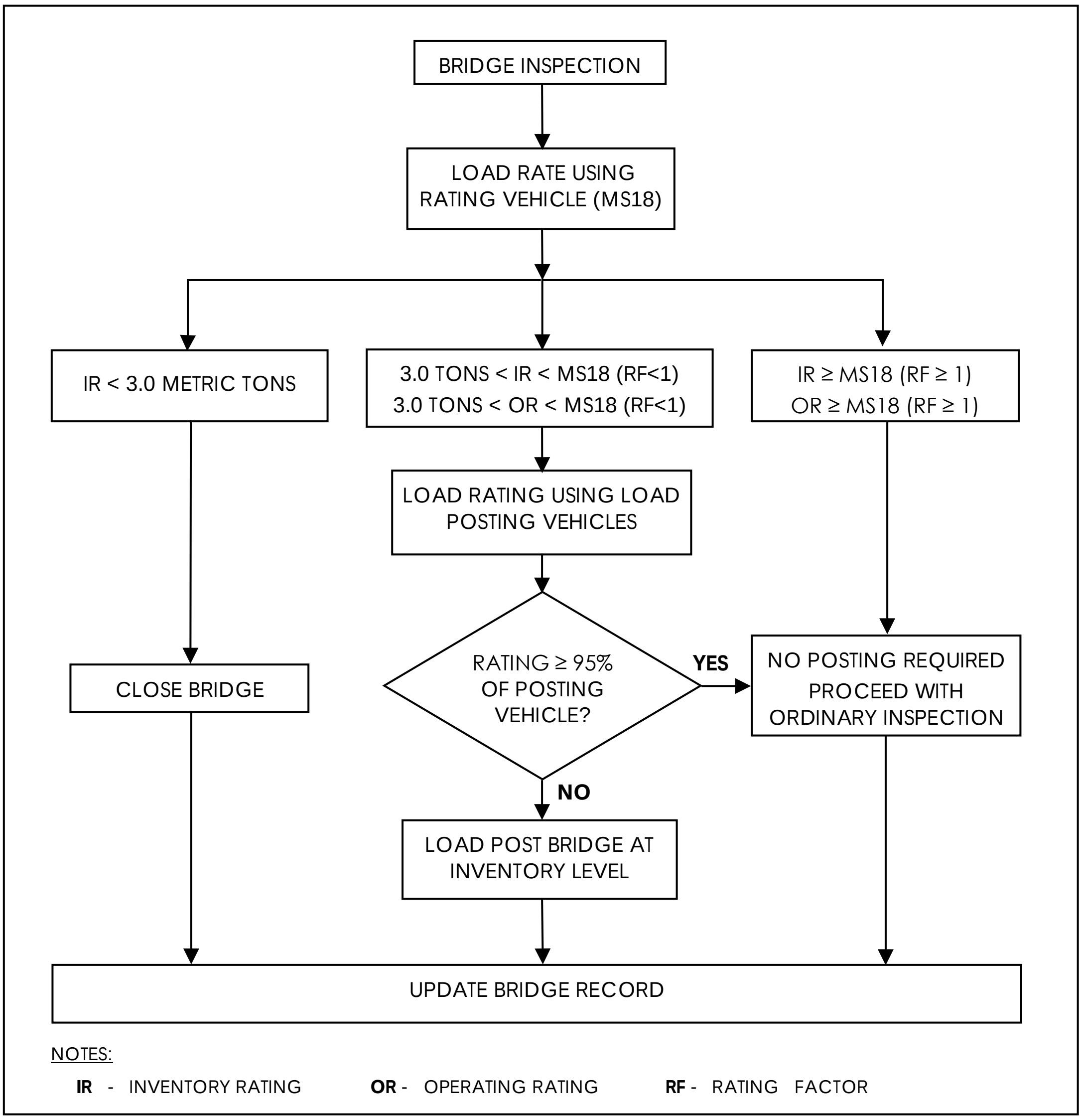


Figure 3.12-1 Flowchart of Load Posting Guideline

3.13 REPORTING AND DOCUMENTATION

The load rating of bridge should be completely documented in writing including all background information such as field inspection reports, material and load test data, all supporting computations, and a clear statement of all assumptions used in calculating the load rating. If a computer model was used, the input data file should be retained for future use.

3.13.1 Results of Rating Calculations

- The results of rating calculations will be summarized by the rating engineer on the Rating Summary Sheet (see Figure 13.3-2) which will be retained in the structure folder as a record of the adequacy of the structure.

Table 3.12-2 Load Posting Vehicles

Truck Type	Gross Weight (metric tons)	Truck Configuration	Description
Type 1-1	17		2-axle truck
Type 1-2	27		3-axle truck
Type 12-2	38		3-axle truck with 2-axle semi-trailer

The above vehicles are in metric tons. To distinguish metric tons with other units, the following conversion are used:

Metric Ton	:	1000.00 kilograms	=	2204 lbs.
British Ton (Long Ton)	:	1016.06 kilograms	=	2240 lbs.
US Ton (Short Ton)	:	907.185 kilograms	=	2000 lbs.

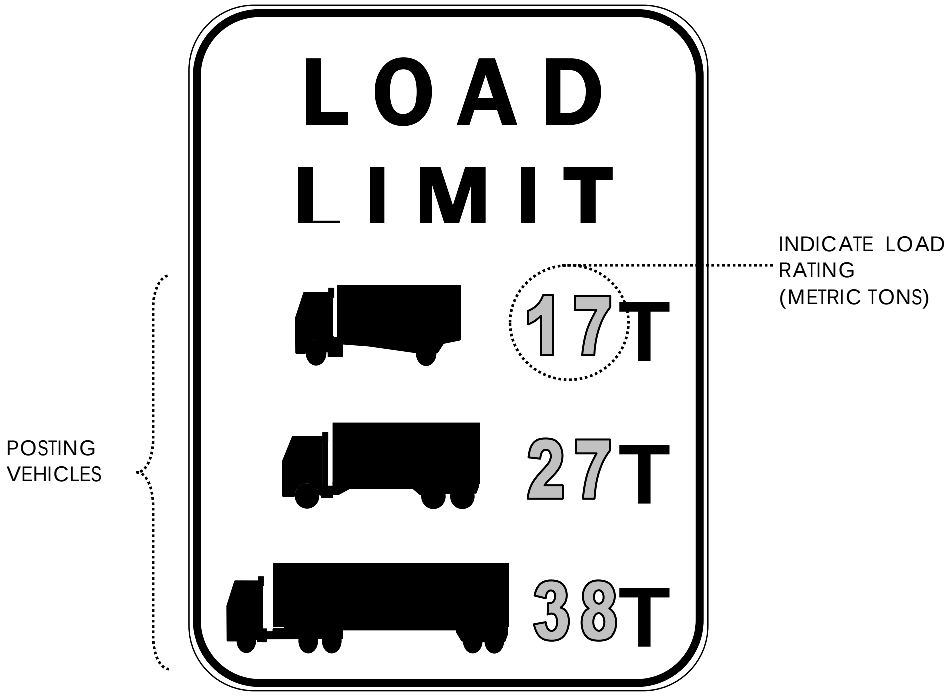
- The necessary information of the bridge structure typical of the BMS-BIM record sheet shall be shown on the summary sheet.
- The Summary Sheet shall reflect the Inventory and Operating Ratings obtained for each element requiring an analysis. Ratings shall be reported to tenths of a metric ton.
- The member being rated, including any relevant information shall be stated in the Summary Sheet.
- If posting vehicle analysis is required, record the posting rating on the Summary Sheet. *Postings shall be reported and recorded in metric ton of vehicle. Posting loads shall be that corresponding to the member or section with the lowest rating factor.*
- State in comments :

  (a) If the individual critical member rates considerably below other structure members, and is not representative of the entire structure, and

  (b) Any reduction in cross-section or allowable stresses used to rate the member and the reason for the reduction.

  (c) Any assumption used in load rating.

  (d) Recommendations for posting, closure or immediate counter-measures or repair.



NOTE:

REFER TO Appendix IV: DRAWING OF LOAD POSTING SIGN FOR DETAILS

Figure 3.13-1 Sample Load Posting Sign

3.13.2 Rating Report Documentation

The rating report submittal for documentation shall include:

1. A completed Rating Summary Sheet
2. Bridge geometry, description and sources of information
3. Results of inspection and testing conducted, including conditions of critical members
4. A set of Calculation Sheets showing
   a. Derivation of dead loads,
   b. Live load distribution factors,
   c. Structure model and assumptions
   d. Computer input information,
   e. Load Rating calculations (capacity and demand), and
   f. Other relevant considerations.

5. As-built plans and field surveys used in the rating process

6. The Rating Engineer and Checker's signature with date signed are required on the Rating Summary Sheet and on the calculation sheets and the first page of each set of computer output.

7. All items that compose the rating package shall be placed in a folder that is clearly labeled with the structure name and number.

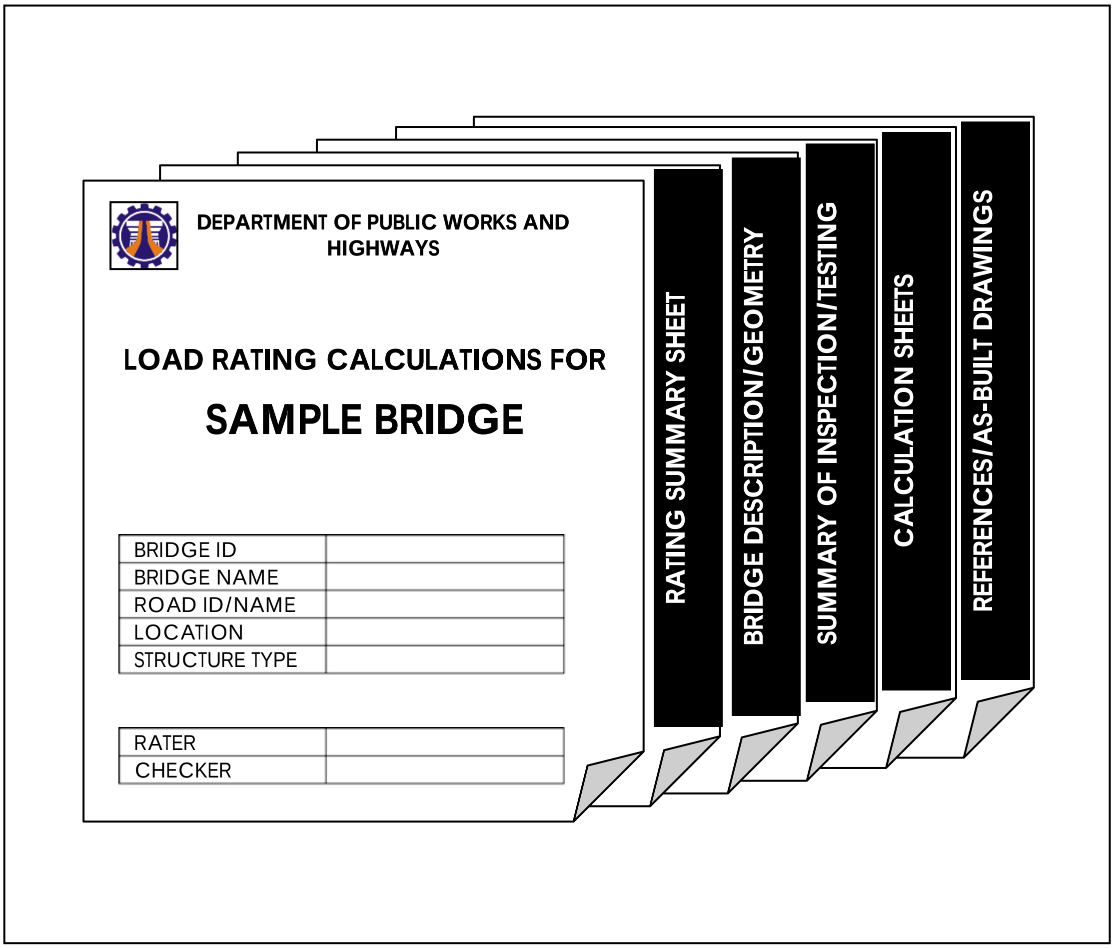


Figure 3.13-2 Load Rating Report and Documentation

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	**BRIDGE ID:**
	BRIDGE NAME:
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**
Rating Condition: Asphalt Thickness : ________ mm	**LOCATION:**
Rating Method: ________________________	**STRUCTURE TYPE:**

INDICATE INFORMATION REQUIRED FOR BRIDGE UNDER RATING

Structural Member				

FILL-UP STRUCTURE MEMBER BEING LOAD RATED

LOAD RATING (Metric Tons)

MS 18 Truck	**Inventory**				
	Operating				

INDICATE LOAD RATING FOR MS18 RATING VEHICLE

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	**Inventory**				
	Operating				
Type 1-2 Truck (27 tons)	**Inventory**				
	Operating				
Type 12-2 Truck (38 tons)	**Inventory**				
	Operating				

IF LOAD RATING < MS18, PERFORM LOAD POSTING USING POSTING VEHICLES

POSTING VEHICLES

____ **Metric Tons**	____ **Metric Tons**	____ **Metric Tons**

POSTING LOAD

INDICATE POSTING LOAD IN METRIC TONS BASED ON LOAD RATING/POSTING CALCULATIONS

Comments:

-
-
-

WRITE ANY COMMENT OR ASSUMPTIONS USED DURING LOAD RATING

Rated by:	**Date:**	**Checked by:**	**Date:**

RATING ENGINEER AND CHECKER MUST INDICATE NAME & SIGN

Figure 3.13-3 Load Rating Summary Sheet

RESOLUTION AMENDING
The IRR of R.A. 8794

WHEREAS, Republic Act No. 8794 (R.A. 8794) entitled "An Act Imposing a Motor Vehicle User's Charge on Owners of all Types of Motor Vehicle and for Other Purposes" was signed into law on June 27, 2000;

WHEREAS, Section 6 of R.A. 8794 provides that an amount equivalent to twenty-five percent (25%) of the MVUC shall be imposed on trucks and trailers for loading beyond their prescribed gross vehicle weight, provided that no axle load shall exceed thirteen thousand five hundred kilograms (13,500 kgs.);

WHEREAS, overloaded vehicles, particularly trucks and trailers have tremendous damaging effects on highways safety and traffic operations, and cause a heavy toll on government investment on infrastructure;

WHEREAS, in line with Section 9 of R.A. 8794 authorizing the Secretaries of the DPWH and the DOTC to jointly promulgate the rules and regulations to implement and carry out its intent objectives, purposes and provisions, the Implementing Rules and Regulations (IRR) of R.A. 8794 was issued on August 16, 2000, which contained provisions on overloading (Article I, paragraph 7c);

WHEREAS, the DPWH, the DOTC and the DILG, in a Joint Circular issued on November 19, 2001, provided the mechanics of implementation and enforcement of the provisions on overloading among the government agencies concerned. Attached as Annex "A" to the Joint Circular was a table prescribing the maximum allowable gross vehicle weights depending on the configuration of the trucks/trailers;

WHEREAS, in line with Article IV, paragraph 18 of the IRR of R.A. 8794, it has been determined that modifications on the provisions of the IRR on overloading are needed to ensure proper and effective enforcement and strict observance on the anti-overloading provisions of R.A. 8794.

NOW, THEREFORE, for and in consideration of the foregoing, and by virtue of the powers vested in us by law, we hereby adopt and promulgate the following amendment to the Implementing Rules and Regulations (IRR) of Republic Act No. 8794.

Article I. Common Provisions

7. Collection of Revenue from Road Users

c) Penalty for Overloading – Pursuant to Section 6 of R.A. 8794, an amount equivalent to twenty-five percent (25%) of the MVUC shall be imposed on trucks and trailers for loading beyond their prescribed gross vehicle weight, provided that no axle load shall exceed thirteen thousand five hundred kilograms (13,500 kgs.)

(1) Overloading Defined: There is overloading of trucks and trailers when the gross vehicle weight (GVW) exceeds that prescribed in Annex "A", provided that the dual-wheel single axle load does not exceed thirteen thousand five hundred kilograms (13,500 kgs.)

(2) Highway Travel Permit: Special Permit to Travel may be issued by the DPWH and shall be required for vehicles loaded with inseparable/ or special cargoes exceeding the corresponding GVW and vehicles with configuration different from those shown in Annex "A".

(3) Enforcement:

a) The DPWH shall install and operate weighbridge stations/ portable weighing machines at strategic locations along national roads for purposes of the implementation of the provisions of R.A. 8794 against overloading. The DPWH may outsource to Private Contractors the operation of the weighbridge stations/portable weighing machines.
b) The weighbridge/portable axle weighing stations shall be operated twenty-four (24) hours a day, including Saturdays, Sundays and holidays;
c) The DOTC, thru the LTO, shall be responsible for imposing penalties on overloaded vehicles as determined through the operation of weighbridge and portable axle load weighing devices; and
d) The LTO personnel or its duly deputized DPWH or PNP-TMG personnel assigned at the station shall issue to the driver of the overloaded vehicle, a Temporary Operator's Permit (TOP) indicating therein the excess load and the corresponding penalty to be paid in the amount equivalent to twenty-five percent (25%) of the Motor Vehicle User's Charge (MVUC) applicable to the vehicle at the time of infringement.

(4) Responsibility of the truck/trailer owner: The vehicle owner shall be responsible for ensuring that the vehicle is not overloaded while traversing the roadway. Such responsibility starts from the vehicle's point of origin up to its final destination. The vehicle owner shall be responsible for taking measures to ensure the security and safety of its personnel and load in case measures have to be adopted to ensure compliance with the provisions of law against overloading.

This amendment shall take effect on June 1, 2013 following its publication in two (2) newspapers of general circulation and filing of three (3) copies hereof with the UP Law Center.

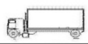
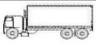
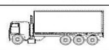
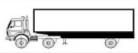
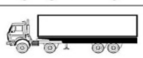
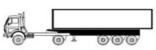
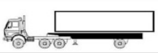
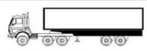
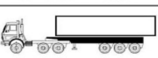
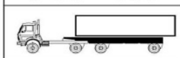
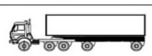
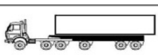
Approved this 5th day of April 2013.

(SGD.) JOSEPH EMILIO AGUINALDO ABAYA
Secretary
Department of Transportation and Communications

(SGD.) ROGELIO L. SINGSON
Secretary
Department of Public Works and Highways

ANNEX "A"

MAXIMUM ALLOWABLE GROSS VEHICLE WEIGHT (GVW) PER RA 8794
(REVISED 2012)

TRUCK/TRAILER	CODE	DESCRIPTION	ALLOWABLE GVW (kg)
	1-1	TRUCK WITH 2 AXLES (6 WHEELS)	18,000
	1-2	TRUCK WITH TANDEM REAR AXLE 3 AXLES (10 WHEELS)	33,300
	1-3	TRUCK WITH TRIDEM REAR AXLE 4 AXLES (14 WHEELS)	35,600
	11-1	TRUCK-TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 1 AXLE AT TRAILER (10 WHEELS)	34,000
	11-2	TRUCK-TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (14 WHEELS)	40,600
	11-3	TRUCK-TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (18 WHEELS)	41,000
	12-1	TRUCK-SEMI-TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 1 AXLE AT TRAILER (14 WHEELS)	39,700
	12-2	TRUCK SEMI-TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (18 WHEELS)	41,500
	12-3	TRUCK SEMI -TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (22 WHEELS)	42,000
	11-11	TRUCK-TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (14 WHEELS)	39,700
	11-12	TRUCK-TRAILER WITH 2 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (18 WHEELS)	43,500
	12-11	TRUCK-TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 2 AXLES AT TRAILER (18 WHEELS)	43,500
	12-12	TRUCK-TRAILER WITH 3 AXLES AT MOTOR VEHICLE & 3 AXLES AT TRAILER (22 WHEELS)	45,000

NOTE:
Special Permit to Travel shall be required for vehicles loaded with inseparable /or special cargoes exceeding the corresponding GVW and vehicles with configuration different from those shown in the above matrix. See attached requirements for processing of application for Special Permit to Travel

Attachment to ANNEX "A"

REQUIREMENTS FOR APPLICATION FOR SPECIAL PERMIT TO TRAVEL

1. Copy of Registration Certificate
2. Copy of Official Receipt of Registration
3. Technical data of the vehicle, either shown in the manufacturer's brochure or in a vehicle diagram duly signed by the owner:
   3.1 Gross weight of the vehicle
   3.2 Plan and side elevation with dimensions of the vehicle
   3.3 Number of wheels per axle
   3.4 Load per axle
4. The specific route to be taken and bridge(s) to be crossed by the vehicle indicated in a road map, duly signed by the owner.

The owner shall evaluate the capacity of the existing derated bridge (with posted load limit of less than 20 tons) to carry the vehicle. If it is necessary to strengthen the bridge, the engineering plan and design computations for shoring and/or reinforcement of the bridge duly signed and sealed by a Structural Bridge Engineer, shall be submitted.

Chapter 4

LOAD RATING EXAMPLES

4.1 GENERAL

This Chapter illustrates some example cases to show load rating procedures for existing bridge structures. The examples given in this Chapter will refer to this Manual and the AASHTO MCEB for bridge rating and the DPWH Design Guidelines and AASHTO Standard Specifications for the design specifications.

Five examples are presented in this Chapter, which includes:

- ☑ Example 1: Reinforced Concrete Flat Slab Bridge
  - 1-1: Simple
  - 1-2: Continuous
- ☑ Example 2: Reinforced Concrete Deck Girder Bridge
  - 2-1: Simple
  - 2-2: Continuous
- ☑ Example 3: Prestressed Concrete Deck Girder Bridge
  - 3-1: Simple
  - 3-2: Continuous
- ☑ Example 4: Steel I - Girder Bridge
  - 4-1: Simple
  - 4-2: Continuous
- ☑ Example 5: Reinforced Concrete Deck Slab

4.2 DESCRIPTION

4.2.1 Reinforced Concrete Flat Slab Bridge

4.2.1.1 Simple

A bridge built in 1958 consists of a simple span supported reinforced concrete flat slab on abutments with span length 8.0m and carriageway width 7.32m curb to curb. The As-Built Plans General Notes obtained indicate that the concrete allowable stress is 6.9MPa and steel allowable stress is137.9MPa. Results of the bridge condition inspection indicate that the bridge is damaged with rebar section loss. There is a 50mm thick wearing course on the deck and barrier rail, sidewalk and other weights can be assumed to be 18.5kN/m.

It is required to load rate the bridge using AASHTO MS18 (33 metric tons) as the rating vehicle. In case of the load rating falls below MS18, the load posting levels will be calculated based on Section 3.4 of this Manual.

The load rating will be done applied 1m widths of RCFS evaluating rebar section loss of the materials occurred. Load rating will be performed using the Load Factor Method.

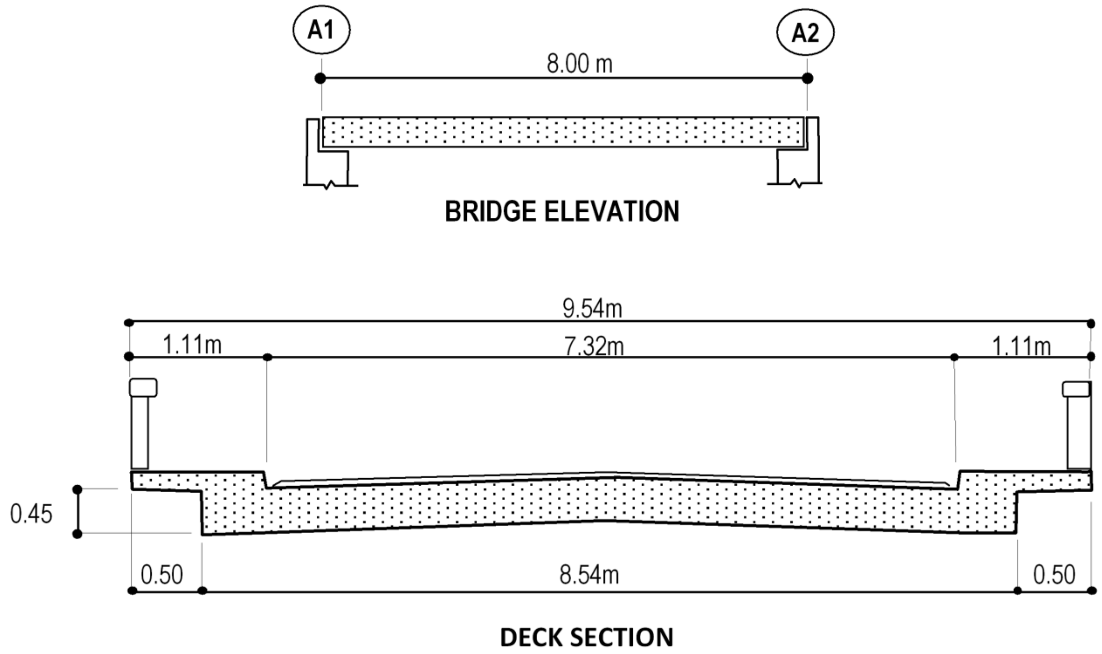


Figure 4.2-1 RCFS Simple Bridge (Example 1-1)

Results of the Load Rating and Load Posting Calculations according to the computer-based Program are presented in Appendix II, Example 1-1 of this Manual. Summary Results of the load rating calculation is shown in Figure 4.2-2.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	
	BRIDGE ID:
	BRIDGE NAME: RCFS SAMPLE 1-1 (Simple)
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**
Rating Condition: Asphalt Thickness : __50__ mm	**LOCATION:**
Rating Method: _Load Factor Method_	**STRUCTURE TYPE:** RCFS BRIDGE

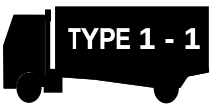
Structural Member		(Bending) at Midspan	(Shear)		

LOAD RATING (Metric Tons)

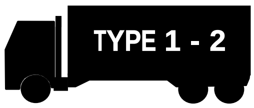
MS 18 Truck (33 tons)	Inventory	40.3			
	Operating	67.0			

LOAD POSTING (Metric Tons)

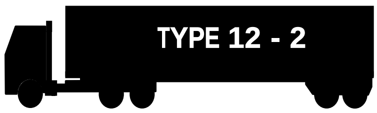
Type 1-1 Truck (17 tons)	Inventory				
	Operating				
Type 1-2 Truck (27 tons)	Inventory				
	Operating				
Type 12-2 Truck (38 tons)	Inventory				
	Operating				



____ Metric Tons



____ Metric Tons

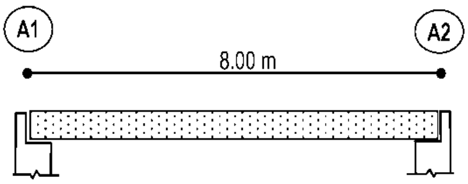


____ Metric Tons

POSTING LOAD

Comments:

- Load Rating done at mid span only for Moment resulted to Rating Factors greater than 1.0.
- Load Posting is not necessary since the bridge can carry normal loads.



BRIDGE ELEVATION

Rated by:	**Date:**	**Checked by:**	**Date:**

Figure 4.2-2 Load Rating Summary Sheet for Example 1-1

4.2.1.2 Continuous

Example 1-2 is a bridge built in 1982 consisting of three (3) continuous spans supported reinforced concrete flat slab on wall type RC Piers and RC Cantilever Abutments with span length 8.0m+8.0m+8.0m and carriageway width 7.32m curb to curb. The As-Built Plans General Notes obtained indicate a concrete allowable stress of 8.3MPa and steel allowable stress of 137.9MPa. Results of the bridge inspection indicate that the bridge condition is no damaged. There are 50mm wearing course found on the deck and barrier rail, sidewalk and other weight can be assumed to be 18.5kN/m.

It is required to load rate the bridge using AASHTO MS18 (33 metric tons) as the rating vehicle. In case of the load rating falls below MS18, the load posting levels will be calculated based on Section 3.4 of this Manual.

The load rating will be done applied 1m widths of RCFS. Load rating will be performed using the Load Factor Method.

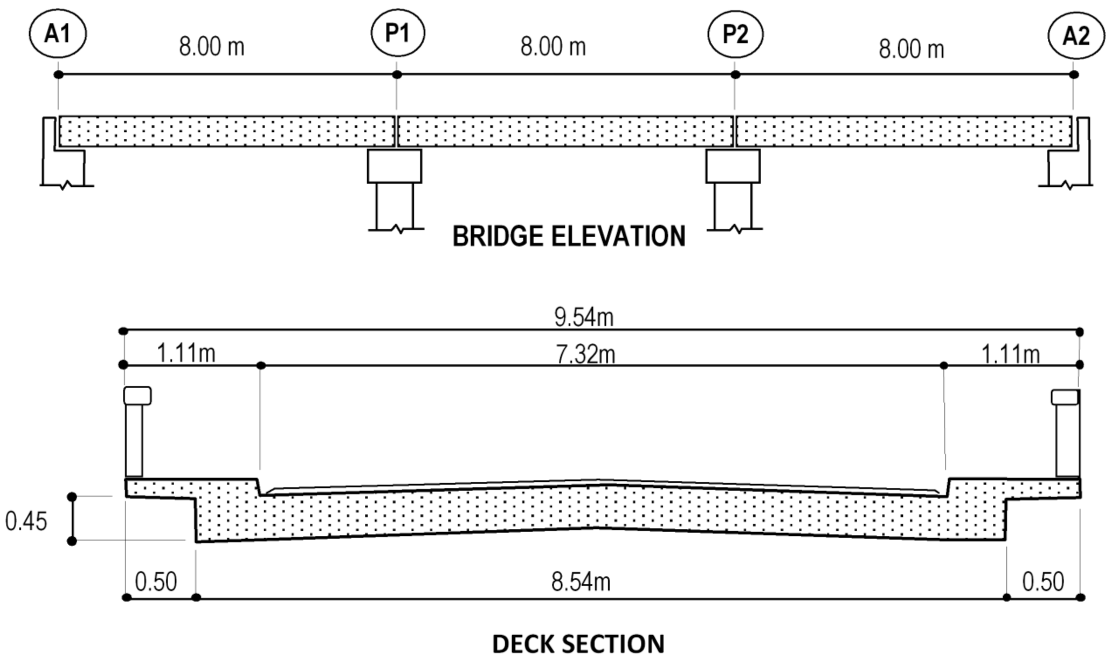


Figure 4.2-3 RCFS Continuous Bridge (Example 1-2)

Results of the Load Rating and Load Posting Calculations according to the computer-based Program are presented in Appendix II, Example 1-2 of this Manual. Summary Results of the load rating calculation is shown in Figure 4.2-4.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	BRIDGE ID:	
	BRIDGE NAME:	**RCFS EXAMPLE 1-2 (Continuous)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons) **Rating Condition:** Asphalt Thickness : __50___ mm **Rating Method:** _Load Factor Method_	ROAD ID / ROAD NAME:	
	LOCATION:	
	STRUCTURE TYPE:	**RCFS BRIDGE**

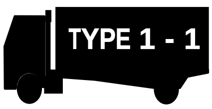
Structural Member	(Bending) at Midspan	(Bending) at Pier		

LOAD RATING (Metric Tons)

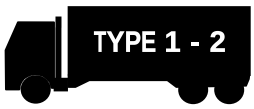
MS 18 Truck (33 tons)	**Inventory**	35.9	36.9		
	Operating	60.0	62.0		

LOAD POSTING (Metric Tons)

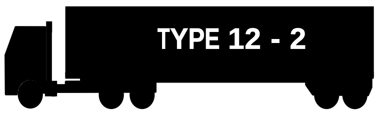
Type 1-1 Truck (17 tons)	**Inventory**				
	Operating				
Type 1-2 Truck (27 tons)	**Inventory**				
	Operating				
Type 12-2 Truck (38 tons)	**Inventory**				
	Operating				



____ Metric Tons



____ Metric Tons

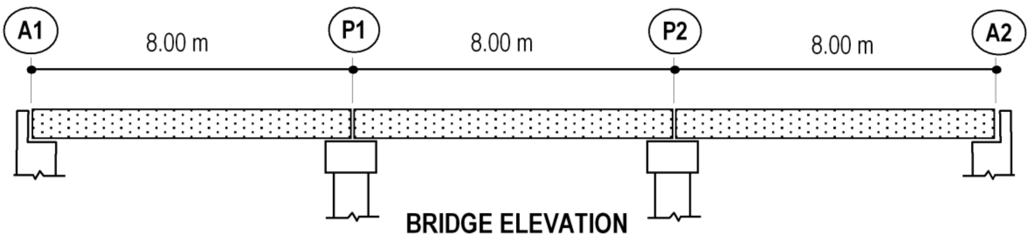


____ Metric Tons

POSTING LOAD

Comments:

- Load Rating done at mid span and at Pier only for Moment resulted to Rating Factors greater than 1.0.
- Load Posting is not necessary since the bridge can carry normal loads.



BRIDGE ELEVATION

Rated by:	**Date:**	**Checked by:**	**Date:**

Figure 4.2-4 Load Rating Summary Sheet for Example 1-2

4.2.2 REINFORCED CONCRETE DECK GIRDER BRIDGE

4.2.2.1 Simple

A bridge built in 1987 consists of a simply supported reinforced concrete T-beams on abutments. The span length is 10.4m. Bridge carriageway is 7.32m supported by four RC girders with spacing 2.400m on centers. The As-Built Plans General Notes obtained indicate a concrete allowable stress of 8.3MPa and steel allowable stress of 137.9MPa. Results of the bridge inspection indicate that the bridge condition is damaged with shear cracks. There are 50mm wearing course found on the deck and barrier rail weight can be assumed to be 3.6kN/m.

It is required to load rate the bridge using AASHTO MS18 (33 metric tons) as the rating vehicle. In case of the load rating falls below MS18, the load posting levels will be calculated based on Section 3.4 of this Manual.

The load rating will be done for the interior girder evaluating shear cracks of the materials occurred. Load rating will be performed using the Allowable Stress and the Load Factor Method.

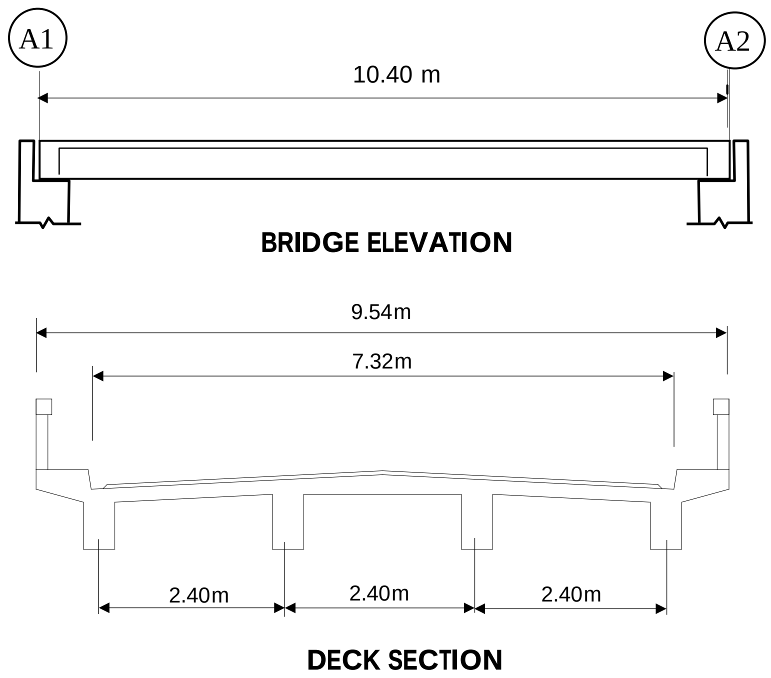


Figure 4.3-1 RCDG Bridge (Example 2-1)

Results of the Load Rating and Load Posting Calculations according to the computer-based Program are presented in Appendix II, Example 2-1 of this Manual. Summary Results of the load rating calculation is shown in Figure 4.3-2.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	**BRIDGE ID:**	
	BRIDGE NAME:	**RCDG SAMPLE 2-1 (Simple)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**	
Rating Condition: Asphalt Thickness : __50___ mm	**LOCATION:**	
Rating Method: __Load Factor Method__	**STRUCTURE TYPE:**	**RCDG BRIDGE**

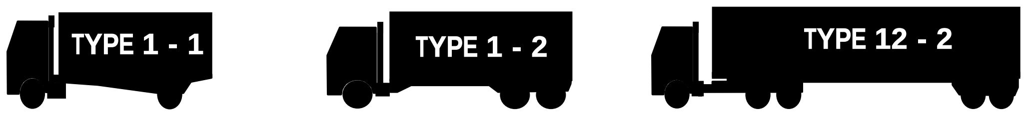
Structural Member		**Interior Girder G2 (Bending) At Midspan**	**Interior Girder G2 (Shear) At Support**		

LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	**Inventory**	16.7	9.6		
	Operating	27.9	16.1		

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	**Inventory**	11.1	**7.6**		
	Operating	18.6	12.7		
Type 1-2 Truck (27 tons)	**Inventory**	14.5	**8.9**		
	Operating	24.2	14.9		
Type 12-2 Truck (38 tons)	**Inventory**	21.8	**14.5**		
	Operating	36.4	24.2		

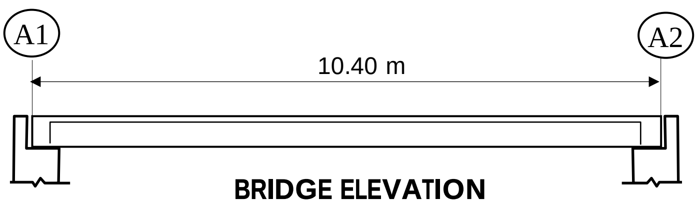


8 Metric Tons	**9 Metric Tons**	**14 Metric Tons**

POSTING LOAD

Comments:

- Load rating is governed by Girder G2 (interior girder).



BRIDGE ELEVATION

Rated by:	**Date:**	**Checked by:**	**Date:**

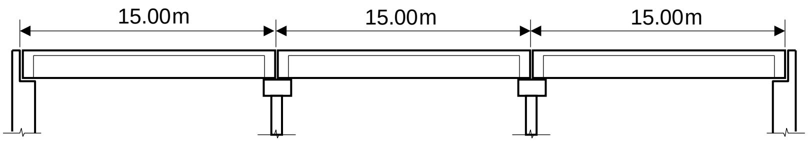
Figure 4.3-2 Load Rating Summary Sheet for Example 2-1

4.2.2.2 Continuous

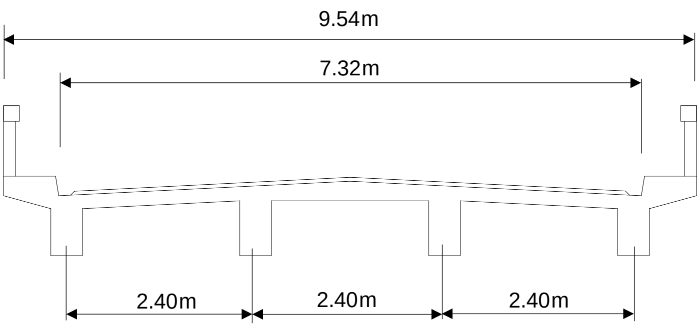
A bridge built in 2000 consists of three-span continuous supported reinforced concrete T-beams on concrete bents and abutments. The span lengths consist of 15.0m, 15.0m and 15.0m with a total bridge length of 45.0m. Bridge carriageway is 7.32m supported by four RC girders spaced at 2.400m on centers. The As-Built Plans General Notes obtained indicate a concrete allowable stress of 8.3MPa and steel allowable stress of 137.9MPa. Results of the bridge inspection indicate that the bridge condition is no damaged. There are no wearing course found on the deck and barrier rail weight can be assumed to be 13.0kN/m.

It is required to load rate the bridge using AASHTO MS18 (33 metric tons) as the rating vehicle. In case of the load rating falls below MS18, the load posting levels will be calculated based on Section 3.4 of this Manual.

The load rating will be done for the interior girder of the first span. Load rating will be performed using the Allowable Stress and the Load Factor Method.



BRIDGE ELEVATION



DECK SECTION

Figure 4.3-3 RCDG Bridge (Example 2-2)

Results of the Load Rating and Load Posting Calculations according to the computer-based Program are presented in Appendix II, Example 2-2 of this Manual. Summary Results of the load rating calculation is shown in Figure 5.3-4.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	BRIDGE ID:	
	BRIDGE NAME:	RCDG SAMPLE 2-2 (Continuous)
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons) **Rating Condition:** Asphalt Thickness : __0__ mm **Rating Method:** _Load Factor Method_	ROAD ID / ROAD NAME:	
	LOCATION:	
	STRUCTURE TYPE:	RCDG BRIDGE

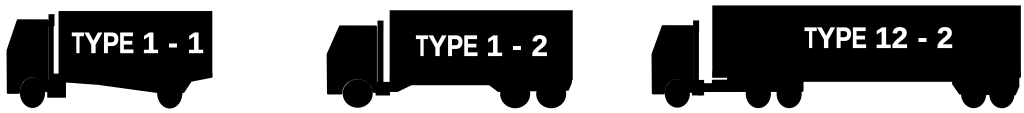
Structural Member		Interior Girder G2 (Bending) At Midspan	Interior Girder G2 (Bending) At Pier	Interior Girder G2 (Shear) At Pier	

LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	Inventory	56.3	41.7	**31.2**	
	Operating	93.9	69.6	52.0	

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	Inventory	40.6	43.6	41.3	
	Operating	67.8	72.8	69.0	
Type 1-2 Truck (27 tons)	Inventory	50.1	46.8	45.4	
	Operating	83.6	78.1	75.7	
Type 12-2 Truck (38 tons)	Inventory	77.1	50.9	59.7	
	Operating	128.7	85.0	99.7	

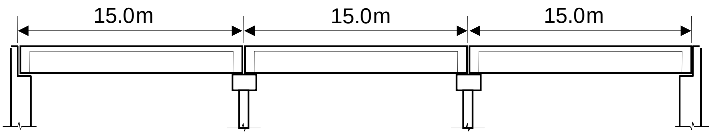


17 Metric Tons | 27 Metric Tons | 38 Metric Tons

POSTING LOAD

COMMENTS:

- LOAD RATING IS GOVERNED BY GIRDER G2 (INTERIOR GIRDER).



BRIDGE ELEVATION

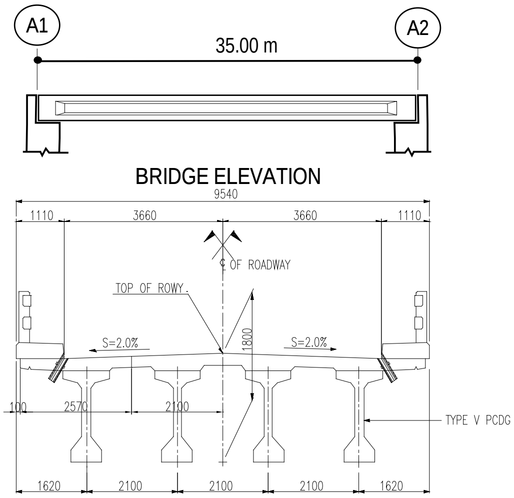
Rated by:	Date:	Checked by:	Date:

Figure 4.3-4 Load Rating Summary Sheet for Example 2-2

4.2.3 PRESTRESSED CONCRETE DECK GIRDER BRIDGE

4.2.3.1 Simple

The following example illustrates a simple span precast, prestressed deck girder bridge. The bridge has a span length 35.0m. The bridge is 9.54m wide with a clear carriageway width of 7.32m designed to carry two lanes of traffic. The deck is supported by four (4) precast, prestressed concrete deck girders spaced at 2.1m on centers. The girder is precast at 1.6m depth with 0.203 wall thickness. Deck slab at 0.20m thick is cast in place over the precast I Girder.



SUPERSTRUCTURE CROSS SECTION

Figure 4.4-1 PC Deck Girder Bridge (Example 3-1)

Notes on As-Built Plans indicate that the concrete strengths are 24.2MPa and 38MPa for the slab and I Girder, respectively. In addition, prestress working force is given as 5270kN at 100mm above the girder soffit at midspan. The reinforcing steel and the prestressing steel are assumed to have strengths of fy = 415MPa and fu = 1860MPa.

Load rating calculations will be done for the interior I girder. Evaluation is done at the midspan and support sections of the girder.

The load rating calculation according to the computer-based Program are presented in Appendix II, Example 3-1 of this Manual while the summary results of load rating is shown in Figure 4.4-2.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	**BRIDGE ID:**	
	BRIDGE NAME:	**PCDG SAMPLE 3-1(Simple)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**	
Rating Condition: Asphalt Thickness : __50___ mm	**LOCATION:**	
Rating Method: _Load Factor Method__	**STRUCTURE TYPE:**	**PCDG BRIDGE**

Structural Member		Interior Girder G2 (Bending) At Midspan	Interior Girder G2 (Shear) At Support		

LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	Inventory	43.4	49.6		
	Operating	72.5	82.7		

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	Inventory				
	Operating				
Type 1-2 Truck (27 tons)	Inventory				
	Operating				
Type 12-2 Truck (38 tons)	Inventory				
	Operating				

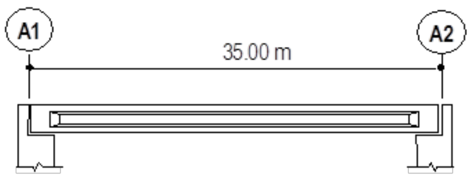
LOAD POSTING NOT NECESSARY

___ Metric Tons	___ Metric Tons	___ Metric Tons

POSTING LOAD

Comments:

- Rating Factors calculated for both serviceability and strength limit states are all greater than one (1).
- Load Posting is not necessary..



BRIDGE ELEVATION

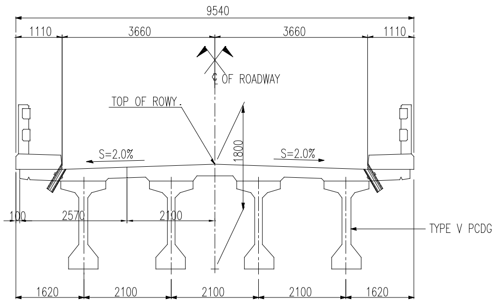
Rated by:	Date:	Checked by:	Date:

Figure 4.4-2 Load Rating Summary Sheet for Example 3-1

4.2.3.2 Continuous

The following example illustrates a three-span continuous precast, prestressed deck girder bridge. The span lengths consist of 35.0m, 35.0m and 35.0m with a total bridge length of 105.0m. The bridge is 9.54m wide with a clear carriageway width of 7.32m designed to carry two lanes of traffic. The deck is supported by four (4) precast, prestressed concrete deck girders spaced at 2.1m on centers. The girder is precast at 1.6m depth with 0.203 wall thickness. Deck slab at 0.20m thick is cast in place over the precast I Girder.

BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

SECTION AT MIDSPAN **SECTION AT PIER SUPPORT**

Figure 4.4-3 PC Deck Girder Bridge (Example 3-2)

Notes on As-Built Plans indicate that the concrete strengths are 24.2MPa and 38MPa for the slab and I-Girder, respectively. In addition, prestress working force is given as 6750kN at 100mm above the girder soffit at midspan. The reinforcing steel and the prestressing steel are assumed to have strengths of fy = 415MPa and fu = 1860MPa.

Load rating calculations will be done for the interior I-Girder. Evaluation is done at the midspan and support sections of the girder.

The load rating calculation according to the computer-based Program are presented in Appendix II, Example 3-2 of this Manual while the summary results of load rating is shown in Figure 4.4-4.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	
	BRIDGE ID:
	BRIDGE NAME: **PCDG SAMPLE 3-2 (Continuous)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons) **Rating Condition:** Asphalt Thickness : __50__ mm **Rating Method:** _Load Factor Method_	**ROAD ID / ROAD NAME:** **LOCATION:** **STRUCTURE TYPE:** **PCDG BRIDGE**

Structural Member		Interior Girder G2 (Bending) At Midspan	Interior Girder G2 (Shear) At Midspan	Interior Girder G2 (Bending) At Pier	Interior Girder G2 (Shear) At Pier

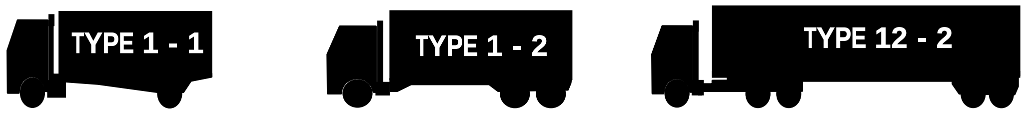
LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	**Inventory**	50.4	53.6	38.5	36.2
	Operating	84.1	89.5	64.3	60.5

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	**Inventory**				
	Operating				
Type 1-2 Truck (27 tons)	**Inventory**				
	Operating				
Type 12-2 Truck (38 tons)	**Inventory**				
	Operating				

LOAD POSTING NOT NECESSARY

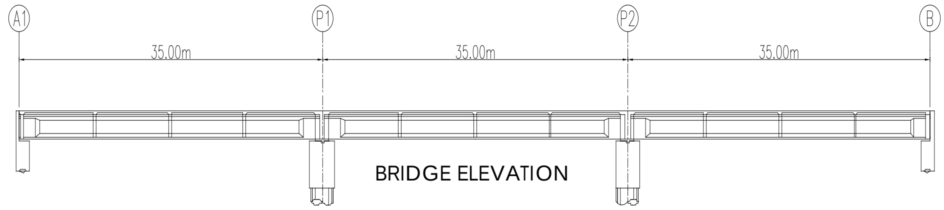


___ **Metric Tons**	___ **Metric Tons**	___ **Metric Tons**

POSTING LOAD

Comments:

- Rating Factors calculated for both serviceability and strength limit states are all greater than one (1).
- Load Posting is not necessary..



Rated by:	**Date:**	**Checked by:**	**Date:**

Figure 4.4-4 Load Rating Summary Sheet for Example 3-2

4.2.4 STEEL I-GIRDER BRIDGE

4.2.4.1 Simple

This example illustrates load rating of an existing Steel I-Girder Bridge built in 1967. The bridge is a simply supported steel girder at 35m long with cast-in-place concrete deck, as shown in the figure below. As-Built Plans for the bridge states that the allowable stresses for steel and concrete are f_s = 265.0MPa and f_c = 8.3MPa, respectively.

In the load rating calculations, assume that:

- the girders are not temporarily supported during concrete pouring of the deck,
- the girder is composite for live load,
- each barrier rail weighs 4.6kN/m.

It is required to load rate the interior girder of this bridge using the Allowable Stress Method.

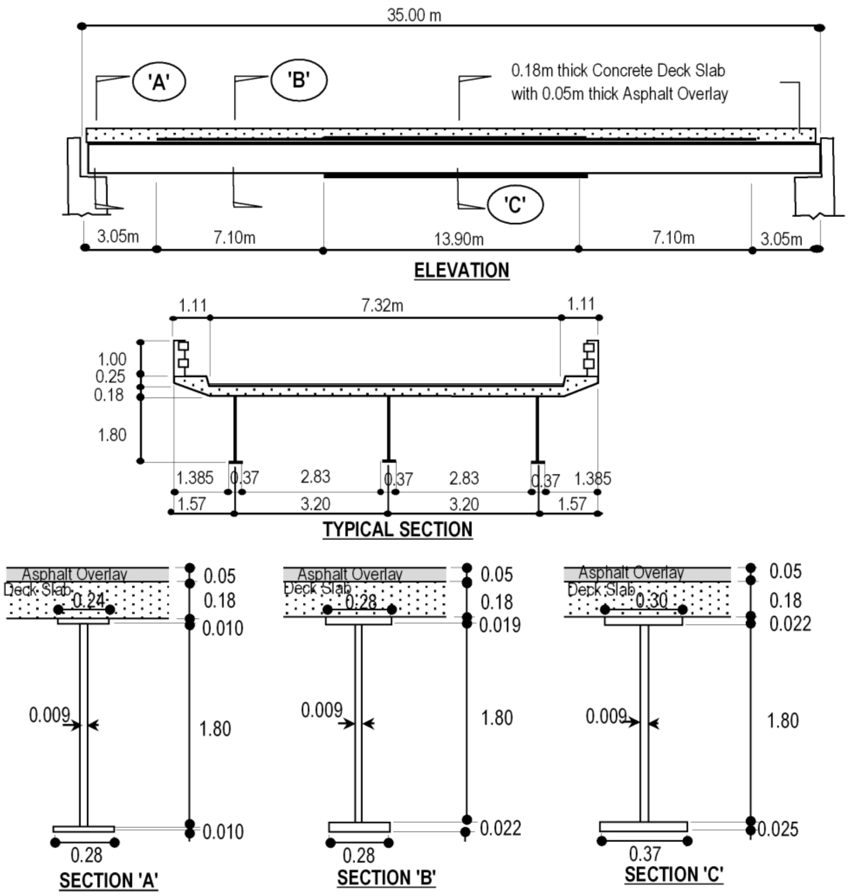


Figure 4.5-1 Steel Girder Bridge (Example 4-1)

Load Rating was done for the interior girder of this bridge focusing at Midspan and at Support of the steel girder. The load rating calculation according to the computer-based Program are presented in Appendix II, Example 4-1 of this Manual while the load rating summary is shown in Figure 4.5-2.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	**BRIDGE ID:**	
	BRIDGE NAME:	**SIG SAMPLE 4-1 (Simple)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**	
Rating Condition: Asphalt Thickness : __None___ mm	**LOCATION:**	
Rating Method: _Allowable Stress Method__	**STRUCTURE TYPE:**	**STEEL I-GIRDER BRIDGE**

Structural Member	**Interior Girder G2 (Bending) At Midspan**	**Interior Girder G2 (Shear) At Support**		

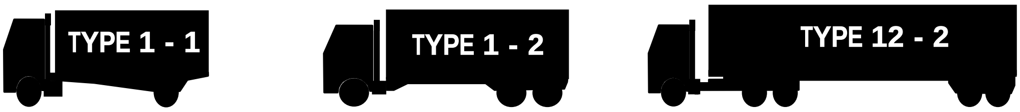
LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	**Inventory**	54.7	231.2		
	Operating	104.4	326.7		

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	**Inventory**				
	Operating				
Type 1-2 Truck (27 tons)	**Inventory**				
	Operating				
Type 12-2 Truck (38 tons)	**Inventory**				
	Operating				

LOAD POSTING NOT NECESSARY

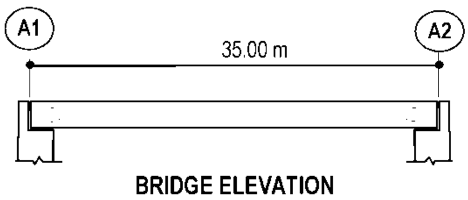


___ **Metric Tons**	___ **Metric Tons**	___ **Metric Tons**

POSTING LOAD

Comments:

- Load Rating done at Midspan and at Support resulted to Rating Factors greater than 1.0.
- Load Posting is not necessary since the bridge can carry normal loads.
- Future wearing course is not included in load rating.



Rated by:	**Date:**	**Checked by:**	**Date:**

Figure 4.5-2 Load Rating Summary Sheet for Example 4-1

4.2.4.2 Continuous

This example illustrates load rating of an existing Steel I - Girder Bridge built in 1967. The bridge is a two-span continuous steel girder at 54m long (27m +27m) with cast-in-place concrete deck, as shown in the figure below. As-Built Plans for the bridge states that the allowable stress for steel and concrete are f_s = 137.9MPa and f_c = 8.3MPa, respectively.

In the load rating calculations, assume that:

- the girders are not temporarily supported during concrete pouring of the deck,
- the girder is composite for live load,
- the girder is braced every 4.5m with bracings weighing 1.47kN per girder,
- each barrier rail weighs 3.6kN/m.

It is required to load rate the interior girder of this bridge using the Allowable Stress Method.

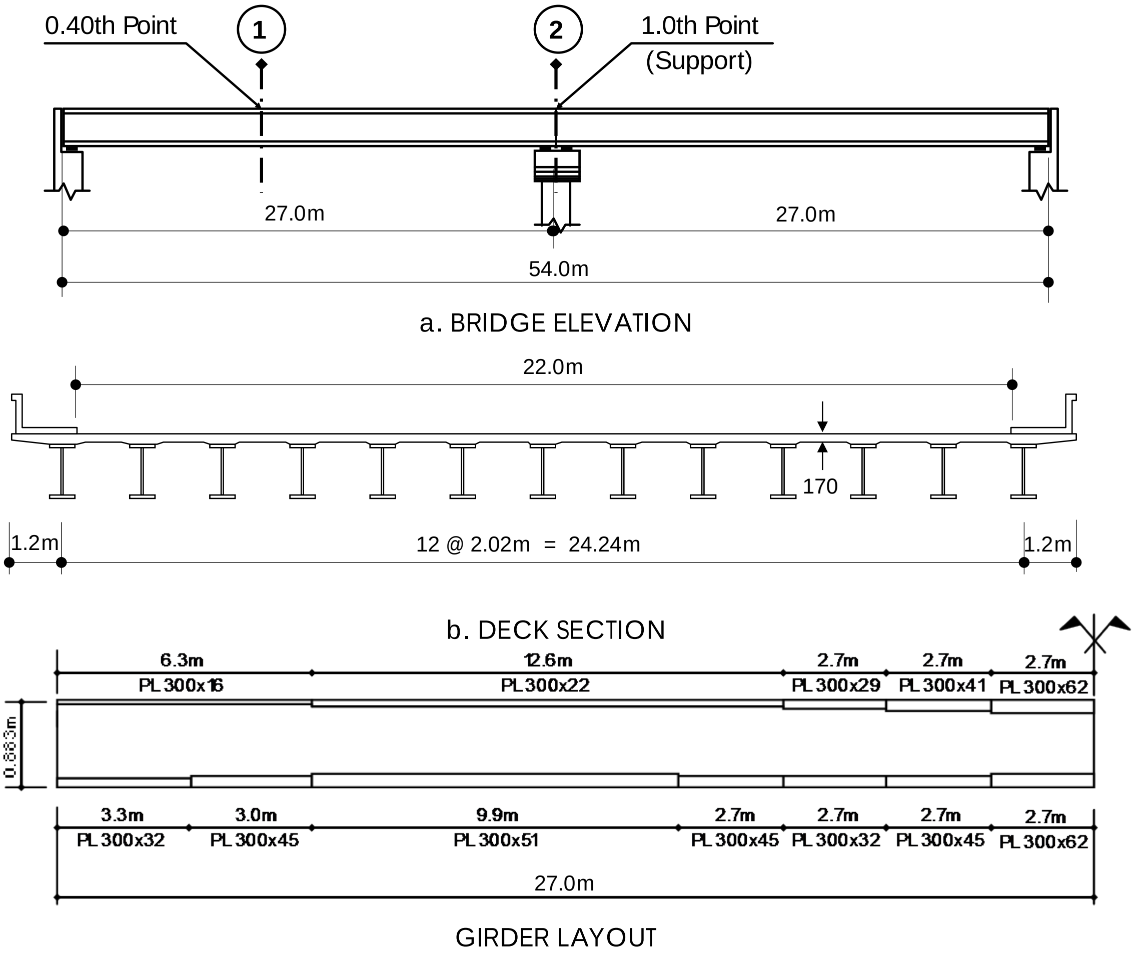


Figure 4.5-3 Steel Girder Bridge (Example 4-2)

Load Rating was done for the interior girder of this bridge focusing on Section 1 (0.40th) and Section 2 (1.0th) points of the steel girder. The load rating calculation according to the computer-based Program are presented in Appendix II, Example 4-2 of this Manual while the load rating summary is shown in Figure 4.5-4.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	BRIDGE ID:	
	BRIDGE NAME:	**SIG SAMPLE 4-2 (Continuous)**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons) **Rating Condition:** Asphalt Thickness : __None__ mm **Rating Method:** _Allowable Stress Method_	ROAD ID / ROAD NAME:	
	LOCATION:	
	STRUCTURE TYPE:	**STEEL I-GIRDER BRIDGE**

Structural Member		S1-G2 SECT 1(Bending)	S1-G2 SECT 1 (Shear)	S1-G2 SECT 2(Bending)	S1-G2 SECT 2 (Shear)

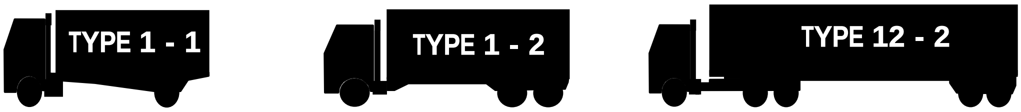
LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	**Inventory**	44.2	250.4	47.5	73.5
	Operating	67.8	334.6	79.3	108.9

LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	**Inventory**				
	Operating				
Type 1-2 Truck (27 tons)	**Inventory**				
	Operating				
Type 12-2 Truck (38 tons)	**Inventory**				
	Operating				

LOAD POSTING NOT NECESSARY

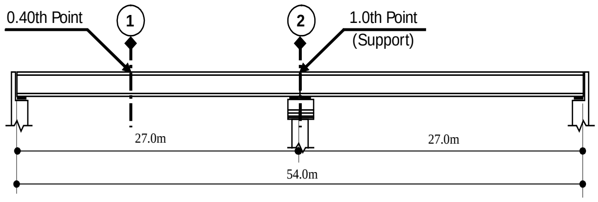


___ Metric Tons	___ Metric Tons	___ Metric Tons

POSTING LOAD

Comments:

- Load Rating done at Section 1(0.40th point) and Section 2(1.0th point) of Span 1 resulted to Rating Factors greater than 1.0.
- Load Posting is not necessary since the bridge can carry normal loads.
- Future wearing course is not included in load rating.



Rated by:	**Date:**	**Checked by:**	**Date:**

Figure 4.5-4 Load Rating Summary Sheet for Example 4-2

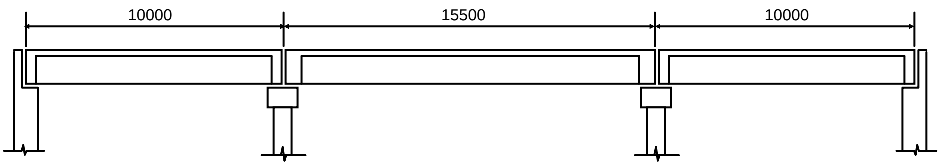
4.2.5 REINFORCED CONCRETE DECK SLAB

This example presents load rating of bridge deck for an existing reinforced concrete deck girder bridge. The bridge built in 1961 has three simple spans (10m + 15.5m + 10m) with 7m wide deck and 180mm thick slab. The concrete decks are supported by three longitudinal reinforced concrete girders monolithic with the deck slab.

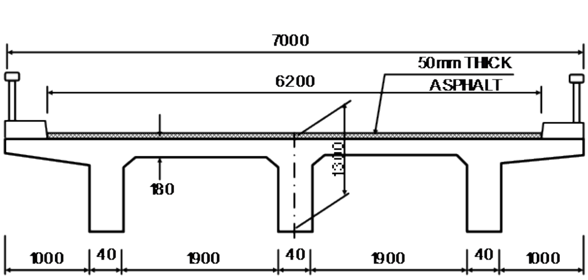
The allowable stresses are 8.3MPa and 137.9MPa for concrete compression and rebar tension, respectively.

It is required to load rate the bridge using AASHTO MS18 (33 metric tons) as the rating vehicle.

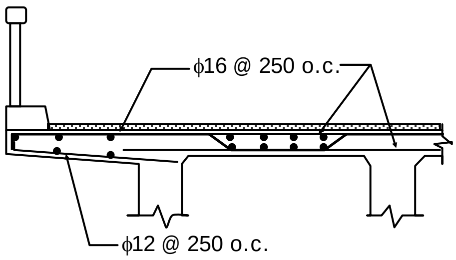
The load rating will be performed for the inner slab and the cantilever slab sections shown below using the Load Factor Method. Live load demand moments are calculated using the DPWH Design Guidelines moment formulation with slab main reinforcement perpendicular to traffic. Similarly, the wheel load on cantilever slab is distributed over the width recommended by the DPWH Design Guidelines.



Bridge Elevation



Deck Section



Slab Reinforcement

Figure 4.6-1 RCDG Bridge (Example 5)

The results of the Load Rating Calculations according to the computer-based Program are presented in Appendix II, Example 5 of this Manual. The Summary Results of the load rating calculation is shown in Figure 4.6-2.

This Example 5 enables to apply to not only RCDG but also to PCDG and SIG.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS **LOAD RATING SUMMARY**	
	BRIDGE ID:
	BRIDGE NAME: **RCDS SAMPLE 5**
Rating Vehicle: ☐ AASHTO MS18 (33 Metric Tons)	**ROAD ID / ROAD NAME:**
Rating Condition: Asphalt Thickness : __50__ mm	**LOCATION:**
Rating Method: __Load Factor Method__	**STRUCTURE TYPE:** **RCDG BRIDGE**

Structural Member		Cantilever Slab Section 1	Interior Slab Section 2, 3		

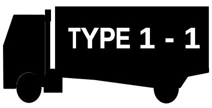
LOAD RATING (Metric Tons)

MS 18 Truck (33 tons)	Inventory	40.8	40.3		
	Operating	68.1	67.3		

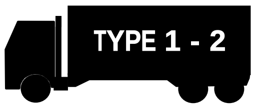
LOAD POSTING (Metric Tons)

Type 1-1 Truck (17 tons)	Inventory				
	Operating				
Type 1-2 Truck (27 tons)	Inventory				
	Operating				
Type 12-2 Truck (38 tons)	Inventory				
	Operating				

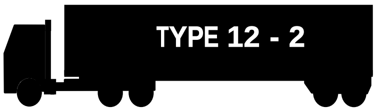
LOAD POSTING NOT NECESSARY



____ Metric Tons



____ Metric Tons

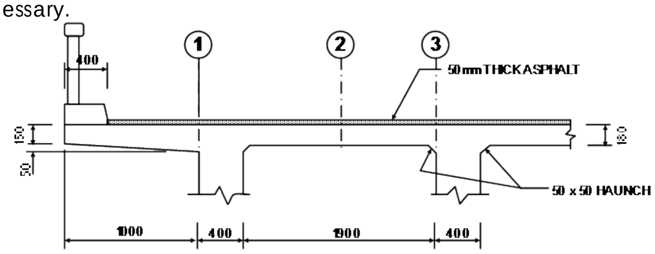


____ Metric Tons

POSTING LOAD

Comments:

- Load rating is performed for cantilever and interior slabs of Span 2.
- The Load Factor Method resulted in load factors greater than 1.0 for both the cantilever and interior slab.
- Load Posting not necessary.



Rated by:	Date:	Checked by:	Date:

Figure 4.6-2 Load Rating Summary Sheet for Example 5

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Chapter 5

COMPUTER-BASED PROGRAM ON LOAD RATING

5.1 PURPOSE OF THE COMPUTER-BASED PROGRAM ON LOAD RATING

The purpose of the Computer-based Program on Load Rating of Bridges (CBPLR) is to guide and provide the Department of Public Works and Highways (DPWH) with uniformity in the procedures and policies for determining the load capacity and load rating of existing bridges based on the MLRB.

In any event, this Program should not overrule sound engineering judgment.

5.2 SCOPE OF THE COMPUTER-BASED PROGRAM

This Program has been developed to provide the DPWH with a load rating calculations consistent with the objectives of the DPWH Bridge Management System. The Program is focused on load rating calculations and load capacity calculations with a Program User's Manual.

This Program is applicable to four bridge types and one deck slab as follows.

RCFS (Reinforced Concrete Flat Slab Bridge): Simple RCFS
Continuous RCFS

RCDG (Reinforced Concrete Deck Girder Bridge): Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

PCDG (Prestressed Concrete Deck Girder Bridge):Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

SIG (Steel I Girder Bridge) : Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

RCDECK (Reinforced Concrete Deck Slab)

The calculations by this Program apply to all conventional concrete and steel highway bridge structures in accordance with the DPWH Design Guidelines and the AASHTO Standards. Special bridges or bridges other than highway bridges may need special calculations not covered in this Program. General calculation is given in this Program but more complex calculations must be used to determine actual load rating.

This Program has been developed according to the Manual for Load Rating of Bridges (MLRB).

For all matters not covered by this Program, the current DPWH and AASHTO Specifications and Standards should be used as a guide. However, if bridge member behavior is not consistent with the controlling specifications, such deviations based on the known behavior of the member may be used but should be fully covered.

5.3 PROCEDURE OF THE COMPUTER-BASED PROGRAM

This Program has been developed according to the Manual for Load Rating of Bridges (MLRB). Though this Program has many advantages, it is required in deep care for determination and assumption on load rating calculations as follows.

Advantages

- It's easy to calculate the Load Rating for Major Bridge Types.
- This Program provides 4 Bridge Types and RC Deck Slab, not only Simple and Continuous Bridges but also Interior and Exterior Girder.
- DPWH Engineers can save time for determination of appropriate Load Rating
- DPWH Engineers can avoid inappropriate Load Rating Calculations

Deep Care

- To determine and assume appropriate Bridge Layout and Dimensions
- To determine and assume appropriate Rebar/PC Tendon Schedule inside of Bridges
- To determine and assume appropriate Material Properties
- To determine appropriate evaluation for Bridge Current Condition (Damage)

Damage evaluation applied to this Program is shown in the Figure 5.3-1.

Procedure of the Computer-based Program on Load Rating is provided in detail in the User's Manual for function, installation, operation and others.

The user should follow and understand the procedure of this Program mentioned in the User's Manual as follows (refer to section 6 in the User's Manual).

- Load Rating Principle for Resistance and Demand
- Damage Evaluation
- Difference between Interior/Exterior Girder
- Difference between Simple/Continuous Girder
- Meaning of Coloring cells
- Drawing attached with each bridge types

Procedure for each bridge types is provided with attached all display (screen) and detailed explanations for note, input and applied equations in the output in the User's Manual. (Refer to Figure 5.3-2)

Damage evaluation is considered in this Program as follows:

Condition State 2-Poor or 3-Bad		
Severity of defect At Midspan At Support	Location (Section)	2-Poor or more at near Support or near Midspan where loaded maximum demand forces
	For Concrete Girder	
	Cracking	greater than 0.3mm and its spacing smaller than 500mm
	Rebar exposure	greater than 50 cm^2 exposed and corroded
	For Concrete Deck Slab	
	Cracking	greater than 0.3mm, 2 directions, and its spacing smaller than 500mm
	Rebar exposure	greater than 50 cm^2 exposed and corroded
	For Steel Girder	
	Corrosion	greater than 10% section loss stratified rust with pitting of metal surface

Damage evaluation method is as follows:

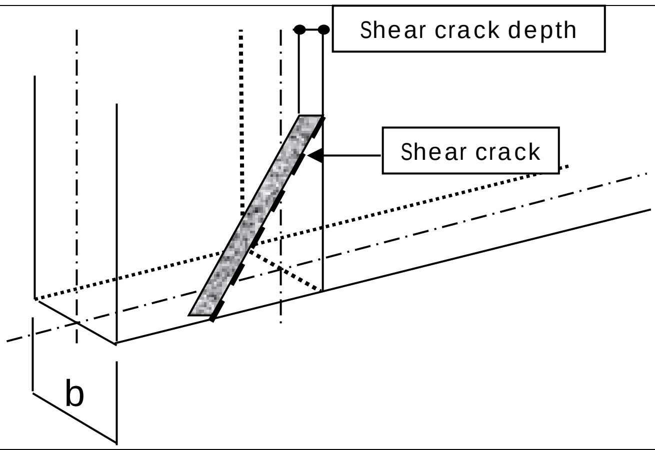
Concrete Girder and Deck Slab	Cracking due to Moment	Not consider concrete section loss of tension fiber
		Consider only by rebar exposure of tension fiber
	Cracking due to Shear	Consider by reduction factor (Φ) according to shear crack depth (Cw) as mentioned below Cw = > 0.5 b applying Φ= 1.0 then Shear resistance due to Concrete Vc = 0 Cw < 0.5 b then Φ= Cw / b then Shear resistance due to Concrete Vc
		For example, b = 400mm and shear crack depth 150mm Vc* = (1-150 / 400) x Vc = 0.625 Vc
		
	Rebar Exposure	Section loss of main Rebar (%) based on exposed Area
		Section loss of stirrups (%) based on exposed Area
Steel Girder	Corrosion	Actual section loss should be applied to steel girder dimension, and then calculate section properties considering section loss

Figure 5.3-1 Damage Evaluation in this Program

B. DEMAND FORCES

B0. INPUT		
FOR DEAD LOAD	Girder width bw(m)	0.400
	Girder Web height h (m)	0.600
	Fillet/Haunch width wf(m)	0.100
	Fillet/Haunch height hf(m)	0.100
	Slab thickness ts (m)	0.180
	Slab width ws (m)	2.400
	Length of Midspan L(m)	10.400

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (kN/m)	Self-weight of Girder		5.760
	Fillet/Haunch		0.240
	Slab Weight	Continuous	10.368
	Barrier Rail		1.800
	Asphalt Overlay		2.640
	Total		20.810
Dead Load	Moment (kN-m/m)	M_{DL}	281.4
	Shear (kN)	V_{DL}	108.2

B2. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS29)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.312			
Impact factor	0.300			
span	10.400			
Max. MS18 moment for 10.40m span /wheel line		without Impact	M_L	236.5
		with Impact	M_{LL}	403.5
Max. MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	117.7
		with Impact	V_{LL}	200.7

Figure 5.3-2 Sample Procedure Sheet in the User's Manual

MANUAL
FOR LOAD RATING
OF BRIDGES

3rd Edition

APPENDIX I

DAMAGE-PRONE MEMBERS

In this Appendix, inspection points for *damage-prone members* are presented. The focus of these inspection items are members or elements of the bridge structure where stresses are concentrated and are easily damaged compared to other members.

The following Inspection Points are classified by structure and by damage types.

A. Bridge Inspection by Structure (Member) Type

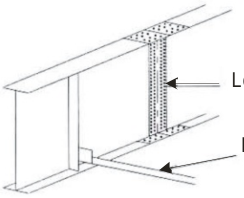
1. Steel I - Girder
2. Steel Box Girder
3. Steel Deck Plate
4. RC Deck Slab
5. PC and RC Girder
6. Abutment
7. Steel Pier
8. RC Pier
9. Bearing Shoe
10. Expansion Joint

B. Bridge Inspection by Damage Type

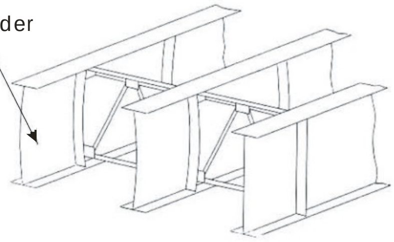
11. Steel Crack Due to Fatigue
12. Deformation
13. Corrosion, Loosening and Missing Bolts
14. Painting Deterioration
15. Corrosion
16. Concrete Cracks Due to External Forces, Etc.
17. Concrete Cracks Due to Construction Method
18. Concrete Crack Due to Environment, Etc.
19. Concrete Crack Due to Material Quality
20. Splitting, Exposed Concrete Reinforcing Bar
21. Honey Comb, Concrete Cavity

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

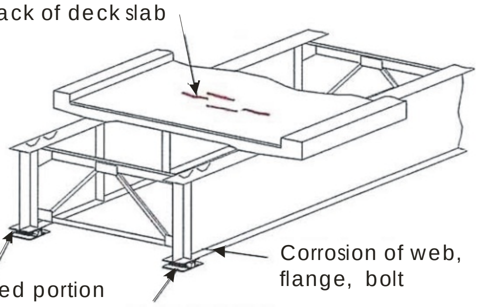
STRUCTURE TYPE	1 Steel I-Girder	
INSPECTION POINTS	• Deformation of main girder • Crack at welded portion • Discoloration of painting and corrosion	• Deformation of secondary member • Water at girder end • Abnormality around bearing shoe bed • Defects of bolt (Loosening, Lost, Corrosion)



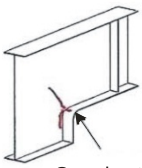
Sample : Loosening of bolt



Sample : Damage of secondary member



Sample : Corrosion of main girder

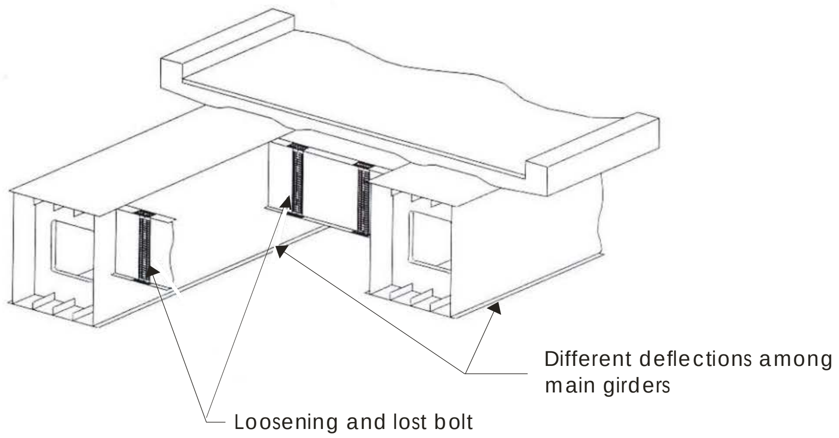


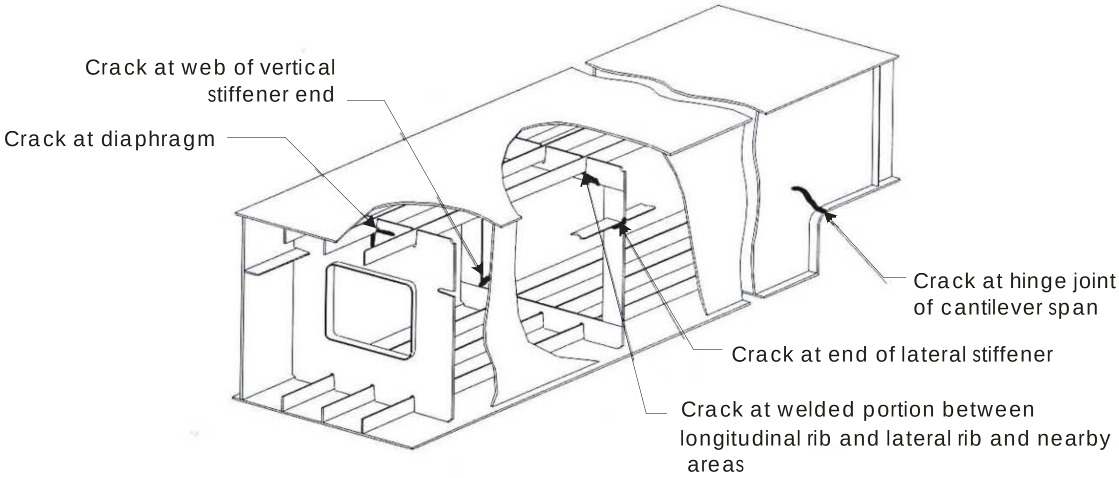
Crack of lower flange

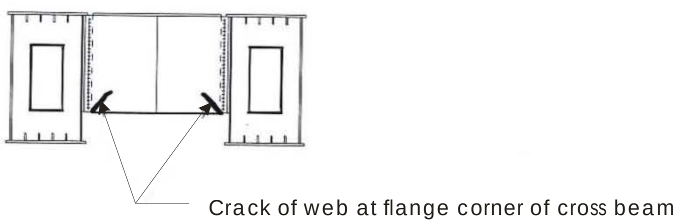
Sample : Corrosion of bearing shoe

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	**2 Steel Box Girder**
INSPECTION POINTS	• Deformation of main girder • Crack at welded portion between main girder and cross beam • Discoloration of painting and corrosion • Abnormality of bearing shoe bed • Defects of bolt • Deformation of girder end • Water at girder end • Damages by animals, birds, or insects • Damages by trespassers/intruders

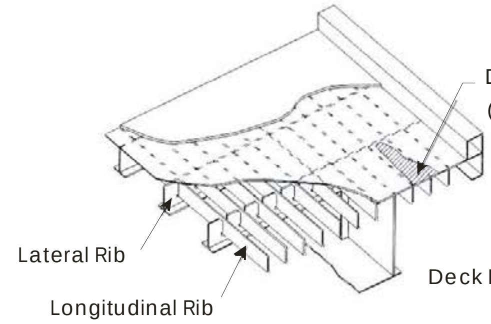


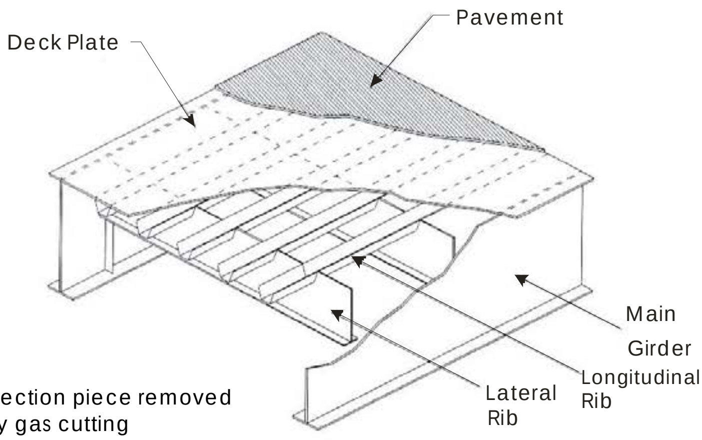


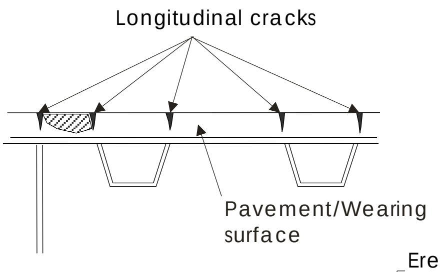


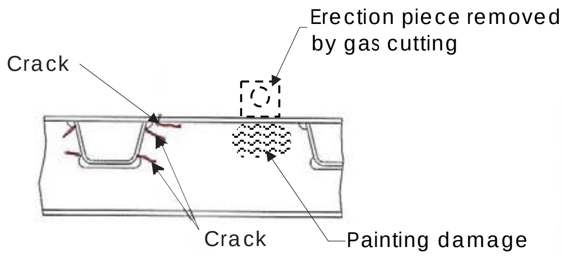
BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	3	Steel Deck Plate
INSPECTION POINTS	• Partial deformation of Deck Plate • Welded cracking of longitudinal & lateral rib • Discoloration, peeling of painting & corrosion at bottom of deck slab and ribs	• Water at end of girder • Loosening of bolt • Abnormality around bearing shoe bed • Damage of pavement/wearing surface

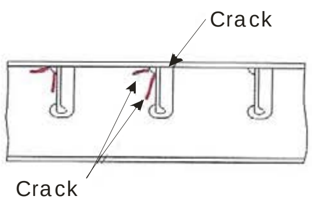


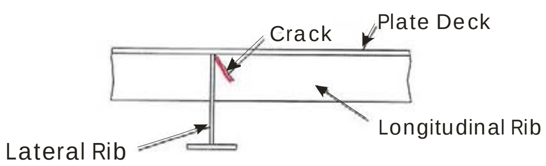






Sample : Crack



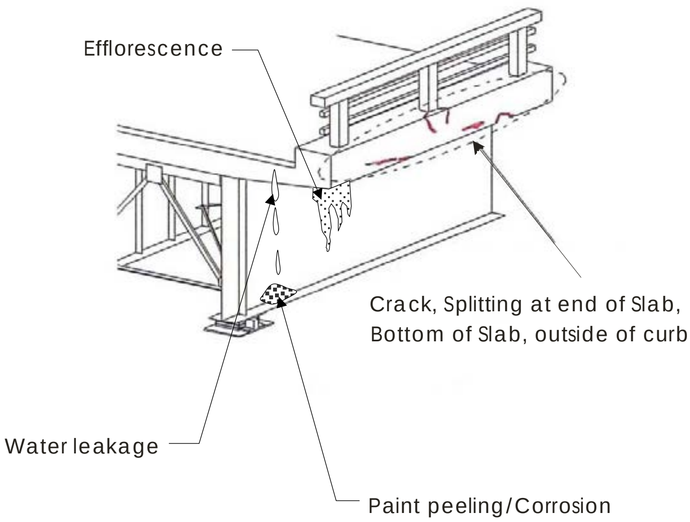


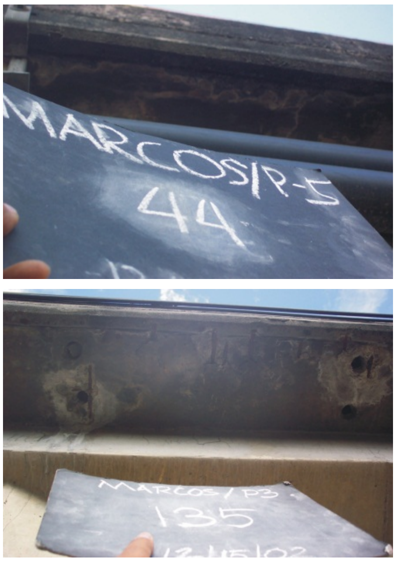
Sample : Corrosion at bottom of deck slab

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	4 RC Deck Slab
INSPECTION POINTS	• Crack at end of slab, Free Lime, Splitting • Crack at bottom of Slab • Damage at Plate Connection

- **Damage at Curb**

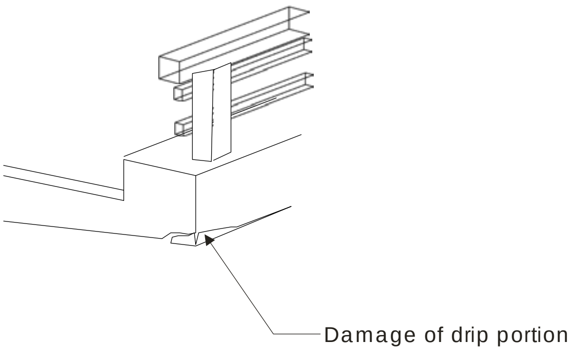




Sample : Splitting, Exposed Reinforcement

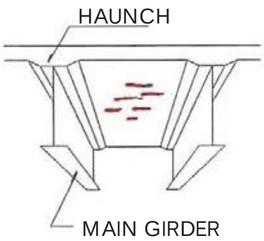
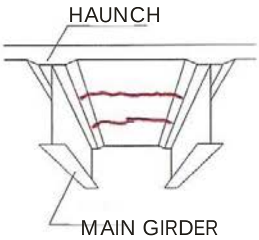
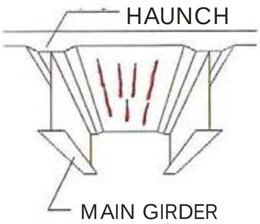
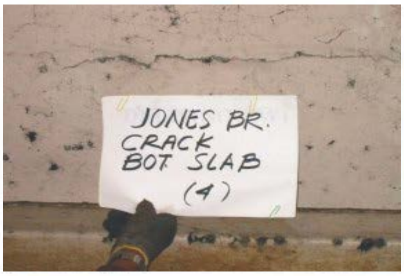
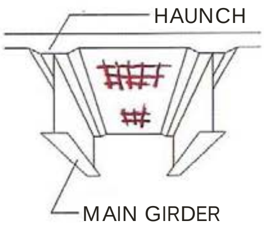
Sample : Crack at Curb

- **Damage of Cantilever of Deck slab**



CORROSION OF STEEL PLATE

CAUSE OF CRACK PATTERN AT THE BOTTOM OF RC DECK SLAB

PATTERN	ILLUSTRATION	SAMPLE OF CRACK DAMAGE	CAUSE
CRACK AT TRANSVERSE DIRECTION (ONE-WAY)			• LACK OF DISTRIBUTION BAR • DRYING SHRINKAGE • FATIGUE (INITIAL CONDITION)
CRACK AT TRANSVERSE DIRECTION (ONE-WAY)			• LACK OF RIGIDITY OF MAIN GIRDER • FATIGUE (PROGRESS CONDITION)
CRACK AT LONGITUDINAL DIRECTION (ONE-WAY)			• DIFFERENT RIGIDITY OF GIRDERS • SETTLEMENT OF BEARING, SUBSTRUC-TURE
CRACK AT LONGITUDINAL AND TRANSVERSE DIRECTIONS (TWO-WAY)			• LACK OF SLAB THICKNESS • TURTLE BACK CRACK FOR TWO WAY • FATIGUE (NEAR FINAL CONDITION)

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	5 PC and RC Girder	
INSPECTION POINTS	• Girder (Center span, 1/4 span, End of girder, Interior support of continuous girder) • Point of change in cross section • Excessive deflection/sagging	• Construction joint • Around bearing • Anchorage • Others

(1) Center of Span

- Location of max bending moment, crack prone location

(2) ¼ of Span Length

- This section is prone to crack under the following circumstances: (a) bent-up of reinforcing bars, (b) differential settlement, (c) poor fit of bearing shoe, (d) temperature change, etc. and for PC Continuous girder , (e) lower and anchorage zone.

(3) Interior Support of Continuous Girder

- Location of negative maximum bending moment is prone to cracking

(4) End portion of Girder

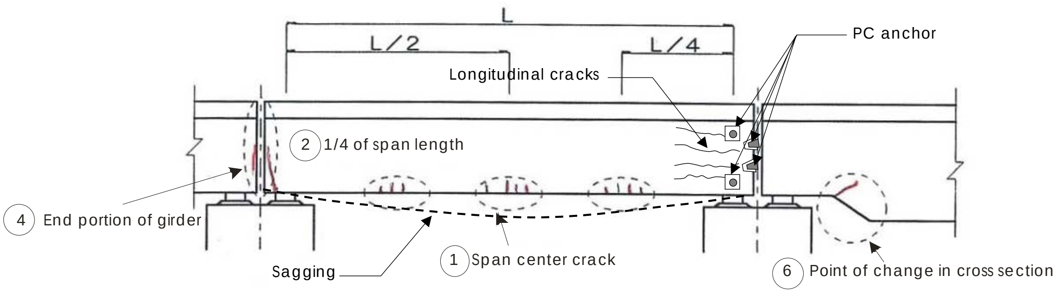
- Damage prone location due to movement restriction of man girder, impact, etc.

(5) Around Bearing Shoe

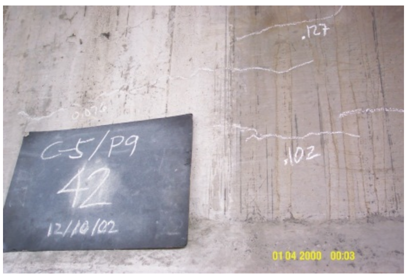
- Damage prone location due to reaction of bearing shoe, horizontal forces of earthquake and temperature change.

(6) Point of change in cross section

- Crack prone location due to stress concentration on sudden change of cross section.

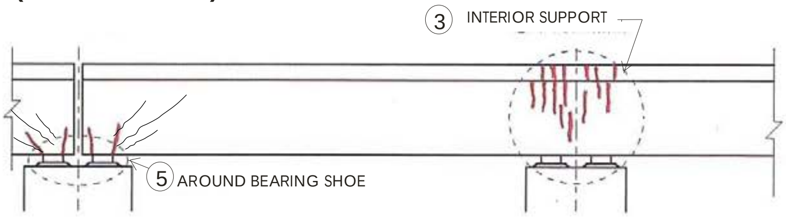


Sample : Crack at Center Span

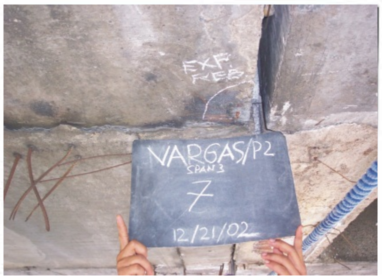


Sample : Crack at End Portion of Girder

Elevation of Girder (Continuous Girder)



AROUND BEARING SHOE

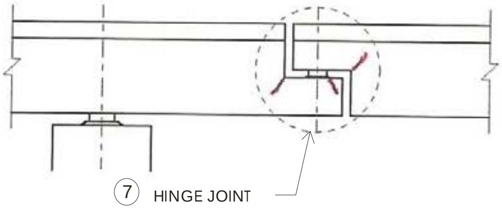


INTERIOR SUPPORT

(7) HINGE OF CANTILEVER BRIDGE

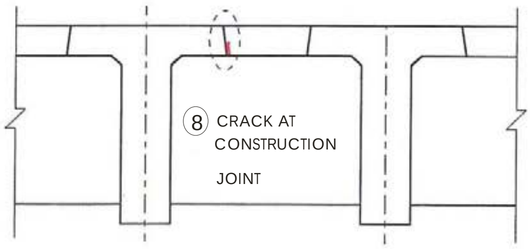
Crack prone location due to stress concentration at Sudden change in cross-section

Elevation of Girder (Cantilever Girder)



Sample : Crack at cantilever hinge

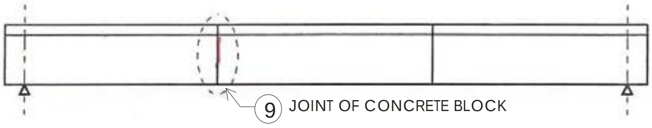
(8) CONSTRUCTION JOINT



Sample : Crack

(9) JOINT OF CONCRETE BLOCK

Crack prone location for the case of block erection Method (under Segmental Construction Method)



(10) OTHERS

- Splitting and lifting at outside of curb, PC anchor (Post-tensioned)

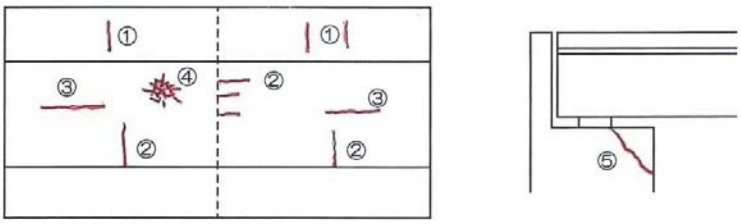
BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	6 Abutment	
INSPECTION POINTS	• Cracks • Construction joints • Concrete surface (honeycomb) • Water leakage	• Deformation by soil pressure • Damage of slope protection, erosion • Vegetation, soil deposit around bearing shoes • Settlement, wall rotation

DAMAGE - PRONE LOCATION

(1) Crack

Location	Crack Pattern	Cause to be Considered
Surface of Abutment	① Regular Crack	• Drying shrinkage at construction joint • Differential settlement
	② Crack at construction joint	• Drying shrinkage at construction joint
	③ Crack around area of reduction in reinforcement	• Less reinforcement • Horizontal force due to earthquake
	④ Crack with turtle back/web pattern	• Alkali-aggregate reaction • Drying shrinkage due to less reinforcing bar • Poor Construction
Bottom of Bearing Shoe	⑤ Crack around bearing shoe	• Increase in load • Less reinforcing bar • Horizontal force due to earthquake



CRACK PATTERN OF ABUTMENT

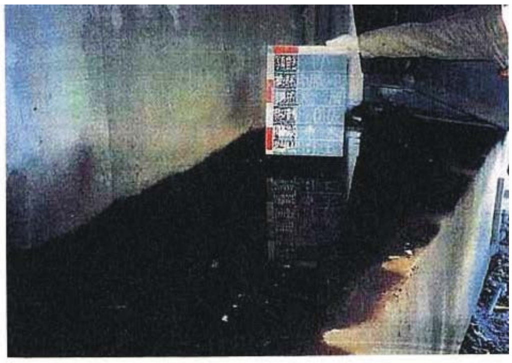
Sample : Crack at Backwall

Sample : Crack at Wall

Sample : Crack around Bearing shoe

(2) Water Leak, Water Ponding

- Water leak from damage of expansion joint, drainage facility



Sample : Water Leak

(3) Settlement, Inclination, Movement

Settlement : Foundation and bearing shoe.

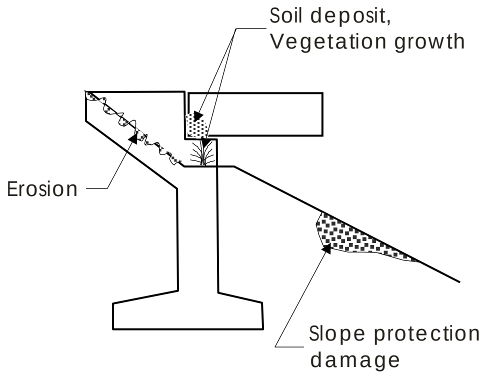
- Settlement of foundation should be observed from road surface.

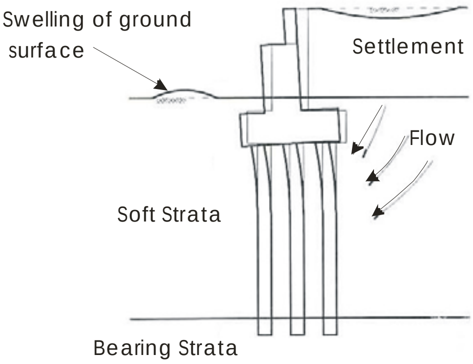
Inclination Movement : Foundation and bearing shoe

- **Foundation :** Inclination of abutment due to lateral movement and differential settlement

- **Bearing Shoe :** Abnormal inclination due to earthquake

(4) Others



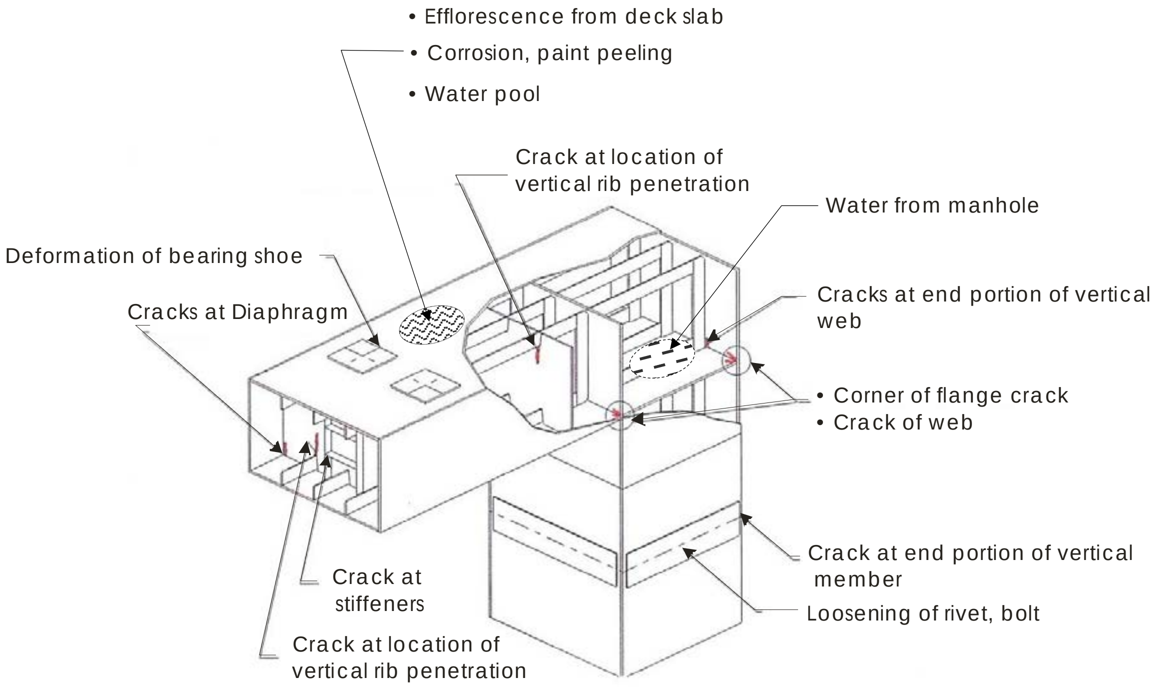


Lateral Movement of Abutment

Sample : Inclination abutment

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	7 Steel Pier
INSPECTION POINTS	• Inclination of column, deflection of beam. • Weld-cracking at connection of diaphragm. • Splitting of painting and corrosion. • Abnormality at bearing shoe. • Weld-cracking at corner. • Water ponding at end portion.



Sample : Corrosion

Sample : Missing Bolt

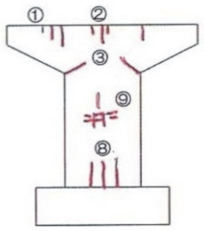
BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	**8 RC Pier**
INSPECTION POINTS	• Crack • Settlement / Inclination • Scouring
INSPECTION METHOD	Close-up Visual Inspection, Measurement by Crack Scale, Photograph, Video, Measurement by Plumb, Level, etc.

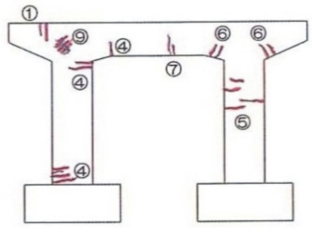
(1) Crack

DAMAGE - PRONE LOCATION

Location	Crack Pattern	Cause to be Considered
Hammer-Head Pier	① Crack at top surface	• Increase in load • Settlement of support • Early form removal
	② Crack at top surface of pier center	• Shrinkage
	③ Crack at bottom surface of cantilever	• Inadequate construction treatment at construction joint • Shrinkage
	⑧ Crack in transverse direction of construction joint	• Inadequate construction method at construction joint • Shrinkage
	⑨ Crack with turtle back/web pattern	• Alkali-aggregate reaction • Shrinkage • Inadequate construction method
Rigid Frame Pier	① Crack at top surface of cantilever	• Increase in load • Settlement of support • Early form removal
	④ Crack at top of column, end portion of haunch	• Inadequate construction method at construction joint • Shrinkage
	⑤ Crack at whole column	• Lack of reinforcing bar for shearing force due to earthquake
	⑥ Crack at top of column, end portion of haunch	• Stress concentration
	⑦ Crack at bottom surface of beam center	• Increase in load • Settlement of support • Early from removal
	⑨ Crack with turtle back/web pattern	• Alkali-aggregate reaction • Drying shrinkage • Inadequate construction method
Bearing Shoe Bed	⑩ Crack around bearing shoe bed	• Increase in load • Lack of reinforcing bar • Horizontal force by earthquake



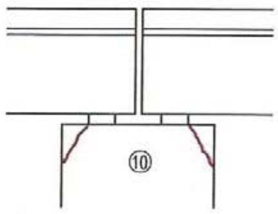
Crack of Hammer Head Pier



Crack of Rigid Frame

Sample : Crack of Cantilever portion

Sample : Crack of Pier

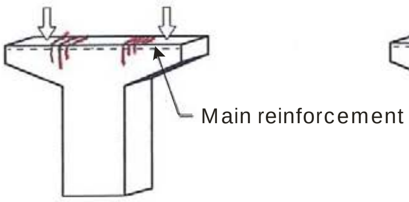


Cracks of Pier Top

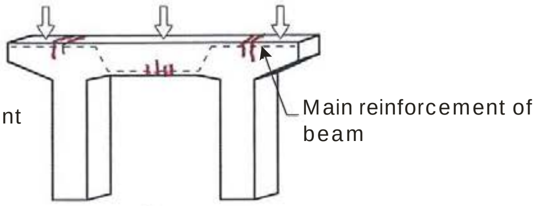
Sample : Cracks at bearing shoe bed

(1) Cracks Due to Increase in Load of Superstructure.

- Hammer head pier : cracks occur at top of cantilever arm.
- Rigid frame pier : cracks occur at the bottom of frame center span and top of cantilever joint



• Hammer Head Pier

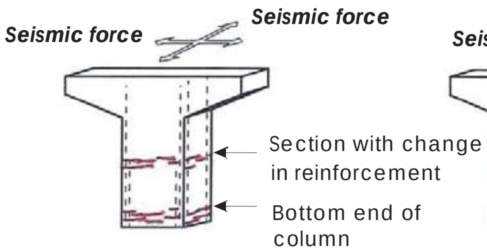


• Rigid Frame Pier

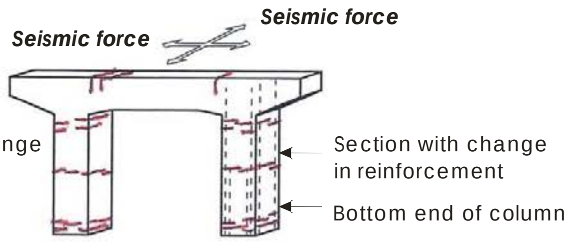
(2) Cracks Due to earthquake.

The location of damage occurring under earthquake are:

- Bottom end of column, and
- Section with change in reinforcement.



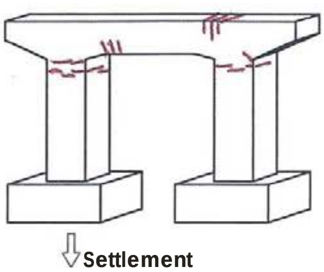
• Crack at Pier



• Crack at Rigid Frame

(3) Cracks Due to settlement of foundation for rigid frame pier.

- For rigid frame piers with isolated foundation, cracks occur at the joint corners due to relative settlement of adjacent footing.

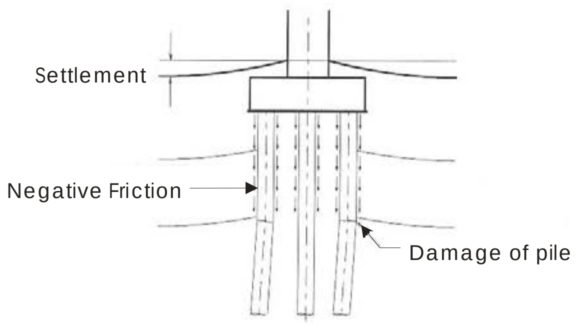


Cracks Due to Settlement of Foundation

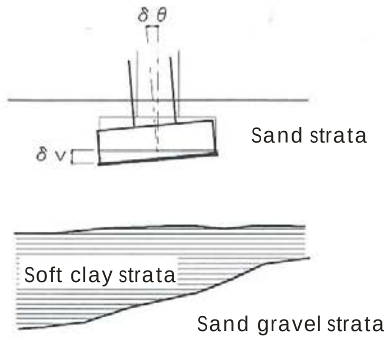
(2) Settlement, Inclination

- When driving piles on soft, unconsolidated soil layer to bearing strata, the possibility of negative skin friction around the pie shaft occurs due to ground settlement, decrease in groundwater (pore water pressure) and increase in load. This negative skin friction leads to damages on the pile foundation

- For the case of spread foundation with soft soil layer below the bearing strata, foundation inclination may occur accompanying soft layer settlement.



Damage of Pile and Settlement due to Negative Friction



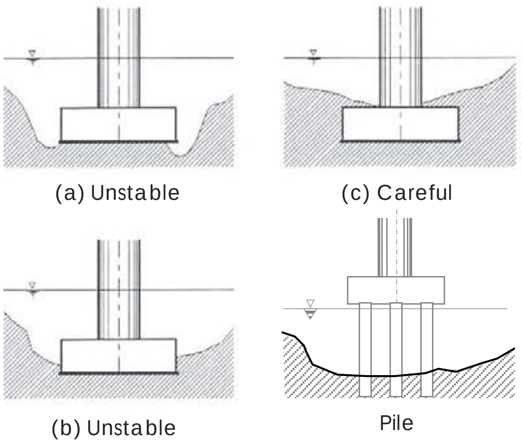
Settlement and Inclination due to Location of Clay under Bearing Strata

* Negative Skin Friction

Negative skin friction (skin friction acting downward) around the pile shaft occurs under ground Settlement/consolidation. Such negative skin friction causes additional pile body force that could damage or break the pile body or pile tip.

(3) Scouring

- Scouring often occurs during flood. For spread foundation, the cavity under the footing formed by bed scouring could cause pier settlement and deformation. Flood water pressure could cause overturning of such scoured pier, followed by structure collapse. After the flood, the cavity can be filled up again by sedimentation of river bed.



Spread Foundation and Scouring

BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	9	Bearing Shoe
INSPECTION POINTS	Bearing Shoe Bed / Base	• Damage of mortar bed / base • Damage of substructure around bearing shoe • Cracks
	Anchor Bolt	• Pull-out of bolt • Damaged
	Set Bolt	• Loosened bolt • Damaged • Corrosion • Loosened nut
	Bearing Shoe	• Damaged side block • Pin and roller damage • Settlement and eccentricity • Fallen-off roller • Corrosion • Movement
	Movement of Bearing Shoe	Abnormality of expansion and rotation due to: • Temperature change • Creep and shrinkage • Deflection

(1) Bearing Shoe Bed Damage

• Crack, damage at bearing shoe bed

Sample : Damage of Mortar

• Damage of structure at bearing shoe bed

Sample : Damage of Pier Top

(2) Anchor Bolt Damage

Sample : Corrosion of Anchor Bolt

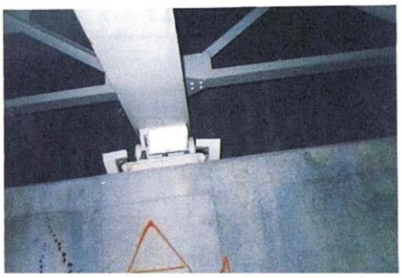
Sample : Bending of Anchor Bolt

(3) Set Bolt Damage

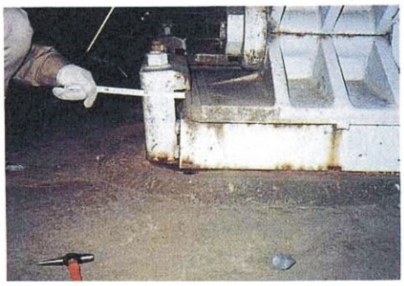
Sample : Loosening of Bolt

(4) Bearing Shoe Condition

- Damage of side block of bearing shoe



Sample : Damage of side block



Sample : Damage of side block

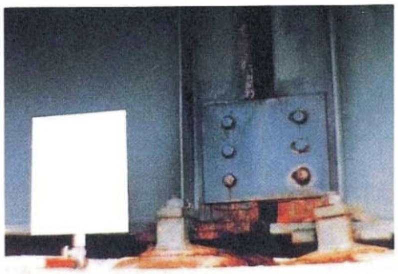
- Damage of Pin, Roller

Sample : Corrosion of Pin

Sample : Falling of Roller

- Settlement and Eccentricity of bearing Shoe

Sample : Settlement of bearing shoe

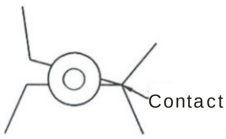


Sample : Eccentricity of bearing shoe

(5) Bearing Movement

Sample : Contact at Stopper of movement bearing

Sample : Contact at Pin



BRIDGE INSPECTION POINTS BY STRUCTURE TYPE

STRUCTURE TYPE	1 Expansion Joint
INSPECTION POINTS	• Damage of Expansion Joint • Abnormality of laying gap of Expansion Joint • Water Leak • Noise • Faulting

(1) Damage of Expansion Joint (E.J)

- Damage prone location at Expansion Joint is at welded portion of face plate and web. Sometimes, the face plate is lifted-up causing damage to the fingers
- Rubber Expansion Joints sometimes fall-off under repeated traffic loading due to damage on the rubber Expansion Joint body and its attachment

Sample : Damage of face plate of Expansion Joint

Sample : Damage of Expansion Joint

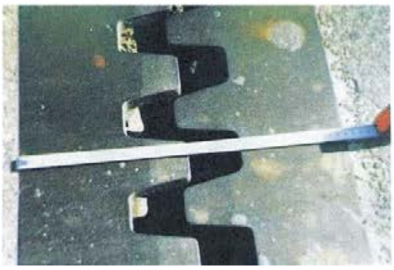
(2) Difference of Level (Faulting)

- Faulting of Expansion Joint causes fracture and tilting of face plates and rubber face
- Faulting causes abnormal noise on the Expansion Joint.

Sample : Difference of Level

(3) Abnormality of Laying Gap at Expansion Joint

- Stresses on main girders occur due to narrow laying gap on Expansion Joint. On the other hand, bigger impact force under large scale vehicles occur duet to wide laying gap of Expansion Joint.



Sample : Abnormality of Laying Gap at Expansion Joint

(4) Water Leak

- Water Leak occurs due to
  - Fracture of rubber joint type Expansion Joint.
  - Mud at drain pipe of steel type Expansion Joint
  - Damage of seal material and backing materials

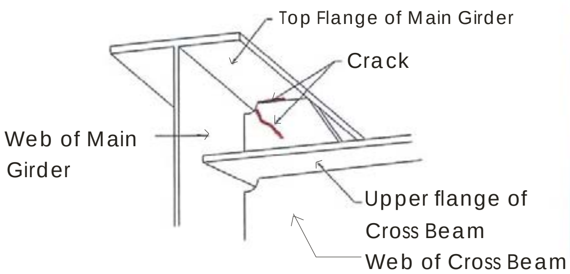
Sample : Drain Pipe Filled with mud

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	1 Steel Crack Due To Fatigue
INSPECTION METHOD	Close-up Visual Inspection, Inspection by Test Hammer

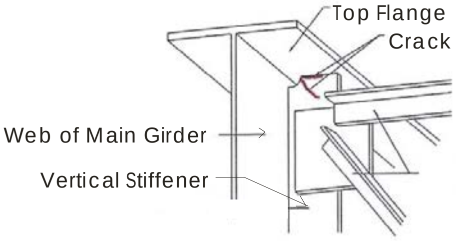
- Crack occurs due to repeated and excessive stress at points of stress concentration. Inspection should be conducted at stress concentration prone areas, points of change in cross-section, notch portion, hole of bolt, collision portion, etc.
- Heavy crack can be recognized by visual inspection. Initial indicators of cracks are rust with fine line and splitting of paint film. Initial cracks can be confirmed by penetrant test, etc.

CRACK PRONE LOCATION



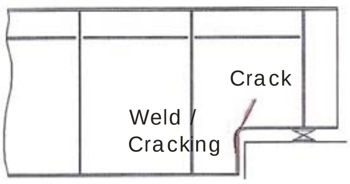
Main Girder and Cross Beam Connection

Sample : Crack 1



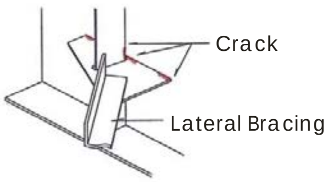
Main Girder and Sway Bracing Connection

Sample : Crack 2



Notch Portion

Sample : Crack 3



Gusset Plate

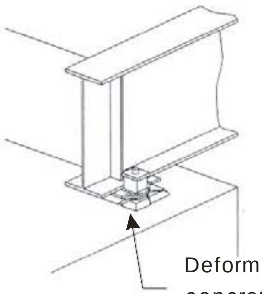
BRIDGE INSPECTION POINTS BY DAMAGE TYPE

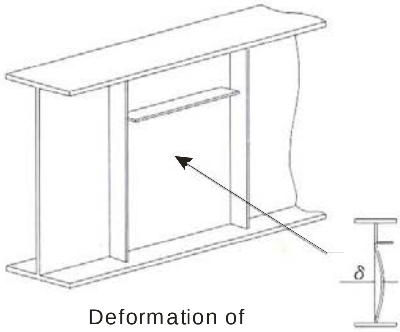
DAMAGE TYPE	1 Deformation
INSPECTION METHOD	Close-up Visual Inspection

• Deformation of main girder, steel members, railings, fence, etc. occurs at the buckling of members due to local stress concentration under vehicle collision and repeated stress.

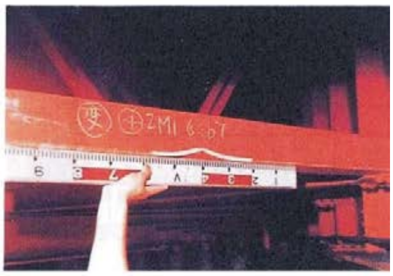
DAMAGE PRONE LOCATION

Samples of deformation including deformation of railing, fence, bearing shoe and and steel members are shown below.





Sample : Damage of bearing shoe bed



Sample : Deformation of lateral bracing

Sample : Deformation of railing

Sample : Deformation of fence

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

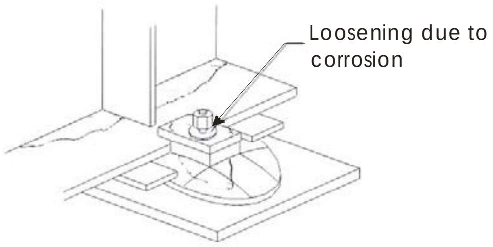
DAMAGE TYPE	**1 Corrosion, Loosening and Missing Bolt**
INSPECTION METHOD	Close-up Visual Inspection, Inspection by Test Hammer, Measurement by Torque Wrench.

- Bolt and rivet damage includes corrosion, loosening, missing, etc. The location of damage, cause of damage, influence of damage should be marked and indicated.
- Bolts at girder end and lower flange connection where water usually stays deteriorates and corrodes heavily. Stress corrosion and cracks at bolt holes should be marked in these areas.
- Loosening of bolts by vibration is usually observed at secondary member due to lack of fastening force or void space between member.
- Delayed fracture of high tension bolt that occurs suddenly for F11T or stronger bolt is called brittle failure. This is due to stress concentration caused by damage on the bolt, fatigue crack, corrosion pit, etc. Therefore, we have to confirm if the bolt is F11T or higher from the as-built drawings.

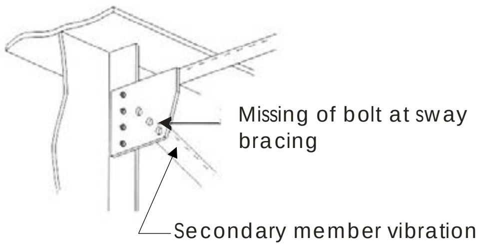
DAMAGE - PRONE LOCATION

The following damages are illustrated below:

- Corrosion due to rain water
- Loosening due to vibration
- Missing high strength bolts due to delayed fracture
- Loosening due to corrosion

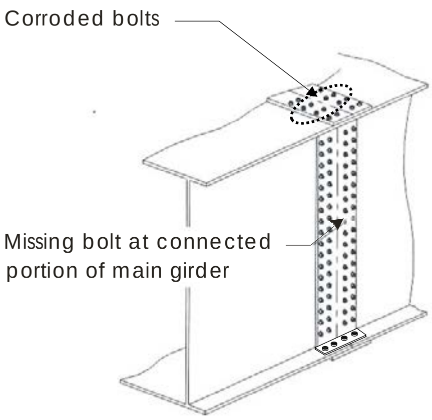


Sample : Loosening of Bolt

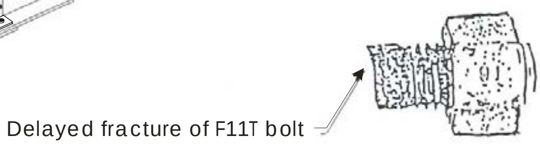


Sample : Missing of Bolt

Sample : Missing of Bolt



Box Girder



BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	**1 Painting Deterioration**
INSPECTION METHOD	Close-up Visual Inspection, Distance Visual Inspection.

- Steel bridge painting normally deteriorates gradually, thus losing its rust-protection ability. Under this condition, the member is susceptible to progressive corrosion. However, painting deterioration does not progress uniformly over the whole bridge. Part of the member paint will peel-off, chalking and cracking will then occur until rust develop
- Discoloration of the painting top coat sometimes spoils the bridge aesthetics.

DAMAGE - PRONE LOCATION

Sample : Deterioration of painting 1

Sample : Deterioration of painting 2

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	**1 Corrosion**
INSPECTION METHOD	Close-up Visual Inspection, Distance Visual Inspection, Measurement by Caliper.

- Corrosion reduces the cross-sectional area and the member strength which causes crack and member deformation
- Corrosion occurs when the member is exposed to dew, water leak, sea salt particle, sulfur dioxide, etc.
- Corrosion in industrial areas and those along seashore are relatively faster due to presence of sulfur dioxide and sea salt particle

DAMAGE - PRONE LOCATION

- Girder end with water leak, accumulation of mud, around bearing shoe, connection with poor ventilation, dew-prone lower flange, sea salt particle attachment without rainfall, etc.

Sample : Corrosion 1

Sample : Corrosion 2

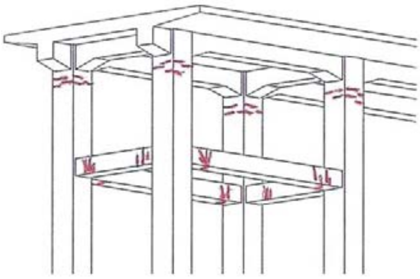
Corrosion of HT bolts/rivets should be checked.

BRIDGE INSPECTION POINTS BY DAMAGE TYPE	
DAMAGE TYPE	1 Concrete Cracks Due to External Forces, Etc.
INSPECTION METHOD	Close-up Visual Inspection, Measurement by Crack Scale, Photograph, Video, etc.

CAUSE AND PATTERN OF CRACK

(1) Dynamic load and short-term load

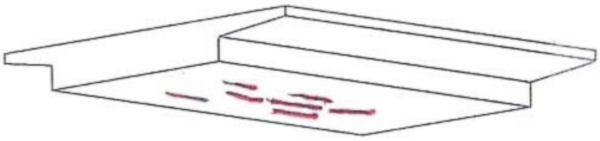
- The figure shown below shows crack due to horizontal force of earthquake.



Sample : Crack due to rebar corrosion

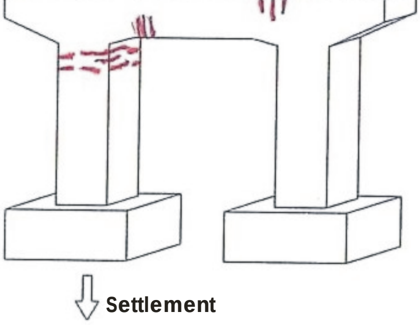
(2) Lack of cross section and quantity of reinforcing bars.

- Crack shown below sometimes occur due to lack of distribution bar.



(3) Differential settlement of structures

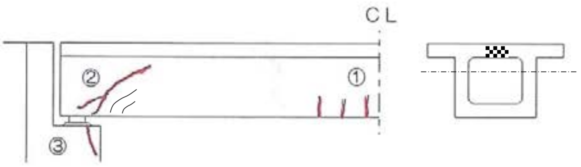
- The figure shown below illustrates cracks occurring due to differential settlement for statically indeterminate structures.



(4) Continuous Load, Long Term Load, Dynamic Load and Short Term Load, Over Design Load

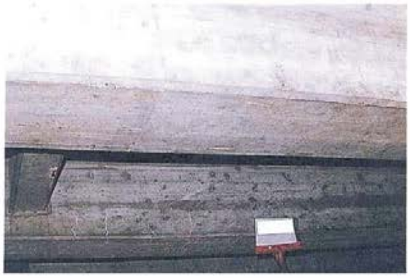
RC Girder: Crack due to external force

1. Crack by bending moment
2. Crack by shearing force
3. Oblique crack at bearing shoe bed of abutment



Sample : Crack 2

Sample : Crack 3



Sample : Crack 1

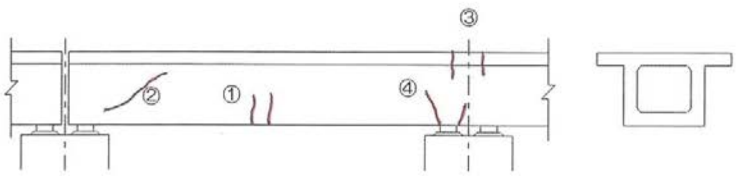
NOTE:

Cracks like 1 and 2 normally causes sag of girder.

(5) Continuous Load, Long Term Load, Dynamic Load and Short Term Load, Over Design Load

PC Girder: Crack due to external force

1. Crack by bending moment
2. Crack by shearing force
3. Excessive partial stress at support
4. Lack of prestressing, influence of settlement at support

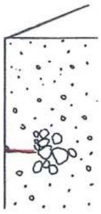


BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	1 Concrete Crack due to Construction Method
INSPECTION METHOD	Close-up Visual Inspection, Measurement by Crack Scale, Photograph, Video, etc.

CAUSE AND PATTERN OF CRACK

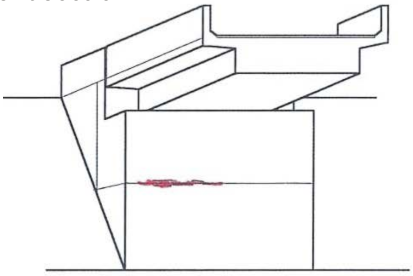
(1) Insufficient Compaction



Sample : Crack

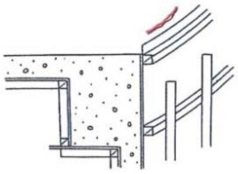
(2) Inadequate Treatment of Construction Joint

- Cold joint occurs

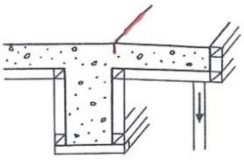


Sample : Crack

(3) Swelling of Form - (Form deformation)

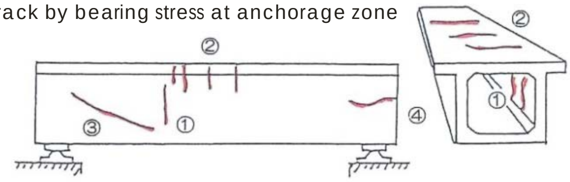


(4) Settlement of Support During Concreting



PC GIRDER : Crack at construction stage due to drying shrinkage

1. Combined temperature change and drying shrinkage at box girder with big cross section
2. Just after prestressing
3. Crack along sheath
4. Crack by bearing stress at anchorage zone



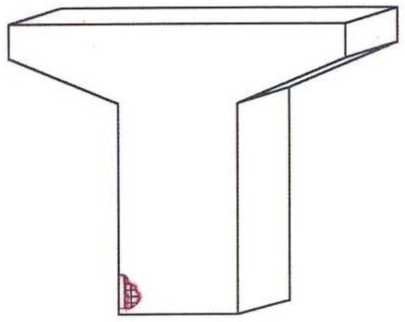
BRIDGE INSPECTION POINTS BY DAMAGE TYPE

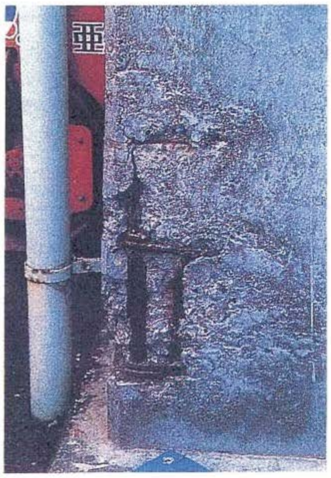
DAMAGE TYPE	1 **Concrete Crack due to Environment, etc.**
INSPECTION METHOD	Close-up Visual Inspection, Measurement by Crack Scale, Photograph, Video, etc.

CAUSE AND PATTERN OF CRACK

(1) Chemical Action of Acid-Salinity

- Crack occurs at the location of reinforcing bars due to attack on concrete surface causing partial splitting of concrete
- Rust of exposed reinforcing bar is a characteristic of this occurrence.



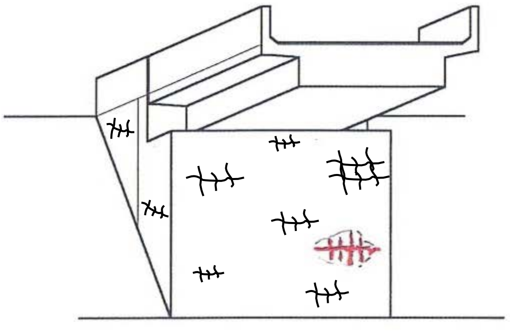


Sample : Crack

(3) Rust of Reinforcing Bar Due to Neutralization and Chloride Intrusion

- Under this condition crack occurs along reinforcing bar, followed by flowing-out of rust on the crack making the concrete surface dirty

In case of remarkable corrosion of reinforcing bars, the concrete partially splits.



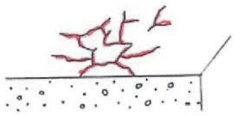
Sample : Crack

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	1 Concrete Crack Due to Material Quality
INSPECTION METHOD	Close-up Visual Inspection, Measurement by Crack Scale, Photograph, Video, etc.

CAUSE AND PATTERN OF CRACK

(1) Crack due to mud in aggregate

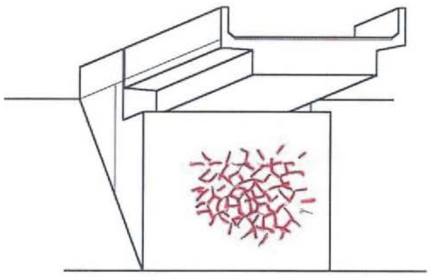


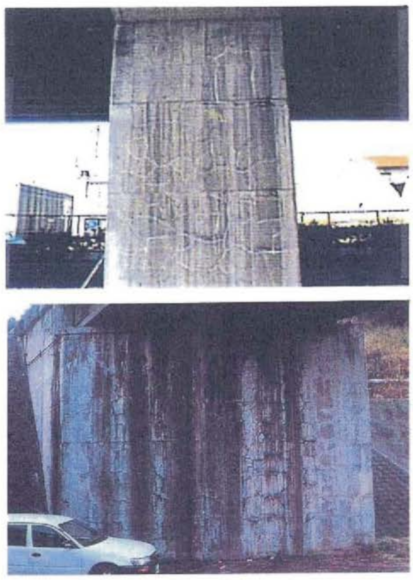
Irregular pattern crack occurs with concrete drying.

Sample : Crack due to mud in aggregate

(2) Crack due to alkali-aggregate reaction

- Crack occurs parallel with member direction at column, beam.
- Crack occurs in all direction at wall and retaining wall.

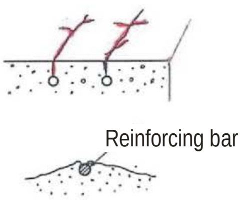




Sample : Crack due to alkali - aggregate reaction

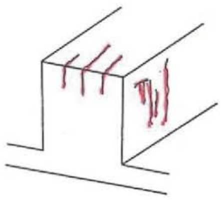
(3) Crack due to settlement

- Crack occurs at top surface along reinforcing bar 1~2 hours after concreting



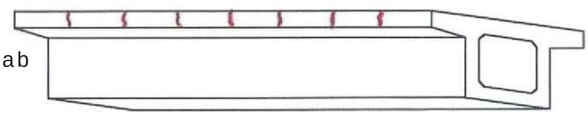
(4) Heat of hydration in cement

- Crack occurs at footing beam with massive cross-section of more than 80 cm on one side and thick underground wall.



(5) R.C. Girder : Crack due to drying shrinkage

- Sample at cantilever of deck slab

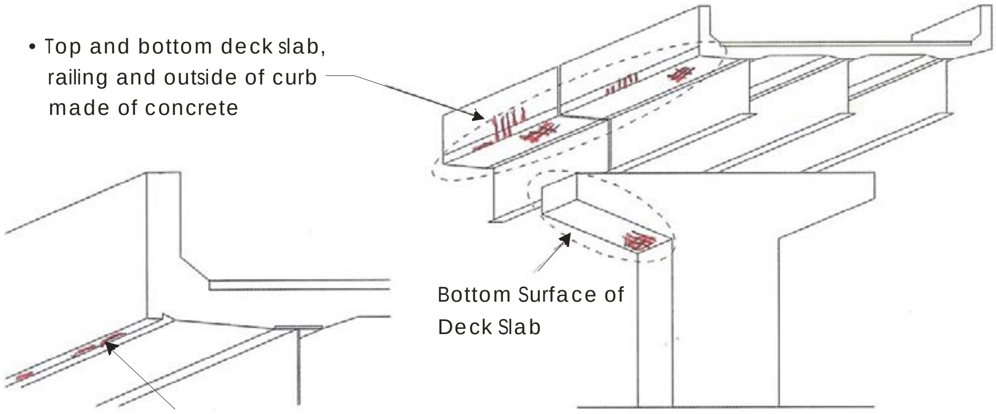


BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	**2 Concrete Splitting, Exposed Reinforcing Bar**
INSPECTION METHOD	Close-up Visual Inspection, Distance Visual Inspection, Inspection by Test Hammer, Photograph, Video, etc.

- Concrete splits and lifts when reinforcing bar and concrete separate
- Splitting and spalling occur with crack progressing on the member. The influence of cracks to bridge is different depending on location which will become the basis of the index of crack rating.
- Modification of concrete work methodology during construction stage causes cracking .
- When inspecting spalling of concrete, there is possibility of concrete falling down.

SAMPLE OF DAMAGE : SPLITTING AND EXPOSED REINFORCING BAR



Bottom Surface of Deck Slab

Drip Portion of Deck Slab

Out Side of Curb

Bottom Surface of Cantilever

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	2 Honey Comb, Cavity in Concrete
INSPECTION METHOD	Close-up Visual Inspection, Distance Visual Inspection, Photograph, Video, etc.

- Mainly insufficient concrete work (hot weather concrete, compaction, etc.); Inadequate composition


Sample : Bottom Surface of Concrete Girder


Sample : Bottom of Railing

BRIDGE INSPECTION POINTS BY DAMAGE TYPE

DAMAGE TYPE	2 Efflorescence of Concrete
INSPECTION METHOD	Close-up Visual Inspection, Distance Visual Inspection, Photograph, Video, etc.

- When construction is not properly done, including poor compaction and inferior joints, concrete cracks causing water to penetrate and react with concrete cement producing efflorescence spot at the surface of concrete.
- Efflorescence can indicate the index rating of crack occurring at different crack locations

DAMAGE - PRONE LOCATION

- It should be noted that efflorescence cannot occur without water and can be commonly observed on construction joints and girder ends. It is thus important to recognize that the source of efflorescence could be by water leak, ponding and crack.


Sample : Pier


Sample : Bottom Surface of Deck Slab

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APPENDIX II

LOAD RATING EXAMPLES

This Section presents the following examples of load rating calculations according to the Computer-based Program on Load Rating:

Load Factor Method (LFM) and Allowable Stress Method (ASM) to be used on above examples of load rating and load posting calculations are the followings.

Examples		Load Rating		Load Posting	
		LFM	ASM	LFM	ASM
Reinforced Concrete Flat Slab Bridge (RCFS)	Simple	○	○	○	○
	Continuous	○	○	○	○
Reinforced Concrete Deck Girder Bridge (RCDG)	Simple	○	○	○	○
	Continuous	○	○	○	○
Pre-stressed Concrete Deck Girder Bridge (PCDG)	Simple	○	○	○	○
	Continuous	○	○	○	○
Steel I - Girder Bridge (SIG)	Simple	---	○	---	○
	Continuous	---	○	---	○
Reinforced Concrete Deck Slab (RCDECK)	---	○	---	---	○

Note: For Pre-stressed Concrete Deck Girder Bridge, LFM is used only under Strength Limit State, on the other hand, ASM is used only under Serviceability Limit State.

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EXAMPLE 1

REINFORCED CONCRETE FLAT SLAB BRIDGE

Example 1-1: Simple

Example 1-2: Continuous

RCFS SIMPLE

A. GENERAL

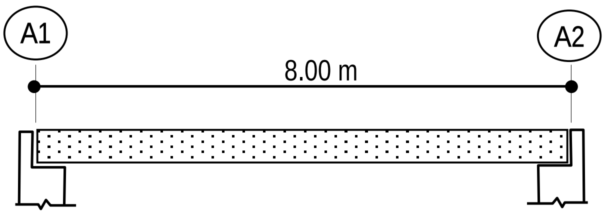
BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION	VII					
Bridge Name							
Bridge Type	Simple or Continuous	Simple					
	Number of Span	1					
Bridge of Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		8.000					=8.000m
Year Built		1958					
Structure	Superstructure	Reinforced Concrete Slab					
	Substructure	Wall Type RC Piers and RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	6.9	Mpa	fs=	137.9	Mpa
		f'c=	17.2	Mpa	fy=	275.8	Mpa
Assumption		Weight of barrier rail Wbr =			18.5	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

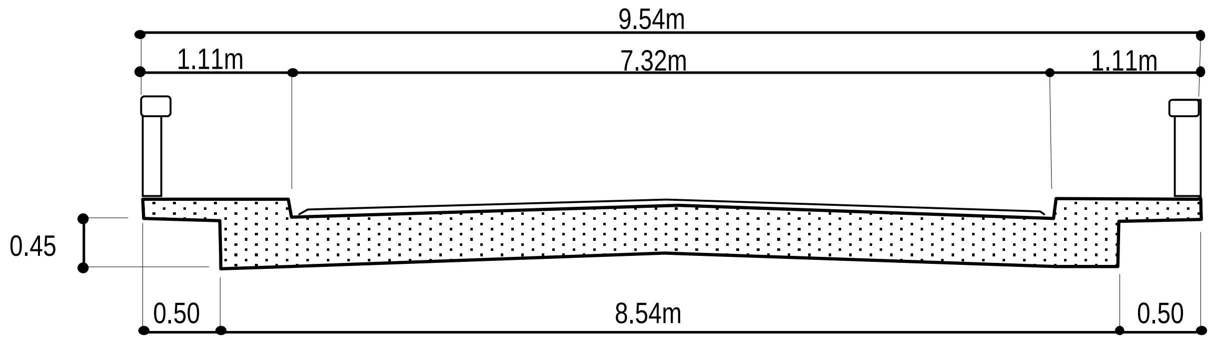
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



DECK SECTION

BRIDGE LAYOUT AND DIMENSION	
Overall width (m)	9.540
Carriageway Width (m)	7.320
Slab width bw(m)	8.540
Slab thickness h (m)	0.450
Span Length L(m)	8.000

NEXT

B. DEMAND FORCES

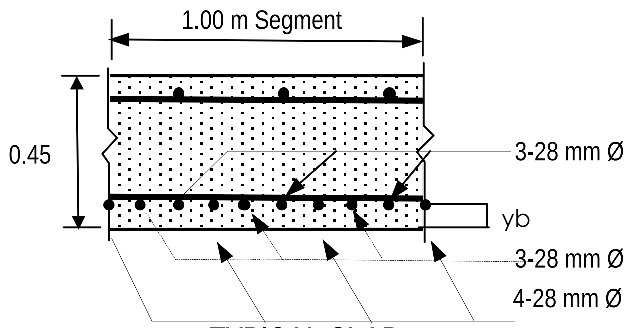
B0. INPUT		
FOR DEAD LOAD	Slab width bw(m)	8.540
	Slab thickness h (m)	0.450
	Span Length L(m)	8.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Slab		10.800
	Barrier Rail		2.708
	Asphalt Overlay		0.943
	Total		14.450
Dead Load	Moment (KN-m/m)	M_{DL}	115.60
	Shear (KN)	V_{DL}	57.80

B2. LIVE-LOAD CALCULATIONS			
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD	
Number of live load wheel line	0.589		
Impact factor	0.300		
span	8.000		
Max.MS18 moment for 8.00m span /wheel line	without Impact	M_L	154.84
	with Impact	M_{LL}	118.46
Max.MS18 shear at a distance "d" from the support/wheel line	without Impact	V_L	105.59
	with Impact	V_{LL}	80.78

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



TYPICAL SLAB REINFORCEMENT

Total area of Rebar	
Nos of Rebar	10
Dia. (mm)	28
As(mm2)	6158
yb (mm)	61

C1. CAPACITY CALCULATIONS

C1. INPUT				
(1) Common Input Data				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	6.9
		Strength	f'c	17.2
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
(2) Input Data for Moment Capacity				
Total Area of Steel As(mm^2)	10 x (28mm rebar)			6158
Section Loss (%)				10
Total Assumed Area of Steel As(mm2)				5542
Centroid of rebars from bottom of deck , d (mm)				61
Centroid of rebars from top of deck , d (mm)				389
Effective width of deck , b_{eff} (mm)				1000
Ultimate capacity factor (Uf)				0.90

C1. MOMENT CAPACITY AT MIDSPAN	
Rectangular stress block depth a (mm)	105.0
The Moment Capacity Mu (kN-m)	462.9

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		
Load factor for dead load		1.3
Load factor for live load	Inventory	2.17
	Operating	1.3
Moment Ultimate Capacity at Midspan (kN-m)		462.92
Dead Load Moment at Midspan (kN-m)		115.60
Live Load Moment at Midspan (kN-m)		118.46
Rating Live Load (Tons)		33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	1.22	40.26
		Operating Rating	2.03	66.99

Depend on the minimum value of Rating Factor > 1 or <1 , instruction is automatically shown below

Return to GENERAL

Click following the above instruction

Return to GENERAL

LOAD POSTING

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	0.589			
Impact factor	0.300			
span	8.00			
Type 1-1 moment for 8.00m span /wheel line		without Impact	M_L	133.60
		with Impact	M_{LL}	102.21
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	74.60
		with Impact	V_{LL}	57.07
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 8.00m span /wheel line		without Impact	M_L	153.79
		with Impact	M_{LL}	117.66
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	94.94
		with Impact	V_{LL}	72.64
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 8.00m span /wheel line		without Impact	M_L	144.93
		with Impact	M_{LL}	110.88
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	85.28
		with Impact	V_{LL}	65.24

NEXT

D2. POSTING RATING CALCULATIONS

D2.1 INPUT			
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
		Moment	
Moment Ultimate Capacity		462.92	
Dead Load		115.60	
		Moment	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	118.46	33.0
	Type 1-1	102.21	17.0
	Type 1-2	117.66	27.0
	Type 12-2	110.88	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM						
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating		Operating Rating		**Posting (Metric Tons)**
		Moment		Moment		
		RF	LR	RF	LR	
MS18	33.0	1.22	40.1	2.03	67.0	**33**
Type 1-1	17.0	1.41	24.0	2.35	40.0	**17**
Type 1-2	27.0	1.22	33.1	2.04	55.2	**27**
Type 12-2	38.0	1.30	49.4	2.17	82.4	**38**

NEXT

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				
Year Built				1958
Material Properties	Concrete	fc	Inventory	6.9
			Operating	10.3
		f'c		17.2
	Rebar	fs	Inventory	137.9
			Operating	193.1
Total Assumed Area of Steel As(mm^2)				5542
Centroid of rebars from top of deck , d (mm)				389
Effective width of deck , beff (mm)				1000
Rebar Ratio ρ = As / (beff x d)				0.01425
Modular Ratio of Elasticity n = Es / Ec				12
$k = \sqrt{[2\rho n + (\rho n)^2]} - \rho n$				0.4383
kd				170.5
j				0.8539
jd				332.2

E1.2 MOMENT CAPACITY CALCULATIONS			
Moment (kN-m)	Capacity by concrete allowable stress	Inventory	195.37
		Operating	291.65
	Capacity by rebar allowable stress	Inventory	253.87
		Operating	355.49

NEXT

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		
Load factor for dead load		1.0
Load factor for live load		1.0
Moment Capacity at Midspan (kN-m)	Inventory	195.37
	Operating	291.65
Dead Load Moment at Midspan (kN-m)		115.60
Live Load Moment at Midspan (kN-m)		118.46
Rating Live Load (Tons)		33.0

E2.2. RATING FACTOR CALCULATIONS (ASM)			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.67	22.11
		Operating Rating	1.49	49.17

NEXT

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

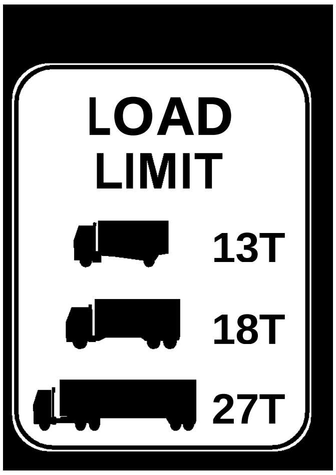
F1. INPUT			
Load factor for dead load		1.0	
Load factor for live load		1.0	
		Moment	
Moment Capacity	Inventory	195.37	
	Operating	291.65	
Dead Load		115.60	
		Moment	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	118.46	33.0
	Type 1-1	102.21	17.0
	Type 1-2	117.66	27.0
	Type 12-2	110.88	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)						
Vehicle Type	Vehicle Weight (Metric Tons)	Moment				**Posting (Metric Tons)**
		Inventory Rating		Operating Rating		
		RF	LR	RF	LR	
MS18	33.0	0.67	22.2	1.49	49.0	**22**
Type 1-1	17.0	0.78	13.3	1.72	29.3	**13**
Type 1-2	27.0	0.68	18.3	1.50	40.4	**18**
Type 12-2	38.0	0.72	27.3	1.59	60.3	**27**

NEXT

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.67	22.2	1.22	40.1	**22T**
Type 1-1	17.0	0.78	13.3	1.41	24.0	**13T**
Type 1-2	27.0	0.68	18.3	1.22	33.1	**18T**
Type 12-2	38.0	0.72	27.3	1.30	49.4	**27T**



BACK TO GENERAL

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**

A. GENERAL

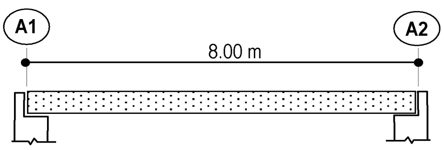
A.1 BRIDGE DESCRIPTION

- Bridge Location : Region VII
- Bridge Type : Simple-span Reinforced Concrete Flat Slab
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 8.0m
- Year Built : 1958
- Structure
  - Girders : Reinforced Concrete Flat Slab
  - Substructure : RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : fc = 6.9 Mpa , fs = 137.9 Mpa
  : fc = 17.2 Mpa , fs = 275.8 Mpa
- Assumption : Weight of barrier rail = 18.5 KN/m
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

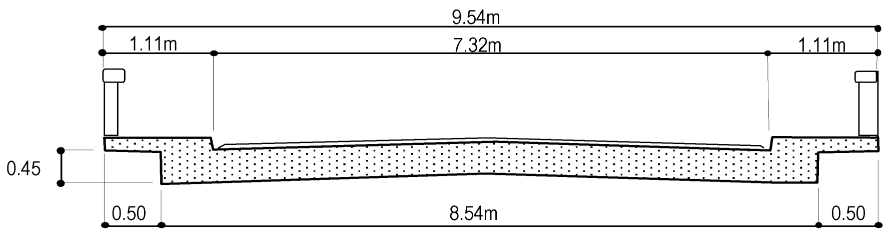
Reqirement :

Determine the load rating of the interior girder of the span (8.0m) for MS18 (HS20) vehicles considering damages on members (Rebar section losses 10%)

A.2 BRIDGE LAYOUT



BRIDGE ELEVATION



DECK SECTION

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**	

NOTES

B. DEMAND FORCES

B.1 DEAD LOAD CALCULATIONS

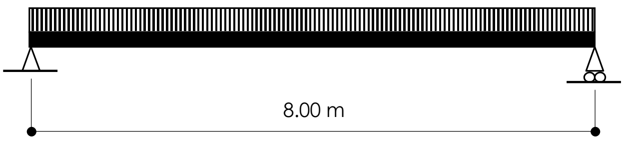
The dead loads considered in the calculations include (1) Flat Slab self-weight, (2) Barrier rails (Assumed to be equally distributed among girders) and (3) Wearing course..

- Self-weight of girder = (8.540m) (0.450m) (24 KN/m^3) / (8.540m) = 10.800 KN/m
- Barrier rail = (18.5m/8.540m)(1.250) = 2.708 KN/m
- Wearing course = (0.05m) (7.320m) (22 KN/m^3) = 0.943 KN/m
  - Total Uniform Load of Interior Girder, w = 14.450 KN/m

- Dead Load Moment at Midspan, M_{DL} = 14.45 x 8.00 ^{2} /8 = 115.60 KN-m — $M_d = wL^2/8$

- Dead Load Shear at "d" from, V_{DL} = 8.00 x 14.45 /2 = 57.80 KN — $V_d = wL/2$
  support

W_{DL} = 14.45



B.2 LIVE LOAD CALCULATIONS

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes. — Manual 1st Ed. Sect 3.4.2

The distribution of wheel loads for two traffic lanes for Slab shall be taken as follows — AASHTO Table 3.24.3.2 ((4+0.06S) in ft.) 1ft.=0.3048m

- Number of live load wheel line = (1.0/0.3048)/(4+0.06*8.0/0.3048) = 0.589
  (4+0.06S)<7 ==> S<50 in ft. (S<50*0.3048=15.24m)
  S>15.24m ==> (4+0.06S) should be applied 7 in ft.

- Impact factor, I = 15.24 / (8.00 + 38.00) = 0.331 — DPWH Sect. 3.2.5.1
  ==> Use Impact = 0.300

The live load moments and shear values are taken from the tables in Appendix III on this manual and are used to determine the live load demand. Interpolation may be used if values are not exact

- Max. MS18 moment for 8.00 m span without impact/whel line = 154.84 KN-m

- Thus, MS18 moment with Impact at midspan M_{LL} = (0.589) (1.300) (154.84) = 118.56 KN-m

- Max. MS18 shear at support/wheel line = 105.59 KN

- Thus, MS18 shear V_{LL} = (0.589) (1.300) (105.59) = 80.85 KN

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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**	

NOTES

C. LOAD RATING BY LOAD FACTOR METHOD

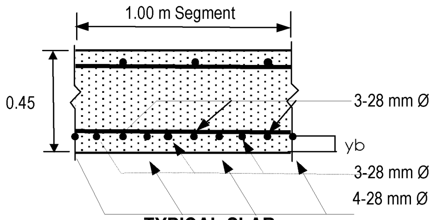
C.1 CAPACITY CALCULATIONS

The strengths of concrete and rebars are determined based on the year of construction and the allowable stresses noted in the plans. Since construction was done in 1958, the corresponding material strengths were as follows (Sect. 3.5).

	ALLOWABLE STRESSES				→	STRENGTH			
Concrete	f_c	=	6.9	Mpa		f'_c	=	17.2	Mpa
Rebar	f_s	=	137.9	Mpa		f_y	=	275.8	Mpa

This Manual Table 3.5-1

C.1.1 MOMENT CAPACITY AT MIDSPAN



TYPICAL SLAB REINFORCEMENT

- Total area of steel (∅– 28 mm rebar)

  As = 10 x (π /4 x 28^2) = 6,158 mm^2

  Section Loss = 10 %

  Total assumed area of Steel = 6,158 x 0.9 = 5,542 mm^2

- Centroid of rebar from top of deck = 450 - 61 = 389 mm

  Total Girder Depth = 450 mm

  Cover of Rebar = 61 mm

- Effective width of deck, b_{eff} = 1 m segment Flat Slab = 1,000 mm

  Ultimate capacity factor (Uf) = 0.90

- The rectangular stress block is calculated as,

$$a = \frac{A_s\, f_y}{0.85\, f'_c\, b_{eff}} = \frac{(5542)\quad(275.80)}{0.85\quad(17.2)\quad(1000)} = 105 \quad \text{mm}$$

- Moment Capacity

$$Mu = \phi \text{ As fy } (d - a/2) = \frac{0.9\quad(5542)\quad(275.80)\left[(389\ -\ 105\ /\ 2\right]}{10^6}$$

$$= 462.9 \quad \text{KN-m}$$

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**

NOTES

C.2 LOAD RATING CALCULATIONS

The manual provides the rating factor to be calculated using the Load Factor Method (LFM) by the formula:

$$RF = \frac{\phi Rn - \gamma_D D}{\gamma_L L\ (1 + I)}$$

where: => γ_L = 2.17 (Inventory)
=> γ_L = 1.30 (Operating)
=> γ_L = 2.17 (Posting)

This Manual
Eq. 3.2-4

By substituting the factors and the load effects to the equation, the moment and shear rating of the interior girder can be estimated as presented below.

RATING FACTOR CALCULATIONS (LFM)

LOCATION	DESCRIPTION	INVENTORY RATING
Midspan	Moment	$\frac{462.92 - 1.30\ (115.6)}{2.17\ (118.46)} = 1.22$
		OPERATING RATING
		$\frac{462.92 - 1.30\ (115.6)}{1.3\ (118.46)} = 2.03$

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
Midspan	Moment	1.22 x 33 = **40.26**	2.03 x 33 = **66.99**

This Manual

This Manual
Eq. 3.1-5

Since the Inventory Rating M_{LR} = **40.26** metric tons are over than the total weight of MS18 truck = 33 metric tons, load posting the bridge is not necessary

However, as a reference, Load Posting Calculation is shown in following pages.

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be taken from Appendix III of the Manual corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

This manual
Fig. 3.4-2

For a 8.00 m span bridge, the Posting Live Load demands are:

Vehicle Type	LL Effects/Wheel Line		LL Dist	Impact	LL Demand	
	Moment	Shear	Factor		Moment (KN-m)	Shear (KN)
Type 1-1	133.60	74.60	0.589	1.300	102.30	57.12
Type 1-2	153.79	94.94	0.589	1.300	117.76	72.70
Type 12-2	144.93	85.28	0.589	1.300	110.97	65.30

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**

NOTES

Similar calculations are done using Eqs. 3.2-4 and 3.1-5 for rating factor and load rating

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING Moment		OPERATING RATING Moment		POSTING (Metric Tons)
		RF	LR	RF	LR	
MS18	33.0	1.22	40.1	2.03	67.0	**33**
Type 1-1	17.0	1.41	24.0	2.35	40.0	**17**
Type 1-2	27.0	1.22	33.1	2.04	55.2	**27**
Type 12-2	38.0	1.30	49.4	2.17	82.4	**38**

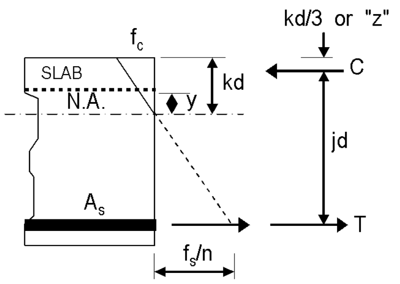
E. LOAD RATING BY ALLOWABLE STRESS METHOD

E1. MOMENT CAPACITY CALCULATIONS

The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete : f_c = 6.9 Mpa
Rebar : f_s = 137.9 Mpa <== Inventory
f_s = 193.1 Mpa <== Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



A_s = 5,542 mm^2

d = 389 mm

b_{ef} = 1,000 mm

ρ = As / bd = 0.01425

n = Es / Ec = 12

MCEB
Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2\,(0.01425)(12) + [0.01425((12)]^2} - (0.01425)(12)$$

k = 0.4383

kd = (0.4383)(389) = 170.5 mm

j = 1 - k/3 = 0.8539

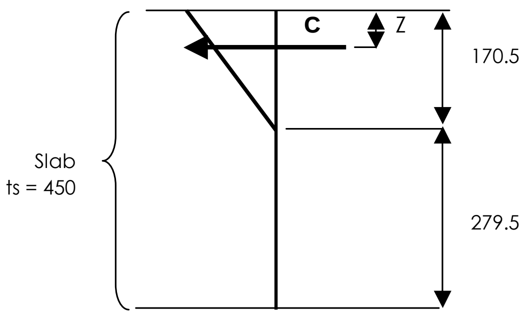
RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**

NOTES

Using k = 0.4383, kd = 170.5mm > ts = 450mm,
Therefore, the capacity will be calculated based on the N.A. .
The neutral axis depth, kd is calculated by summing moments at the top of the slab:

The compression zone resultant force (C) & location (z) is calculated as



Z = 170.5 / 3 = 56.83 mm

C = 1/2 (170.5) = 85.25

Therefore, jd = d - Z
= 389 - 56.83 = 332.2 mm

If concrete allowable stress controls, the capacity becomes:

At Inventory Level
Mc = be x **C** x fc x jd
= (1000)(85.25)(6.9)(332.2)(10^{-6})
= **195.37** kN-m

At Operating Level
Mc = be x **C** x fc x jd
= (1000)(85.25)(10.3)(332.2)(10^{-6})
= **291.65** kN-m

<<== Governing since Mc < Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level
Ms = As fs jd
= (5542)(137.9)(332.2)
= 253.87 kN-m

At Operating Level
Ms = As fs jd
= (5542)(193.1)(332.2)
= 355.49 kN-m

E2. LOAD RATING CALCULATIONS

The Manual provides the rating factor to be calculated using the
Allowable Stress Method (ASM) by the formula:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)}$$

where A_1 = 1.0
A_2 = 1.0

RATING FACTOR CALCULATIONS (ASM)

LOCATION	DESCRIPTION	INVENTORY RATING	
Midspan	Moment	$\frac{195.37 - (115.60)}{(118.46)}$	= 0.67
		OPERATING RATING	
		$\frac{291.65 - (115.60)}{(118.46)}$	= 1.49

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS SIMPLE**

NOTES

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

The procedure for load posting is similar to the above using load posting vehicles for live load and the demand moments and shears as calculated in the previous Section D, as follows:

Vehicle Type	LL Demand Moment (KN-m)
Type 1-1	102.21
Type 1-2	117.66
Type 12-2	110.88

Similarly, using Eq. 3.2-1 and Eq. 3.1-5, load posting calculations are presented below

LOAD POSTING RATING FACTOR CALCULATIONS BY ASM

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING		OPERATING RATING		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.67	22.2	1.49	49.0	**22**
Type 1-1	17.0	0.78	13.3	1.72	29.3	**13**
Type 1-2	27.0	0.68	18.3	1.50	40.4	**18**
Type 12-2	38.0	0.72	27.3	1.59	60.3	**27**

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.67	22.2	1.22	40.1	**22**
Type 1-1	17.0	0.78	13.3	1.41	24.0	**13**
Type 1-2	27.0	0.68	18.3	1.22	33.1	**18**
Type 12-2	38.0	0.72	27.3	1.30	49.4	**27**

RATED BY :	DATE :	CHECKED BY :	DATE :

RCFS CONTINUOUS

A. GENERAL

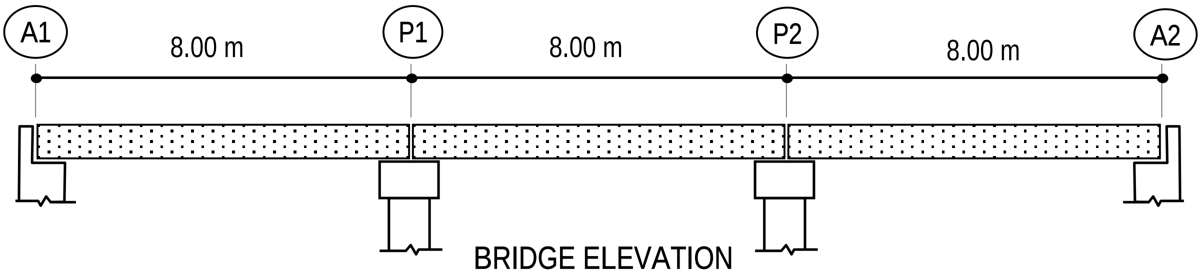
BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION	VII					
Bridge Name							
Bridge Type	Simple or Continuous	C					
	Number of Span	3					
Bridge of Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		8.000	8.000	8.000			=24.000m
Year Built		1982					
Structure	Superstructure	Reinforced Concrete Slab					
	Substructure	Wall Type RC Piers and RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa
		f'c=	20.7	Mpa	fy=	275.8	Mpa
Assumption		Weight of barrier rail Wbr =			18.5	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

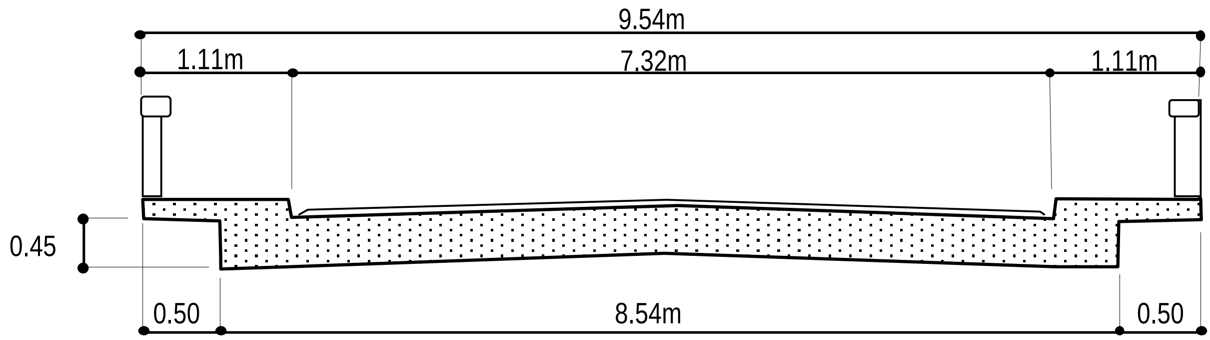
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



DECK SECTION

BRIDGE LAYOUT AND DIMENSION	
Overall width (m)	9.540
Carriageway Width (m)	7.320
Slab width bw(m)	8.540
Slab thickness h (m)	0.450
Span Length L(m)	8.000

NEXT

B. DEMAND FORCES

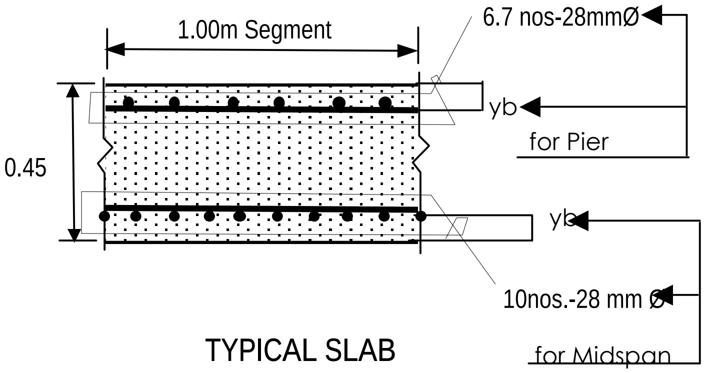
B0. INPUT		
FOR DEAD LOAD	Slab width bw(m)	8.540
	Slab thickness h (m)	0.450
	Span Length L(m)	8.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Slab		10.800
	Barrier Rail		2.708
	Asphalt Overlay		0.943
	Total		14.450
Dead Load	Moment (KN-m/m)	M_{DL}	115.60
	Shear (KN)	V_{DL}	57.80

B2. LOAD DEMAND MIDSPAN AND SUPPORT OF RCS		
Conducting a Structural Analysis, the load demands for the RCS should be obtained separately and input the necessary load demands in the Table below.		
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD
Number of live load wheel line	0.589	
Impact factor	0.300	
span	8.000	
Description	At Midspan	At Pier Support
Dead load moments, KN-m	115.60	-66.30
Additional Dead load moments, KN-m	7.65	-7.45
MS18 max. positive moment, KN-m	152.50	-
MS18 max. negative moment, KN-m	-	-109.10

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



TYPICAL SLAB
REINFORCEMENT

Total area of Rebar		
	Midspan	At Pier
Nos of Rebar	10	6.7
Dia. (mm)	28	28
As(mm2)	6158	4126
yb (mm)	61	64

C1. CAPACITY CALCULATIONS

C1. INPUT					
(1) Common Input Data				At Midspan	At Pier
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3	
		Strength	f'c	20.7	
	Rebar	Allowable Stress	fs	137.9	
		Strength	fy	275.8	
(2) Input Data for Moment Capacity				At Midspan	At Pier
Total Area of Steel As(mm^2)	10 x (28mm rebar)			6158	4126
Section Loss (%)				0	0
Total Assumed Area of Steel As(mm2)				6158	4126
Centroid of rebars from bottom of deck , d (mm)				61	64
Centroid of rebars from top of deck , d (mm)				389	386
Effective width of deck , b_{eff} (mm)				1000	1000
Ultimate capacity factor (Uf)				0.90	0.90

C1. MOMENT CAPACITY AT MIDSPAN	At Midspan	At Pier
Rectangular stress block depth a (mm)	97.0	65.0
The Moment Capacity Mu (kN-m)	520.4	362.0

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
Moment Ultimate Capacity at Midspan (kN-m)		520.43	-362.00
Dead Load Moment at Midspan (kN-m)		123.25	-73.75
Live Load Moment at Midspan (kN-m)		152.50	-109.10
Rating Live Load (Tons)		33.0	33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.09	35.97
			Operating Rating	1.82	60.06
		At Pier	Inventory Rating	1.12	36.96
			Operating Rating	1.88	62.04

Depend on the minimum value of Rating Factor > 1 or <1 , instruction is automatically shown below

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the RCS should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	105.2	-83.9
	Shear	-	-23.1
Type 1-2	Moment	137.7	-109.2
	Shear	-	-31.2
Type 12-2	Moment	142.8	-115.9
	Shear	-	-30.4

NEXT

D2. POSTING RATING CALCULATIONS

D2.1 INPUT				
Load factor for dead load		1.3		
Load factor for live load	Inventory	2.17		
	Operating	1.3		
		Midspan	At Pier	
Moment Ultimate Capacity		520.43	362.00	
Dead Load		123.25	-73.75	
		Midspan	At Pier	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	152.50	-109.10	33.0
	Type 1-1	105.20	-83.90	17.0
	Type 1-2	137.70	-109.20	27.0
	Type 12-2	142.80	-115.90	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM						
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating		Operating Rating		**Posting (Metric Tons)**
		Moment		Moment		
		RF	LR	RF	LR	
(1) AT MIDSPAN						
MS18	33.0	1.09	35.9	1.82	60.0	**33**
Type 1-1	17.0	1.58	26.8	2.63	44.8	**17**
Type 1-2	27.0	1.21	32.5	2.01	54.3	**27**
Type 12-2	38.0	1.16	44.2	1.94	73.7	**38**
(2) AT PIER						
MS18	33.0	1.12	37.1	1.88	61.9	**33**
Type 1-1	17.0	1.46	24.8	2.44	41.5	**17**
Type 1-2	27.0	1.12	30.3	1.87	50.6	**27**
Type 12-2	38.0	1.06	40.2	1.77	67.1	**38**

NEXT

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				At Midspan	At Pier
Year Built				1982	
Material Properties	Concrete	fc	Inventory	8.3	
			Operating	13.1	
		f'c		20.7	
	Rebar	fs	Inventory	137.9	
			Operating	193.1	
Total Assumed Area of Steel As(mm	8 x (28mm rebar)			6158	4126
Centroid of rebars from top of deck , d (mm)				389	386
Effective width of deck , beff (mm)				1000	1000
Rebar Ratio ρ = As / (beff x d)				0.01583	0.01069
Modular Ratio of Elasticity n = Es / Ec				12	12
$k = \sqrt{[2\rho n + (\rho n)^2]} - \rho n$				0.4550	0.3942
kd				177.0	152.2
j				0.8483	0.8686
jd				330.0	335.3

E1.2 MOMENT CAPACITY CALCULATIONS			At Midspan	At Pier
Moment (kN-m)	Capacity by concrete allowable stress	Inventory	242.40	211.72
		Operating	382.59	334.16
	Capacity by rebar allowable stress	Inventory	280.21	190.74
		Operating	392.38	267.10

NEXT

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.0	
Load factor for live load		1.0	
Moment Capacity at Midspan (kN-m)	Inventory	242.40	190.74
	Operating	382.59	267.10
Dead Load Moment at Midspan (kN-m)		123.25	-73.75
Live Load Moment at Midspan (kN-m)		152.50	-109.10
Rating Live Load (Tons)		33.0	

E2.2. RATING FACTOR CALCULATIONS (ASM)				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment ( )	Midspan	Inventory Rating	0.78	25.74
			Operating Rating	1.70	56.10
		At Pier	Inventory Rating	1.07	35.31
			Operating Rating	1.77	58.41

NEXT

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

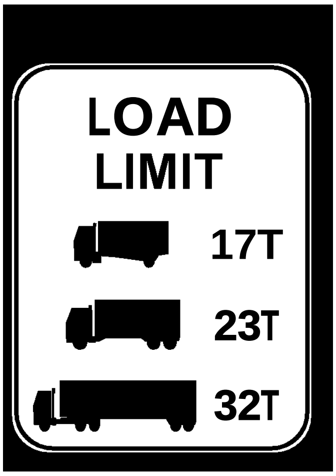
F1. INPUT				
Load factor for dead load		1.0		
Load factor for live load		1.0		
		Moment		
		Midspan	At Pier	
Moment Capacity	Inventory	242.40	-190.74	
	Operating	382.59	-267.10	
Dead Load		123.25	-73.75	
		Moment		Vehicle Weight
		Midspan	At Pier	
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	152.50	-109.10	33.0
	Type 1-1	105.20	-83.90	17.0
	Type 1-2	137.70	-109.20	27.0
	Type 12-2	142.80	-115.90	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)						
Vehicle Type	Vehicle Weight (Metric Tons)	Moment				**Posting (Metric Tons)**
		Inventory Rating		Operating Rating		
		RF	LR	RF	LR	
(1) AT MIDSPAN						
MS18	33.0	0.78	25.8	1.70	56.1	**26**
Type 1-1	17.0	1.13	19.3	2.47	41.9	**17**
Type 1-2	27.0	0.87	23.4	1.88	50.9	**23**
Type 12-2	38.0	0.83	31.7	1.82	69.0	**32**
(2) AT PIER						
MS18	33.0	1.07	35.4	1.77	58.5	**33**
Type 1-1	17.0	1.39	23.7	2.30	39.2	**17**
Type 1-2	27.0	1.07	28.9	1.77	47.8	**27**
Type 12-2	38.0	1.01	38.4	1.67	63.4	**38**

NEXT

G. SUMMARY OF RESULTS FOR LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.78	25.8	1.09	35.9	26T
Type 1-1	17.0	1.13	19.3	1.46	24.8	17T
Type 1-2	27.0	0.87	23.4	1.12	30.3	23T
Type 12-2	38.0	0.83	31.7	1.06	40.2	32T



BACK TO GENERAL

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	**** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**RCFS CONTINUOUS**

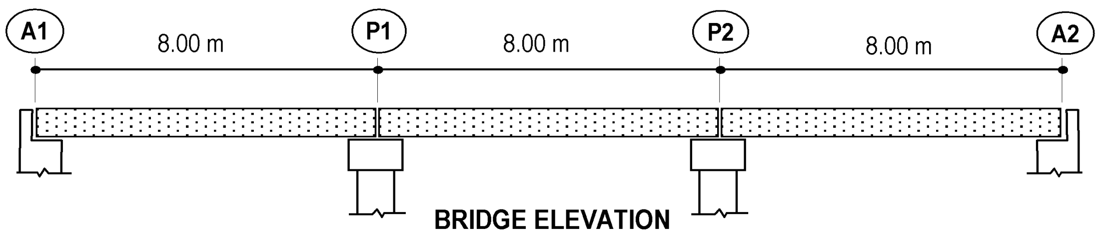
A. GENERAL

A.1 BRIDGE DESCRIPTION

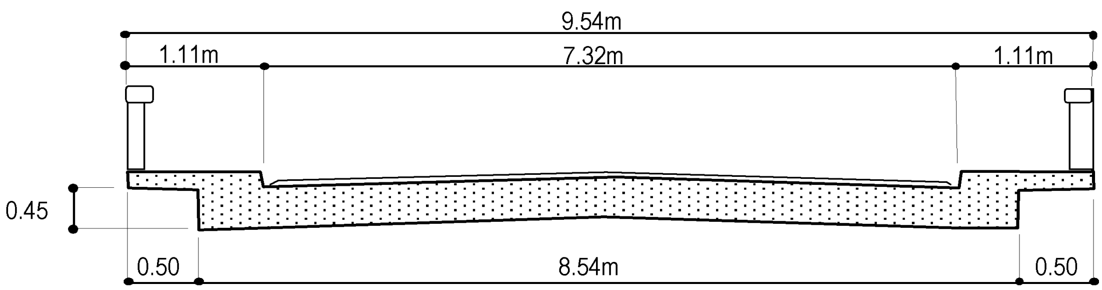
- Bridge Location : Region VII
- Bridge Type : 3-span Continuous Reinforced Concrete Flat Slab
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 8.0m + 8.0m + 8.0m = 24.0m
- Year Built : 1982
- Structure
  - Girders : Reinforced Concrete Flat Slab
  - Substructure : Wall Type RC Pier and RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : fc = 8.3 Mpa , fs = 137.9 Mpa
  : fc = 20.7 Mpa , fs = 275.8 Mpa
- Assumption : Weight of barrier rail = 18.5 KN/m
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

Reqirement :
Determine the load rating of the interior girder of the span (8.0m) for MS18 (HS20) vehicles considering no damages on members

A.2 BRIDGE LAYOUT



BRIDGE ELEVATION



DECK SECTION

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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

B. DEMAND FORCES

B.1 DEAD LOAD CALCULATIONS

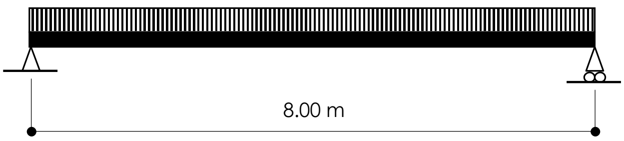
The dead loads considered in the calculations include (1) Flat Slab self-weight, (2) Barrier rails (Assumed to be equally distributed among girders) and (3) Wearing course..

- Self-weight of girder = (8.540m) (0.450m) (24 KN/m^3) / (8.540m) = 10.800 KN/m
- Barrier rail = (18.5m/8.540m)(1.250) = 2.708 KN/m
- Wearing course = (0.05m) (7.320m) (22 KN/m^3) = 0.943 KN/m
  - Total Uniform Load of Interior Girder, w = 14.450 KN/m

- Dead Load Moment at Midspan, M_{DL} = 14.45 x 8.00 ^{2} /8 = 115.60 KN-m — $M_d = wL^2/8$

- Dead Load Shear at "d" from, V_{DL} = 8.00 x 14.45 /2 = 57.80 KN — $V_d = wL/2$
  support

W_{DL} = 14.45



B.2 LIVE LOAD CALCULATIONS

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes. — Manual 1st Ed. Sect 3.4.2

The distribution of wheel loads for two traffic lanes for Slab shall be taken as follows — AASHTO Table 3.24.3.2

- Number of live load wheel line = (1.0/0.3048)/(4+0.06*8.0/0.3048) = 0.589 — ((4+0.06S) in ft.) 1ft.=0.3048m
  (4+0.06S)<7 ==> S<50 in ft. (S<50*0.3048=15.24m)
  S>15.24m ==> (4+0.06S) should be applied 7 in ft.

- Impact factor, I = 15.24 / (8.00 + 38.00) = 0.331 — DPWH Sect. 3.2.5.1
  ==> Use Impact = 0.300

Conducting a Structural Analysis, the load demands for the RCFS Continuous should be obtained separately and input the necessary load demands in the Table below.

Description	At Midspan	At Pier Support
	0.4L	1.0L
Dead load moments, KN-m	115.60	-66.30
Additional Dead load moments, KN-m	7.65	-7.45
MS18 max. positive moment, KN-m	152.50	-
MS18 max. negative moment, KN-m	-	-109.10

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

C. LOAD RATING BY LOAD FACTOR METHOD

C.1 CAPACITY CALCULATIONS

The strengths of concrete and rebars are determined based on the year of construction and the allowable stresses noted in the plans. Since construction was done in 1958, the corresponding material strengths were as follows (Sect. 3.5).

	ALLOWABLE STRESSES				→	STRENGTH			
Concrete	f_c	=	8.3	Mpa	→	f'_c	=	20.7	Mpa
Rebar	f_s	=	137.9	Mpa	→	f_y	=	275.8	Mpa

This Manual Table 3.5-1

C.1.1 MOMENT CAPACITY CALCULATIONS

AT MIDSPAN

- Total area of steel (∅– 28 mm rebar)
  As = 10 x (π /4 x 28^2) = 6,158 mm^2
- Centroid of rebar from top of deck = 450 - 61 = 389 mm

  Total Girder Depth = 450 mm

  Cover of Rebar = 61 mm
- Effective width of deck, b_{eff} = 1 m segment Flat Slab = 1,000 mm

  Ultimate capacity factor (Uf) = 0.90
- The rectangular stress block is calculated as,

$$a = \frac{A_s f_y}{0.85 f'_c b_{eff}} = \frac{(6158)\quad(275.80)}{0.85\quad(20.7)\quad(1000)} = 97 \text{ mm}$$

- Moment Capacity

$$Mu = \phi \text{ As fy } (d - a/2) = \frac{0.9 \quad (6158) \quad (275.80) \left[(389 - 97 / 2) \right]}{10^6}$$

$$= 520.43 \text{ KN-m}$$

AT PIER SUPPORT

- Total area of steel (∅– 28 mm rebar)
  As = 6.7 x (π /4 x 28^2) = 4,126 mm^2
- Centroid of rebar from top of deck = 450 - 64 = 386 mm

  Total Girder Depth = 450 mm

  Cover of Rebar = 64 mm

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

- Effective width of deck, b_{eff} = 1 m segment Flat Slab = 1,000 mm

  Ultimate capacity factor (Uf) = 0.90

- The rectangular stress block is calculated as,

$$a = \frac{A_s\, f_y}{0.85\, f'_c\, b_{eff}} = \frac{(4126)\quad(275.80)}{0.85\quad(20.7)\quad(1000)} = 65 \text{ mm}$$

- Moment Capacity

$$Mu = \phi\, As\, fy\, (d - a/2) = \frac{0.9\quad(4126)\quad(275.80)\left(386 - 65\ /\ 2\right)}{10^6}$$

$$= 362.00 \text{ KN-m}$$

C.2 LOAD RATING CALCULATIONS

The manual provides the rating factor to be calculated using the Load Factor Method (LFM) by the formula:

$$RF = \frac{\phi\, Rn - \gamma_D D}{\gamma_L L\,(1 + I)}$$

where: => γ_L = 2.17 (Inventory)
=> γ_L = 1.30 (Operating)
=> γ_L = 2.17 (Posting)

This Manual Eq. 3.2-4

By substituting the factors and the load effects to the equation, the moment rating of the flat slab can be estimated as presented below.

RATING FACTOR CALCULATIONS (LFM)

LOCATION	DESCRIPTION	RATING	Calculation	Result
Midspan	Moment	**INVENTORY RATING**	(520.40 - 1.30 (123.25)) / (2.17 (152.50))	= 1.09
Midspan	Moment	**OPERATING RATING**	(520.40 - 1.30 (123.25)) / (1.3 (152.50))	= 1.82
Pier Support	Moment	**INVENTORY RATING**	(-362.00 - 1.30 (-73.75)) / (2.17 (-109.10))	= 1.12
Pier Support	Moment	**OPERATING RATING**	(-362.00 - 1.30 (-73.75)) / (1.3 (-109.10))	= 1.88

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
Midspan	Moment	1.09 x 33 = **35.97**	1.82 x 33 = **60.06**
Pier Support	Moment	1.12 x 33 = **36.96**	1.88 x 33 = **62.04**

This Manual Eq. 3.1-5

Since the Inventory Rating M_{LR} = **35.97** metric tons are over than the total weight of MS18 truck = 33 metric tons, load posting the bridge is not necessary

However, as a reference, Load Posting Calculation is shown in following pages.

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be separately taken from conducting a structural analysis corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

This manual Fig. 3.4-2

For 3-span continuous (3@15.0m) bridge, the Posting Live Load demands are:

Vehicle Type	LL Demand	At Midspan	At Pier Support
Type 1-1	Moment	105.2	-83.9
	Shear	---	-23.1
Type 1-2	Moment	137.7	-109.2
	Shear	---	-31.2
Type 12-2	Moment	142.8	-115.9
	Shear	---	-30.4

Similar calculations are done using Eqs. 3.2-4 and 3.1-5 for rating factor and load rating

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM AT MIDSPAN

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING		OPERATING RATING		POSTING (Metric Tons)
		Moment		Moment		
		RF	LR	RF	LR	
MS18	33.0	1.09	35.9	1.82	60.0	**33**
Type 1-1	17.0	1.58	26.8	2.63	44.8	**17**
Type 1-2	27.0	1.21	32.5	2.01	54.3	**27**
Type 12-2	38.0	1.16	44.2	1.94	73.7	**38**

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM AT PIER SUPPORT

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING		OPERATING RATING		POSTING (Metric Tons)
		Moment		Moment		
		RF	LR	RF	LR	
MS18	33.0	1.12	37.1	1.88	61.9	**33**
Type 1-1	17.0	1.46	24.8	2.44	41.5	**17**
Type 1-2	27.0	1.12	30.3	1.87	50.6	**27**
Type 12-2	38.0	1.06	40.2	1.77	67.1	**38**

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

E. LOAD RATING BY ALLOWABLE STRESS METHOD

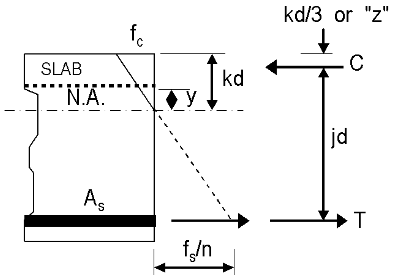
E1. MOMENT CAPACITY CALCULATIONS

AT MIDSPAN

The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete :	fc = 8.3 Mpa		
Rebar :	fs = 137.9 Mpa	<==	Inventory
	fs = 193.1 Mpa	<==	Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



As = 6,158 mm^2

d = 389 mm

b_{ef} = 1,000 mm

ρ = As / bd = 0.01583

n = Es / Ec = 12

MCEB
Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2\,(0.01583)(12) + [0.01583((12)]^2} - (0.01583)(12)$$

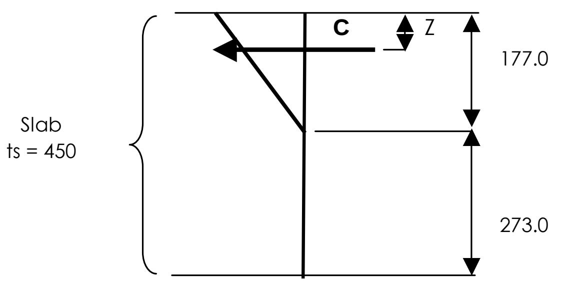
$$k = 0.4550$$

$$kd = (0.4550)(389) = 177.0 \text{ mm}$$

$$j = 1 - k/3 = 0.8483$$

Using k = 0.4550, kd = 177.0mm > ts = 450mm,
Therefore, the capacity will be calculated based on the N.A. .
The neutral axis depth, kd is calculated by summing moments at the top of the slab:

The compression zone resultant force (C) & location (z) is calculated as



Z = 177.0 / 3 = 59.00 mm

C = 1/2 (177.0) = 88.5

Therefore, jd = d - Z
= 389 - 59.00 = 330.0 mm

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

If concrete allowable stress controls, the capacity becomes:

At Inventory Level

Mc = be x **C** x fc x jd

= (1000)(88.5)(8.3)(330.0)(10^{-6})

= 242.4 kN-m

At Operating Level

Mc = be x **C** x fc x jd

= (1000)(88.5)(13.1)(330.0)(10^{-6})

= 382.6 kN-m

<<== Not governing since Mc > Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level

Ms = As fs jd

= (6158)(137.9)(330.0)

= **280.21** kN-m

At Operating Level

Ms = As fs jd

= (6158)(193.1)(330.0)

= **392.38** kN-m

AT PIER SUPPORT

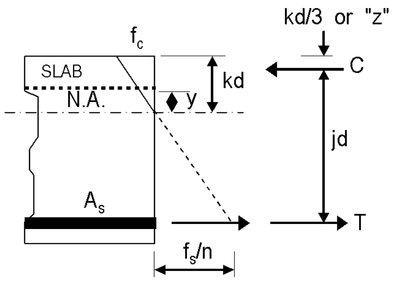
The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete : fc = 8.3 Mpa

Rebar : fs = 137.9 Mpa <== Inventory

fs = 193.1 Mpa <== Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



As = 4,126 mm^2

d = 386 mm

b_{ef} = 1,000 mm

ρ = As / bd = 0.01069

n = Es / Ec = 12

MCEB Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2\,(0.01069)(12) + [(0.01069)(12)]^2} - (0.01069)(12)$$

k = 0.3942

kd = (0.3942)(386) = 152.2 mm

j = 1 - k/3 = 0.8686

RATED BY :	DATE :	CHECKED BY :	DATE :

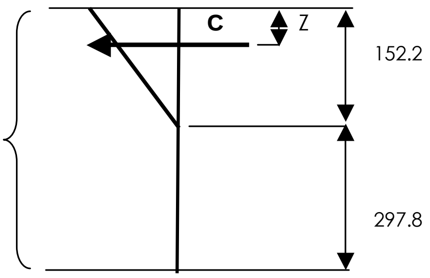
	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ******** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

Using k = 0.3942, kd = 152.2 mm > ts = 450mm,
Therefore, the capacity will be calculated based on the N.A. .
The neutral axis depth, kd is calculated by summing moments at the top of the slab:

The compression zone resultant force (C) & location (z) is calculated as

Slab
ts = 450



Z = 152.2 / 3 = 50.73 mm

C = 1/2 (152.2) = 76.1

Therefore, jd = d - Z
= 386 - 50.73 = 335.3 mm

If concrete allowable stress controls, the capacity becomes:

At Inventory Level

Mc = be x **C** x fc x jd
= $(1000)(76.1)(8.3)(335.3)(10^{-6})$
= 211.72 kN-m

At Operating Level

Mc = be x **C** x fc x jd
= $(1000)(76.1)(13.1)(335.3)(10^{-6})$
= 334.26 kN-m

<<== Not governing since Mc > Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level

Ms = As fs jd
= (4126)(137.9)(335.3)
= **190.74** kN-m

At Operating Level

Ms = As fs jd
= (4126)(193.1)(335.3)
= **267.10** kN-m

E2. LOAD RATING CALCULATIONS

The Manual provides the rating factor to be calculated using the Allowable Stress Method (ASM) by the formula:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)}$$

where A_1 = 1.0
A_2 = 1.0

RATING FACTOR CALCULATIONS (ASM)

LOCATION	DESCRIPTION	RATING		Posting (Tons)
Midspan	Moment	**INVENTORY RATING**		
		280.21 - (123.25) / (152.50)	= 1.03	33.99
		OPERATING RATING		
		392.38 - (123.25) / (152.50)	= 1.76	58.08
Pier Support		**INVENTORY RATING**		
		-190.74 - -(73.75) / -(109.10)	= 1.07	35.31
		OPERATING RATING		
		-267.10 - -(73.75) / -(109.10)	= 1.77	58.41

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : RCFS CONTINUOUS

NOTES

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

The procedure for load posting is similar to the above using load posting vehicles for live load and the demand moments and shears as calculated in the previous Section D, as follows:

Vehicle Type	LL Demand Moment (KN-m)	
	At Midspan	At Pier Support
Type 1-1	105.20	-83.90
Type 1-2	137.70	-109.20
Type 12-2	142.80	-115.90

Similarly, using Eq. 3.2-1 and Eq. 3.1-5, load posting calculations are presented below

LOAD POSTING RATING FACTOR CALCULATIONS BY ASM AT MIDSPAN

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING		OPERATING RATING		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.03	34.0	1.76	58.2	**33**
Type 1-1	17.0	1.49	25.4	2.56	43.5	**17**
Type 1-2	27.0	1.14	30.8	1.95	52.8	**27**
Type 12-2	38.0	1.10	41.8	1.88	71.6	**38**

LOAD POSTING RATING FACTOR CALCULATIONS BY ASM AT PIER SUPPORT

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING		OPERATING RATING		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.07	35.4	1.77	58.5	**33**
Type 1-1	17.0	1.39	23.7	2.30	39.2	**17**
Type 1-2	27.0	1.07	28.9	1.77	47.8	**27**
Type 12-2	38.0	1.01	38.4	1.67	63.4	**38**

RATED BY :	DATE :	CHECKED BY :	DATE :

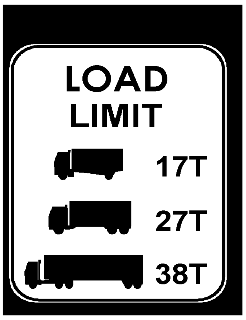
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCFS CONTINUOUS**

NOTES

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.03	34.0	1.09	35.9	**33**
Type 1-1	17.0	1.39	23.7	1.46	24.8	**17**
Type 1-2	27.0	1.07	28.9	1.12	30.3	**27**
Type 12-2	38.0	1.01	38.4	1.06	40.2	**38**



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EXAMPLE 2

REINFORCED CONCRETE DECK GIRDER BRIDGE

Example 2-1: Simple

Example 2-2: Continuous

INTERIOR RCDG SIMPLE

A. GENERAL

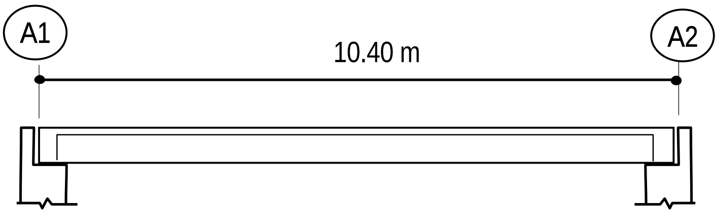
BACK TO MENU

A1. BRIDGE DESCRIPTION								
Bridge Location		REGION	XI					
Bridge Name			Sample Bridge					
Bridge Type	Simple or Continuous		S	Reinforced Concrete T-beams				
	Number of Span		1					
Bridge of Width (curb to curb) (m)			7.32					
Number of Lanes			2					
Bridge Length (m)			10.400					=10.400m
Year Built			1987					
Structure	Nos. of Girder		4	Multiple monotholic with deck slab.				
	Girder Spacing (m)		2.400	on centers				
	Substructure		Concrete bents and Abutments					
Wearing Course	thickness (mm)		50					
	material		Asphalt					
Material Properties			fc=	8.3	Mpa	fs=	137.9	Mpa
			f'c=	20.7	Mpa	fy=	275.8	Mpa
Assumption			Weight of barrier rail Wbr =			3.6	KN/m	
			Concrete Unit Weight Wu =			24.0	KN/m^3	
			Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others			Rating Live Load is AASHTO MS18 (HS20-44)					

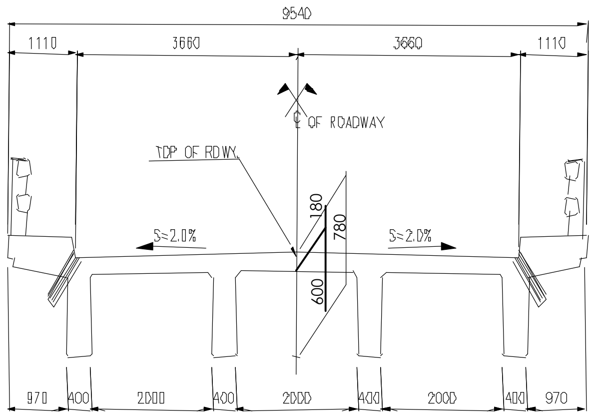
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

BRIDGE LAYOUT AND DIMENSION	
Girder width bw(m)	0.400
Girder Web height h (m)	0.600
Fillet/Haunch width wf(m)	0.100
Fillet/Haunch height hf(m)	0.100
Slab thickness ts (m)	0.180
Span Length L(m)	10.400

NEXT

B. DEMAND FORCES

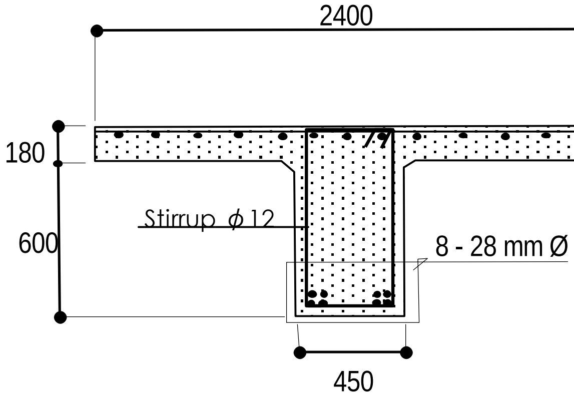
B0. INPUT		
FOR DEAD LOAD	Girder width bw(m)	0.400
	Girder Web height h (m)	0.600
	Fillet/Haunch width wf(m)	0.100
	Fillet/Haunch height hf(m)	0.100
	Slab thickness ts (m)	0.180
	Slab width ws (m)	2.400
	Span Length L(m)	10.400

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder		5.760
	Fillet/Haunch		0.240
	Slab Weight	Continuous	10.368
	Barrier Rail		1.800
	Asphalt Overlay		2.640
	Total		20.810
Dead Load	Moment (KN-m/m)	M_{DL}	281.4
	Shear (KN)	V_{DL}	108.2

B2. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.312			
Impact factor	0.300			
span	10.400			
Max.MS18 moment for 10.40m span /wheel line		without Impact	M_L	236.5
		with Impact	M_{LL}	403.5
Max.MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	117.7
		with Impact	V_{LL}	200.7

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



GIRDER AND SLAB DETAILS

Total area of Rebar	
Nos of Rebar	8
Dia. (mm)	28
As(mm2)	4926
yb (mm)	102

Stirrups	
Dia. (mm)	12
As(mm2)	113.1
Spacing (mm)	200

C1. CAPACITY CALCULATIONS

C1. INPUT				
(1) Common Input Data				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
(2) Input Data for Moment Capacity				
Total Area of Steel As(mm^2)				4926
Section Loss due to Rebar Exposure (%)				0
Total Assumed Area of Steel As(mm2)				4926
Centroid of rebars from bottom of deck , d (mm)				102
Centroid of rebars from top of deck , d (mm)				678
Effective width of deck , b_{eff} (mm)		12ts + bw		2560
		Span Length / 4		2600
		beff		2400
Ultimate capacity factor (Uf)				0.90
(3) Input Data for Shear Capacity				
Girder width bw(mm)				400
Depth of Shear Cracks (mm)				199
The Reduction Factor due to Shear Cracks				0.50
Centroid of rebars from top of deck , d (mm)				678
Area of rebar Av(mm^2)				113.1
Section Loss due to Stirrups Exposure (%)				0
Total Assumed Area of Steel As(mm2)				113.1
Spacing of stirrups S (mm)				200
Ultimate capacity factor (Uf)				0.85

C1.1 MOMENT CAPACITY AT MIDSPAN	
Rectangular stress block depth a (mm)	32.2
The Moment Capacity Mu (kN-m)	809.3
C1.2 SHEAR CAPACITY AT SUPPORT	
The shear **FULL capacity** due to concrete section Vc (kN)	206.1
The shear **capacity** due to concrete section Vc (kN)	103.5
The shear **FULL capacity** due to shear reinforcement Vs (kN)	211.5
The shear **capacity** due to Stirrups Vs (kN)	211.5
The total shear capacity Vu (kN)	267.8

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		
Load factor for dead load		1.3
Load factor for live load	Inventory	2.17
	Operating	1.3
Moment Ultimate Capacity at Midspan (kN-m)		809.3
Dead Load Moment at Midspan (kN-m)		281.4
Live Load Moment at Midspan (kN-m)		403.5
Shear Ultimate Capacity at Support (KN)		267.8
Dead Load Shear at Support (KN)		108.2
Live Load Shear at Support (KN)		200.7
Rating Live Load (Tons)		33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.51	16.7
		Operating Rating	0.85	27.9
	Shear (At Support)	Inventory Rating	0.29	9.6
		Operating Rating	0.49	16.1

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Load Posting

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.312			
Impact factor	0.300			
span	10.40			
Type 1-1 moment for 10.40m span /wheel line		without Impact	M_L	183.0
		with Impact	M_{LL}	312.1
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	76.7
		with Impact	V_{LL}	130.8
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 10.40m span /wheel line		without Impact	M_L	223.6
		with Impact	M_{LL}	381.4
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	103.6
		with Impact	V_{LL}	176.7
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 10.40m span /wheel line		without Impact	M_L	208.6
		with Impact	M_{LL}	355.8
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	90.1
		with Impact	V_{LL}	153.7

NEXT

D2. POSTING RATING CALCULATIONS

D2.1 INPUT					
Load factor for dead load			1.3		
Load factor for live load	Inventory		2.17		
	Operating		1.3		
			Moment	Shear	
Moment Ultimate Capacity			809.3	267.8	
Dead Load			281.4	108.2	
			Moment	Shear	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)		MS18	403.5	200.7	33.0
		Type 1-1	312.1	130.8	17.0
		Type 1-2	381.4	176.7	27.0
		Type 12-2	355.8	153.7	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.51	16.7	0.29	9.6	0.85	27.9	0.49	16.1	**10**
Type 1-1	17.0	0.65	11.1	0.45	7.6	1.09	18.6	0.75	12.7	**8**
Type 1-2	27.0	0.54	14.5	0.33	8.9	0.89	24.2	0.55	14.9	**9**
Type 12-2	38.0	0.57	21.8	0.38	14.5	0.96	36.4	0.64	24.2	**14**

NEXT

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				
Material Properties	Concrete	fc	Inventory	8.3
			Operating	13.1
		f'c		20.7
	Rebar	fs	Inventory	137.9
			Operating	193.1
Total Assumed Area of Steel As(mm^2)				4926
Area of rebar Av(mm^2)				113.1
Spacing of stirrups S (mm)				200
Centroid of rebars from top of deck , d (mm)				678
Effective width of deck , beff (mm)				2400
Girder width bw(m)				400
Rebar Ratio ρ = As / (beff x d)				0.00303
Modular Ratio of Elasticity n = Es / Ec				12
$k = \sqrt{[2\rho n + (\rho n)^2]} - \rho n$				0.2357
j				0.9214
kd				159.8
Slab thickness ts (mm)				180.0
k				0.2357
z				53.26
jd				624.74

Calculation of kd					
n	As	d	b	ts	bw
12	4926	678	2400	180.0	400
nAs	nAsd	bts	$1/2bts^2$	bwy	y/2+ts
59112	40077936	432000	38880000	0	180.0
ts+y	$y_{calculate}$				y_{input}
180.0	0.0				0.0

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS				
Moment (kN-m)	Capacity by concrete allowable stress Mc		Inventory	994.18
			Operating	1569.13
	Capacity by rebar allowable stress Ms		Inventory	424.38
			Operating	594.26
Shear (kN)	Capacity due to concrete section	Vc	Inventory	49.60
			Operating	74.40
	Capacity due to rebar	Vs	Inventory	105.74
			Operating	148.07
	Shear capacity	Vu	Inventory	155.34
			Operating	222.47

NEXT

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		
Load factor for dead load		1.0
Load factor for live load		1.0
Moment Capacity at Midspan (kN-m)	Inventory	424.4
	Operating	594.3
Dead Load Moment at Midspan (kN-m)		281.4
Live Load Moment at Midspan (kN-m)		403.5
Shear Capacity at Support (KN)	Inventory	155.3
	Operating	222.5
Dead Load Shear at Support (KN)		108.2
Live Load Shear at Support (KN)		200.7
Rating Live Load (Tons)		33.0

E2.2. RATING FACTOR CALCULATIONS (ASM)			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.35	11.7
		Operating Rating	0.78	25.6
	Shear (At Support)	Inventory Rating	0.23	7.7
		Operating Rating	0.57	18.8

NEXT

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

F1. INPUT				
Load factor for dead load		1.0		
Load factor for live load		1.0		
		Moment	Shear	
Moment and Shear Capacity	Inventory	424.4	155.3	
	Operating	594.3	222.5	
Dead Load		281.4	108.2	
		Moment	Shear	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	403.5	200.7	33.0
	Type 1-1	312.1	130.8	17.0
	Type 1-2	381.4	176.7	27.0
	Type 12-2	355.8	153.7	38.0

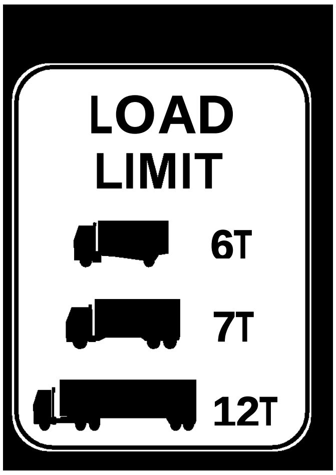
F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.35	11.7	0.23	7.7	0.78	25.6	0.57	18.8	**8**
Type 1-1	17.0	0.46	7.8	0.36	6.1	1.00	17.0	0.87	14.9	**6**
Type 1-2	27.0	0.38	10.1	0.27	7.2	0.82	22.2	0.65	17.5	**7**
Type 12-2	38.0	0.40	15.3	0.31	11.7	0.88	33.4	0.74	28.2	**12**

NEXT

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.23	7.7	0.29	9.6	8T
Type 1-1	17.0	0.36	6.1	0.45	7.6	6T
Type 1-2	27.0	0.27	7.2	0.33	8.9	7T
Type 12-2	38.0	0.31	11.7	0.38	14.5	12T



END GO TO RC DECK SLAB

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**

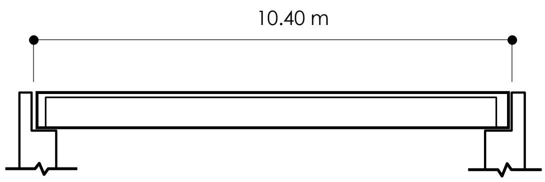
A. GENERAL

A.1 BRIDGE DESCRIPTION

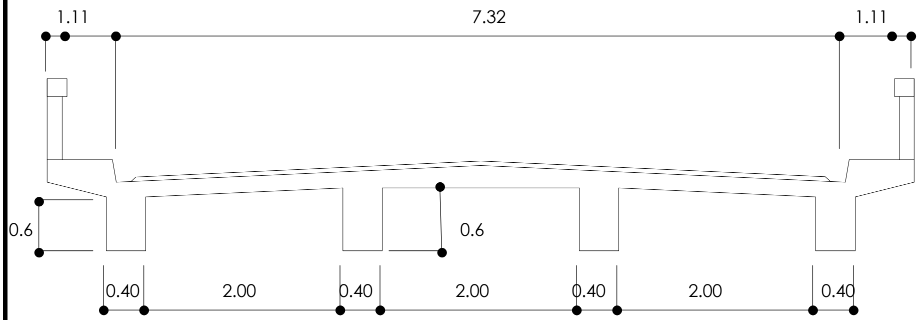
- Bridge Location : Region XI
- Bridge Type : Simple-span Reinforced Concrete T-Beams
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 10.40m
- Year Built : 1987
- Structure
  - Girders : Multiple Girders per span (4-Girders), Monolithic with deck slab
    : Girder spacing at 2.40m on center
  - Substructure : RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : fc = 8.3 Mpa , fs = 137.9 Mpa
  : f'c = 20.7 Mpa , fy = 275.8 Mpa
- Assumption : Weight of barrier rail = 3.6 KN/m
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

Reqirement :
Determine the load rating of the interior girder of the span (10.40m) for MS18 (HS20) vehicles considering damages on members (Shear crack depth 199mm occurred)

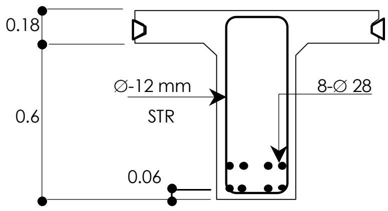
A.2 BRIDGE LAYOUT



BRIDGE ELEVATION



DECK SECTION



GIRDER SECTION

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :	
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**		

NOTES

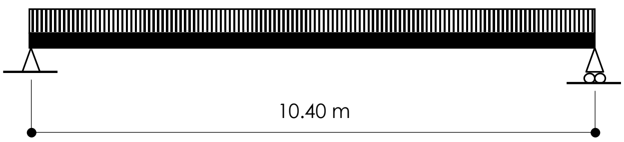
B. DEMAND FORCES

B.1 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight, (2) Fillet/haunch, (3) Tributary area of slab, (4) Barrier rails (Assumed to be equally distributed among girders). (5) Wearing course.

• Self-weight of girder	=	(0.40m) (0.60m) ($24\ KN/m^3$)	=	5.76	KN/m	
• Fillet/haunch	=	2 (1/2) (0.1m) (0.1m) ($24\ KN/m^3$)	=	0.24	KN/m	
• Slab Weight (Tributary)	=	(0.18m) (2.40m) ($24\ KN/m^3$)	=	10.368	KN/m	
• Barrier rail	=	2 (3.6/4)	=	1.80	KN/m	
• Wearing course	=	(0.05m) (2.40m) ($22\ KN/m^3$)	=	2.64	KN/m	
		• Total Uniform Load of Interior Girder, w	=	20.81	KN/m	
• Dead Load Moment at Midspan, M_{DL}	=	20.81 x 10.40^2 /8	=	281.4	KN-m	$M_d = wL^2/8$
• Dead Load Shear at "d" from, V_{DL} support	=	20.81 x 10.40 /2	=	108.20	KN	$V_d = wL/2$

W_{DL} = 20.81



B.2 LIVE LOAD CALCULATIONS

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes. — Manual 1st Ed. Sect 3.4.2

The distribution of wheel loads for two traffic lanes for T-beams shall be taken as S/1.829 — DPWH Table 3-4 AASHTO Table 3.23.1 (S/6 in ft.)

- Number of live load wheel line = 2.40 / 1.829 = 1.312

- Impact factor, I = 15.24 / (10.4) + 38.00) = 0.552 — DPWH Sect. 3.2.5.1

  ==> Use Impact = 0.300

The live load moments and shear values are taken from the tables in Appendix III on this manual and are used to determine the live load demand. Interpolation may be used if values are not exact

• Max. MS18 moment for (10.4) m span without impact/whel line			=	236.5	KN-m
• Thus, MS18 moment with Impact at midspan	M_{LL} =	(1.312m) (1.300m) (236.50)	=	403.5	KN-m
• Max. MS18 shear at support/wheel line			=	117.7	KN
• Thus, MS18 shear	V_{LL} =	(1.312m) (1.300m) (117.70)	=	200.7	KN

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**

NOTES

C. LOAD RATING BY LOAD FACTOR METHOD

C.1 CAPACITY CALCULATIONS

The strengths of concrete and rebars are determined based on the year of construction and the allowable stresses noted in the plans. Since construction was done in 1987, the corresponding material strengths were as follows (Sect. 3.5).

	ALLOWABLE STRESSES				→	STRENGTH			
Concrete	f_c	=	8.30	Mpa		f'_c	=	20.70	Mpa
Rebar	f_s	=	137.90	Mpa		f_y	=	275.80	Mpa

This Manual Table 3.5-1

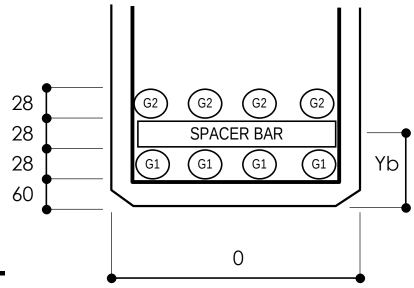
C.1.1 MOMENT CAPACITY AT MIDSPAN

- Total area of steel (∅– 28 mm rebar)

  As = 8 x (π /4 x 28^2) = 4,926 mm^2

- Centroid of rebar from top of deck

  Total Girder Depth = T_{SLAB} + Girder Depth
  = 180 + 600
  = 780 mm



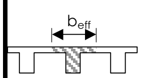
Bar No.	Area	No.	Y-Dist	A_{TOT}	A_{TOT} * Y
G1	615.8	4	74	2463.009	182263
G2	615.8	4	130	2463.009	320191
				4926	502454

Rebar centroid from bottom $= \dfrac{A_{TOT} * Y}{A_{TOT}} = \dfrac{502{,}454}{4{,}926} = 102$ mm

Rebar centroid from top = 780 - 102 = 678 mm

- Effective width of deck, b_{eff} = Minimum of the following :

  12 ts + bw = 2560 mm
  Span /4 = 2600 mm
  Controls ⇨ Spacing = $\boxed{2400}$ mm



- The rectangular stress block is calculated as,

$$a = \frac{A_s\, f_y}{0.85\, f'_c\, b_{eff}} = \frac{(4{,}926)\quad(275.80)}{0.85\quad(20.70)\quad(2{,}400)} = 32.2 \text{ mm} < ts$$

- Moment Capacity

$$Mu = \phi \text{ As fy } (d - a/2) = \frac{0.9\quad(4{,}926)\quad(275.80)\left[678 - 32.17\ /2\right]}{10^6}$$

$$= 809.3 \text{ KN-m}$$

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C.1.2 SHEAR CAPACITY AT SUPPORT

The AASHTO Design Specification requires that the design shear be taken at a distance "d" from the support. However, shear at support may be used conservatively.
In the absence of data, the standard reinforcement for a 10.0m span under DPWH standards had been used.

- The shear capacity of the concrete section

$Vc = 0.167\ Sqrt(f'c)\ b\ d = 0.167\ Sqrt\ (20.70)\ (400)\ (678)$
$= 206.1$ KN ==>> Full Capacity

Vc' (reduced) = 0.5 x 206.1 = 103.5 KN ==>> Use 50% concrete capacity due to shear cracks (199mm depth)

- The shear capacity of the shear reinforcement

$Vs = 2\ Av\ fy\ d_{eff} / S = 2\ (113.1)\ (275.80)\ (678.00)\ /\ 200$
$= 211.5$ KN

- The total shear capacity becomes

$Vu = \phi\ (Vc + Vs) = 0.85\ (103.5 + 211.5)$
$= 267.8$ KN

C.2 LOAD RATING CALCULATIONS

The manual provides the rating factor to be calculated using the Load Factor Method (LFM) by the formula:

$$RF = \frac{\phi\ Rn - \gamma_D D}{\gamma_L L\ (1 + I)}$$

where: => γ_L = 2.17 (Inventory)
=> γ_L = 1.30 (Operating)
=> γ_L = 2.17 (Posting)

By substituting the factors and the load effects to the equation, the moment and shear rating of the interior girder can be estimated as presented below.

RATING FACTOR CALCULATIONS (LFM)

LOCATION	DESCRIPTION	INVENTORY RATING	OPERATING RATING
Midspan	Moment	$\frac{809.3 - 1.30\ (281.4)}{2.17\ (403.5)} = 0.51$	$\frac{809.3 - 1.30\ (281.4)}{1.3\ (403.5)} = 0.85$
At Support	Shear	$\frac{267.8 - 1.30\ (108.2)}{2.17\ (200.7)} = 0.29$	$\frac{267.8 - 1.30\ (108.2)}{1.3\ (200.7)} = 0.49$

NOTES

Stirrups :
D12mm
A = 113.1 mm^2

This Manual
Eq. 3.2-4

This Manual
Eq. 3.2-4

This Manual
Eq. 3.2-4

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NOTES

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)	Notes
Midspan	Moment	0.51 x 33 = **16.7**	0.85 x 33 = **27.9**	This Manual Eq. 3.1-5
At Support	Shear	0.29 x 33 = **9.6**	0.49 x 33 = **16.1**	This Manual Eq. 3.1-5

Since the Inventory Rating M_{LR} = **16.7** metric tons and V_{LR} = **9.6** metric tons are less than the total weight of MS18 truck = 33 metric tons, load posting the bridge is necessary

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be taken from Appendix III of the Manual corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

This manual Fig. 3.4-2

For a 10.40 m span bridge, the Posting Live Load demands are:

Vehicle Type	LL Effects/Wheel Line		LL Dist Factor	Impact	LL Demand	
	Moment	Shear			Moment (KN-m)	Shear (KN)
Type 1-1	183.0	76.7	1.312	1.300	312.1	130.8
Type 1-2	223.6	103.6	1.312	1.300	381.4	176.7
Type 12-2	208.6	90.1	1.312	1.300	355.8	153.7

Similar calculations are done using Eqs. 3.2-4 and 3.1-5 for rating factor and load rating

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.51	16.7	0.29	9.6	0.85	27.9	0.49	16.1	**10**
Type 1-1	17.0	0.65	11.1	0.45	7.6	1.09	18.6	0.75	12.7	**8**
Type 1-2	27.0	0.54	14.5	0.33	8.9	0.89	24.2	0.55	14.9	**9**
Type 12-2	38.0	0.57	21.8	0.38	14.5	0.96	36.4	0.64	24.2	**14**

RATED BY : EAB	DATE : 1900/1/0 0:00	CHECKED BY : JCS	DATE :

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LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**	

NOTES

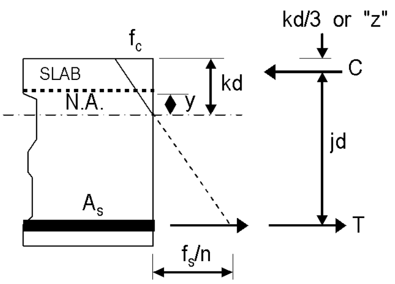
E. LOAD RATING BY ALLOWABLE STRESS METHOD

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete :	fc = 8.3 Mpa		
Rebar :	fs = 137.9 Mpa	<==	Inventory
	fs = 193.1 Mpa	<==	Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



As = 4,926 mm^2

d = 678 mm

b_{ef} = 2,400 mm

ρ = As / bd = 0.00303

n = Es / Ec = 12

MCEB
Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2\,(0.00303)(12) + [0.00303((12)]^2} - (0.00303)(12)$$

k = 0.2357

kd = (0.2357)(678) = 159.8 mm

j = 1 - k/3 = 0.9214

Using k = 0.2357, kd = 159.8mm < ts = 180mm, therefore N.A. lies above the web and into the slab. Therefore, the capacity will be calculated based on the N.A. above the web. The neutral axis depth, kd is calculated by summing moments at the top of the slab:

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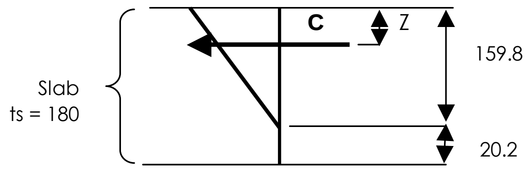
NOTES

The compression zone resultant force (C) & location (z) is calculated as



Z = 159.8 / 3 = 53.26 mm

C = 1/2 (159.8) = 79.89

Therefore, jd = d - Z
= 678 - 53.26 = 624.74 mm

If concrete allowable stress controls, the capacity becomes:

Mc = be x **C** x fc x jd
= $(2400)(79.89)(8.3)(624.74)(10^{-6})$
= 994.18 kN-m <<== Not governing since Mc > Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level
Ms = As fs jd
= (4926)(137.9)(624.74)
= **424.38** kN-m

At Operating Level
Ms = As fs jd
= (4926)(193.1)(624.74)
= **594.26** kN-m

SHEAR CAPACITY CALCULATIONS

The conditions for shear capacity calculations is the same as that previously calculated.

- The shear capacity due to concrete section:

At Inventory Level
Vc = 0.08 fc bw d = $0.08\sqrt{(20.7)}$ (400) (678) = 99.20
Vc' (reduced) = 99.2 x 0.5 = 49.60 KN ==>> Use 50% concrete capacity due to shear cracks (199mm depth)

At Operating Level
Vc = 0.12 fc bw d = $0.12\sqrt{(20.7)}$ (400) (678) = 148.80
Vc' (reduced) = 148.8 x 0.5 = 74.40 KN ==>> Use 50% concrete capacity due to shear cracks (199mm depth)

- The shear capacity due to shear reinforcement:

At Inventory Level
Vs = 2 Av fs ds / S = 2(113.10)(137.9)(678)/200
= 105.74 kN

At Operating Level
Vs = 2 Av fs ds / S = 2(113.10)(193.1)(678)/200
= 148.07 kN

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	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**

NOTES

- The total shear capacity becomes:

At Inventory Level

Vs = Vc + Vs = 49.6 + 105.74

= **155.34 kN**

At Operating Level

Vs = Vc + Vs = 74.4 + 148.07

= **222.47 kN**

E2. LOAD RATING CALCULATIONS

The Manual provides the rating factor to be calculated using the Allowable Stress Method (ASM) by the formula:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)} \quad \text{where} \quad A_1 = 1.0, \quad A_2 = 1.0$$

RATING FACTOR CALCULATIONS (ASM)

LOCATION	DESCRIPTION	INVENTORY RATING	Posting (Tons)
Midspan	Moment	$\frac{424.4 - (281.4)}{(403.5)} = 0.35$	11.7
		OPERATING RATING	
		$\frac{594.3 - (281.4)}{(403.5)} = 0.78$	25.6
LOCATION	DESCRIPTION	**INVENTORY RATING**	
At Support	Shear	$\frac{155.3 - (108.2)}{(200.7)} = 0.23$	7.7
		OPERATING RATING	
		$\frac{222.5 - (108.2)}{(200.7)} = 0.57$	18.8

Since the Inventory Rating Factor $M_{RF} = 0.57$ and $V_{RF} = 0.34$ are less than one, load posting calculations are necessary.

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

The procedure for load posting is similar to the above using load posting vehicles for live load and the demand moments and shears as calculated in the previous Section D, as follows:

Vehicle Type	LL Demand	
	Moment (KN-m)	Shear (KN)
Type 1-1	312.1	130.8
Type 1-2	381.4	176.6
Type 12-2	355.8	153.7

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LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG SIMPLE**

NOTES

Similarly, using Eq. 3.2-1 and Eq. 3.1-5, load posting calculations are presented below

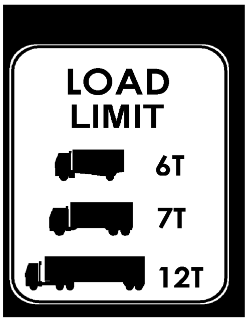
LOAD POSTING RATING FACTOR CALCULATIONS BY LFM

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.35	11.7	0.23	**7.7**	0.78	25.6	0.57	18.8	**8**
Type 1-1	17.0	0.46	7.8	0.36	**6.1**	1.00	17.0	0.87	14.89	**6**
Type 1-2	27.0	0.38	10.1	0.27	**7.2**	0.82	22.2	0.65	17.5	**7**
Type 12-2	38.0	0.40	15.3	0.31	**11.7**	0.88	33.4	0.74	28.2	**12**

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.23	7.7	0.29	9.6	**8**
Type 1-1	17.0	0.36	6.1	0.45	7.6	**6**
Type 1-2	27.0	0.27	7.2	0.33	8.9	**7**
Type 12-2	38.0	0.31	11.7	0.38	14.5	**12**



RATED BY :	DATE :	CHECKED BY :	DATE :

INTERIOR RCDG CONTINUOUS

A. GENERAL

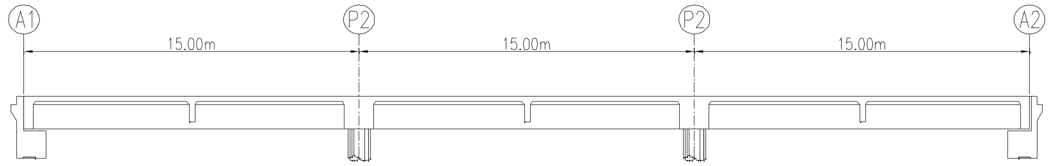
BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION						
Bridge Name		STANDARD BRIDGE					
Bridge Type	Simple or Continuous	C	Reinforced Concrete T-beams				
	Number of Span	3					
Bridge of Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		15.000	15.000	15.000			=45.000m
Year Built		2000					
Structure	Nos. of Girder	4	Multiple monotholic with deck slab.				
	Girder Spacing (m)	2.400	on centers				
	Substructure	Wall Type RC Piers and RC Cantilever Abutments					
Wearing Course	thickness (mm)	0					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa
		f'c=	20.7	Mpa	fy=	275.8	Mpa
Assumption		Weight of barrier rail Wbr =			13.0	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

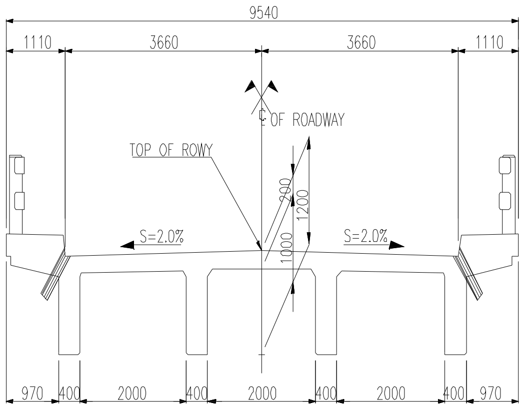
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

BRIDGE LAYOUT AND DIMENSION	
Girder width bw(m)	0.400
Girder Web height h (m)	1.000
Fillet/Haunch width wf(m)	0.100
Fillet/Haunch height hf(m)	0.100
Slab thickness ts (m)	0.200
Span Length L(m)	15.000

NEXT

B. DEMAND FORCES

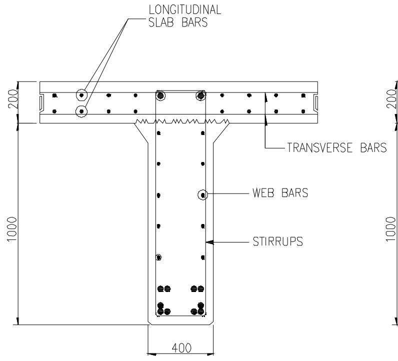
B0. INPUT		
FOR DEAD LOAD	Girder width bw(m)	0.400
	Girder Web height h (m)	1.000
	Fillet/Haunch width wf(m)	0.100
	Fillet/Haunch height hf(m)	0.100
	Slab thickness ts (m)	0.200
	Slab width ws (m)	2.400
	Span Length L(m)	15.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder		9.600
	Fillet/Haunch		0.240
	Slab Weight	Continuous	11.520
	Barrier Rail		6.500
	Asphalt Overlay		0.000
	Total Load		27.860
	Total DeadLoad		21.360
	Total Superimposed Dead Load		6.500

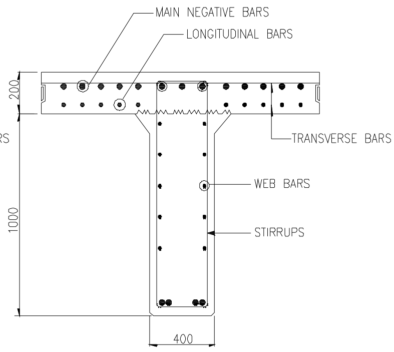
B2. LOAD DEMAND MIDSPAN AND SUPPORT OF RCDG		
Conducting a Structural Analysis, the load demands for the RCDG should be obtained		
Description	At Midspan	At Pier Support
	0.4L	1.0L
Dead load moments, KN-m	496.7	-620.1
Dead load shears, KN	-	-248.2
MS18 max. positive moment, KN-m	536.3	0.0
MS18 max. negative moment, KN-m	-	-416.4
MS18 max. negative Shear force, KN	-	-334.5

NEXT

C. LOAD RATING CALCULATIONS



SECTION AT MIDSPAN



SECTION AT PIER SUPPORT

Total area of Rebar		
	Midspan	Pier
Nos of Rebar	10	13
Dia. (mm)	36	28
As(mm2)	10179	8005
yb (mm)	126	63

Stirrups	
	At Pier
Dia. (mm)	16
As(mm2)	201.1
Spacing (mm)	150

C1. CAPACITY CALCULATIONS

C1. INPUT					
(1) Common Input Data				At Midspan	At Pier
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3	
		Strength	f'c	20.7	
	Rebar	Allowable Stress	fs	137.9	
		Strength	fy	275.8	
(2) Input Data for Moment Capacity				At Midspan	At Pier
Total Area of Steel As(mm^2)				10179	8005
Section Loss due to Rebar Exposure (%)				0	0
Total Assumed Area of Steel As(mm2)				10179	8005
Centroid of rebars from bottom of deck , yb (mm)				126	63
Centroid of rebars from top of deck , d (mm)				1074	1137
Effective width of deck , b_{eff} (mr		12ts + bw		2800	-
		Span Length / 4		3750	-
		beff		2400	400
Ultimate capacity factor (Uf)				0.90	0.90
(3) Input Data for Shear Capacity				At Midspan	At Pier
Girder width bw(mm)				-	400
Depth of Shear Cracks (mm)				-	0
The Reduction Factor due to Shear Cracks				-	1.00
Centroid of rebars from top of deck , d (mm)				-	1137
Area of rebar Av(mm^2)				-	201.1
Section Loss due to Stirrups Exposure (%)				-	0
Total Assumed Area of Steel As(mm2)				-	201.1
Spacing of stirrups S (mm)				-	150
Ultimate capacity factor (Uf)				-	0.85
C1.1 MOMENT CAPACITY AT MIDSPAN				At Midspan	At Pier
Rectangular stress block depth a (mm)				66.5	313.7
The Moment Capacity Mu (kN-m)				2629.6	1947.6
C1.2 SHEAR CAPACITY AT SUPPORT				At Midspan	At Pier
The shear **FULL capacity** due to concrete section Vc (kN)				-	345.6
The shear **capacity** due to concrete section Vc (kN)				-	345.6
The shear **FULL capacity** due to shear reinforcement Vs (kN)				-	840.7
The shear **capacity** due to Stirrups Vs (kN)				-	840.7
The total shear capacity Vu (kN)				-	1008.3

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
Moment Ultimate Capacity at Midspan (kN-m)		2629.6	-1947.6
Dead Load Moment at Midspan (kN-m)		496.7	-620.1
Live Load Moment at Midspan (kN-m)		536.3	-416.4
Shear Ultimate Capacity at Support (KN)		–	-1008.3
Dead Load Shear at Support (KN)		–	-248.2
Live Load Shear at Support (KN)		–	-334.5
Rating Live Load (Tons)		33.0	

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.70	56.3
			Operating Rating	2.85	93.9
		At Pier	Inventory Rating	1.26	41.7
			Operating Rating	2.11	69.6
	Shear	At Pier	Inventory Rating	0.94	31.2
			Operating Rating	1.58	52.0

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Load Posting

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the RCDG should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	382.8	-205.0
	Shear	-	-130.0
Type 1-2	Moment	492.6	-303.4
	Shear	-	-188.1
Type 12-2	Moment	450.5	-392.6
	Shear	-	-201.1

NEXT

D2. POSTING RATING CALCULATIONS

D2.1 INPUT						
Load factor for dead load		1.3			
Load factor for live load	Inventory	2.17			
	Operating	1.3			
		Moment		Shear	
		Midspan	At Pier	At Pier	
Moment Ultimate Capacity		2629.6	1947.6	1008.3	
Dead Load		496.7	620.1	248.2	
		Moment		Shear	Vehicle Weight
		Midspan	At Pier		
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	536.3	416.4	334.5	33.0
	Type 1-1	382.8	205.0	130.0	17.0
	Type 1-2	492.6	303.4	188.1	27.0
	Type 12-2	450.5	392.6	201.1	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) At Midspan										
MS18	33.0	1.70	56.3	-	-	2.85	93.9	-	-	**33**
Type 1-1	17.0	2.39	40.6	-	-	3.99	67.8	-	-	**17**
Type 1-2	27.0	1.86	50.1	-	-	3.10	83.6	-	-	**27**
Type 12-2	38.0	2.03	77.1	-	-	3.39	128.7	-	-	**38**
(2) At Pier Support										
MS18	33.0	1.26	41.7	0.94	31.2	2.11	69.6	1.58	52.0	**31**
Type 1-1	17.0	2.57	43.6	2.43	41.3	4.28	72.8	4.06	69.0	**17**
Type 1-2	27.0	1.73	46.8	1.68	45.4	2.89	78.1	2.80	75.7	**27**
Type 12-2	38.0	1.34	50.9	1.57	59.7	2.24	85.0	2.62	99.7	**38**

NEXT

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				Midspan	At Pier
Material Properties	Concrete	fc	Inventory	8.3	
			Operating	13.1	
		f'c		20.7	
	Rebar	fs	Inventory	137.9	
			Operating	193.1	
Total Assumed Area of Steel As(mm^2)				10179	8005
Area of rebar Av(mm^2)				201.1	201.1
Spacing of stirrups S (mm)				150	150
Centroid of rebars from top of deck , d (mm)				1074	1137
Effective width of deck , beff (mm)				2400	400
Girder width bw(m)				400	400
Rebar Ratio ρ = As / (beff x d)				0.00395	0.01760
Modular Ratio of Elasticity n = Es / Ec				12	12
$k = \sqrt{[2\rho n + (\rho n)^2]} - \rho n$				0.2641	0.4722
j				0.9120	0.8426
kd				294.6	536.9
Slab thickness ts (mm)				200.0	200.0
k				0.2743	-
z				98.20	-
jd				975.80	958.04

Calculation of kd					
n	As	d	b	ts	bw
12	10179	1074	2400	200.0	400
nAs	nAsd	bts	$1/2bts^2$	bwy	y/2+ts
122148	131186952	480000	48000000	37840	247.3
ts+y	$y_{calculate}$				y_{input}
294.6	94.6				94.6

E1.2 MOMENT AND SHEAR CAPACITY CALCULATIONS				Midspan	At Pier
Moment (kN-m)	Capacity by concrete allowable stress Mc		Inventory	2617.2	-853.8
			Operating	4130.8	-1347.6
	Capacity by rebar allowable stress Ms		Inventory	1369.7	-1057.6
			Operating	1918.0	-1480.9
Shear (kN)	Capacity due to concrete section	Vc	Inventory	–	165.5
			Operating	–	248.3
	Capacity due to rebar	Vs	Inventory	–	420.3
			Operating	–	588.6
	Shear capacity	Vu	Inventory	–	585.9
			Operating	–	836.9

NEXT

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		Midspan	At Pier
Load factor for dead load		1.0	
Load factor for live load		1.0	
Moment Capacity at Midspan (kN-m)	Inventory	1369.71	-853.82
	Operating	1918.0	-1347.6
Dead Load Moment at Midspan (kN-m)		496.7	-620.1
Live Load Moment at Midspan (kN-m)		536.3	-416.4
Shear Capacity at Support (KN)	Inventory	-	-585.9
	Operating	-	-836.9
Dead Load Shear at Support (KN)		-	-248.2
Live Load Shear at Support (KN)		-	-334.5
Rating Live Load (Tons)		33.0	

E2.2. RATING FACTOR CALCULATIONS (ASM)				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.63	53.72
			Operating Rating	2.65	87.46
		At Pier	Inventory Rating	0.56	18.52
			Operating Rating	1.75	57.65
	Shear	At Pier	Inventory Rating	1.01	33.31
			Operating Rating	1.76	58.08

NEXT

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

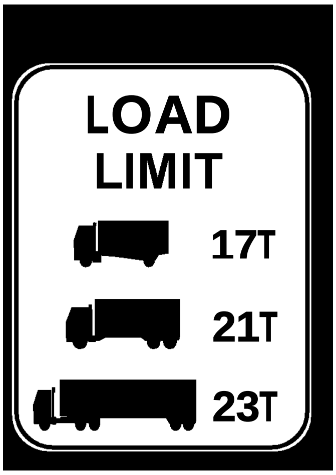
F1. INPUT					
Load factor for dead load		1.0			
Load factor for live load		1.0			
		Moment		Shear	
		Midspan	At Pier	At Pier	
Moment and Shear Capacity	Inventory	1369.7	-853.8	-585.9	
	Operating	1918.0	-1347.6	-836.9	
Dead Load		496.7	-620.1	-248.2	
		Moment		Shear	Vehicle Weight
		Midspan	At Pier	At Pier	
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	536.3	-416.4	-334.5	33.0
	Type 1-1	382.8	-205.0	-130.0	17.0
	Type 1-2	492.6	-303.4	-188.1	27.0
	Type 12-2	450.5	-392.6	-201.1	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) AT MIDSPAN										
MS18	33.0	1.63	53.7	-	-	2.65	87.5	-	-	**33**
Type 1-1	17.0	2.28	38.8	-	-	3.71	63.1	-	-	**17**
Type 1-2	27.0	1.77	47.9	-	-	2.89	77.9	-	-	**27**
Type 12-2	38.0	1.94	73.6	-	-	3.15	119.9	-	-	**38**
(2) AT PIER SUPPORT										
MS18	33.0	0.56	18.5	1.01	33.3	1.75	57.7	1.76	58.1	**19**
Type 1-1	17.0	1.14	19.4	2.60	44.2	3.55	60.3	4.53	77.0	**17**
Type 1-2	27.0	0.77	20.8	1.80	48.5	2.40	64.7	3.13	84.5	**21**
Type 12-2	38.0	0.60	22.6	1.68	63.8	1.85	70.4	2.93	111.2	**23**

NEXT

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.56	18.5	0.94	31.2	**19T**
Type 1-1	17.0	1.14	19.4	2.39	40.6	**17T**
Type 1-2	27.0	0.77	20.8	1.68	45.4	**21T**
Type 12-2	38.0	0.60	22.6	1.34	50.9	**23T**



END AND GO TO DECK SLAB

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**RCDG CONTINUOUS**

A. GENERAL

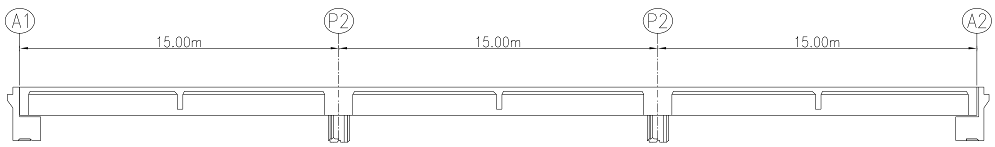
A.1 BRIDGE DESCRIPTION

- Bridge Location : None (Standard Bridge)
- Bridge Type : 3-span Continuous Reinforced Concrete T-Beams
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 15.0m + 15.0m +15.0m = 45.0m
- Year Built : 2000
- Structure
  - Girders : Multiple Girders per span (4-Girders), Monolithic with deck slab
    : Girder spacing at 2.40m on center
  - Substructure : Wall Type RC Pier and RC Cantilever Abutments
- Wearing Course : None
- Material Properties : fc = 8.3 Mpa , fs = 137.9 Mpa
  : f'c = 20.7 Mpa , fy = 275.8 Mpa
- Assumption : Weight of barrier rail = 13.0 KN/m
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

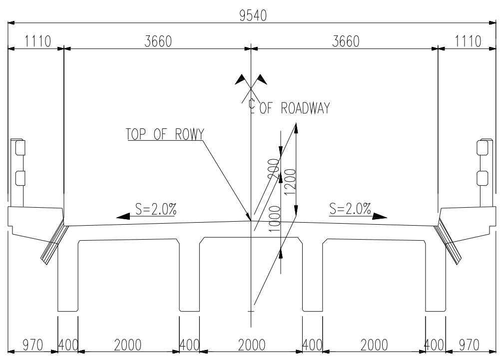
Reqirement :

Determine the load rating of the interior girder of the span (10.40m) for MS18 (HS20) vehicles considering no damages on members

A.2 BRIDGE LAYOUT



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

B. DEMAND FORCES

B.1 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight, (2) Fillet/haunch, (3) Tributary area of slab, (4) Barrier rails (Assumed to be equally distributed among girders).

- Self-weight of girder = (0.40m) (1.00m) (24 KN/m^3) = 9.600 KN/m
- Fillet/haunch = 2 (1/2) (0.1m) (0.1m) (24 KN/m^3) = 0.240 KN/m
- Slab Weight (Tributary) = (0.20m) (2.40m) (24 KN/m^3) = 11.520 KN/m
- Barrier rail = 2 (3.6/4) = 6.500 KN/m
- Total Uniform Load of Interior Girder, w = 27.860 KN/m

B.2 LOAD DEMAND MIDSPAN AND SUPPORT OF RCDG

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes.

NOTES: Manual 1st Ed. Sect 3.4.2

The distribution of wheel loads for two traffic lanes for T-beams shall be taken as S/1.829

NOTES: DPWH Table 3-4 AASHTO Table 3.23.1 (S/6 in ft.)

- Number of live load wheel line = 3.20 / 1.829 = 1.750

- Impact factor, I = 15.24 / (15.0) + 38.00) = 0.287

NOTES: DPWH Sect. 3.2.5.1

Conducting a Structural Analysis, the load demands for the RCDGContinuous should be obtained separately and input the necessary lo

Description	At Midspan	At Pier Support
	0.4L	1.0L
Dead load moments, KN-m	496.7	-620.1
Dead load shears, KN	-	-248.2
MS18 max. positive moment, KN-m	536.3	0.0
MS18 max. negative moment, KN-m	-	-416.4
MS18 max. negative Shear force, KN	-	-334.5

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LOAD RATING CALCULATIONS	BRIDGE NAME : RCDG CONTINUOUS	

NOTES

C. LOAD RATING BY LOAD FACTOR METHOD

C.1 CAPACITY CALCULATIONS

The strengths of concrete and rebars are determined based on the year of construction and the allowable stresses noted in the plans. Since construction was done in 2000, the corresponding material strengths were as follows (Sect. 3.5).

	ALLOWABLE STRESSES					STRENGTH			
Concrete	f_c	=	8.30	Mpa	→	f'_c	=	20.70	Mpa
Rebar	f_s	=	137.90	Mpa	→	f_y	=	275.80	Mpa

This Manual Table 3.5-1

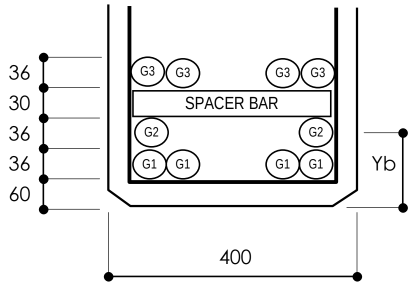
C.1.1 MOMENT CAPACITY AT MIDSPAN

- Total area of steel (∅– 36 mm rebar)

  As = 10 x (π /4 x 36^2) = 10,179 mm^2

- Centroid of rebar from top of deck

  Total Girder Depth = T_{SLAB} + Girder Depth
  = 200 + 1000
  = 1200 mm



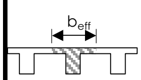
Bar No.	Area	No.	Y-Dist	A_{TOT}	A_{TOT} * Y
G1	1017.9	4	78	4071.504	317577
G2	1017.9	2	114	2035.752	232076
G3	1017.9	4	180	4071.50	732871
				10179	1282524

$$\text{Rebar centroid from bottom} = \frac{A_{TOT} * Y}{A_{TOT}} = \frac{1{,}282{,}524}{10{,}179} = 126 \text{ mm}$$

Rebar centroid from top = 1200 - 126 = 1074 mm

- Effective width of deck, b_{eff} = Minimum of the following :

  12 ts + bw = 2800 mm
  Span /4 = 3750 mm
  Controls ⇨ Spacing = $\boxed{2400}$ mm



- The rectangular stress block is calculated as,

$$a = \frac{A_s\, f_y}{0.85\, f'_c\, b_{eff}} = \frac{(10{,}179)\quad(275.80)}{0.85\quad(20.70)\quad(2{,}400)} = 66.5 \text{ mm} < ts$$

- Moment Capacity

$$Mu = \phi \text{ As fy } (d - a/2) = \frac{0.9\quad(10{,}179)\quad(275.80)\left[1074 - 66.5 \;/\; 2\right]}{10^6}$$

$$= 2{,}629.6 \text{ KN-m}$$

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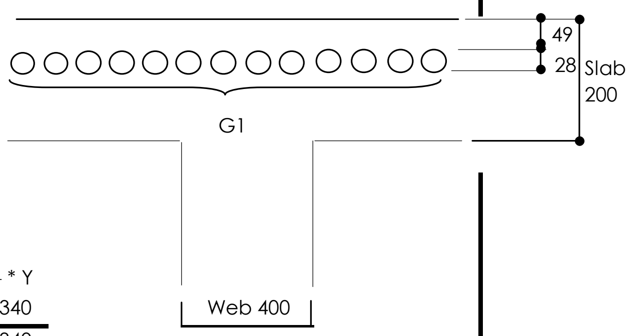
	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	RCDG CONTINUOUS

NOTES

C.1.1 MOMENT CAPACITY AT PIER

- Total area of steel (∅– 36 mm rebar)

  $As = 13 \times (\pi/4 \times 28^2) = 8{,}005 \text{ mm}^2$



- Centroid of rebar from top of deck

  Total Girder Depth = T_{SLAB} + Girder Depth
  = 200 + 1000
  = 1200 mm

Bar No.	Area	No.	Y-Dist	A_{TOT}	A_{TOT} * Y
G1	615.8	13	63	8005.4	504340
				8005	504340

$$\text{Rebar centroid from bottom} = \frac{A_{TOT} * Y}{A_{TOT}} = \frac{504{,}340}{8{,}005} = 63 \text{ mm}$$

Rebar centroid from top = 1200 - 63 = 1137 mm

- Effective width of girder, b_{eff} = 400 mm

- The rectangular stress block is calculated as,

$$a = \frac{A_s f_y}{0.85 f'_c b_{eff}} = \frac{(8{,}005)\quad(275.80)}{0.85\quad(20.70)\quad(0{,}400)} = 313.7 \text{ mm} < ts$$

- Moment Capacity

$$Mu = \phi\, As\, fy\, (d - a/2) = \frac{0.9\quad(8{,}005)\quad(275.80)\left[1137 - 313.7\ /\ 2\right]}{10^6}$$
$$= 1{,}947.6 \text{ KN-m}$$

C.1.2 SHEAR CAPACITY AT SUPPORT

The AASHTO Design Specification requires that the design shear be taken at a distance "d" from the support. However, shear at support may be used conservatively.
In the absence of data, the standard reinforcement for a 10.0m span under DPWH standards had been used.

- The shear capacity of the concrete section

  Vc = 0.167 Sqrt(f'c) b d = 0.167 Sqrt (20.70) (400) (1137)
  = 345.6 KN ==>> Full Capacity

- The shear capacity of the shear reinforcement

  Vs = 2 Av fy d_{eff} / S = 2 (201.1) (275.80) (1137) / 150
  = 840.7 KN ==>> Full Capacity

  Stirrups :
  D16mm
  A = 201.1 mm^2

- The total shear capacity becomes

  Vu = ϕ (Vc + Vs) = 0.85 (345.6 + 840.7)
  = 1008.3 KN

RATED BY :	DATE :	CHECKED BY :	DATE :

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	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

C.2 LOAD RATING CALCULATIONS

The manual provides the rating factor to be calculated using the Load Factor Method (LFM) by the formula:

$$RF = \frac{\phi\, Rn - \gamma_D D}{\gamma_L L\,(1 + I)}$$

where: => γ_L = 2.17 (Inventory)
=> γ_L = 1.30 (Operating)
=> γ_L = 2.17 (Posting)

This Manual Eq. 3.2-4

By substituting the factors and the load effects to the equation, the moment and shear rating of the interior girder can be estimated as presented below.

RATING FACTOR CALCULATIONS (LFM)

LOCATION	DESCRIPTION	RATING	RF
Midspan	Moment	**INVENTORY RATING**	
		$\frac{2,629.6 - 1.30\ (496.7)}{2.17\ (536.3)}$	= 1.70
		OPERATING RATING	
		$\frac{2,629.6 - 1.30\ (496.7)}{1.3\ (536.3)}$	= 2.85
LOCATION	DESCRIPTION	**INVENTORY RATING**	
At Support	Moment	$\frac{1,947.6 - 1.30\ (620.1)}{2.17\ (416.4)}$	= 1.26
		OPERATING RATING	
		$\frac{1,947.6 - 1.30\ (620.1)}{1.3\ (416.4)}$	= 2.11
	DESCRIPTION	**INVENTORY RATING**	
	Shear	$\frac{1,008.3 - 1.30\ (248.2)}{2.17\ (334.5)}$	= 0.94
		OPERATING RATING	
		$\frac{1,008.3 - 1.30\ (248.2)}{1.3\ (334.5)}$	= 1.58

This Manual Eq. 3.2-4

This Manual Eq. 3.2-4

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
Midspan	Moment	1.70 x 33 = **56.3**	2.85 x 33 = **93.9**
At Support	Moment	1.26 x 33 = **41.7**	2.11 x 33 = **69.6**
At Support	Shear	0.94 x 33 = **31.2**	1.58 x 33 = **52.0**

This Manual Eq. 3.1-5

Since the Inventory Rating M_{LR} = **41.7** metric tons and V_{LR} = **31.2** metric tons are less than the total weight of MS18 truck = 33 metric tons, load posting the bridge is necessary

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be separately taken from conducting a structural analysis corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

For 3-span continuous (3@15.0m) bridge, the Posting Live Load demands are:

Vehicle Type	LL Demand	At Midspan	At Pier Support
Type 1-1	Moment	382.8	-205.0
	Shear	---	-130.0
Type 1-2	Moment	492.6	-303.4
	Shear	---	-188.1
Type 12-2	Moment	450.5	-392.6
	Shear	---	-201.1

Similar calculations are done using Eqs. 3.2-4 and 3.1-5 for rating factor and load rating

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM AT MIDSPAN

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	1.70	56.3	---	---	2.85	93.9	---	---	**33**
Type 1-1	17.0	2.39	40.6	---	---	3.99	67.8	---	---	**17**
Type 1-2	27.0	1.86	50.1	---	---	3.10	83.6	---	---	**27**
Type 12-2	38.0	2.03	77.1	---	---	3.39	128.7	---	---	**38**

LOAD POSTING RATING FACTOR CALCULATIONS BY LFM AT PIER SUPPORT

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	1.26	41.7	0.94	31.2	2.11	69.6	1.58	52.0	**31**
Type 1-1	17.0	2.57	43.6	2.43	41.3	4.28	72.8	4.06	69.0	**17**
Type 1-2	27.0	1.73	46.8	1.68	45.4	2.89	78.1	2.80	75.7	**27**
Type 12-2	38.0	1.34	50.9	1.57	59.7	2.24	85.0	2.62	99.7	**38**

RATED BY : EAB	DATE : 1900/1/0 0:00	CHECKED BY : JCS	DATE :

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	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

E. LOAD RATING BY ALLOWABLE STRESS METHOD

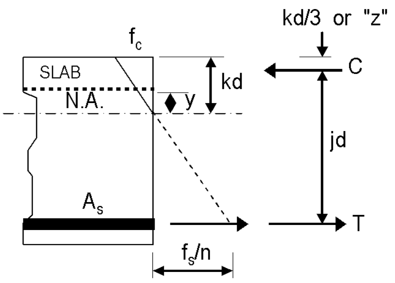
E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

MOMENT CAPACITY CALCULATIONS AT MIDSPAN

The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete :	fc = 8.3 Mpa		
Rebar :	fs = 137.9 Mpa	<==	Inventory
	fs = 193.1 Mpa	<==	Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



$As = 10{,}179\ mm^2$

$d = 1{,}074\ mm$

$b_{ef} = 2{,}400\ mm$

$\rho = As / bd = 0.00395$

$n = Es / Ec = 12$

MCEB
Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2\,(0.00395)(12) + [0.00395((12)]^2} - (0.00395)(12)$$

$k = 0.2641 \qquad kd = 0.2641 \times 1074 = 283.6\ mm$

$j = 1 - k/3 = 0.9120$

Using k = 0.2641, kd = 283.6mm > ts = 180mm, therefore N.A. lies below the slab and into the web. Therefore, the capacity will be calculated based on the N.A. below the slab. The neutral axis depth, kd is calculated by summing moments at the top of the slab:

$$kd = ts + y = \frac{n\,As\,d + 1/2\,b\,ts2 + bw\,y\,(y/2 + ts)}{nAs + b\,ts + bw\,y}$$

$$= \frac{(12)(10{,}179)(1074) + 1/2(2400)(200)^2 + (400)y\,(y/2 + 200)}{(12)(10{,}179) + (2400)(200) + (400)\,y}$$

$$= \frac{200\,y^2 + 80{,}000y + 179{,}186{,}952}{400y + 602{,}148} = 200 + y \quad ===> \quad y = 94.6\ mm$$

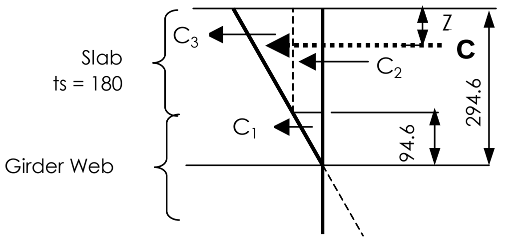
$k = kd / d = 294.6 / 1074 = 0.2743$

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

The compression zone resultant force (C) & location (z) is calculated as



	Magnitude	Dist. From top	Moment
C_1	15.19	231.54	3517.14
C_2	64.23	100	6422.58
C_3	67.89	66.67	4525.81
	147.31		14465.53

Z = 14465.53 / 147.31 = 98.20mm

Therefore, jd = d - Z

= 1074 - 98.20 = 975.8 mm

If concrete allowable stress controls, the capacity becomes:

At Inventory Level

$Mc = (b_w C_1 + b_{ef} C_2 + b_{ef} C_3)\ fc\ jd$

$= [\ \{(400)(15.19) + (2{,}400)\ (64.23) + (2{,}400)(67.89)\}(8.3)(975.8)\ ]\ /\ (10^{-6})$

= 2,617.2 kN-m <<== Not governing since Mc > Ms

At Operating Level

$Mc = (b_w C_1 + b_{ef} C_2 + b_{ef} C_3)\ fc\ jd$

$= [\ \{(400)(15.19) + (2{,}400)\ (64.23) + (2{,}400)(67.89)\}(13.1)(975.8)\ ]\ /\ (10^{-6})$

= 4,130.8 kN-m <<== Not governing since Mc > Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level

Ms = As fs jd

= (10,179)(137.9)(975.80)

= **1,369.70** kN-m

At Operating Level

Ms = As fs jd

= (10,179)(193.1)(975.80)

= **1,918.00** kN-m

RATED BY :	DATE :	CHECKED BY :	DATE :

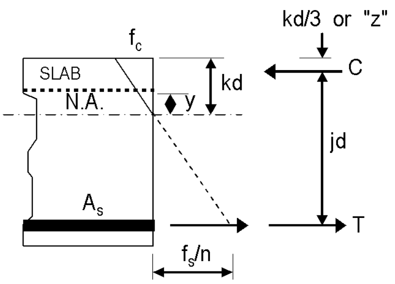
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**	

MOMENT CAPACITY CALCULATIONS AT PIER SUPPORT

The concrete and rebar allowable stresses are as noted in the plans as follows:

Concrete : fc = 8.3 Mpa
Rebar : fs = 137.9 Mpa <== Inventory
fs = 193.1 Mpa <== Operating

When the neutral axis is within the slab, the rectangular beam formulation can be used



As = 8,005 mm^2

d = 1,137 mm

b_{ef} = 400 mm

$\rho = As / bd = 0.01760$

n = Es / Ec = 12

NOTES: MCEB Sect. 6.6.2.4

Assume neutral axis (N.A.) is within slab and solving for the neutral axis position

$$k = \sqrt{2\rho n + (\rho n)^2} - \rho n$$

$$= \sqrt{2(0.01760)(12) + [0.01760((12)]^2} - (0.01760)(12)$$

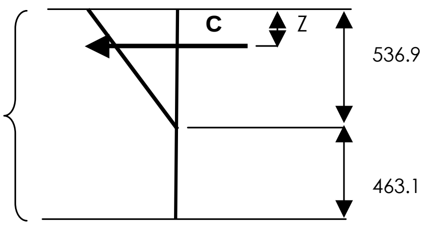
k = 0.4722 kd = (0.4722)(1137) = 536.9 mm

j = 1 - k/3 = 0.8426 jd = (0.8426)(1137) = 958.0 mm

Using k = 0.4722, kd = 536.9mm < ts = 1000mm,
Therefore, the capacity will be calculated based on the N.A. .
The neutral axis depth, kd is calculated by summing moments at the bottom of the girder:

The compression zone resultant force (C) & location (z) is calculated as

Web height = 1000



Z = 536.9 / 3 = 178.96 mm

C = 1/2 (536.9) = 268.45

Therefore, jd = d - Z
= 1,137 - 178.96 = 958.04 mm

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

If concrete allowable stress controls, the capacity becomes:

At Inventory Level

Mc = - (be x **C** x fc x jd)
= - (400)(268.45)(8.3)(958.04)(10^{-6})
= **- 853.8** kN-m

At Operating Level

Mc = - (be x **C** x fc x jd)
= - (400)(268.45)(13.1)(958.04)(10^{-6})
= **- 1,347.6** kN-m

<<== Governing since Mc < Ms

If rebar allowable stress controls, the capacity becomes,

At Inventory Level

Ms = - As fs jd
= - (8,005)(137.9)(958.04)
= -1,057.60 kN-m

At Operating Level

Ms = - As fs jd
= - (8,005)(193.1)(958.04)
= -1,480.90 kN-m

SHEAR CAPACITY CALCULATIONS

The conditions for shear capacity calculations is the same as that previously calculated.

- The shear capacity due to concrete section:

At Inventory Level

Vc = 0.08 fc bw d = 0.08 $\sqrt{(20.7)}$ (400) (1,137) = 165.50

==>> full concrete capacity

At Operating Level

Vc = 0.12 fc bw d = 0.12 $\sqrt{(20.7)}$ (400) (1,137) = 248.30

==>> full concrete capacity

- The shear capacity due to shear reinforcement:

At Inventory Level

Vs = 2 Av fs ds / S = 2(201.1)(137.9)(1,137)/150
= 420.3 kN

At Operating Level

Vs = 2 Av fs ds / S = 2(201.1)(193.1)(1,137)/150
= 588.6 kN

- The total shear capacity becomes:

At Inventory Level

Vu = Vc + Vs = 165.5 + 420.3
= **585.9 kN**

At Operating Level

Vu = Vc + Vs = 248.3 + 588.6
= **836.9 kN**

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

E2. LOAD RATING CALCULATIONS

The Manual provides the rating factor to be calculated using the Allowable Stress Method (ASM) by the formula:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)} \quad \text{where} \quad A_1 = 1.0, \quad A_2 = 1.0$$

RATING FACTOR CALCULATIONS (ASM)

LOCATION	DESCRIPTION	INVENTORY RATING
Midspan	Moment	$\frac{1{,}369.7 - (496.7)}{(536.3)} = 1.63$
		OPERATING RATING
		$\frac{1{,}918.0 - (496.7)}{(536.3)} = 2.65$
At Support		**INVENTORY RATING**
		$\frac{-853.8 - -(620.1)}{-(416.4)} = 0.56$
		OPERATING RATING
		$\frac{-1{,}347.6 - -(620.1)}{-(416.4)} = 1.75$
LOCATION	DESCRIPTION	**INVENTORY RATING**
At Support	Shear	$\frac{-585.9 - -(248.2)}{-(334.5)} = 1.01$
		OPERATING RATING
		$\frac{-836.9 - -(248.2)}{-(334.5)} = 1.76$

Since the Inventory Rating Factor $M_{RF} = 0.56$ and $V_{RF} = 1.01$ are less than one, load posting calculations is necessary.

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

The procedure for load posting is similar to the above using load posting vehicles for live load and the demand moments and shears as calculated in the previous Section D, as follows:

Vehicle Type	LL Demand		
	Moment (KN-m)		Shear (KN)
	At Midspan	At Pier Support	At Pier Support
Type 1-1	382.8	-205.0	-130.0
Type 1-2	492.6	-303.4	-188.1
Type 12-2	450.5	-392.6	-201.1

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **RCDG CONTINUOUS**

NOTES

Similarly, using Eq. 3.2-1 and Eq. 3.1-5, load posting calculations are presented below

LOAD POSTING RATING FACTOR CALCULATIONS BY ASM AT MIDSPAN

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	1.63	53.7	---	---	2.65	87.5	---	---	**33**
Type 1-1	17.0	2.28	38.8	---	---	3.71	63.1	---	---	**17**
Type 1-2	27.0	1.77	47.9	---	---	2.89	77.9	---	---	**27**
Type 12-2	38.0	1.94	73.6	---	---	3.15	119.9	---	---	**38**

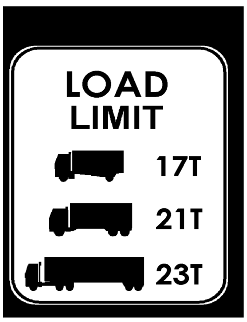
LOAD POSTING RATING FACTOR CALCULATIONS BY ASM AT PIER SUPPORT

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				POSTING (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.56	18.5	1.01	33.3	1.75	57.7	1.76	58.1	**18**
Type 1-1	17.0	1.14	19.4	2.60	44.2	3.55	60.3	4.53	77.0	**17**
Type 1-2	27.0	0.77	20.8	1.80	48.5	2.40	64.7	3.13	84.5	**21**
Type 12-2	38.0	0.60	22.6	1.68	63.8	1.85	70.4	2.93	111.2	**23**

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.56	18.5	0.94	31.2	**18**
Type 1-1	17.0	1.14	19.4	2.38	40.6	**17**
Type 1-2	27.0	0.77	20.8	1.68	45.4	**21**
Type 12-2	38.0	0.60	22.6	1.34	50.9	**23**



RATED BY :	DATE :	CHECKED BY :	DATE :

EXAMPLE 3

PRESTRESSED CONCRETE DECK GIRDER BRIDGE

Example 3-1: Simple

Example 3-2: Continuous

INTERIOR PCDG SIMPLE

A. GENERAL

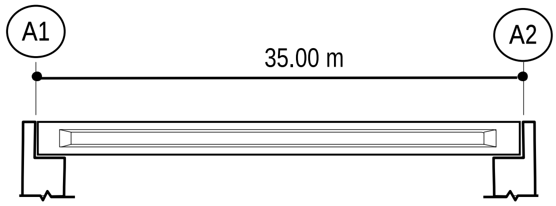
BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location		REGION					
Bridge Name							
Bridge Type	Simple or Continuous		S	Precast, Prestressed I Girder Bridge			
	Number of Span		1				
Bridge Width (curb to curb) (m)			7.32				
Number of Lanes			2				
Bridge Length (m)			35.000				=35.000 m
Year Built			2003				
Structure	Nos. of Girder		4				
	Girder Spacing (m)		2.100	on centers			
	Substructure		Concrete bents and abutments				
Wearing Course	thickness (mm)		50				
	material		Asphalt				
Notes on Plans		f'c (Girder)		38	MPa		
		f'c (Slab)		24.2	MPa		
		Ultimate Strength of Tendons fu		1860	MPa		
		Working Force		5270	kN (Effective after losses)		
		Centroid of PC Tendons		100	mm (from soffit at Midspan)		
				824	mm (from soffit at Anchorage)		
Assumption		Weight of barrier rail Wbr =		13.0	KN/m		
		fy (Reinforcing Bars)		415	Mpa		
		Concrete Unit Weight Wu =		24.0	KN/m^3		
		Asphalt Unit Weight Wa =		22.0	KN/m^3		
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

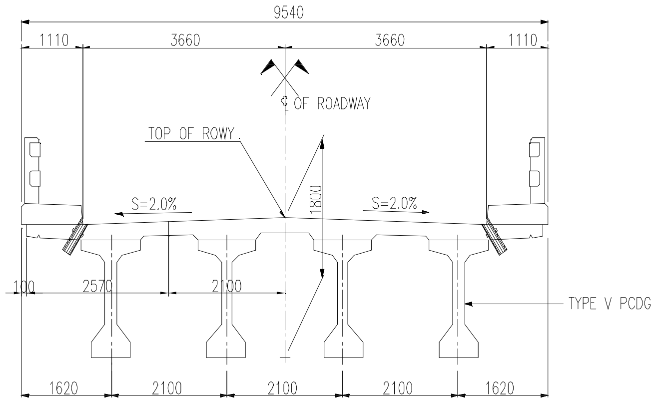
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

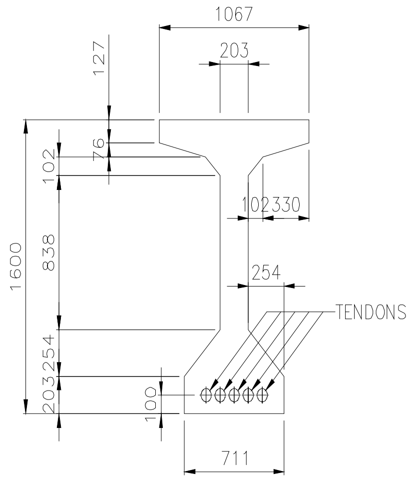
A2. BRIDGE LAYOUT AND DIMENSION

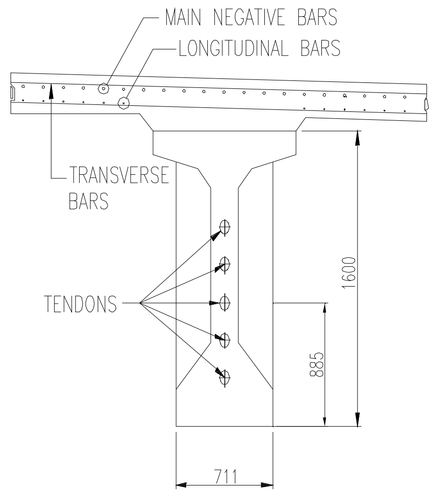


BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION





GIRDER SECTION			
Girder Height	1.600		
Dimension	b	h	
Slab	2.100	0.2	*1.00 (Modulas Ratio)
Uflg	1.067	0.127	
	0.330	0.076	
	0.102	0.076	
	0.102	0.102	
Web	0.203	1.270	
Lflg	0.254	0.254	
	0.711	0.203	

NEXT

B. DEMAND FORCES

B1. DEAD LOAD CALCULATIONS

B1.1 INPUT		
FOR DEAD LOAD	Area of Girder (m^2)	0.645
	Span Length (m)	35.0
	Composite Girder Height (m)	1.800
	Girder Height (m)	1.600
	Slab thickness (m)	0.200
	Slab Spacing (m)	2.100
	Weight of Diaphram (kN/m)	1.5
	Weight of Barrier Rail (kN/m)	13
	Number of Girder (nos.)	4

B1.2 DEAD LOAD CALCULATIONS		
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	15.49
	Slab weight	10.08
	Weight of Diaphram	1.50
	Barrier Rail	6.50
	Asphalt Overlay	2.31
	Total	35.88
	Total of Dead Load	27.07
	Total of Superimposed Dead Load	8.81
Dead Load Moment at Midspan M_{DL}(kN-m)		4145.0
Superimposed Dead Load Moment at Midspan M_{SDL} (kN-m)		1349.0
Dead Load Shear at Support V_{DL} (kN)		473.7
Superimposed Dead Load Shear at Support V_{SDL} (kN)		154.2

B2. LIVE LOAD CALCULATIONS

B2. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.148			
Impact factor	0.209			
span	35.00			
Max.MS18 moment for 35.00m span /wheel line		without Impact	M_L	1227.9
		with Impact	M_{LL}	1704.1
Max.MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	148.8
		with Impact	V_{LL}	206.6

B2. FORCE DEMAND CALCULATIONS		
Description	Moment	Shear
	C (0.5L)	At Support
Dead load (kN-m)	4145.0	473.7
Superimposed Dead load (kN-m)	1349.0	154.2
MS18 moment with Impact (kN-m)	1704.1	206.6

NEXT

B3. SECTION PROPERTIES CALCULATION					
Load Condition	A (m^2)	Iz (m^4)	Y_b (m)	Y_t (m)	Y_t slab (m)
For Dead Loads	0.645	0.214	0.804	0.796	NA
For Superposed Dead Load and Live Loads	1.065	0.419	1.157	0.443	0.643

B4. STRESS CALCULATIONS

(1) Stress at Midspan

Loading	Stresses in the PCI Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.44	-15.61	6.85
Prestress (Pef=5270kN)	-5.66	22.14	2.03
Superimposed Dead Load	1.42	-3.73	0.00
Live Load	1.80	-4.71	0.00

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 LOAD RATING BASED ON SERVICEABILITY LIMIT STATE	
(1) USING COMPRESSIVE STRESS	
For Strength Factor	0.6
For Strength Factor	0.4
For Dead Load Factor	0.5
Concrete Compressive Stress	38
Dead Load Stress	16.87
Prestress after all losses	-5.66
Secondary Prestress	0.00
Live Load stresses including Impact	1.80
Using Compressive Stress Under All Load Combination	6.44
Using Compressive Stress Under Live Load	5.33
(2) USING ALLOWABLE TENSION STRESS	
Dead Load Stress	-19.33
Prestress after all losses	22.14
Secondary Prestress	0.00
Live Load stresses including Impact	-4.71
Using the Allowable Tension in Concrete	1.25

C2.2 LOAD RATING BASED ON STRENGTH LIMIT STATE			
Dead Load Factor		1.3	
Live Load factors	Inventory	2.17	
	Operating	1.3	
		ection C (at Midspan	Section B (Support)
		Moment	Shear
Moment and Shear Capacity		12006.6	1489.4
Moment and Shear due to Dead Load		4145.0	473.7
Moment and Shear due to Superimposed Dead Load		1349.0	154.2
Moment and Shear due to Live Load		1704.1	206.6

C2.3 LOAD RATING CALCULATIONS				
Description	Moment		Shear	
	Inventory	Operating	Inventory	Operating
Rating Factor	1.32	2.20	1.50	2.51
Rating Live Load (MS18) (Metic Tons)	33.0			
Load Rating Calculations	43.4	72.5	49.6	82.7

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)

C1. CAPACITY CALCULATIONS

C1.1 MOMENT CAPACITY at MIDSPAN		
Assumed total prestressing loss σ_{LOSS} (Mpa)	158.1	
Ultimate Strength of Tendons fu (Mpa)	1860	
Web Width bw (mm)	203	
Φ	1.00	
Prestressing Steel Area As* (mm^2)	4261	
Section Loss (%)	0	
Total Assumed Area of Steel As(mm2)	4261	
Effective width of deck , beff (mm)	2100	
Centroid of Prestressing Steel from top of deck , d (mm)	1700	
Yield Strength of Tendons fy (Mpa)	1570	
k=2(1.04-fy/fu)	0.39	C_{input}
Neutral axis location (mm)	231.2	231.2
Moment Capacity at Midspan R (kN-m)	12007	

C1.2 SHEAR CAPACITY at SUPPORT	
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	0
The Reduction Factor due to Shear Cracks	1.00
Diameter of Stirrups (mm)	12
Area of Stirrups Φs (mm^2)	113.1
Spacing of Stirrups (mm)	200
Section Loss due to Stirrups Exposure (%)	0
Total Assumed Area of Steel As(mm2)	113.1
Nominal Shear Capacity Factor Φc	0.85
Nominal Shear Strength provided by concrete Vc (kN)	109.5
Nominal Shear Strength provided by Rebar Vs (kN)	1642.7
Shear Capacity Vu	1489.4

NEXT

C2.3 SUMMARY OF RATING FACTOR AND LOAD RATING

Weight of Vehicle (Metric Tons)			33	At Midspan		At Support	
				RF	LR	RF	LR
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	6.44	212.6	-	-
			Live Load	5.33	176.0	-	-
		Allowable Tension		1.25	41.3	-	-
	Strength Limit State	Moment	Inventory	1.32	43.4	-	-
			Operating	2.20	72.5	-	-
		Shear	Inventory	-	-	1.50	49.6
			Operating	-	-	2.51	82.7
Minimum Rating Factor and Load Rating				1.25	41.3	1.50	49.6

Depend on the minimum value of Rating Factor > 1 or <1 ,
instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.148			
Impact factor	0.209			
span	35.00			
Type 1-1 moment for 35.00m span /wheel line		without Impact	M_L	695.45
		with Impact	M_{LL}	965.19
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	81.46
		with Impact	V_{LL}	113.06
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 35.00m span /wheel line		without Impact	M_L	1036.00
		with Impact	M_{LL}	1437.83
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	123.91
		with Impact	V_{LL}	171.97
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 35.00m span /wheel line		without Impact	M_L	1261.27
		with Impact	M_{LL}	1750.48
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	156.27
		with Impact	V_{LL}	216.88

NEXT

D2. POSTING RATING CALCULATIONS

D2.1 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE			
(1) USING COMPRESSIVE STRESS			
Description		At Midspan	At Support
For Strength Factor		0.6	
For Strength Factor		0.4	
For Dead Load Factor		0.5	
Concrete Compressive Stress		38	
Dead Load Stress		16.87	-
Prestress after all losses		-5.66	-
Secondary Prestress		0.00	-
Live Load stresses including Impact	Type 1-1	1.02	-
	Type 1-2	1.52	-
	Type 12-2	1.85	-
Using Compressive Stress Under All Load Combination	Type 1-1	11.37	-
	Type 1-2	7.64	-
	Type 12-2	6.27	-
Using Compressive Stress of Live Load	Type 1-1	9.42	-
	Type 1-2	6.32	-
	Type 12-2	5.19	-
(2) USING ALLOWABLE TENSION STRESS			
Dead Load Stress		-19.33	-
Prestress after all losses		22.14	-
Secondary Prestress		0.00	-
Live Load stresses including Impact	Type 1-1	-2.67	-
	Type 1-2	-3.97	-
	Type 12-2	-4.83	-
Using the Allowable Tension in Concrete	Type 1-1	2.21	-
	Type 1-2	1.48	-
	Type 12-2	1.22	-

NEXT

D3. LOAD RATING CALCULATIONS

D3.1 POSTING RATING BASED ON STRENGTH LIMIT STATE			
Dead Load Factor		1.3	
Live Load factors	Inventory	2.17	
	Operating	1.3	
Description		Moment at Midspan	Shear at Support
Moment and Shear Capacity		12007	1489
Moment and Shear due to Dead Load		4145.0	473.7
Moment and Shear due to Superimposed Dead Load		1349.0	154.2
Moment and Shear due to Live Load	Type 1-1	965.2	113.1
	Type 1-2	1437.8	172.0
	Type 12-2	1750.5	216.9

D3.2 POSTING RATING CALCULATIONS						
Description			Moment at Midspan		Shear at Support	
			Inventory	Operating	Inventory	Operating
Rating Factor		Type 1-1	2.32	3.88	2.74	4.58
		Type 1-2	1.56	2.60	1.80	3.01
		Type 12-2	1.28	2.14	1.43	2.39
Postting Live Load (Metic Tons)	Weight of vehicle	Type 1-1	17.0			
		Type 1-2	27.0			
		Type 12-2	38.0			
Load Rating Calculations		Type 1-1	39.5	65.9	46.6	77.9
		Type 1-2	26.5	70.3	30.7	81.3
		Type 12-2	21.8	81.2	24.3	90.7

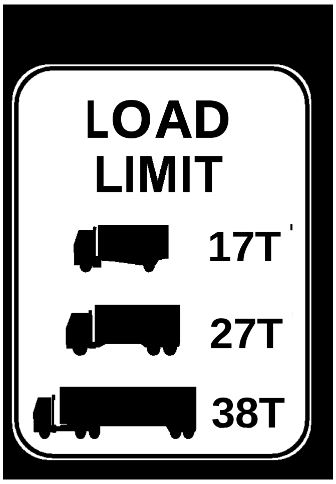
NEXT

D3.3 SUMMARY OF POSTING RATING FACTOR AND LOAD RATING							
				At Midspan		At Support	
				RF	LR	RF	LR
(1) POSTING VEHICLE TYPE 1-1				Weight of Vehicle		17 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	11.37	193.4	-	-
			Live Load	9.42	160.1	-	-
		Allowable Tension		2.21	37.6	-	-
	Strength Limit State	Moment	Inventory	2.32	39.5	-	-
			Operating	3.88	65.9	-	-
		Shear	Inventory	-	-	2.74	46.6
			Operating	-	-	4.58	77.9
Minimum Rating Factor and Load Rating				2.21	37.6	2.74	46.6
(2) POSTING VEHICLE TYPE 1-2				Weight of Vehicle		27 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	7.64	206.2	-	-
			Live Load	6.32	170.7	-	-
		Allowable Tension		1.48	40.1	-	-
	Strength Limit State	Moment	Inventory	1.56	42.1	-	-
			Operating	2.60	70.3	-	-
		Shear	Inventory	-	-	1.80	48.7
			Operating	-	-	3.01	81.3
Minimum Rating Factor and Load Rating				1.48	40.1	1.80	48.7
(3) POSTING VEHICLE TYPE 12-2				Weight of Vehicle		38 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	6.27	238.3	-	-
			Live Load	5.19	197.3	-	-
		Allowable Tension		1.22	46.3	-	-
	Strength Limit State	Moment	Inventory	1.28	48.7	-	-
			Operating	2.14	81.2	-	-
		Shear	Inventory	-	-	1.43	54.4
			Operating	-	-	2.39	90.7
Minimum Rating Factor and Load Rating				1.22	46.3	1.43	54.4

NEXT

E. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	AT MIDSPAN		AT SUPPORT		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.25	41.3	1.50	49.6	33T
Type 1-1	17.0	2.21	37.6	2.74	46.6	17T
Type 1-2	27.0	1.48	40.1	1.80	48.7	27T
Type 12-2	38.0	1.22	46.3	1.43	54.4	38T



END AND GO TO DECK SLAB

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ******** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG SIMPLE**

A. GENERAL

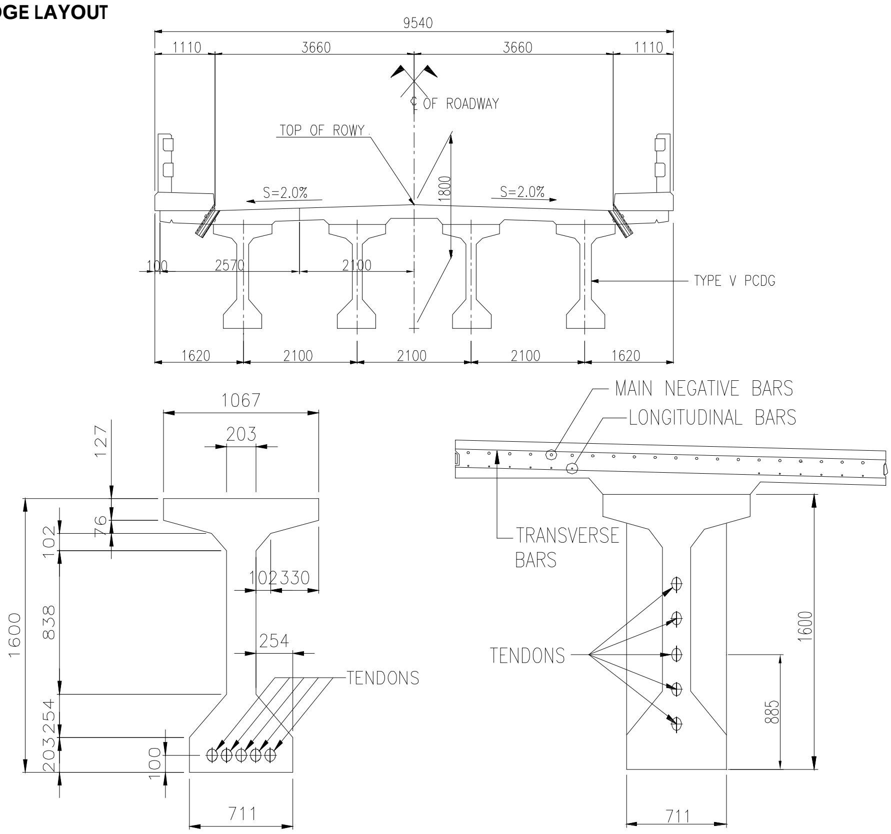
A.1 BRIDGE DESCRIPTION

- Bridge Location : None (Sample)
- Bridge Type : Simple-span Precast, Prestressed I Girder Bridge
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 35.00m
- Year Built : 2003
- Structure
  - Girders : Precast, Prestressed I Girder Bridge (4-Girders), Monolithic with deck slab
    : Girder spacing at 2.10m on center
  - Substructure : RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : f'c = 38 Mpa (Girder) , 24.2 Mpa (Slab)
  : fu = 1860 Mpa , Workinf Force: 5270.0 kN (effective after losses)
  : Centroid of PS Tendons: 100 mm from soffit @ midspan, 824mm at Anchorage
- Assumption : Weight of barrier rail = 13.0 KN/m
  : fy (reinforcing bars) = 415 Mpa
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

Reqirement :

Determine the load rating of the interior girder of the span (35.0m) for MS18 (HS20) vehicles considering damages on members

A.2 BRIDGE LAYOUT



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NOTES

B. DEMAND FORCES

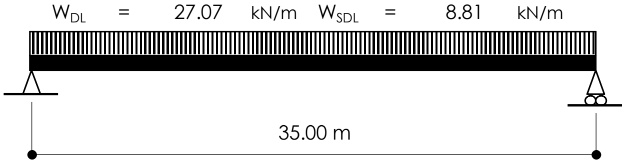
B.1 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight, (2) Fillet/haunch, (3) Tributary area of slab, (4) Barrier rails (Assumed to be equally distributed among girders). (5) Wearing course.

- Self-weight of girder = (0.6454m2) (24 KN/m^3) = 15.49 KN/m
- Slab Weight (Tributary) = (0.20m) (2.10m) (24 KN/m^3) = 10.08 KN/m
- Weight of Diaphram = = 1.50 KN/m
- Barrier rail = 2 (13.0/4) = 6.50 KN/m
- Wearing course = (0.05m) (2.10m) (22 KN/m^3) = 2.31 KN/m
  - Total Uniform Load of Interior Girder, w = 35.88 KN/m
  - Total Uniform Dead Load of Girder, w_{DL} = 27.07 KN/m
  - Total Uniform Superimposed Dead Load of Girder, w_{SDL} = 8.81 KN/m

- Dead Load Moment at Midspan, M_{DL} = 27.07 x 35.00^2 /8 = 4145.0 KN-m — $M_d = wL^2/8$
- Superimposed Dead Load Moment at Midspan, M_{SDL} = 8.81 x 35.00^2 /8 = 1349.0 KN-m
- Dead Load Shear at support, V_{DL} = 27.07 x 35.00 /2 = 473.7 KN — $V_d = wL/2$
- Superimposed Dead Load Shear at support, V_{SDL} = 8.81 x 35.00 / 2 = 154.2 KN

W_{DL} = 27.07 kN/m W_{SDL} = 8.81 kN/m



B.2 LIVE LOAD CALCULATIONS

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes. — Manual 1st Ed. Sect 3.4.2

The distribution of wheel loads for two traffic lanes for T-beams shall be taken as S/1.829 — DPWH Table 3-4 AASHTO Table 3.23.1 (S/6 in ft.)

- Number of live load wheel line = 2.10 / 1.829 = 1.148

- Impact factor, I = 15.24 / (35.00 + 38.00) = 0.209 — DPWH Sect. 3.2.5.1

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NOTES

The live load moments and shear values are taken from the tables in Appendix III on this manual and are used to determine the live load demand. Interpolation may be used if values are not exact

- Max. MS18 moment for 35.00 m span without impact/whel line = 1227.9 KN-m
- Thus, MS18 moment with Impact at midspan M_{LL} = (1.148) (1.209) (1227.90) = 1704.1 KN-m
- Max. MS18 shear at support/wheel line = 148.8 KN
- Thus, MS18 shear V_{LL} = (1.148) (1.209) (148.80) = 206.6 KN

LOAD DEMANDS ON DIFFERENT SECTIONS OF CONCRETE I GIRDER

ESTIMATED LOAD DEMANDS AT GIRDER SECTIONS (MS18)

LOADING	Moment (kN-m) At Midspan	Shear (kN) At Support
Dead load	4145.0	473.7
Superimposed Dead load	1349.0	154.2
Live Load + Impact	1704.1	206.6

B.3 SECTION PROPERTIES CALCULATION

The section properties of the prestressed concrete I-girder including that for the composite girder are calculated and given in thetable below:

Description	Area (m^2)	Moment of Inertia (m^4)	Y_{bot} Girder (m)	Y_{top} Girder (m)	Y_{top} Slab (m)
For Dead Load	0.645	0.214	0.804	0.796	NA
For (SDL) and (LL+I)	1.065	0.419	1.157	0.443	0.643

B.4 LOAD STRESS CALCULATIONS

The stresses at different fiber locations are calculated using

$$\sigma = \frac{P}{A} \pm \frac{Mc}{y / I}$$

The summary of results at Midspan are shown in the table below.

Estimated Stress Demands at Girder Sections

LOADING	Stresses in the PCI Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.44	-15.61	6.85
Prestress (Pef = 5270 kN)	-5.66	22.14	2.03
Superimposed Dead Load	1.42	-3.73	0.00
Live Load	1.80	-4.71	0.00

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NOTES

- Stresses due to Dead Load

Top Concrete Fiber	= 4,145.0 x 0.796 / 0.214 / 1000	= 15.44 Mpa
Bottom Concrete Fiber	= 4,145.0 x (-0.804) / 0.214 / 1000	= -15.61Mpa
Centroid of Composite	= 15.44 - (15.44 - (- 15.61) x (0.443 / 1.600)	= 6.85 Mpa

- Stresses due to Prestress

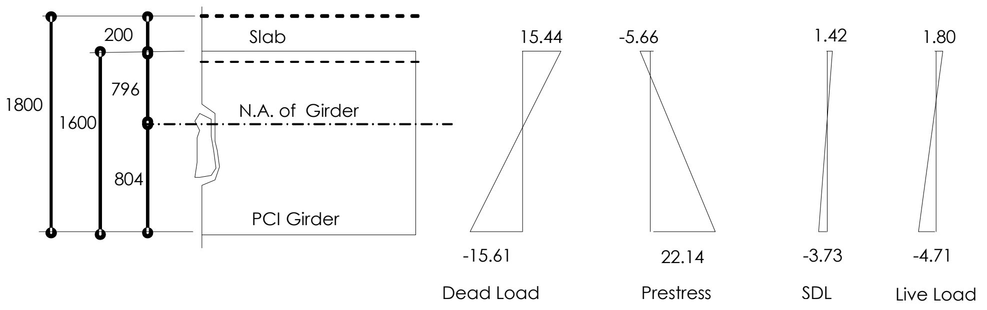
Top Concrete Fiber	= (5270 / 0.645 - 5270 x (0.804 - 0.100) x 0.796 / 0.214) / 1000	= -5.66 Mpa
Bottom Concrete Fiber	= (5270 / 0.645 + 5270 x (0.804 - 0.100) x 0.804 / 0.214) / 1000	= 22.14 Mpa
Centroid of Composite	= -5.66 - (-5.66-22.14) x (0.443/1.6)	= 2.03 Mpa

- Stresses due to Superimposed Dead Load

Top Concrete Fiber	= 1,349.0 x 0.443 / 0.419 / 1000	= 1.42 Mpa
Bottom Concrete Fiber	= 1,349.0 x (-1.157) / 0.419 / 1000	= -3.73 Mpa
Centroid of Composite	= 1.42 - (1.42 - (- 3.73) x (0.443 / 1.600)	= 0.00 Mpa

- Stresses due to Live Load

Top Concrete Fiber	= 1,704.1 x 0.443 / 0.419 / 1000	= 1.80 Mpa
Bottom Concrete Fiber	= 1,704.1 x (-1.157) / 0.419 / 1000	= -4.71 Mpa
Centroid of Composite	= 1.80 - (1.80 - (- 4.71) x (0.443 / 1.600)	= 0.00 Mpa



STRESSES AT SECTION C (MIDSPAN) OF GIRDER

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NOTES

C. LOAD RATING UNDER SERVICEABILITY LIMIT STATE BY ALLOWABLE STRESS METHOD (ASM) AND UNDER STRENGTH LIMIT STATE BY LOAD FACTOR METHOD (LFM)

C.1 CAPACITY CALCULATIONS

C.1.1 MOMENT CAPACITY AT MIDSPAN

The actual area of prestressing steel can be obtained from as-built plans.
However in the absence of as-built darwings, the following approach can be used.
Assume total loss including creep loss to be
σ_{LOSS} = 158.1 Mpa with $f_{u(Tendons)}$ = 1860.0 Mpa fy = 1570.0 Mpa

Therefore,
Prestressing steel area $= \dfrac{\text{Working Force}}{\text{Effective Stress}} = \dfrac{5270}{(0.75 \times 1860 - 158.1)} \times (1000)$
$= 4261\ mm^2$

b_{eff} = 2100 mm , t_s = 200 mm , b_w = 203 mm
d_p = 1800 - 100 = 1700 mm , f'c (girder) = 38 Mpa , f'c (slab) = 24.2 Mpa

k = 2 x (1.04 - fy / fu) = 2 x (1.04 - 1570.0 / 1860.0) = 0.39

β (girder) = 0.85 - 0.05 / 7 x (f'c - 28) = 0.85 - 0.05 / 7 x (38 - 28) = 0.7786
[in case of, 56 > f'c > 28 ==> β = 0.85 - 0.05 / 7 x (f'c - 28)]

β (slab) = 0.85 [in case of, f'c < 28 ==> β = 0.85]

Ac (girder) = b_w x (N.A. - t_s) = 203 x (231.2 - 200) = 6,333.6 mm^2 (N.A.: Neutral axis location)

Ac (slab) = b_{eff} x t_s = 2100 x 200 = 420,000 mm^2

$$\beta\ (\text{average}) = \frac{[\ f'c\ (\text{slab}) \times Ac\ (\text{slab}) \times \beta\ (\text{slab}) + f'c\ (\text{girder}) \times Ac\ (\text{girder}) \times \beta\ (\text{girder})\ ]}{[\ f'c\ (\text{slab}) \times Ac\ (\text{slab}) + f'c\ (\text{girder}) \times Ac\ (\text{girder})\ ]}$$

$$= \frac{(\ 24.2 \times 420{,}000 \times 0.85 + 38 \times 6333.6 \times 0.7786\ )}{(\ 24.2 \times 420{,}000 + 38 \times 6333.6\ )} = 0.848348$$

$$C\ (\text{slab}) = \frac{Ap \times fu}{[\ 0.85 \times f'c\ (\text{slab}) \times \beta\ (\text{slab}) \times b_{eff} + k \times Ap \times fu / d_p\ ]}$$

$$= \frac{4{,}261 \times 1{,}860}{[\ 0.85 \times 24.2 \times 0.85 \times 2{,}100 + 0.39 \times 4{,}261 \times 1{,}860 / 1{,}700\ ]} = 205.6\ mm$$

fps = fu x [1 - k x C (slab) / d_p] = 1,860 x [1 - 0.39 x 205.6 / 1,700] = 1771.9 Mpa

a = β (slab) x C (slab) = 0.85 x 205.6 = 174.8 mm

S = Ap x fps x (d_p - a / 2) / 10^{-6} = 4,261x 1,771.9 x (1,700 - 174.8 / 2) / 10-6 = 12,174 kN-m

$$C\ (\text{girder}) = \frac{[\ Ap \times fu - 0.85 \times t_s \times \beta\ (\text{average}) \times \{\ f'c\ (\text{slab}) \times b_{eff} - f'c\ (\text{girder}) \times b_w \}\ ]}{[\ 0.85 \times f'c\ (\text{girder}) \times \beta\ (\text{average}) \times b_w + k \times Ap \times fu / d_p\ ]}$$

$$= \frac{[\ 4{,}261 \times 1{,}860 - 0.85 \times 200 \times 0.848348 \times \{\ 24.2 \times 2{,}100 - 38 \times 203 \}\ ]}{[\ 0.85 \times 38 \times 0.848348 \times 203 + 0.39 \times 4{,}261 \times 1{,}860 / 1{,}700\ ]} = 231.2\ mm$$

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fps = fu x [1 - k x C (girder) / d_p] = 1,860 x [1 - 0.39 x 231.2 / 1,700] = 1760.9 Mpa

a = β (average) x C (girder) = 0.848348 x 231.2 = 196.1 mm

S = [Ap x fps x (d_p - a / 2)
+ 0.85 x β (average) x (f'c (slab) x b_{eff} - f'c (girder) x b_w) x t_s x (a / 2 - t_s / 2) } / 10^{-6}
= 4,261x 1,760.9 x (1,700 - 196.1 / 2)
+ 0.85 x 0.848348 x (24.2 x 2,100 - 38 x 203) x 200 x (196.1 / 2 - 200 / 2) } / 10^{-6}
= **12,007** kN-m <== Governing Moment Capacity (< 12,174 kN-m)

C.1.2 SHEAR CAPACITY AT SUPPORT

The AASHTO Design Specification requires that the design shear be taken at a distance "d" from the support. However, shear at support may be used conservatively.
In the absence of data, the standard reinforcement for a 35.0m span under DPWH standards had been used.

- The shear capacity of the concrete section

Vc = 0.05 Sqrt(f'c) b d = 0.05 [Sqrt (38.00)] (203) (1.800 - 0.050) (1.00)
= 109.5 KN ==>> Full Capacity

- The shear capacity of the shear reinforcement

Vs = 2 Av fy d_{eff} / S = 2 x (2 x 113.1) (415) (1.800 - 0.050) / (200)
= 1642.7 KN

- The total shear capacity becomes

Vu = ϕ (Vc + Vs) = 0.85 (109.5 + 1642.7)
= 1489.4 KN

C.2 LOAD RATING CALCULATIONS

C.2.1 Load Rating Based on Serviceability Limit State by ASM

Serviceability conditions are given in the AASHTO Design Specifications (Section 9.15) and the AASHTO MCEB Manual (Sec. 6.6.3.3)

i. Using **compressive stress** under all load combination:

Location	$RF_{INV-COMALL} = \dfrac{0.6\ f'c - (Fd + Fp + Fs)}{FI}$	$RF_{INV-COMALL}$
At Midspan	$= \dfrac{0.6\ (38) - (15.44 + 1.42 + (-5.66) + 0.00)}{1.80} =$	6.44

ii. Using **compressive stress** of Live Load, half the prestressing and permanent dead load:

Location	$RF_{INV-COMLIVE} = \dfrac{0.4\ f'c - 0.5\ (Fd + Fp + Fs)}{FI}$	$RF_{INV-COMLIVE}$
At Midspan	$= \dfrac{0.4\ (38) - 0.5\ (15.44 + 1.42 + (-5.66) + 0.00)}{1.80} =$	5.33

NOTES

Stirrups :
D12mm
A = 113.1 mm^2

See Sect. 3.5 of this Manual

This Manual Eq. 3.5-2

This Manual Eq. 3.5-3

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NOTES

This Manual Eq. 3.5-1

iii. Using **allowable tension** in concrete:

Location $RF_{INV\text{-}COMLIVE} = \dfrac{0.5\, f'c^{1/2} - (Fd + Fp + Fs)}{Fl}$ $RF_{INV\text{-}COMLIVE}$

At Midspan $= \dfrac{-0.5\,(38)^{1/2} - (-15.61 - 3.73 + 22.14 + 0.00)}{-4.71} = 1.25$

C.2.2 Load Rating Based on Strength Limit State by LFM

The general expression for the Rating Factor is:

$$RF = \frac{\phi\, Rn - \gamma_D\, D}{\gamma_L\, \beta_L\, L\,(1+I)}$$

where

γ_D : 1.30
γ_L : 1.30
β_L : 1.67 for inventory
β_L : 1.00 for Operating

LOAD RATING CALCULATIONS (LFM)

Location	Description	Inventory Rating (Tons)		Operating Rating (Tons)	
Midspan	Moment	$\dfrac{12007-1.3(4145+1349)}{1.3(1.67)(1704)}$	= 1.32	$\dfrac{12007-1.3(4145+1349)}{1.3(1.00)(1704)}$	= 2.20
At Support	Shear	$\dfrac{1489-1.3(474+154)}{1.3(1.67)(207)}$	= 1.50	$\dfrac{1489-1.3(474+154)}{1.3(1.00)(207)}$	= 2.51

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
Midspan	Moment	1.32 x 33 = **43.4**	2.20 x 33 = **72.5**
At Support	Shear	1.50 x 33 = **49.6**	2.51 x 33 = **82.7**

In this example, the Rating Factors (RF) for both the serviceability limit state and the strength limit state are greater than one (RF >> 1) so that there is no need to perform load posting calculations. Therefore, the bridge can safely carry the intended traffic loads.

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NOTES

D. LOAD POSTING UNDER SERVICEABILITY LIMIT STATE BY ALLOWABLE STRESS METHOD (ASM) AND UNDER STRENGTH LIMIT STATE BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be taken from Appendix III of the Manual corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

This manual Fig. 3.4-2

For a 35.00 m span bridge, the Posting Live Load demands are:

Vehicle Type	LL Effects/Wheel Line		LL Dist Factor	Impact	LL Demand	
	Moment	Shear			Moment (KN-m)	Shear (KN)
Type 1-1	695.45	81.46	1.148	1.209	965.19	113.06
Type 1-2	1036.00	123.91	1.148	1.209	1437.83	171.97
Type 12-2	1261.27	156.27	1.148	1.209	1750.48	216.88

D.2 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE by ASM

Similar calculations are done using Eqs. 3.5-2, 3.5-3 and 3.5-1 for rating factor and load rating

i. Using **compressive stress** under all load combination:

This Manual Eq. 3.5-2

Location $RF_{INV\text{-}COMALL} = \dfrac{0.6\, f'c - (Fd + Fp + Fs)}{FI}$ $RF_{INV\text{-}COMALL}$

At Midspan

Type 1-1 $= \dfrac{0.6\,(38) - (15.44 + 1.42 + (-5.66) + 0.00)}{1.02} = 11.37$

Type 1-2 $= \dfrac{0.6\,(38) - (15.44 + 1.42 + (-5.66) + 0.00)}{1.52} = 7.64$

Type 12-2 $= \dfrac{0.6\,(38) - (15.44 + 1.42 + (-5.66) + 0.00)}{1.85} = 6.27$

ii. Using **compressive stress** of Live Load, half the prestressing and permanent dead load:

This Manual Eq. 3.5-3

Location $RF_{INV\text{-}COMLIVE} = \dfrac{0.4\, f'c - 0.5\,(Fd + Fp + Fs)}{FI}$ $RF_{INV\text{-}COMLIVE}$

At Midspan

Type 1-1 $= \dfrac{0.4\,(38) - 0.5\,(15.44 + 1.42 + (-5.66) + 0.00)}{1.02} = 9.42$

Type 1-2 $= \dfrac{0.4\,(38) - 0.5\,(15.44 + 1.42 + (-5.66) + 0.00)}{1.52} = 6.32$

Type 12-2 $= \dfrac{0.4\,(38) - 0.5\,(15.44 + 1.42 + (-5.66) + 0.00)}{1.85} = 5.19$

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NOTES

This Manual Eq. 3.5-1

iii. Using **allowable tension** in concrete:

Location $RF_{INV\text{-}COMLIVE} = \dfrac{0.5\, f'c^{1/2} - (Fd + Fp + Fs)}{Fl}$ $RF_{INV\text{-}COMLIVE}$

At Midspan

Location	Equation	RF
Type 1-1	$= \dfrac{-0.5\,(38)^{1/2} - (-15.61 - 3.73 + 22.14 + 0.00)}{-2.67} =$	2.21
Type 1-2	$= \dfrac{-0.5\,(38)^{1/2} - (-15.61 - 3.73 + 22.14 + 0.00)}{-3.97} =$	1.48
Type 12-2	$= \dfrac{-0.5\,(38)^{1/2} - (-15.61 - 3.73 + 22.14 + 0.00)}{-4.83} =$	1.22

D.3 Load Rating Based on Strength Limit State by LFM

Similar calculations are done same as section C.2.2

LOAD RATING CALCULATIONS (LFM)

Location	Description	Inventory Rating (Tons)		Operating Rating (Tons)	
At Midspan Moment	Type 1-1	$\dfrac{12007-1.3(4145+1349)}{1.3(1.67)(965.2)} =$	2.32	$\dfrac{12007-1.3(4145+1349)}{1.3(1.00)(965.2)} =$	3.88
	Type 1-2	$\dfrac{12007-1.3(4145+1349)}{1.3(1.67)(1437.8)} =$	1.56	$\dfrac{12007-1.3(4145+1349)}{1.3(1.00)(1437.8)} =$	2.60
	Type 12-2	$\dfrac{12007-1.3(4145+1349)}{1.3(1.67)(1750.5)} =$	1.28	$\dfrac{12007-1.3(4145+1349)}{1.3(1.00)(1750.5)} =$	2.14
At Support Shear	Type 1-1	$\dfrac{1489-1.3(474+154)}{1.3(1.67)(113.1)} =$	2.74	$\dfrac{1489-1.3(474+154)}{1.3(1.00)(113.1)} =$	4.58
	Type 1-2	$\dfrac{1489-1.3(474+154)}{1.3(1.67)(172.0)} =$	1.80	$\dfrac{1489-1.3(474+154)}{1.3(1.00)(172.0)} =$	3.01
	Type 12-2	$\dfrac{1489-1.3(474+154)}{1.3(1.67)(216.9)} =$	1.43	$\dfrac{1489-1.3(474+154)}{1.3(1.00)(216.9)} =$	2.39

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG SIMPLE**

NOTES

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

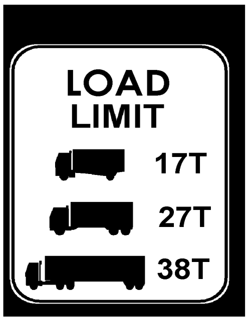
Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
At Midspan Moment	Type1-1	2.32 x 17 = **39.5**	3.88 x 17 = **65.9**
	Type 1-2	1.56 x 27 = **42.1**	2.60 x 27 = **70.3**
	Type 12-2	1.28 x 38 = **48.7**	2.14 x 38 = **81.2**
At Support Shear	Type1-1	2.74 x 17 = **46.6**	4.58 x 17 = **77.9**
	Type 1-2	1.80 x 27 = **48.7**	3.01 x 27 = **81.3**
	Type 12-2	1.43 x 38 = **54.4**	2.39 x 38 = **90.7**

D. SUMMARY OF LOAD POSTING

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	At Midspan		At Support		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.25	41.3	1.50	49.6	**33**
Type 1-1	17.0	2.21	37.6	2.74	46.6	**17**
Type 1-2	27.0	1.48	40.1	1.80	48.7	**27**
Type 12-2	38.0	1.22	46.3	1.43	54.4	**38**



RATED BY : DATE : CHECKED BY : DATE :

INTERIOR PCDG CONTINUOUS

A. GENERAL

BACK TO MENU

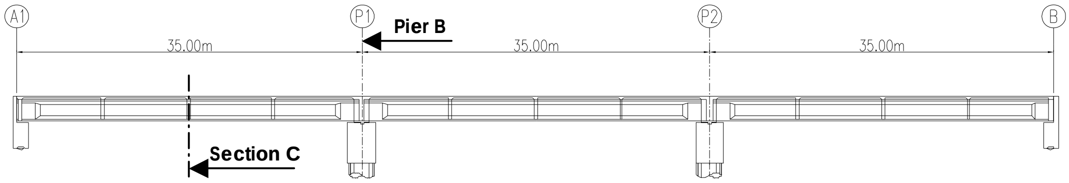
A1. BRIDGE DESCRIPTION

Bridge Location	REGION	II					
Bridge Name							
Bridge Type	Simple or Continuous	C	Precast, Prestressed PC I Girder Bridge				
	Number of Span	3					
Bridge Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		35.000	35.000	35.000			=105.000m
Year Built		2000					
Structure	Nos. of Girder	4	Superstructure made continuous for live loading				
	Girder Spacing (m)	2.100	on centers				
	Substructure	Concrete bents and abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Notes on Plans	f'c (Girder)		38	MPa			
	f'c (Slab)		24.2	MPa			
	Ultimate Strength of Tendons fu		1860	MPa			
	Working Force		6750	kN (Effective after losses)			
	Centroid of PC Tendons		100	mm (from soffit at Midspan)			
			885	mm (from soffit at Anchorage)			
Assumption	Weight of barrier rail Wbr =		13.0	KN/m			
	fy (Reinforcing Bars)		415	Mpa			
	Concrete Unit Weight Wu =		24.0	KN/m^3			
	Asphalt Unit Weight Wa =		22.0	KN/m^3			
Others	Rating Live Load is AASHTO MS18 (HS20-44)						

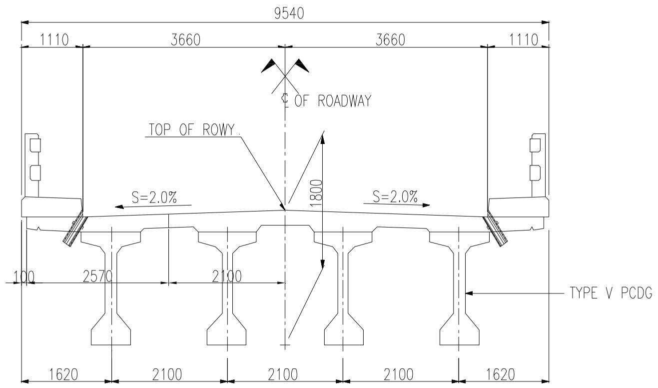
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

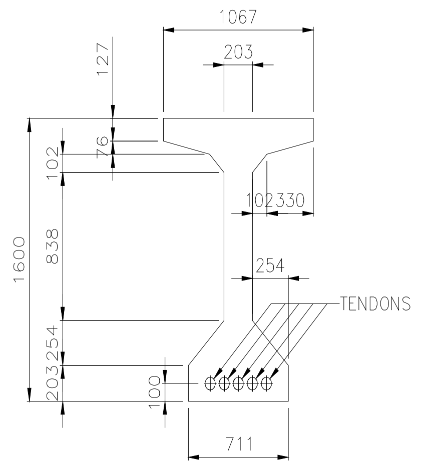
A2. BRIDGE LAYOUT AND SECTION



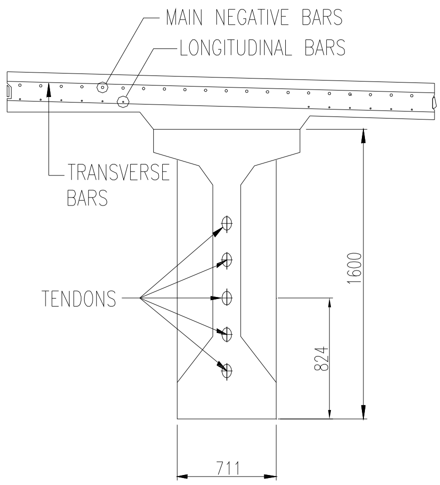
BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION



SECTION AT MIDSPAN



SECTION AT PIER SUPPORT

GIRDER SECTION			
Girder Height	1.600		
Dimension	b	h	
Slab	2.100	0.2	*1.00 (Modulas Ratio)
Uflg	1.067	0.127	
	0.330	0.076	
	0.102	0.076	
	0.102	0.102	
Web	0.203	1.270	
Lflg	0.254	0.254	
	0.711	0.203	

NEXT

B. DEMAND FORCES

B1. DEAD LOAD CALCULATIONS

B1.1 INPUT		
FOR DEAD LOAD	Area of Girder (m^2)	0.653
	Span Length (m)	35.000
	Composite Girder Height (m)	1.80
	Girder Height (m)	1.60
	Slab thickness (m)	0.200
	Slab Spacing (m)	2.100
	Weight of Diaphram (kN/m)	1.5
	Weight of Barrier Rail (kN/m)	13
	Number of Girder (nos.)	4

B1.2 DEAD LOAD CALCULATIONS	
Dead Load Moment at Midspan M_{DL}(kN-m)	4173.5
Dead Load Shear at Support V_{DL} (kN)	477.0

B2. FORCE DEMAND CALCULATIONS

B2.1 INPUT	
Number of Lanes	2
Fraction DF	1.148

B2.2 FORCE DEMAND CALCULATIONS			
Conducting a Structural Analysis, the load demands for the PCDG should be obtained separately and input the necessary load demands in the Table below.			
Description		C (0.5L)	At Pier Support
Moments	Dead load (kN-m)	4173.5	0.0
	Superimposed Dead load (kN-m)	594.7	-792.9
	MS18 moment with Impact (kN-m)	2441.4	-2770.7
Shears	Dead load (kN)	0.0	-477.0
	Superimposed Dead load (kN)	0.0	-135.9
	MS18 max. positive shear force (kN)	202.9	67.0
	MS18 max. negative shear force (kN)	-202.9	-465.3
	MS18 max. positive moment for shear (kN-m)	2319.3	457.9
	MS18 max. negative moment for shear (kN-m)	-2319.3	-449.8

NEXT

B3. SECTION PROPERTIES CALCULATION					
Load Condition	A (m^2)	Iz (m^4)	Y_b (m)	Y_t (m)	Y_t slab (m)
For Dead Loads	0.653	0.217	0.812	0.788	NA
For Live Loads	1.073	0.420	1.159	0.441	0.641

B4. STRESS CALCULATIONS

(1) Stress at Midspan

Loading	Stresses in the PC Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.17	-15.63	6.69
Prestress (Pef=6750kN)	-7.13	28.32	2.63
Superimposed Dead Load	0.62	-1.64	0.00
Live Load	2.56	-6.74	0.00
Live Load Moment for Shear	2.43	-6.40	0.00

(2) Stress at Pier Support

Loading	Stresses in the PC Girder (Mpa)			
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite	Top of Slab
Dead Load (Self + Slab)	0.00	0.00	0.00	0.00
Prestress (Pef=6750kN)	12.13	8.48	11.13	0.00
Superimposed Dead Load	-0.83	2.19	0.00	-1.21
Live Load	-2.91	7.65	0.00	-4.23
Live Load Moment for Shear	-0.47	1.24	0.00	-0.69

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD

C1. CAPACITY CALCULATIONS

C1.1 MOMENT CAPACITY at MIDSPAN		
Assumed total prestressing loss including creep σ_{LOSS} (Mpa)	204.6	
Ultimate Strength of Tendons fu (Mpa)	1860	
Web Width bw (mm)	203	
Prestressing Steel Area As* (mm^2)	5670	
Section Loss (%)	0	
Total Assumed Area of Steel As(mm2)	5670	
Effective width of deck , beff (mm)	2100	
Centroid of Prestressing Steel from top of deck , d (mm)	1700	
Yield Strength of Tendons fy (Mpa)	1570	
k=2(1.04-fy/fu)	0.39	C_{input}
Neutral axis location (mm)	560.6	560.6
Moment Capacity at Midspan R (kN-m)	14284	

C1.2 MOMENT CAPACITY at PIER SUPPORT	
Ultimate Strength of Rebar fy (Mpa)	415
Number of Rebars (nos.)	15
Diameter of Main Rebar (mm)	36
Area of one main rebar Φs (mm2)	1017
Concrete Cover (mm)	38
Resistance Reduction Factor	0.90
Rebars Area As (mm^2)	15255
Section Loss (%)	10
Total Assumed Area of Steel As(mm2)	13730
Centroid of Rebar from top of compression fiber, d (mm)	1744
Web Width bw (mm)	711.0
Rebar Ratio ρ = As / (beff x d) ρ	0.01107
Neutral axis location (mm)	608.1
Moment Capacity at Face of Support R (kN-m)	8045

NEXT

C1. CAPACITY CALCULATIONS

C1.3 SHEAR CAPACITY at MIDSPAN	
Diameter of Stirrups (mm)	12
Area of Stirrups (mm^2)	113
Spacing of Stirrups (mm)	250
Nominal Shear Capacity Factor Φ	0.85
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	40
The Reduction Factor due to Shear Cracks	0.80
Cracking Moment (kN-m)	3775.4
Factored Total Moment Mmax (kN-m)	11231.6
Factored Shear Force Vi (kN)	440.3
Nominal Shear Strength Vci (kN)	254.4
Nominal Shear Strength Vcw (kN)	1474.5
Nominal Shear Strength provided by concrete Vc (kN)	204.2
Nominal Shear Strength provided by Rebar Vs (kN)	637.8
Shear Capacity Vu = Φ (Vc + Vs) (kN)	715.7

C1.4 SHEAR CAPACITY at PIER B	
Diameter of Stirrups (mm)	12
Area of Stirrups (mm^2)	113
Spacing of Stirrups (mm)	150
Nominal Shear Capacity Factor Φ	0.85
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	30
The Reduction Factor due to Shear Cracks	0.85
Cracking Moment (kN-m)	-819.2
Factored Total Moment Mmax (kN-m)	-2006.8
Factored Shear Force Vi (kN)	-1806.4
Nominal Shear Strength Vci (kN)	1350.4
Nominal Shear Strength Vcw (kN)	1836.5
Nominal Shear Strength provided by concrete Vc (kN)	1150.9
Nominal Shear Strength provided by Rebar Vs (kN)	1090.5
Shear Capacity Vu	1905.1

NEXT

C2. LOAD RATING CALCULATIONS

C2.1 LOAD RATING BASED ON SERVICEABILITY LIMIT STATE		
(1) USING COMPRESSIVE STRESS		
	Section C	Pier Support B
For Strength Factor	0.6	
For Strength Factor	0.4	
For Dead Load Factor	0.5	
Concrete Compressive Stress	38	
Dead Load Stress	15.80	2.19
Prestress after all losses	-7.13	8.48
Secondary Prestress	0.00	0.00
Live Load stresses including Impact	2.56	7.65
Using Compressive Stress Under All Load Combination	5.52	1.59
Using Compressive Stress of Live Load	4.24	1.29
(2) USING ALLOWABLE TENSION STRESS		
Dead Load Stress	-17.27	-0.83
Prestress after all losses	28.32	12.13
Secondary Prestress	0.00	0.00
Live Load stresses including Impact	-6.74	-2.91
Using the Allowable Tension in Concrete	2.10	4.95

C2.2 LOAD RATING BASED ON STRENGTH LIMIT STATE					
Dead Load Factor		1.3			
Live Load factors	Inventory	2.17			
	Operating	1.3			
		Section C (at Midspan)		Section B (Support)	
		Moment	Shear	Moment	Shear
Moment and Shear Capacity		14284	716	-8045	-1905
Moment and Shear due to Dead Load		4174	0.00	0.00	-477
Moment and Shear due to Superimposed Dead Load		595	0.00	-793	-136
Moment and Shear due to Live Load		2441	203	-2771	-465

C2.3 LOAD RATING CALCULATIONS					
Description		Moment		Shear	
		Inventory	Operating	Inventory	Operating
Rating Factor	Section C (Midspan)	1.53	2.55	1.63	2.71
	Pier B (Support)	1.51	1.95	1.10	1.83
Rating Live Load (MS18) (Metic Tons	Weight of vehicle	33.0			
Load Rating Calculations	Section C (Midspan)	50.4	84.1	53.6	89.5
	Pier B (Support)	49.8	64.3	36.2	60.5

NEXT

C2.3 SUMMARY OF RATING FACTOR AND LOAD RATING

Weight of Vehicle (Metric Tons)			33	Section C		Pier Support B	
				RF	LR	RF	LR
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	5.52	182.1	1.59	52.3
			Live Load	4.24	140.0	1.29	42.5
		Allowable Tension		2.10	69.2	4.95	163.2
	Strength Limit State	Moment	Inventory	1.53	50.4	1.51	49.8
			Operating	2.55	84.1	1.95	64.3
		Shear	Inventory	1.63	53.6	1.10	36.2
			Operating	2.71	89.5	1.83	60.5
Minimum Rating Factor and Load Rating				1.53	50.4	1.10	36.2

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES				
Conducting a Structural Analysis, the load demands for the PCDG should be obtained separately and input the necessary load demands in the Table below.				
Description			Section C	Pier Support B
Posting Vehicle Moment and Shear	Moment	Type 1-1	822.1	-448.7
		Type 1-2	1219.9	-702.9
		Type 12-2	1447.3	-934.3
	Shear	Type 1-1	60.3	-123.2
		Type 1-2	85.5	-191.8
		Type 12-2	84.1	-248.8

D2. POSTING RATING CALCULATIONS

D2.1 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE			
(1) USING COMPRESSIVE STRESS			
Description		Section C	Pier Support B
For Strength Factor		0.6	
For Strength Factor		0.4	
For Dead Load Factor		0.5	
Concrete Compressive Stress		38	
Dead Load Stress		15.80	2.19
Prestress after all losses		-7.13	8.48
Secondary Prestress		0.00	0.00
Live Load stresses including Impact	Type 1-1	0.86	1.24
	Type 1-2	1.28	1.94
	Type 12-2	1.52	2.58
Using Compressive Stress Under All Load Combination	Type 1-1	16.38	9.79
	Type 1-2	11.04	6.25
	Type 12-2	9.31	4.70
Using Compressive Stress of Live Load	Type 1-1	12.60	7.96
	Type 1-2	8.49	5.08
	Type 12-2	7.16	3.82
(2) USING ALLOWABLE TENSION STRESS			
Dead Load Stress		-17.27	-0.83
Prestress after all losses		28.32	12.13
Secondary Prestress		0.00	0.00
Live Load stresses including Impact	Type 1-1	-2.27	-0.47
	Type 1-2	-3.37	-0.74
	Type 12-2	-4.00	-0.98
Using the Allowable Tension in Concrete	Type 1-1	6.23	30.54
	Type 1-2	4.20	19.50
	Type 12-2	3.54	14.67

NEXT

D2. LOAD RATING CALCULATIONS

D2.2 POSTING RATING BASED ON STRENGTH LIMIT STATE					
Dead Load Factor		1.3			
Live Load factors	Inventory	2.17			
	Operating	1.3			
		Section C (at Midspan)		Section B (Support)	
		Moment	Shear	Moment	Shear
Moment and Shear Capacity		14284	716	-8045	-1905
Moment and Shear due to Dead Load		4174	0.00	0.00	-477
Moment and Shear due to Superimposed Dead Load		595	0.00	-792.9	-136
Moment and Shear due to Live Load	Type 1-1	822	60	-449	-123
	Type 1-2	1220	86	-703	-192
	Type 12-2	1447	84	-934	-249

D2.3 POSTING RATING CALCULATIONS							
Description			Moment		Shear	
			Inventory	Operating	Inventory	Operating
Rating Factor	Section C (Midspan)	Type 1-1	4.53	7.57	5.47	9.13
		Type 1-2	3.05	5.10	3.86	6.44
		Type 12-2	2.57	4.30	3.92	6.55
	Pier B (Support)	Type 1-1	7.20	12.02	4.15	6.92
		Type 1-2	4.60	7.68	2.66	4.45
		Type 12-2	3.46	5.77	2.05	3.43
Postting Live Load (Metic Tons)	Weight of vehicle	Type 1-1	17.0			
		Type 1-2	27.0			
		Type 12-2	38.0			
Load Rating Calculations	Section C (Midspan)	Type 1-1	77.0	128.6	93.0	155.2
		Type 1-2	82.5	137.7	104.2	173.9
		Type 12-2	97.8	163.3	149.0	248.8
	Pier B (Support)	Type 1-1	122.5	204.4	70.5	117.6
		Type 1-2	124.2	207.3	71.9	120.0
		Type 12-2	131.5	219.4	78.0	130.2

NEXT

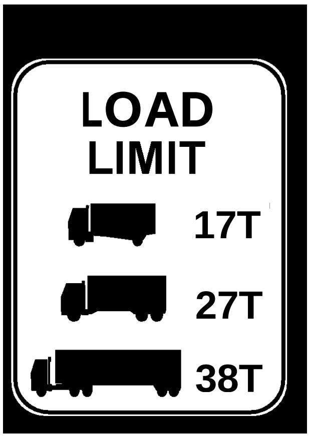
D2.3 SUMMARY OF POSTING RATING FACTOR AND LOAD RATING

				Section C		Pier Support B	
				RF	LR	RF	LR
(1) POSTING VEHICLE TYPE 1-1				Weight of Vehicle		17 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	16.38	278.5	9.79	166.4
			Live Load	12.60	214.1	7.96	135.3
		Allowable Tension		6.23	105.9	30.54	519.3
	Strength Limit State	Moment	Inventory	4.53	77.0	7.20	122.5
			Operating	7.57	128.6	12.02	204.4
		Shear	Inventory	5.47	93.0	4.15	70.5
			Operating	9.13	155.2	6.92	117.6
Minimum Rating Factor and Load Rating				4.53	77.0	4.15	70.5
(2) POSTING VEHICLE TYPE 1-2				Weight of Vehicle		27 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	11.04	298.1	6.25	168.7
			Live Load	8.49	229.2	5.08	137.2
		Allowable Tension		4.20	113.3	19.50	526.5
	Strength Limit State	Moment	Inventory	3.05	82.5	4.60	124.2
			Operating	5.10	137.7	7.68	207.3
		Shear	Inventory	3.86	104.2	2.66	71.9
			Operating	6.44	173.9	4.45	120.0
Minimum Rating Factor and Load Rating				3.05	82.5	2.66	71.9
(3) POSTING VEHICLE TYPE 12-2				Weight of Vehicle		38 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	9.31	353.7	4.70	178.6
			Live Load	7.16	271.9	3.82	145.3
		Allowable Tension		3.54	134.4	14.67	557.4
	Strength Limit State	Moment	Inventory	2.57	97.8	3.46	131.5
			Operating	4.30	163.3	5.77	219.4
		Shear	Inventory	3.92	149.0	2.05	78.0
			Operating	6.55	248.8	3.43	130.2
Minimum Rating Factor and Load Rating				2.57	97.8	2.05	78.0

NEXT

E. SUMMARY OF RESULTS FOR LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	SECTION C		PIER SUPPORT B		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.53	50.4	1.10	36.2	33T
Type 1-1	17.0	4.53	77.0	4.15	70.5	17T
Type 1-2	27.0	3.05	82.5	2.66	71.9	27T
Type 12-2	38.0	2.57	97.8	2.05	78.0	38T



END AND GO TO DECK SLAB

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : PCDG CONTINUOUS

A. GENERAL

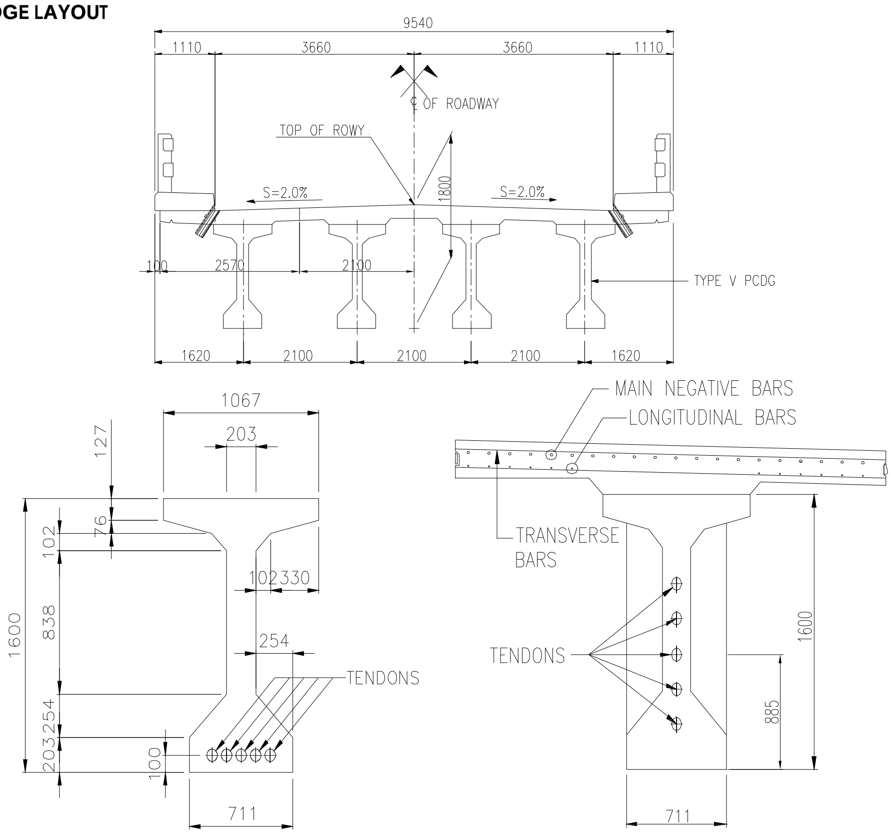
A.1 BRIDGE DESCRIPTION

- Bridge Location : Region II
- Bridge Type : 3-spans Continuous Precast, Prestressed I Girder Bridge
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 35.00m + 35.00m + 35.00m = 105.00m
- Year Built : 2000
- Structure
  - Girders : Precast, Prestressed I Girder Bridge (4-Girders), Monolithic with deck slab
    : Girder spacing at 2.10m on center
  - Substructure : RC bents and RC Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : f'c = 38 Mpa (Girder) , 24.2 Mpa (Slab)
  : fu = 1860 Mpa , Workinf Force: 6750.0 kN (effective after losses)
  : Centroid of PS Tendons: 100 mm from soffit @ midspan, 885mm at Anchorage
- Assumption : Weight of barrier rail = 13.0 KN/m
  : fy (reinforcing bars) = 415 Mpa
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

Reqirement :

Determine the load rating of the interior girder of the span (35.0m) for MS18 (HS20) vehicles considering damages on members

A.2 BRIDGE LAYOUT



RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG CONTINUOUS**

NOTES

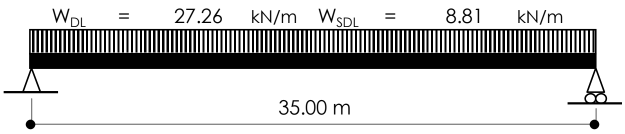
B. DEMAND FORCES

B.1 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight, (2) Fillet/haunch, (3) Tributary area of slab, (4) Barrier rails (Assumed to be equally distributed among girders). (5) Wearing course.

- Self-weight of girder = (0.6532m2) (24 KN/m^3) = 15.680 KN/m
- Slab Weight (Tributary) = (0.20m) (2.10m) (24 KN/m^3) = 10.080 KN/m
- Weight of Diaphram = = 1.50 KN/m
- Barrier rail = 2 (13.0/4) = 6.50 KN/m
- Wearing course = (0.05m) (2.10m) (22 KN/m^3) = 2.31 KN/m
    - Total Uniform Load of Interior Girder, w = 36.07 KN/m
    - Total Uniform Dead Load of Girder, w_{DL} = 27.260 KN/m
    - Total Uniform Superimposed Dead Load of Girder, w_{SDL} = 8.81 KN/m

- Dead Load Moment at Midspan, M_{DL} = 27.26 x 35.00^{2} /8 = 4173.5 KN-m — $M_d = wL^2/8$
- Dead Load Shear at support, V_{DL} = 27.26 x 35.00 /2 = 477.0 KN — $V_d = wL/2$



B.2 LIVE LOAD CALCULATIONS

The carriageway width is 7.32m curb to curb. AASHTO specifies a clear lane width of 5.4m, thus the deck shall carry two-lanes. (Manual 1st Ed. Sect 3.4.2)

The distribution of wheel loads for two traffic lanes for T-beams shall be taken as S/1.829 (DPWH Table 3-4; AASHTO Table 3.23.1 (S/6 in ft.))

- Number of live load wheel line = 2.10 / 1.829 = 1.148
- Impact factor, I = 15.24 / (35.00 + 38.00) = 0.209 (DPWH Sect. 3.2.5.1)

Conducting a Structural Analysis, the load demands for the PCDG Continuous should be obtained separately and input the necessary load demands in the Table below.

Description		At Midspan	At Pier Support
		0.5L	1.0L
Moments	Dead load moments, KN-m	4173.5	0.0
	Superimposed Dead load moments, KN-m	594.7	-792.9
	MS18 moments with impact, KN-m	2441.4	-2770.7
Shears	Dead load shears, KN	0.0	-477.0
	Superimposed Dead load moments, KN-m	0.0	-135.9
	MS18 max. positive Shear force, KN	202.9	67.0
	MS18 max. negative Shear force, KN	-202.9	-465.3
	MS18 max. positive moment, KN-m	2319.3	457.9
	MS18 max. negative moment, KN-m	-2319.3	-449.8

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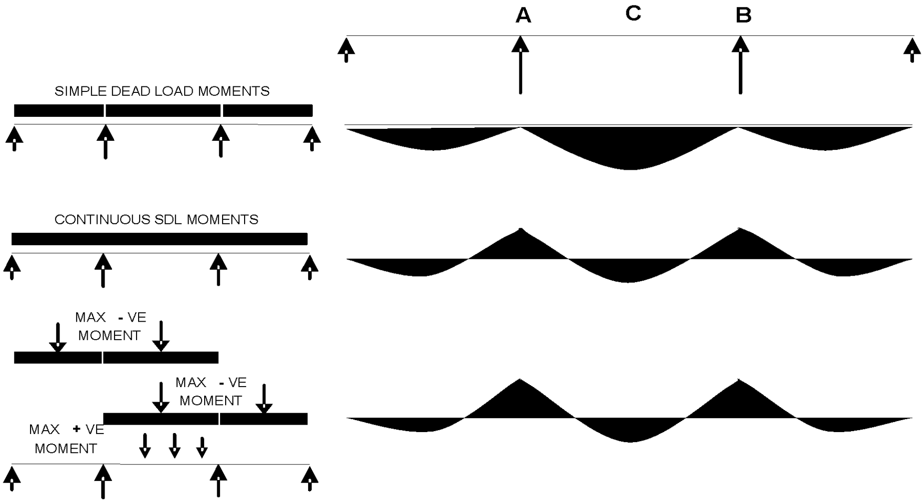

Dead Load Moments (Simple supports)

Superimposed DL Moments (Continuous spans)

MS18 Moments (Continuous Spans)

B.3 SECTION PROPERTIES CALCULATION

The section properties of the prestressed concrete I-girder including that for the composite girder are calculated and given in thetable below:

Description	Area (m^2)	Moment of Inertia (m^4)	Y_{bot} Girder (m)	Y_{top} Girder (m)	Y_{top} Slab (m)
For Dead Load	0.653	0.217	0.812	0.788	NA
For (SDL) and (LL+I)	1.073	0.420	1.159	0.441	0.641

B.4 LOAD STRESS CALCULATIONS

The stresses at different fiber locations are calculated using

$$\sigma = \frac{P}{A} \pm \frac{Mc}{y / I}$$

Estimated Stress Demands at Midspan

LOADING	Stresses in the PCI Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.17	-15.63	6.69
Prestress (Pef = 6750 kN)	-7.13	28.32	2.63
Superimposed Dead Load	0.62	-1.64	0.00
Live Load	2.56	-6.74	0.00
Live Load Moment for Shear	2.43	-6.40	0.00

Estimated Stress Demands at Pier Support

LOADING	Stresses in the PCI Girder (Mpa)			
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite	Centroid of Composite
Dead Load (Self + Slab)	0.00	0.00	0.00	0.00
Prestress (Pef = 6750 kN)	12.13	8.48	11.13	0.00
Superimposed Dead Load	-0.83	2.19	0.00	-1.21
Live Load	-2.91	7.65	0.00	-4.23
Live Load Moment for Shear	-0.47	1.24	0.00	-0.69

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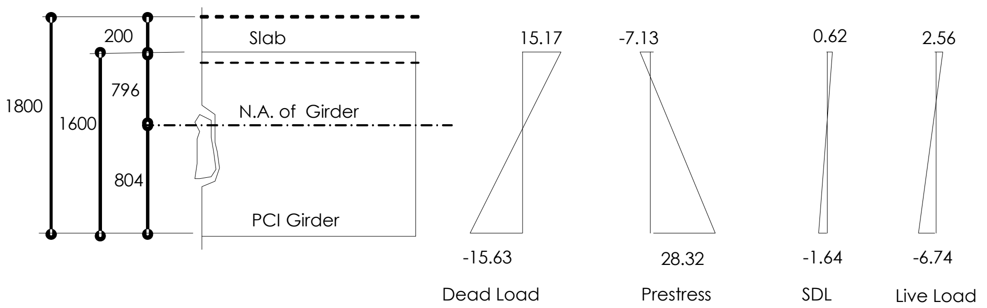
- Stresses due to Dead Load
  - Top Concrete Fiber = 4,173.5 x 0.788 / 0.217 / 1000 = 15.17 Mpa
  - Bottom Concrete Fiber = 4,173.5 x (-0.812) / 0.217 / 1000 = -15.63Mpa
  - Centroid of Composite = 15.17 - (15.17 - (- 15.63) x (0.441 / 1.600) = 6.69 Mpa

- Stresses due to Prestress
  - Top Concrete Fiber = (6750 / 0.653 - 6750 x (0.812 - 0.100) x 0.788 / 0.217) / 1000 = -7.13 Mpa
  - Bottom Concrete Fiber = (6750 / 0.653 + 6750 x (0.812 - 0.100) x 0.812 / 0.217) / 1000 = 28.32 Mpa
  - Centroid of Composite = -7.13 - (-7.13-28.32) x (0.441/1.600) = 2.63 Mpa

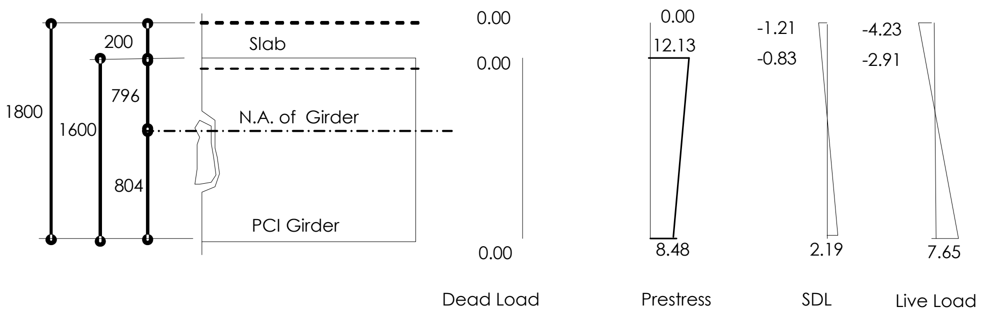
- Stresses due to Superimposed Dead Load
  - Top Concrete Fiber = 594.7 x 0.441 / 0.420 / 1000 = 0.62 Mpa
  - Bottom Concrete Fiber = 594.7 x (-1.159) / 0.420 / 1000 = -1.64 Mpa
  - Centroid of Composite = 1.42 - (1.42 - (- 3.73) x (0.443 / 1.600) = 0.00 Mpa

- Stresses due to Live Load
  - Top Concrete Fiber = 2441.4 x 0.441 / 0.420 / 1000 = 2.56 Mpa
  - Bottom Concrete Fiber = 2441.4 x (-1.159) / 0.420 / 1000 = -6.74 Mpa
  - Centroid of Composite = 1.80 - (1.80 - (- 4.71) x (0.443 / 1.600) = 0.00 Mpa

Stresses due to Live Load for shear force and stresses at Pier Support are obtained by same way of stress calculations. The stresses at Midspan and Pier Support are shown in the following figures.



STRESSES AT MIDSPAN OF GIRDER



STRESSES PIER SUPPORT OF GIRDER

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C. LOAD RATING UNDER SERVICEABILITY LIMIT STATE BY ALLOWABLE STRESS METHOD (ASM) AND UNDER STRENGTH LIMIT STATE BY LOAD FACTOR METHOD (LFM)

C.1 CAPACITY CALCULATIONS

C.1.1 MOMENT CAPACITY AT MIDSPAN

The actual area of prestressing steel can be obtained from as-built plans.
However in the absence of as-built darwings, the following approach can be used.
Assume total loss including creep loss to be
σ_{LOSS} = 204.6 Mpa with $f_{u(Tendons)}$ = 1860.0 Mpa fy = 1570.0 Mpa

Therefore,
Prestressing steel area $= \dfrac{\text{Working Force}}{\text{Effective Stress}} = \dfrac{6750}{(0.75 \times 1860 - 204.6)} \times (1000)$

$= 5670\ mm^2$

b_{eff} = 2100 mm , t_s = 200 mm , b_w = 203 mm
d_p = 1800 - 100 = 1700 mm , f'c (girder) = 38 Mpa , f'c (slab) = 24.2 Mpa

k = 2 x (1.04 - fy / fu) = 2 x (1.04 - 1570.0 / 1860.0) = 0.39

β (girder) = 0.85 - 0.05 / 7 x (f'c - 28) = 0.85 - 0.05 / 7 x (38 - 28) = 0.7786
[in case of, 56 > f'c > 28 ==> β = 0.85 - 0.05 / 7 x (f'c - 28)]

β (slab) = 0.85 [in case of, f'c < 28 ==> β = 0.85]

Ac (girder) = b_w x (N.A. - t_s) = 203 x (560.6 - 200) = 73,201.8 mm^2 (N.A.: Neutral axis location)

Ac (slab) = b_{eff} x t_s = 2100 x 200 = 420,000 mm^2

$$\beta\ (\text{average}) = \frac{[\ f'c\ (\text{slab}) \times Ac\ (\text{slab}) \times \beta\ (\text{slab}) + f'c\ (\text{girder}) \times Ac\ (\text{girder}) \times \beta\ (\text{girder})\ ]}{[\ f'c\ (\text{slab}) \times Ac\ (\text{slab}) + f'c\ (\text{girder}) \times Ac\ (\text{girder})\ ]}$$

$$= \frac{(\ 24.2 \times 420{,}000 \times 0.85 + 38 \times 73201.8 \times 0.7786\ )}{(\ 24.2 \times 420{,}000 + 38 \times 73201.8\ )} = 0.834652$$

$$C\ (\text{slab}) = \frac{Ap \times fu}{[\ 0.85 \times f'c\ (\text{slab}) \times \beta\ (\text{slab}) \times b_{eff} + k \times Ap \times fu / d_p\ ]}$$

$$= \frac{5{,}670 \times 1{,}860}{[\ 0.85 \times 24.2 \times 0.85 \times 2{,}100 + 0.39 \times 5{,}670 \times 1{,}860 / 1{,}700\ ]} = 269.4\ mm$$

fps = fu x [1 - k x C (slab) / d_p] = 1,860 x [1 - 0.39 x 269.4 / 1,700] = 1744.5 Mpa

a = β (slab) x C (slab) = 0.85 x 269.4 = 229.0 mm

S = Ap x fps x (d_p - a / 2) / 10^{-6} = 5,670 x 1,744.5 x (1,700 - 229.0 / 2) / 10-6 = 15,684 kN-m

$$C\ (\text{girder}) = \frac{[\ Ap \times fu - 0.85 \times t_s \times \beta\ (\text{average}) \times \{\ f'c\ (\text{slab}) \times b_{eff} - f'c\ (\text{girder}) \times b_w\ \}\ ]}{[\ 0.85 \times f'c\ (\text{girder}) \times \beta\ (\text{average}) \times b_w + k \times Ap \times fu / d_p\ ]}$$

$$= \frac{[\ 5{,}670 \times 1{,}860 - 0.85 \times 200 \times 0.834652 \times \{\ 24.2 \times 2{,}100 - 38 \times 203\ \}\ ]}{[\ 0.85 \times 38 \times 0.834652 \times 203 + 0.39 \times 5{,}670 \times 1{,}860 / 1{,}700\ ]} = 560.6\ mm$$

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fps = fu x [1 - k x C (girder) / d_p] = 1,860 x [1 - 0.39 x 560.6 / 1,700] = 1619.7 Mpa

a = β (average) x C (girder) = 0.834652 x 560.6 = 467.9 mm

S = [Ap x fps x (d_p - a / 2)
+ 0.85 x β (average) x (f'c (slab) x b_{eff} - f'c (girder) x b_w) x t_s x (a / 2 - t_s / 2) } / 10^{-6}
= 5,670x 1,619.7 x (1,700 - 467.9 / 2)
+ 0.85 x 0.834652 x (24.2 x 2,100 - 38 x 203) x 200 x (467.9 / 2 - 200 / 2) } / 10^{-6}
= **14,284** kN-m <== Governing Moment Capacity (< 15,684 kN-m)

C.1.2 MOMENT CAPACITY AT PIER SUPPORT

There are $15^{nos.}$ - Φ36mm rebars used at Pier Support, thus, the total area of rebars is:

$$AΦ = \frac{\pi}{4} \times 36 \times 36 \times 15 = 1{,}017\ mm^2 \times 15 = 15{,}255\ mm^2$$

Section Loss = 10 % Total assumed area of Steel = 15,255 x 0.9 = 13,730 mm^2

where, Ultimate strength of rebar fy = 415 Mpa, Concrete cover = 38 mm

Centroid of rebar from top of deck = 1800 - 38 - 36 /2 = 1744 mm

Web width beff = 711.0 mm

ρ = As / bd = 13,730 / (1744 x 711) = 0.01107

$$C\ (slab) = \frac{As \times fy}{[\,0.85 \times f'c\ (girder) \times \beta\ (girder) \times b_{eff}\,]}$$

* lower flange

$$= \frac{13{,}730 \times 415}{[\,0.85 \times 38 \times 0.7786 \times 711.0\,]} = 318.7\ mm$$

S = As fy (d - a/2) / 10^{-6} = 13,730 x 415 x (1,744 - 248.1 / 2) / 10-6 = 9,230 kN-m

$$C\ (girder) = \frac{[\,As \times fy - 0.85 \times bw \times \beta\ (girder) \times f'c\ (girder) \times (b_{eff} - b_w)\,]}{[\,0.85 \times f'c\ (girder) \times \beta\ (girder) \times b_{eff}\,]}$$

$$= \frac{[\,13{,}730 \times 415 - 0.85 \times 203 \times 0.7786 \times 38 \times \{\,711.0 - 203\,\}\,]}{[\,0.85 \times 38 \times 0.7786 \times 203\,]} = 608.1\ mm$$

a = β (girder) x C (girder) = 0.7786 x 608.1 = 473.5 mm

S = [As x fy x (d - a / 2)
+ 0.85 x f'c (girder) x (beff - bw) x β (girder) x t_s x (a / 2 - t_s / 2) } / 10^{-6}
= 13,730x 415 x (1,744 - 473.5 / 2)
+ 0.85 x 38 x (711.0 - 203) x 0.7786 x 203 x (473.5 / 2 - 203 / 2) } / 10^{-6}
= 8,939 kN-m <== Governing Moment Capacity (< 15,684 kN-m)

Moment Capacity at Pier Support

R = Φ x S = 0.9 x 8,939 = **8,045** kN-m

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C.1.3 SHEAR CAPACITY AT MIDSPAN

The shear capacity of a section is addressed by the DPWH and AASHTO Design Guidelines and Specifications. Shear capacity depends on the cracking moment of the section. When the live load causes tension at the bottom fiber, cracking moment is to be calculated based on the bottom fiber stress. On the other hand, when the live load causes tension at the top fiber of the beam, cracking moment is to be calculated based on the top fiber stress.

At the midspan location, the moment reported with the maximum live load shear is positive. Positive moments will induce tension at the bottom fiber and thus cracking moment is to be based on the stress at the bottom fiber.

- The cracking moment

  = $(Iz / Y_{bot}) \times (0.5 f'c^{1/2} + fpe - fd)$
  = (0.217 / 0.812) x { 0.5 x sqrt (38) + 28.32 + (-15.63 - 1.64) } x 1000
  = 3775.4 kN-m

- The factored total moment Mmax

  Mmax = $1.3 M_D + 1.3 \times 1.67 \times M_{LL+I}$
  = 1.3 x (4173.5 + 594.7) + 1.3 x 1.67 x 2319.3
  = 11231.6 kN-m

- The factored shear

  Vi = $1.3 V_D + 1.3 \times 1.67 \times V_{LL+I}$
  = 1.3 x (0.0 + 0.0) + 1.3 x 1.67 x 202.9
  = 440.3 kN

  Vci = $0.05 \text{Sqrt}(f'c) b_w d + V_d + V_i M_{cr} / M_{max}$
  = 0.05 Sqrt (38.00) (203) (1.700) + 0.0 + (440.3) (3,775.4 / 11,231.6)
  = 254.4 KN

  Vcw = $(0.3 \times f'c^{1/2} + 0.3 \times fpc) \times bw \times d + Vp$
  = [{ 0.3 x sqrt (24.2) + 0.3 x (6.69 + 2.63 + 0.0) } x 203 x 1700] / 1000
  = 1,474.5 kN

- The shear capacity of the concrete section

  Vc = 254.4 kN ==>> Full Capacity
  Vc' (reduced) = 0.8 x 254.4 = 204.2 KN ==>> Use 80% concrete capacity due to shear cracks (40mm depth)

- The shear capacity of the shear reinforcement

  Vs = $2 Av fy d_{eff} / S$ = 2 x (113.1) (415) (1.700) / (250)
  = 637.8 KN

- The total shear capacity becomes

  Vu = ϕ (Vc + Vs) = 0.85 x (204.2 + 637.8)
  = 715.7 KN

NOTES

Stirrups :
D12mm
A = 113.1 mm^2

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C.1.3 SHEAR CAPACITY AT PIER SUPPORT

At the pier support location, the moment reported with the maximum live load shear is negative. Negative moments will induce tension at the top fiber and thus cracking moment is to be based on the stress at the top fiber.

- The cracking moment

= - (Iz / Y_{bot}) x (0.5 f'c $^{1/2}$ + fpe - fd)
= - (0.420 / 0.641) x { 0.5 x sqrt (24.2) + 0.0 + (0.0 - 1.21) } x 1000
= - 819.2 kN-m

- The factored total moment Mmax

Mmax = 1.3 M_D + 1.3 x 1.67 x M_{LL+I}
= 1.3 x (0.0 - 792.9) + 1.3 x 1.67 x (- 449.8)
= - 2,006.8 kN-m

- The factored shear

Vi = 1.3 V_D + 1.3 x 1.67 x V_{LL+I}
= 1.3 x (- 477.0 - 135.9) + 1.3 x 1.67 x (- 465.3)
= - 1,806.4 kN

Vci = 0.05 Sqrt(f'c) b_w d + V_d + V_i M_{cr} / M_{max}
= 0.05 x sqrt (38) x 203 x 1.744 + (- 477.0 - 135.9) + (- 1806.4) x (- 819.2 / - 2006.8)
= 1,350.4 KN

Vcw = (0.3 x f'c $^{1/2}$ + 0.3 x fpc) x bw x d + Vp
= [{ 0.3 x sqrt (38) + 0.3 x (0.0 + 11.13 + 0.0) } x 203 x 1744] / 1000
= 1,836.5 kN

- The shear capacity of the concrete section

Vc = 1,350.4 kN ==>> Full Capacity
Vc' (reduced) = 0.85 x 1350.4 = 1150.9 KN ==>> Use 85% concrete capacity due to shear cracks (30mm depth)

- The shear capacity of the shear reinforcement

Vs = 2 Av fy d_{eff} / S = 2 x (113.1) (415) (1.744) / (150)
= 1,090.5 KN

Stirrups :
D12mm
A = 113.1 mm^2

- The total shear capacity becomes

Vu = ϕ (Vc + Vs) = 0.85 x (1150.9 + 1090.5)
= 1,905.1 KN

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C.2 LOAD RATING CALCULATIONS

C.2.1 Load Rating Based on Serviceability Limit State by ASM

Serviceability conditions are given in the AASHTO Design Specifications (Section 9.15) and the AASHTO MCEB Manual (Sec. 6.6.3.3)

Note: See Sect. 3.5 of this Manual

i. Using **compressive stress** under all load combination:

Note: This Manual Eq. 3.5-2

Location	$RF_{INV\text{-}COMALL} = \dfrac{0.6\,f'c - (Fd + Fp + Fs)}{Fl}$	$RF_{INV\text{-}COMALL}$
At Midspan	$= \dfrac{0.6\,(38) - (15.80 + (-7.13) + 0.00)}{2.56} =$	5.52
At Pier Support	$= \dfrac{0.6\,(38) - (2.19 + 8.48 + 0.00)}{7.65} =$	1.59

ii. Using **compressive stress** of Live Load, half the prestressing and permanent dead load:

Note: This Manual Eq. 3.5-3

Location	$RF_{INV\text{-}COMLIVE} = \dfrac{0.4\,f'c - 0.5\,(Fd + Fp + Fs)}{Fl}$	$RF_{INV\text{-}COMLIVE}$
At Midspan	$= \dfrac{0.4\,(38) - 0.5\,(15.80 + (-7.13) + 0.00)}{2.56} =$	4.24
At Pier Support	$= \dfrac{0.4\,(38) - 0.5\,(2.19 + 8.48 + 0.00)}{7.65} =$	1.29

iii. Using **allowable tension** in concrete:

Note: This Manual Eq. 3.5-1

Location	$RF_{INV\text{-}COMLIVE} = \dfrac{0.5\,f'c^{\,1/2} - (Fd + Fp + Fs)}{Fl}$	$RF_{INV\text{-}COMLIVE}$
At Midspan	$= \dfrac{-0.5\,(38)^{1/2} - (-17.27 + 28.32 + 0.00)}{-6.74} =$	2.10
At Pier Support	$= \dfrac{-0.5\,(38)^{1/2} - (-0.83 + 12.13 + 0.00)}{-2.91} =$	4.95

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C.2.2 Load Rating Based on Strength Limit State by LFM

The general expression for the Rating Factor is:

$$RF = \frac{\phi \, Rn - \gamma_D D}{\gamma_L \, \beta_L \, L(1+I)}$$

where

γ_D : 1.30
γ_L : 1.30
β_L : 1.67 for inventory
β_L : 1.00 for Operating

LOAD RATING CALCULATIONS (LFM)

Location	Description	Inventory Rating (Tons)		Operating Rating (Tons)	
Midspan	Moment	$\frac{14284-1.3(4174+595)}{1.3(1.67)(2441)}$	= 1.53	$\frac{14284-1.3(4174+595)}{1.3(1.00)(2441)}$	= 2.55
	Shear	$\frac{716-1.3(0+0)}{1.3(1.67)(203)}$	= 1.63	$\frac{716-1.3(0+0)}{1.3(1.00)(203)}$	= 2.71
At Support	Moment	$\frac{-8045-1.3(0-793)}{1.3(1.67)(-2771)}$	= 1.17	$\frac{-8045-1.3(0-793)}{1.3(1.00)(-2771)}$	= 1.95
	Shear	$\frac{-1905-1.3(-477-136)}{1.3(1.67)(-465)}$	= 1.10	$\frac{-1905-1.3(-477-136)}{1.3(1.00)(-465)}$	= 1.83

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
Midspan	Moment	1.53 x 33 = **50.4**	2.55 x 33 = **84.1**
	Shear	1.63 x 33 = **53.6**	2.71 x 33 = **89.5**
At Support	Moment	1.17 x 33 = **38.5**	1.95 x 33 = **64.3**
	Shear	1.10 x 33 = **36.2**	1.83 x 33 = **60.5**

In this example, the Rating Factors (RF) for both the serviceability limit state and the strength limit state are greater than one (RF >> 1) so that there is no need to perform load posting calculations. Therefore, the bridge can safely carry the intended traffic loads.

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D. LOAD POSTING UNDER SERVICEABILITY LIMIT STATE BY ALLOWABLE STRESS METHOD (ASM) AND UNDER STRENGTH LIMIT STATE BY LOAD FACTOR METHOD (LFM)

The procedure for load posting is similar to the above using load posting vehicles for live load.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The live load moments and shears can be separately taken from conducting a structural analysis corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

For 3-span continuous (3@35.0m) bridge, the Posting Live Load demands are:

Vehicle Type	LL Demand	At Midspan	At Pier Support
Moment	Type 1-1	822.1	-448.7
	Type 1-2	1219.9	-702.9
	Type 12-2	1447.3	-934.3
Shear	Type 1-1	60.3	-123.2
	Type 1-2	85.5	-191.8
	Type 12-2	84.1	-248.8

D.2 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE by ASM

Similar calculations are done using Eqs. 3.5-2, 3.5-3 and 3.5-1 for rating factor and load rating

i. Using **compressive stress** under all load combination:

Location $RF_{INV\text{-}COMALL} = \dfrac{0.6\, f'c - (Fd + Fp + Fs)}{FI}$ $RF_{INV\text{-}COMALL}$

This Manual Eq. 3.5-2

Location	Type	Calculation	RF INV-COMALL
At Midspan	Type 1-1	$= \dfrac{0.6\,(38) - (15.80 + (-7.13) + 0.00)}{0.86}$	= 16.38
	Type 1-2	$= \dfrac{0.6\,(38) - (15.80 + (-7.13) + 0.00)}{1.28}$	= 11.04
	Type 12-2	$= \dfrac{0.6\,(38) - (15.80 + (-7.13) + 0.00)}{1.52}$	= 9.31
At Pier Support	Type 1-1	$= \dfrac{0.6\,(38) - (2.19 + 8.48 + 0.00)}{1.24}$	= 9.79
	Type 1-2	$= \dfrac{0.6\,(38) - (2.19 + 8.48 + 0.00)}{1.94}$	= 6.25
	Type 12-2	$= \dfrac{0.6\,(38) - (2.19 + 8.48 + 0.00)}{2.58}$	= 4.70

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG CONTINUOUS**

NOTES

ii. Using **compressive stress** of Live Load, half the prestressing and permanent dead load:

This Manual Eq. 3.5-3

Location		$RF_{INV\text{-}COMLIVE} = \dfrac{0.4\,f'c - 0.5\,(Fd + Fp + Fs)}{Fl}$	$RF_{INV\text{-}COMLIVE}$
At Midspan	Type 1-1	$= \dfrac{0.4\,(38) - 0.5\,(15.80 + (-7.13) + 0.00)}{0.86} =$	12.60
	Type 1-2	$= \dfrac{0.4\,(38) - 0.5\,(15.80 + (-7.13) + 0.00)}{1.28} =$	8.49
	Type 12-2	$= \dfrac{0.4\,(38) - 0.5\,(15.80 + (-7.13) + 0.00)}{1.52} =$	7.16
At PierSupport	Type 1-1	$= \dfrac{0.4\,(38) - 0.5\,(2.19 + 8.48 + 0.00)}{1.24} =$	7.96
	Type 1-2	$= \dfrac{0.4\,(38) - 0.5\,(2.19 + 8.48 + 0.00)}{1.94} =$	5.08
	Type 12-2	$= \dfrac{0.4\,(38) - 0.5\,(2.19 + 8.48 + 0.00)}{2.58} =$	3.82

iii. Using **allowable tension** in concrete:

This Manual Eq. 3.5-1

Location		$RF_{INV\text{-}COMLIVE} = \dfrac{0.5\,f'c^{1/2} - (Fd + Fp + Fs)}{Fl}$	$RF_{INV\text{-}COMLIVE}$
At Midspan	Type 1-1	$= \dfrac{-0.5\,(38)^{1/2} - (-17.27 + 28.32 + 0.00)}{-2.27} =$	6.23
	Type 1-2	$= \dfrac{-0.5\,(38)^{1/2} - (-17.27 + 28.32 + 0.00)}{-3.37} =$	4.20
	Type 12-2	$= \dfrac{-0.5\,(38)^{1/2} - (-17.27 + 28.32 + 0.00)}{-4.00} =$	3.54
At Pier Support	Type 1-1	$= \dfrac{-0.5\,(38)^{1/2} - (-0.83 + 12.13 + 0.00)}{-0.47} =$	30.54
	Type 1-2	$= \dfrac{-0.5\,(38)^{1/2} - (-0.83 + 12.13 + 0.00)}{-0.74} =$	19.50
	Type 12-2	$= \dfrac{-0.5\,(38)^{1/2} - (-0.83 + 12.13 + 0.00)}{-0.98} =$	14.67

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LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG CONTINUOUS**

NOTES

D.3 Load Rating Based on Strength Limit State by LFM

Similar calculations are done same as section C.2.2

LOAD RATING CALCULATIONS (LFM)

Location	Description	Inventory Rating (Tons)		Operating Rating (Tons)	
At Midspan Moment	Type 1-1	$\frac{14284-1.3(4174+595)}{1.3(1.67)(822)}$	= 4.53	$\frac{14284-1.3(4174+595)}{1.3(1.00)(822)}$	= 7.57
	Type 1-2	$\frac{14284-1.3(4174+595)}{1.3(1.67)(1220)}$	= 3.05	$\frac{14284-1.3(4174+595)}{1.3(1.00)(1220)}$	= 5.10
	Type 12-2	$\frac{14284-1.3(4174+595)}{1.3(1.67)(1447)}$	= 2.57	$\frac{14284-1.3(4174+595)}{1.3(1.00)(1447)}$	= 4.30
At Midspan Shear	Type 1-1	$\frac{716-1.3(0+0)}{1.3(1.67)(60)}$	= 5.47	$\frac{716-1.3(0+0)}{1.3(1.00)(60)}$	= 9.13
	Type 1-2	$\frac{716-1.3(0+0)}{1.3(1.67)(86)}$	= 3.86	$\frac{716-1.3(0+0)}{1.3(1.00)(86)}$	= 6.44
	Type 12-2	$\frac{716-1.3(0+0)}{1.3(1.67)(84)}$	= 3.92	$\frac{716-1.3(0+0)}{1.3(1.00)(84)}$	= 6.55
At Pier Support Moment	Type 1-1	$\frac{-8045-1.3(0-793)}{1.3(1.67)(-449)}$	= 7.20	$\frac{-8045-1.3(0-793)}{1.3(1.00)(-449)}$	= 12.02
	Type 1-2	$\frac{-8045-1.3(0-793)}{1.3(1.67)(-703)}$	= 4.60	$\frac{-8045-1.3(0-793)}{1.3(1.00)(-449)}$	= 7.68
	Type 12-2	$\frac{-8045-1.3(0-793)}{1.3(1.67)(-934)}$	= 3.46	$\frac{-8045-1.3(0-793)}{1.3(1.00)(-449)}$	= 5.77
At Pier Support Shear	Type 1-1	$\frac{-1905-1.3(-477-136)}{1.3(1.67)(-123)}$	= 4.15	$\frac{-1905-1.3(-477-136)}{1.3(1.00)(-123)}$	= 6.92
	Type 1-2	$\frac{-1905-1.3(-477-136)}{1.3(1.67)(-192)}$	= 2.66	$\frac{-1905-1.3(-477-136)}{1.3(1.00)(-192)}$	= 4.45
	Type 12-2	$\frac{-1905-1.3(-477-136)}{1.3(1.67)(-249)}$	= 2.05	$\frac{-1905-1.3(-477-136)}{1.3(1.00)(-249)}$	= 3.43

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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : **** PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG CONTINUOUS**

NOTES

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18, W = 33 Metric Tons)

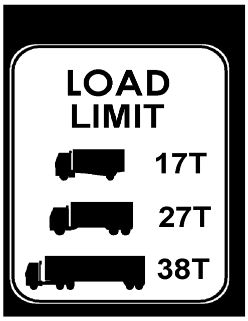
Location	Description	Inventory Rating (Tons)	Operating Rating (Tons)
At Midspan Moment	Type1-1	4.53 x 17 = **77.0**	7.57 x 17 = **128.6**
	Type 1-2	3.05 x 27 = **82.5**	5.10 x 27 = **137.7**
	Type 12-2	2.57 x 38 = **97.8**	4.30 x 38 = **163.3**
At Midspan Shear	Type1-1	5.47 x 17 = **93.0**	9.13 x 17 = **155.2**
	Type 1-2	3.86 x 27 = **104.2**	6.44 x 27 = **173.9**
	Type 12-2	3.92 x 38 = **149.0**	6.55 x 38 = **248.8**
At Support Moment	Type1-1	7.20 x 17 = **122.5**	12.02 x 17 = **204.4**
	Type 1-2	4.60 x 27 = **124.2**	7.68 x 27 = **207.3**
	Type 12-2	3.46 x 38 = **131.5**	5.77 x 38 = **219.4**
At Support Shear	Type1-1	4.15 x 17 = **70.5**	6.92 x 17 = **117.6**
	Type 1-2	2.66 x 27 = **71.9**	4.45 x 27 = **120.0**
	Type 12-2	2.05 x 38 = **78.0**	3.43 x 38 = **130.2**

D. SUMMARY OF LOAD POSTING

The summary of calculation results for both the load factor and the allowable stress methods are presented below.

SUMMARY OF RESULTS FOR LOAD POSTING

Vehicle Type	Vehicle Weight (Metric Tons)	At Midspan		At Support		POSTING (Metric Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.53	50.4	1.10	36.2	**33**
Type 1-1	17.0	4.53	77.0	4.15	70.5	**17**
Type 1-2	27.0	3.05	82.5	2.66	71.9	**27**
Type 12-2	38.0	2.57	97.8	2.05	78.0	**38**



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	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : ****	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **PCDG CONTINUOUS**	

NOTES

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RATED BY :	DATE :	CHECKED BY :	DATE :

EXAMPLE 4

STEEL I-GIRDER BRIDGE

Example 4-1: Simple

Example 4-2: Continuous

INTERIOR SIG SIMPLE

A. GENERAL

BACK TO MENU

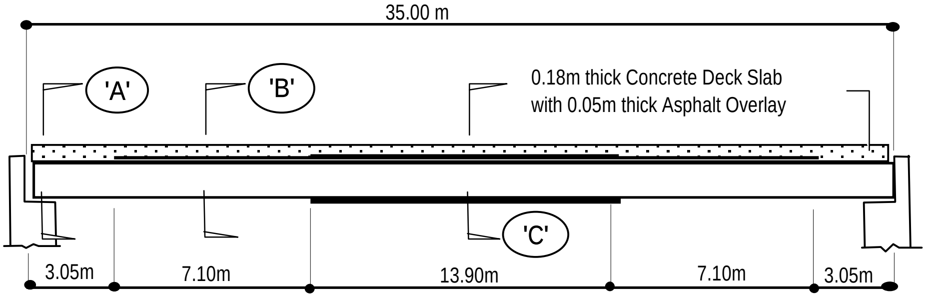
A1. BRIDGE DESCRIPTION

Bridge Location	REGION	VII					
Bridge Name		MANANGA II Bridge					
Bridge Type	Simple or Continuous	S	Steel I-Girder Bridge				
	Number of Span	4					
Bridge Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		35.000	35.000	35.000	35.000		=140.000m
Year Built		1970					
Structure	Nos. of Girder	3	Multiple Girder composite for live load				
	Girder Spacing (m)	3.200	on centers				
	Substructure	RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	265.0	Mpa
		f'c=	20.7	Mpa	fy=	482.0	Mpa
Assumption		Weight of barrier rail Wbr =			4.600	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Steel Girder Unit Weight Ws =			77.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

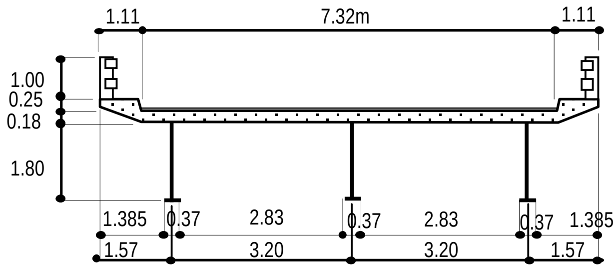
NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Structural Steel Bending	**Prior to 1905**	179.3	96.5	134.4	96.5	
	1905 to 1936	206.8	110.3	155.1	110.3	
	1936 to 1963	227.5	124.1	168.9	124.1	
	after 1963	248.2	137.9	186.2	137.9	
Structural Steel Web Shear	**Prior to 1905**	179.3	58.6	79.3	58.6	
	1905 to 1936	206.8	65.5	93.1	65.5	
	1936 to 1963	227.5	75.8	103.4	75.8	
	after 1963	248.2	82.7	110.3	82.7	
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	189.8	224.1	137.9	*pc
	Grade 60	413.7	227.5	248.2	165.5	*pc
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc

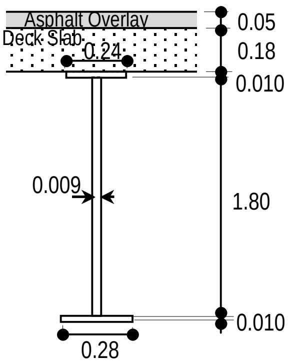
A2. BRIDGE LAYOUT AND DIMENSION



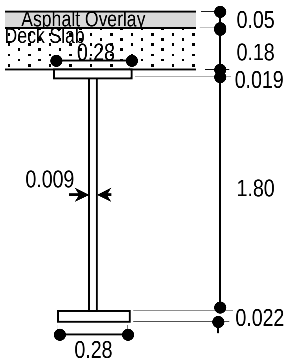
ELEVATION



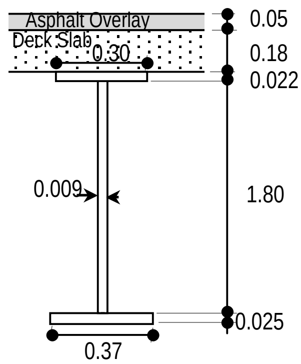
TYPICAL SECTION



SECTION 'A'



SECTION 'B'



SECTION 'C'

GIRDER SECTION							
SECTION	SECTION A (At Support)		SECTION B (Dummy)		SECTION C (At Midspan)		
Location (m)	0.010		1.000		17.500		
Dimension	b (m)	h (m)	b (m)	h (m)	b (m)	h (m)	
Slab	thickness = 0.180 m						
	0.320	0.180	0.320	0.180	0.320	0.180	*10 (Modular Ratio)
Uflg	0.240	0.010	0.280	0.019	0.300	0.022	
	0.000	0.000	0.000	0.000	0.000	0.000	
Web	0.009	1.800	0.009	1.800	0.009	1.800	
	0.000	0.000	0.000	0.000	0.000	0.000	
Lflg	0.280	0.010	0.280	0.022	0.370	0.025	
	0.000	0.000	0.000	0.000	0.000	0.000	
Length	6.100		14.200		13.900		

NEXT

B. DEMAND FORCES

B.1 INPUT AND SECTION PROPERTIES

B0. INPUT	
Slab thickness ts (m)	0.180
Slab width ws (m)	3.200
Span Length L(m)	35.000

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) UNDER DEAD LOAD (NON-COMPOSIE GIRDER)							
SECTION	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
A (At Support)	0.02140	0.01620	0.00863	0.89308	0.92692	0.00966	0.00931
B (Dummy)	0.02768	0.01620	0.01387	0.89407	0.94693	0.01551	0.01464
C (At Midspan)	0.03205	0.01620	0.01737	0.84924	0.99776	0.02045	0.01741
(2) UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (COMPOSIE GIRDER)							
A (At Support)	0.07900	0.01620	0.02492	1.63453	0.18547	0.01524	0.13435
B (Dummy)	0.08528	0.01620	0.03412	1.59443	0.24657	0.02140	0.13840
C (At Midspan)	0.08965	0.01620	0.04189	1.54813	0.29887	0.02706	0.14016

Standard Section Area of "SECTION A"	
Original Section Area (m^2)	0.0214

B.2 DEAD LOAD CALCULATIONS

B2. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	Section A (At Support)	0.287
		Section B (Dummy)	0.865
		Section C (At Midspan)	0.980
		Stiffener and Bracing	0.267
	Slab Weight	Continuous	13.824
	Barrier Rail		3.067
	Asphalt Overlay		3.520
	Total Load		22.809
	Total DeadLoad		16.223
	Total Superimposed Dead Load		6.587
Dead Load	Moment (KN-m/m)	M_{DL}	2484.1
	Shear (KN)	V_{DL}	283.9
Superimposed Dead Load	Moment (KN-m/m)	M_{DL}	1008.6
	Shear (KN)	V_{DL}	115.3

NEXT

B3. LIVE LOAD CALCULATIONS

B3. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.750			
Impact factor	0.209			
span	35.00			
Max.MS18 moment for 35.00m span /wheel line		without Impact	M_L	819.75
		with Impact	M_{LL}	1733.65
Max.MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	143.49
		with Impact	V_{LL}	303.46

B4. LOAD DEMANDS ON DIFFERENT SECTIONS OF STEEL GIRDER

B4. LOAD DEMAND MIDSPAN AND SUPPORT OF STEEL GIRDER			
Loading	At Support	Section B (Dummy)	At Midspan
	0.01m	1.00m	17.50m
Dead load moments, KN-m	2.8	275.8	2484.1
Dead load shears, KN	283.7	267.7	0.0
SDL moments, KN-m	1.2	112.0	1008.58
SDL shears, KN	115.2	108.7	0.0
LL moment + Impact, KN-m	3.1	305.0	1733.6
LL shear + Impact, KN	314.7	305.0	118.7

B5. LOAD STRESS CALCULATIONS

ESTIMATED STRESS DEMANDS AT GIRDER SECTIONS				
Loading	Location	At Support	Section B (Dummy)	At Midspan
DL moment	Top	**0.30**	**18.83**	**142.69**
	Bottom	**-0.29**	**-17.78**	**-121.45**
SDL moment	Top	**0.01**	**0.81**	**7.20**
	Bottom	**-0.08**	**-5.23**	**-37.27**
LL+I moment, σ_{LL+I}^{t}	Top	**0.02**	**2.20**	**12.37**
	Bottom	**-0.21**	**-14.25**	**-64.07**
DL shear, v_{DL}		**17.51**	**16.52**	**0.00**
SDL shear, v_{SDL}		**7.11**	**6.71**	**0.00**
LL+I shear, v_{LL+I}		**19.42**	**18.83**	**7.33**

NEXT

C. LOAD RATING BY ALLOWABLE STRESS METHOD

C1. ALLOWABLE STRESS CALCULATIONS

C.1.1 ALLOWABLE STRESSES FOR CONCRETE AND STEEL				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	265.0
		Strength	fy	482.0

C.1.2 COMPRESSION AND TENSILE STRESSES		
Allowable compressive stress	Inventory	265.0
	Operating	361.5
Allowable tensile stress	Inventory	265.0

C.1.3 ALLOWABLE SHEAR STRESS		
Allowable Shear Stress	Inventory	160.7
	Operating	216.9

C2. LOAD RATING CALCULATIONS

C2.1 RATING FACTOR CALCULATIONS USING ASM

Section	Description	Inventory	Operating
At Support	Stress at Top Fiber	11301.38	15421.66
	Stress at Bottom Fiber	1282.08	1749.61
	Shear	7.01	9.90
B (Dummy)	Stress at Top Fiber	111.34	155.14
	Stress at Bottom Fiber	16.98	23.75
	Shear	7.30	10.29
At Midspan	Stress at Top Fiber	9.31	17.11
	Stress at Bottom Fiber	1.66	3.17
	Shear	21.94	29.61

C2.2 LOAD RATING CALCULATIONS

Section	Description	Rating Live Load (Metric Tons)			33.0
		Inventory		Operating	
At Support	Moment	1282.08	42308.7	1749.61	57737.0
	Shear	7.01	231.2	9.90	326.7
B (Dummy)	Moment	16.98	560.4	23.75	783.9
	Shear	7.30	241.0	10.29	339.5
At Midspan	Moment	1.66	54.7	3.17	104.4
	Shear	21.94	723.9	29.61	977.1

Depend on the minimum value of Rating Factor > 1 or <1 ,
instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY ALLOWABLE STRESS (ASM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

(1) POSTING VEHICLE Type 1-1

LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.750			
Impact factor	0.209			
span	35.00			
Type 1-1 moment for 35.00m span /wheel line		without Impact	M_L	695.45
		with Impact	M_{LL}	1470.77
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	80.64
		with Impact	V_{LL}	170.54

(2) POSTING VEHICLE Type 1-2

LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 35.00m span /wheel line		without Impact	M_L	1036.00
		with Impact	M_{LL}	2190.98
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	120.43
		with Impact	V_{LL}	254.69

(3) POSTING VEHICLE Type 12-2

LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 35.00m span /wheel line		without Impact	M_L	1261.27
		with Impact	M_{LL}	2667.39
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	144.01
		with Impact	V_{LL}	304.56

D1.2 POSTING VEHICLE DEMAND FORCES AT MIDSPAN, SUPPORT

Posting Vehicle	Demand Forces	At Support	B (Dummy)	At Midspan
		0.01m	1.00m	17.50m
Type 1-1	Moment	1.72	167.24	1470.77
	Shear	172.24	167.24	83.99
Type 1-2	Moment	2.62	254.05	2190.98
	Shear	261.98	254.05	121.95
Type 12-2	Moment	3.30	319.22	2667.39
	Shear	330.38	319.22	133.28

D1.3 POSTING VEHICLE DEMAND STRESSES AT MIDSPAN, SUPPORT

Posting Vehicle	Demand Forces	At Support	B (Dummy)	At Midspan
Type 1-1	Top Fiber	0.01	1.21	10.49
	Bottom Fiber	-0.11	-7.81	-54.35
	Shear	10.63	10.32	5.18
Type 1-2	Top Fiber	0.02	1.84	15.63
	Bottom Fiber	-0.17	-11.87	-80.97
	Shear	16.17	15.68	7.53
Type 12-2	Top Fiber	0.02	2.31	19.03
	Bottom Fiber	-0.22	-14.92	-98.58
	Shear	20.39	19.70	8.23

NEXT

E. POSTING LOAD RATING FACTOR CALCULATIONS

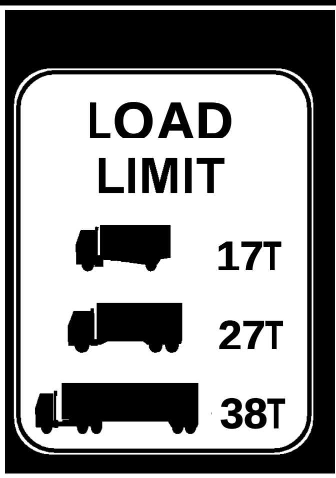
E1. LOAD POSTING RATING FACTOR CALCULATIONS (1)

Posting Vehicle		At Supprot		B (Dummy)		At Midspan	
		Inventory	Operating	Inventory	Operating	Inventory	Operating
Type 1-1	Top Fiber	19138.80	26666.17	203.04	282.89	10.97	20.17
	Bott Fiber	2141.82	2995.94	30.97	43.32	1.96	3.73
	Shear	12.80	18.08	13.32	18.76	31.00	41.84
Type 1-2	Top Fiber	12582.61	17531.41	133.66	21.80	7.36	13.54
	Bott Fiber	1408.12	1969.65	20.39	28.51	1.31	2.50
	Shear	8.41	11.89	8.77	12.35	21.35	28.81
Type 12-2	Top Fiber	9977.65	13901.90	106.37	148.21	6.05	11.12
	Bott Fiber	1116.60	1561.88	16.22	22.69	1.08	2.06
	Shear	6.67	9.43	6.98	9.83	19.53	26.36

E2. LOAD POSTING RATING FACTOR CALCULATIONS (2)

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory				Operating				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) AT SUPPORT										
MS18	33.0	1,282.08	42308.7	7.01	231.2	1,749.61	57737.0	9.90	326.7	**33**
Type 1-1	17.0	2,141.82	36410.9	12.80	217.6	2,995.94	50931.0	18.08	307.4	**17**
Type 1-2	27.0	1,408.12	38019.1	8.41	227.2	1,969.65	53180.5	11.89	321.0	**27**
Type 12-2	38.0	1,116.60	42430.6	6.67	253.6	1,561.88	59351.3	9.43	358.3	**38**
(2) SECTION B (Dummy)										
MS18	33.0	16.98	560.4	7.30	241.0	23.75	783.9	10.29	339.5	**33**
Type 1-1	17.0	30.97	526.4	13.32	226.4	43.32	736.4	18.76	318.9	**17**
Type 1-2	27.0	20.39	550.4	8.77	236.7	21.80	588.6	12.35	333.4	**27**
Type 12-2	38.0	16.22	616.5	6.98	265.1	22.69	862.3	9.83	373.5	**38**
(3) AT MIDSPAN										
MS18	33.0	1.66	54.7	21.94	723.9	3.17	104.4	29.61	977.1	**33**
Type 1-1	17.0	1.96	33.2	31.00	526.9	3.73	63.4	41.84	711.2	**17**
Type 1-2	27.0	1.31	35.4	21.35	576.4	2.50	67.6	28.81	778.0	**27**
Type 12-2	38.0	1.08	41.0	19.53	742.2	2.06	78.2	26.36	1001.8	**38**

Load Posting	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**



END AND GO TO DECK SLAB

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG SIMPLE**

A. GENERAL

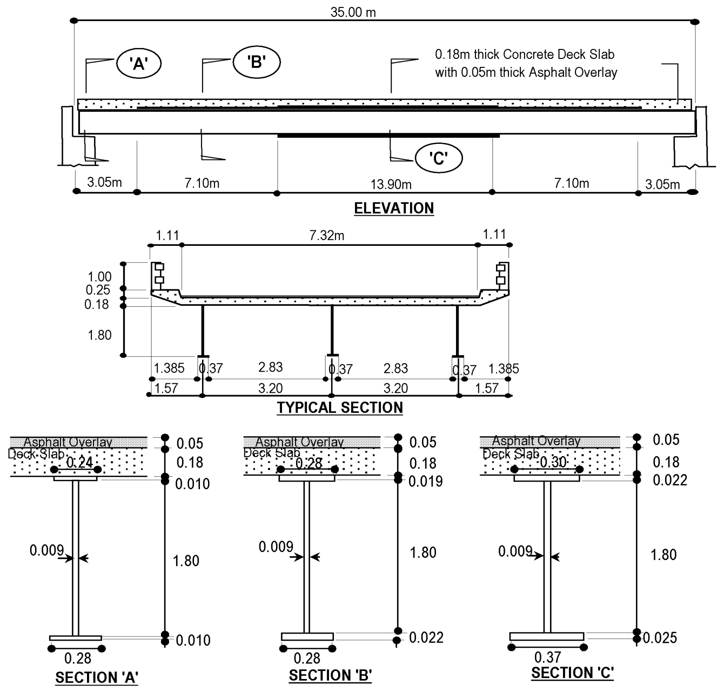
A.1 BRIDGE DESCRIPTION

- Bridge Location : REGION VII
- Bridge Type : 1-Span Steel I-Girder
- Br. Width / No. of Lanes : 7.32m curb to curb / Two-lanes
- Bridge Length : 35.000 m (Back of backwall)
- Year Built : 1970
- Structure :
  - Girders : Multiple Girders (3-Girders) composite for live load
    : Girder spacing at 3.20m on center
  - Substructure : RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : fc = 8.3 Mpa , fs = 265.0 Mpa
  : f'c = 20.7 Mpa , fy = 482.0 Mpa
- Assumption : Weight of barrier rail = 4.6 KN/m (Assumed including sidewalk,etc)
  : Concrete unit weight = 24.0 KN/m^3
  : Steel Girder unit weight = 77.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

  Reqirement :

  Determine the critical rating factor of the interior girder using ASM Method

A.2 BRIDGE LAYOUT AND SECTION



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B. DEMAND FORCES

NOTES

B.1 SECTION PROPERTIES

The section properties of the steel I-girder on each section are calculated and given in the table below:

A. UNDER DEAD LOAD (Non-composite Girder)

SECTION	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
A	0.02140	0.01620	0.00863	0.89308	0.92692	0.00966	0.00931
B	0.02768	0.01620	0.01387	0.89407	0.94693	0.01551	0.01464
C	0.03205	0.01620	0.01737	0.84924	0.99776	0.02045	0.01741

B. UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (Composite Girder)

SECTION	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
A	0.07900	0.01620	0.02492	1.63453	0.18547	0.01524	0.13435
B	0.08528	0.01620	0.03412	1.59443	0.24657	0.02140	0.13840
C	0.08965	0.01620	0.04189	1.54813	0.29887	0.02706	0.14016

B.2 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight,
(2) Tributary area of slab, (3) Barrier rails (Assumed to be equally distributed among girders).
(4) Wearing course.

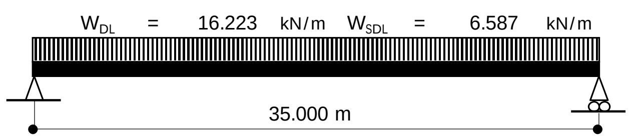
- Self-weight of girder = (0.02140 Sq.m.) x (6.10m) x 77 / 35.000 m = 0.287 KN/m
  = (0.02768 Sq.m.) x (14.20m) x 77 / 35.000 m = 0.865 KN/m
  = (0.03205 Sq.m.) x (13.90m) x 77 / 35.000 m = 0.980 KN/m
  = (0.287 + 0.865 + 0.980) x 15% = 0.267 KN/m
- Slab Weight (Tributary) = (0.18m) (3.20m) (24 KN/m^3) = 13.824 KN/m
- Barrier rail = 2 (4.6 /3) = 3.067 KN/m
- Wearing course = (0.05m) (3.20m) (22 KN/m^3) = 3.520 KN/m
  - Total Uniform Load of Girder, w = 22.809 KN/m
  - Total Uniform Dead Load of Girder, w_{DL} = 16.223 KN/m
  - Total Uniform Superimposed Dead Load of Girder, w_{SDL} = 6.587 KN/m

- Dead Load Moment at Midspan, M_{DL} = 16.223 x 35.00^2 /8 = 2484.1 KN-m

- Superimposed Dead Load Moment at Midspan, M_{SDL} = 6.587 x 35.00^2 /8 = 1008.6 KN-m

- Dead Load Shear at support, V_{DL} = 16.223 x 35.00 / 2 = 283.9 KN

- Superimposed Dead Load Shear at support, V_{SDL} = 6.587 x 35.00 / 2 = 115.3 KN



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B.3 LIVE LOAD CALCULATIONS

The carriageway width is 7.35m curb to curb. Thus, the bridge can carry 2-lanes of traffic.

The distribution of wheel loads for two traffic lanes shall be taken as S/1.676

- Number of live load wheel line = 3.20 / 1.829 = 1.750
- Impact factor, I = 15.24 / (35.00 + 38.00) = 0.209

The live load moments and shear values are taken from the tables in Appendix III on this manual and are used to determine the live load demand forces.

- Max. MS18 moment for 35.00 m span without impact/whel line = 819.80 KN-m
- Thus, MS18 moment with Impact at midspan M_{LL} = 1.750 1.209 (819.80) = 1733.75 KN-m
- Max. MS18 shear at the support/wheel line = 143.50 KN
- Thus, MS18 shear V_{LL} = 1.750 1.209 (143.50) = 303.48 KN

B.4 LOAD DEMANDS ON DIFFERENT SECTIONS OF STEEL GIRDER

ESTIMATED LOAD DEMANDS AT GIRDER SECTIONS (MS18)

LOADING	At Support 0.01 m	Sect. B (Dummy) 1.00 m	At Midspan 17.50 m
Dead load moment, kN-m	2.8	275.8	2484.1
Dead load shear, kN	283.7	267.7	0.0
SDL moment, kN-m	1.2	112.0	1008.6
SDL shear, kN	115.2	108.7	0.0
LL Moment + Impact, kN-m	3.1	305.0	1733.6
LL Shear + Impact, kN	314.7	305.0	118.7

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B.5 LOAD STRESS CALCULATIONS

The resulting stresses due to bending and shear are calculated using the given load demands and the appropriate section properties at given section locations under consideration. The stress results are shown in the table below.

Estimated Stress Demands at Girder Sections In Mpa

LOADING	At Support	Sect. B (Dummy)	At Midspan
	0.01 m	1.00 m	17.50 m
Dead Load Moment, Top	0.30	18.84	142.69
Dead Load Moment, Bottom	-0.29	-17.78	-121.47
SDL Moment, Top	0.01	0.81	7.20
SDL Moment, Bottom	-0.08	-5.23	-37.27
Live Load Moment, Top	0.02	2.20	12.37
Live Load Moment, Bottom	-0.20	-14.25	-64.07
Dead Load Shear	17.51	16.52	0.00
SDL Shear	7.11	6.71	0.00
Live Load Shear	19.43	18.83	7.33

-ve : tension
+ve : compression

C. LOAD RATING BY ALLOWABLE STRESS METHOD (ASM)

C.1 ALLOWABLE STRESS CALCULATIONS

C.1.1 Allowable Stresses for Concrete and Steel

The actual material properties for concrete and steel can be obtained from as-built plans.

Concrete : f'c = fc / 0.40 = 8.3 / 0.4 = 20.7 Mpa
(fc = 8.27 Mpa) (After 1959, f'c= 20.7 Mpa)

Steel : fs = 265.0 Mpa => fy = 482.0 Mpa

C.1.2 Compression and Tensile Stresses

Note that the section is fully braced at this location.

i. Allowable compressive stress at inventory 0.55 fy = 265.0 Mpa

ii. Allowable comp./tensile stress at operating 0.75 fy = 361.5 Mpa

iii. Allowable tensile stress at inventory 0.55 fy = 265.0 Mpa

C.1.3 Allowable Shear Stress

i. Allowable shear stress at inventory fy/3 = 160.7 Mpa

ii. Allowable shear stress at operating (0.45 fy) = 216.9 Mpa

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C.2 LOAD RATING CALCULATIONS

The rating factor (RF) in the Allowable Stress Method (ASD) is given by:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)} \qquad \text{Where : } A_1 = 1.0, \quad A_2 = 1.0$$

and substituting the values will give us the results as presented in the table below:

RATING FACTOR CALCULATIONS USING ALLOWABLE STRESS METHOD

Section	Description	INVENTORY RATING	OPERATING RATING
At Support	Stress at top Fiber	$\frac{265.0 - 0.31}{0.02} = 13234.50$	$\frac{361.5 - 0.31}{0.02} = 18059.50$
	Stress at Bot Fiber	$\frac{-265.0 - -0.37}{-0.21} = 1260.14$	$\frac{-361.5 - -0.37}{-0.21} = 1719.67$
	Shear	$\frac{160.7 - 24.62}{19.42} = 7.01$	$\frac{216.9 - 24.62}{19.42} = 9.90$
Sect. B Dummy	Stress at top Fiber	$\frac{265.0 - 19.64}{2.20} = 111.53$	$\frac{361.5 - 19.64}{2.20} = 155.39$
	Stress at Bot Fiber	$\frac{-265.0 - -23.01}{-14.25} = 16.98$	$\frac{-361.5 - -23.01}{-14.25} = 23.75$
	Shear	$\frac{160.7 - 23.23}{18.83} = 7.30$	$\frac{216.9 - 23.23}{18.83} = 10.29$
At Midspan	Stress at top Fiber	$\frac{265.0 - 149.89}{12.37} = 9.31$	$\frac{361.5 - 149.89}{12.37} = 17.11$
	Stress at Bot Fiber	$\frac{-265.0 - -158.72}{-64.07} = 1.66$	$\frac{-361.5 - -158.72}{-64.07} = 3.16$
	Shear	$\frac{160.7 - 0.00}{7.33} = 21.92$	$\frac{216.9 - 0.00}{7.33} = 29.59$

LOAD RATING CALCULATIONS
(Rating Live Load = MS18 W=33 Metric Tons

Section	Description	INVENTORY RATING (Tons)					OPERATING RATING (Tons)				
At Support	Moment	1260.14	x	33	=	**41584.7**	1719.67	x	33	=	56749.0
	Shear	7.01	x	33	=	231.2	9.90	x	33	=	326.7
Sect. B Dummy	Moment	16.98	x	33	=	560.4	23.75	x	33	=	783.9
	Shear	7.30	x	33	=	**240.9**	10.29	x	33	=	339.4
At Midspan	Moment	1.66	x	33	=	**54.7**	3.16	x	33	=	104.4
	Shear	21.92	x	33	=	723.5	29.59	x	33	=	976.5

Rating Factors at sections At Support, Sect. B, and At Midspan have values over than 1, thus Posting Loads is not necessary.

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D. LOAD POSTING BY ALLOWABLE STRESS METHOD (ASM)

The procedure for load posting is similar to the above using load posting vehicles for live load. Posting live loads Type 1-1, Type 1-2 and Type 12-2 will be used as live load vehicles.

D.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

The demand forces are calculated based on the Appendix III of the Manual using the Type 1-1, 1-2 and 12-2 posting vehicles.

POSTING VEHICLE DEMAND FORCES AT SECTIONS AT SUPPORT, SECT. B AND AT MIDSPAN

Demand Forces	TYPE 1-1			TYPE 1-2			TYPE 12-2		
	At Support	SECT. B Dummy	At Midspan	At Support	SECT. B Dummy	At Midspan	At Support	SECT. B Dummy	At Midspan
Moment (kN-m)	1.72	167.24	1470.77	2.62	254.05	2190.98	3.30	319.22	2667.39
Shear (kN)	172.24	167.24	83.99	261.98	254.05	121.95	330.38	319.22	133.28

DF = 1.750 I = 1.209

The stress demands corresponding to the above forces are calculated and tabulated below:

(In Mpa)

Demand Forces	TYPE 1-1			TYPE 1-2			TYPE 12-2		
	At Support	SECT. B Dummy	At Midspan	At Support	SECT. B Dummy	At Midspan	At Support	SECT. B Dummy	At Midspan
Top Fiber	0.01	1.21	10.49	0.02	1.84	15.63	0.02	2.31	19.03
Bottom Fiber	-0.11	-7.81	-54.35	-0.17	-11.87	-80.97	-0.22	-14.92	-98.57
Shear	10.63	10.32	5.18	16.17	15.68	7.53	20.39	19.70	8.23

-ve : tension +ve : compression

Using the capacities and dead load demand stresses calculated, the load posting values are obtained by substituting the posting live load stress demands in the rating equation.

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NOTES

E. LOAD POSTING RATING FACTOR CALCULATIONS

LOAD POSTING RATING FACTOR CALCULATIONS
AT SUPPORT

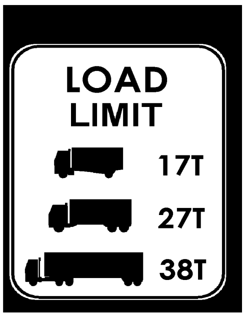
Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	**33.0**	1282	42306	7.01	231.2	1750	57750	9.90	326.7	**33**
Type 1-1	**17.0**	2142	36414	12.80	217.6	2996	50932	18.08	307.36	**17**
Type 1-2	**27.0**	1408	38016	8.41	227.1	1970	53190	11.89	321.03	**27**
Type 12-2	**38.0**	1117	42446	6.67	253.5	1562	59356	9.43	358.34	**38**

LOAD POSTING RATING FACTOR CALCULATIONS
SECTION "B" (DUMMY)

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	**33.0**	16.98	560.4	7.30	240.9	23.75	783.87	10.29	339.41	**33**
Type 1-1	**17.0**	30.97	526.5	13.32	226.4	43.32	736.44	18.76	318.92	**17**
Type 1-2	**27.0**	20.39	550.5	8.77	236.8	21.80	588.6	12.35	333.45	**27**
Type 12-2	**38.0**	16.22	616.4	6.98	265.2	22.69	862.22	9.83	373.54	**38**

LOAD POSTING RATING FACTOR CALCULATIONS
SECTION "C"

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	**33.0**	1.66	54.7	21.94	724.0	3.17	104.6	29.61	977.13	**33**
Type 1-1	**17.0**	1.96	33.3	31.00	527.0	3.73	63.4	41.84	711.28	**17**
Type 1-2	**27.0**	1.31	35.4	21.35	576.5	2.50	67.5	28.81	777.87	**27**
Type 12-2	**38.0**	1.08	41.0	19.53	742.1	2.06	78.3	26.36	1001.7	**38**



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INTERIOR SIG CONTINUOUS

A. GENERAL

BACK TO MENU

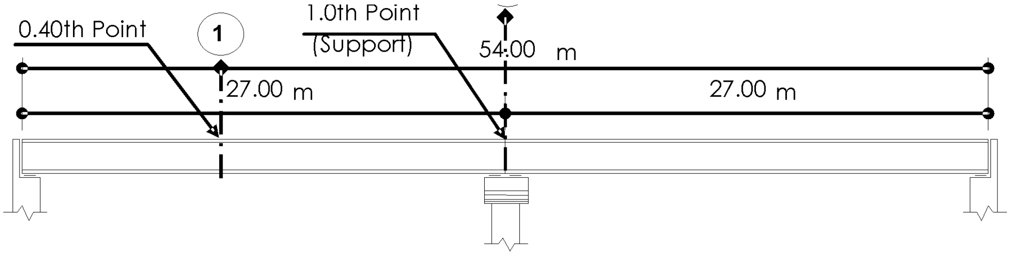
A1. BRIDGE DESCRIPTION

Bridge Location	REGION						
Bridge Name							
Bridge Type	Simple or Continuous	C	Steel I-Girder Bridge				
	Number of Span	2					
Bridge Width (curb to curb) (m)		24.00					
Number of Lanes		6					
Bridge Length (m)		27.000	27.000				=54.000m
Year Built		1967					
Structure	Nos. of Girder	13	Multiple Girder composite for live load				
	Girder Spacing (m)	2.020	on centers				
	Substructure	Wall Type RC Pier and RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa
		f'c=	20.7	Mpa	fy=	248.2	Mpa
Assumption		Weight of barrier rail Wbr =			3.600	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Steel Girder Unit Weight Ws =			77.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

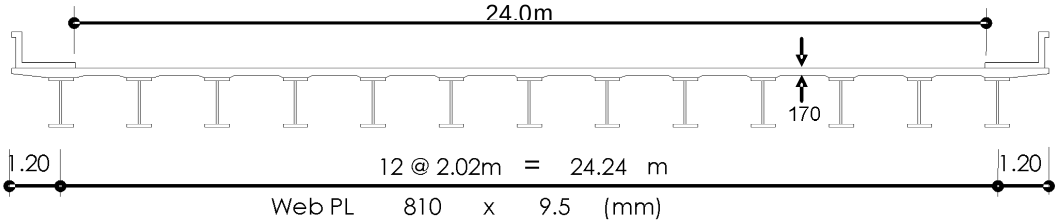
NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Structural Steel Bending	**Prior to 1905**	179.3	96.5	134.4	96.5	
	1905 to 1936	206.8	110.3	155.1	110.3	
	1936 to 1963	227.5	124.1	168.9	124.1	
	after 1963	248.2	137.9	186.2	137.9	
Structural Steel Web Shear	**Prior to 1905**	179.3	58.6	79.3	58.6	
	1905 to 1936	206.8	65.5	93.1	65.5	
	1936 to 1963	227.5	75.8	103.4	75.8	
	after 1963	248.2	82.7	110.3	82.7	
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	189.8	224.1	137.9	*pc
	Grade 60	413.7	227.5	248.2	165.5	*pc
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc

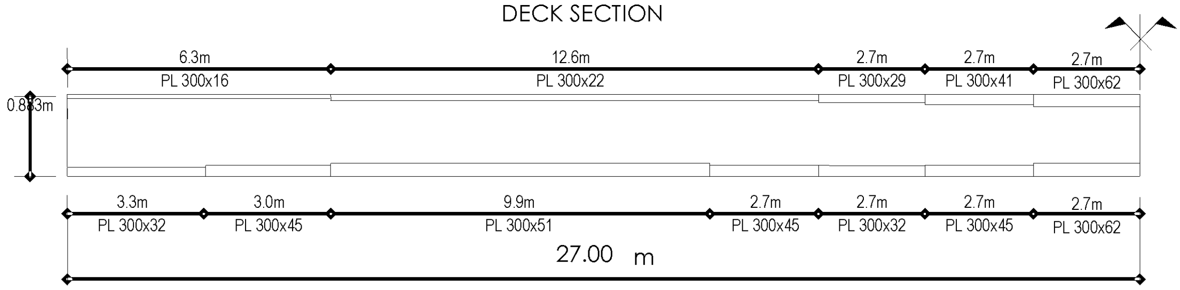
A2. BRIDGE LAYOUT AND SECTION



BRIDGE ELEVATION



DECK SECTION



GIRDER LAYOUT

GIRDER SECTION						
SECTION	SECTION A (At Pier)		SECTION B (Dummy)		SECTION C (At Midspan)	
Location (m)	0.010		1.000		13.500	
Dimension	b (m)	h (m)	b (m)	h (m)	b (m)	h (m)
Slab	thickness = 0.170 m					
	0.202	0.170	0.202	0.170	0.202	0.170
Uflg	0.300	0.062	0.300	0.029	0.300	0.022
	0.000	0.000	0.000	0.000	0.000	0.000
Web	0.010	0.810	0.010	0.810	0.010	0.810
	0.000	0.000	0.000	0.000	0.000	0.000
Lflg	0.300	0.062	0.300	0.032	0.300	0.051
	0.000	0.000	0.000	0.000	0.000	0.000
Length	2.700		2.700		16.200	

*10 (Modular Ratio)

NEXT

B. DEMAND FORCES

B.1 INPUT AND SECTION PROPERTIES

B0. INPUT	
Slab thickness ts (m)	0.170
Slab width ws (m)	2.020
Span Length L(m)	27.000

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) UNDER DEAD LOAD (NON-COMPOSIE GIRDER)							
SECTION	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
A (At Pier)	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
B (Dummy)	0.02600	0.00770	0.00365	0.42192	0.44908	0.00865	0.00813
C (At Midspan)	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701
(2) UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (COMPOSIE GIRDER)							
A (At Pier)	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934
B (Dummy)	0.06034	0.00770	0.00795	0.72590	0.14510	0.01095	0.05480
C (At Midspan)	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967

Standard Section Area of "SECTION A"	
Original Section Area (m^2)	0.0449

B.2 LOAD DEMAND CALCULATIONS

B2.1 DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	Section A (At Pier)	0.691
		Section B (Dummy)	0.400
		Section C (At Midspan	1.367
		Stiffener and Bracing	0.307
	Slab Weight	Continuous	8.242
	Barrier Rail		0.554
	Asphalt Overlay		2.222
	Total Load		13.784
	Total DeadLoad		11.008
	Total Superimposed Dead Load		2.776

B2.2 LOAD DEMAND MIDSPAN AND SUPPORT OF STEEL GIRDER		
Conducting a Structural Analysis, the load demands for the SPG should be obtained separately and input the necessary load demands in the Table below.		
Description	At Midspan	At Pier Support
	10.8 m	27.0 m
Dead load moments, KN-m	546.52	-1016.85
Dead load shears, KN	-4.24	-184.41
Additional Dead load moments, KN-m	27.65	-51.45
Additional Dead load shears, KN	-0.21	-9.93
MS18 max. positive moment, KN-m	1060.52	0.00
MS18 max. negative moment, KN-m	-273.15	-957.00
MS18 max. positive shear force, KN	83.28	0.00
MS18 max. negative shear force, KN	-84.40	-198.35

NEXT

B3. LOAD STRESS CALCULATIONS

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) At Midspan							
	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
For Dead Load	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701
For Add.DL and Live Load	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967
(2) At Pier Support							
For Dead Load	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
For Add.DL and Live Load	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934

ESTIMATED STRESS DEMANDS AT GIRDER SECTIONS			
Loading	Location	At Midspan	At Pier Support
DL moment	Top	**77.95**	**-63.28**
	Bottom	**-45.67**	**63.28**
SDL moment	Top	**0.56**	**-0.87**
	Bottom	**-1.76**	**2.69**
LL+I moment, σ_{LL+I}^{t}	Top	**21.35**	**-16.13**
	Bottom	**-67.55**	**50.01**
DL shear, v_{DL}		**0.55**	**23.96**
SDL shear, v_{SDL}		**0.03**	**1.29**
LL+I shear, v_{LL+I}		**10.82**	**25.78**

NEXT

C. LOAD RATING BY ALLOWABLE STRESS METHOD

C1. ALLOWABLE STRESS CALCULATIONS

C.1.1 ALLOWABLE STRESSES FOR CONCRETE AND STEEL				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c = fc/0.4	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy = fs/0.55	248.2

C.1.2 COMPRESSION AND TENSILE STRESSES		
Allowable compressive stress	Inventory	137.9
	Operating	186.2
Allowable tensile stress	Inventory	137.9

C.1.3 ALLOWABLE SHEAR STRESS		
Allowable Shear Stress	Inventory fy/3	82.7
	Operating 0.45fy	110.3

C2. LOAD RATING CALCULATIONS

C2.1 RATING FACTOR CALCULATIONS USING ASM			
Section	Description	Inventory	Operating
At Midspan	Stress at Top Fiber	2.78	5.04
	Stress at Bottom Fiber	1.34	2.05
	Shear	7.59	10.14
At Pier Support	Stress at Top Fiber	4.57	7.57
	Stress at Bottom Fiber	1.44	2.40
	Shear	2.23	3.30

C2.2 LOAD RATING CALCULATIONS					
Section	Description	Rating Live Load (Metric Tons)			33.0
		Inventory		Operating	
At Midspan	Moment	1.34	44.2	2.05	67.8
	Shear	7.59	250.4	10.14	334.6
At Pier Support	Moment	1.44	47.5	2.40	79.3
	Shear	2.23	73.5	3.30	108.9

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the SPG should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	657.5	-593.3
	Shear	45.8	-109.1
Type 1-2	Moment	869.3	-784.7
	Shear	65.0	-154.7
Type 12-2	Moment	859.0	-775.2
	Shear	64.1	-152.7

D1.3 POSTING VEHICLE DEMAND STRESSES			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Top Fiber	13.24	-10.00
	Bottom Fiber	-41.88	31.00
	Shear	5.95	14.18
Type 1-2	Top Fiber	17.50	-13.22
	Bottom Fiber	-55.37	41.00
	Shear	8.45	20.10
Type 12-2	Top Fiber	17.29	-13.06
	Bottom Fiber	-54.71	40.51
	Shear	8.33	19.84

NEXT

E. LOAD POSTING RATING FACTOR CALCULATIONS

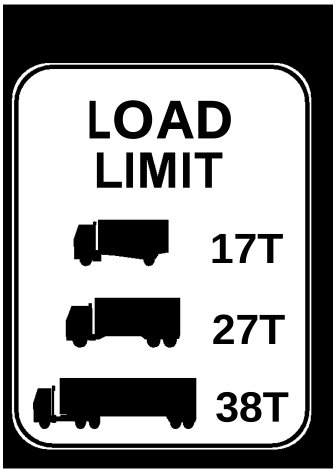
E1. LOAD POSTING RATING FACTOR CALCULATIONS (1)

Posting Vehicle		At Midspan		At Pier Support	
		Inventory	Operating	Inventory	Operating
Type 1-1	Top Fiber	4.49	8.13	7.38	12.21
	Bottom Fiber	2.16	3.31	2.32	3.88
	Shear	13.80	18.43	4.05	6.00
Type 1-2	Top Fiber	3.39	6.15	5.58	9.23
	Bottom Fiber	1.63	2.51	1.75	2.93
	Shear	9.72	12.99	2.86	4.23
Type 12-2	Top Fiber	3.43	6.23	5.65	9.34
	Bottom Fiber	1.65	2.54	1.78	2.97
	Shear	9.86	13.17	2.89	4.29

E2. LOAD POSTING RATING FACTOR CALCULATIONS (2)

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory				Operating				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) SECTION A										
MS18	33.0	1.34	44.2	7.59	250.4	2.05	67.8	10.14	334.6	**33**
Type 1-1	17.0	2.16	36.7	13.80	234.6	3.31	56.3	18.43	313.4	**17**
Type 1-2	27.0	1.63	44.1	9.72	262.5	2.51	67.7	12.99	350.7	**27**
Type 12-2	38.0	1.65	62.8	9.86	374.6	2.54	96.4	13.17	500.5	**38**
(2) SECTION B										
MS18	33.0	1.44	47.5	2.23	73.5	2.40	79.3	3.30	108.9	**33**
Type 1-1	17.0	2.32	39.4	4.05	68.9	3.88	65.9	6.00	102.0	**17**
Type 1-2	27.0	1.75	47.4	2.86	77.1	2.93	79.2	4.23	114.2	**27**
Type 12-2	38.0	1.78	67.5	2.89	110.0	2.97	112.8	4.29	162.9	**38**

Load Posting	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**



END AND GO TO DECK SLAB

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID : PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME : **SIG CONTINUOUS**

A. GENERAL

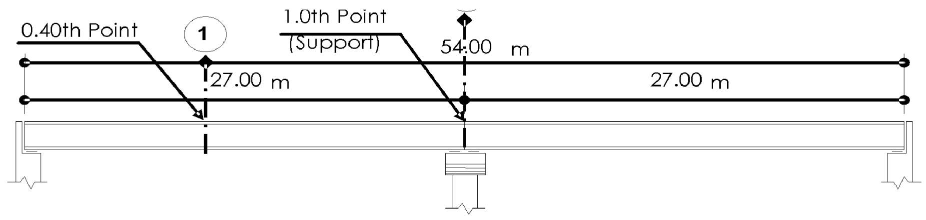
A.1 BRIDGE DESCRIPTION

- Bridge Location : Region VII
- Bridge Type : 2-Span Steel I-Girder
- Br. Width / No. of Lanes : 24.0m curb to curb / Six-lanes
- Bridge Length : 27.0m + 27.0m = 54.0m
- Year Built : 1967
- Structure :
  - Girders : Multiple Girders (13-Girders) composite for live load
    : Girder spacing at 2.020m on center
  - Substructure : Wall Type RC Pier and RC Cantilever Abutments
- Wearing Course : 50mm thick Asphalt Overlay
- Material Properties : fc = 8.3 Mpa , fs = 137.9 Mpa
  : f'c = 20.7 Mpa , fy = 248.2 Mpa
- Assumption : Weight of barrier rail = 3.600 KN/m (Assumed including sidewalk,etc)
  : Concrete unit weight = 24.0 KN/m^3
  : Steel Girder unit weight = 77.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)

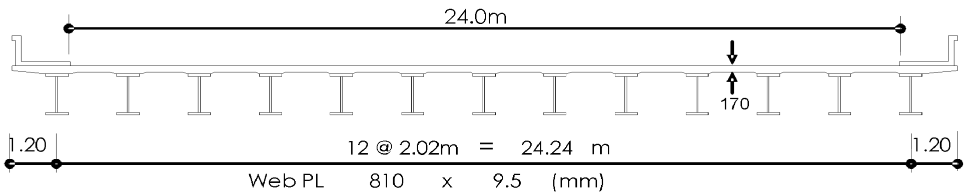
Reqirement :

Determine the critical rating factor of the interior girder using ASM Method

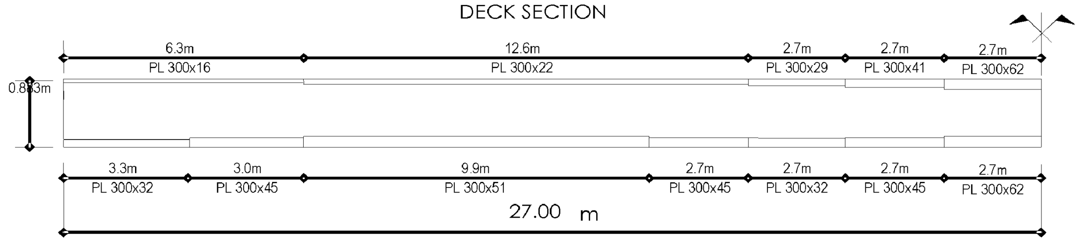
A.2 BRIDGE LAYOUT AND SECTION



BRIDGE ELEVATION



DECK SECTION



GIRDER LAYOUT

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B. DEMAND FORCES

NOTES

B.1 SECTION PROPERTIES

The section properties of the steel I-girder on each section are calculated and given in the table below:

A. UNDER DEAD LOAD (Non-composite Girder)

SECTION	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
A	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
B	0.02600	0.00770	0.00365	0.42192	0.44908	0.00865	0.00813
C	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701

B. UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (Composite Girder)

SECTION	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
A	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934
B	0.06034	0.00770	0.00795	0.72590	0.14510	0.01095	0.05480
C	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967

B.2.1 DEAD LOAD CALCULATIONS

The dead loads considered in the calculations include (1) Girder self-weight,
(2) Tributary area of slab, (3) Barrier rails (Assumed to be equally distributed among girders).
(4) Wearing course.

• Self-weight of girder	=	(0.04490 Sq.m.) x 2 x 2.7 x 77 / 27.00 m	=	0.691	KN/m
	=	(0.02600 Sq.m.) x 2 x 2.7 x 77 / 27.00 m	=	0.400	KN/m
	=	(0.02960 Sq.m.) x (16.20m) x 77 / 27.00 m	=	1.367	KN/m
	=	(0.691 + 0.400 + 1.367) x 12.5%	=	0.307	KN/m
• Slab Weight (Tributary)	=	(0.17m) (2.02m) (24 KN/m^3)	=	8.242	KN/m
• Barrier rail	=	2 (3.6 /13)	=	0.554	KN/m
• Wearing course	=	(0.05m) (2.02m) (22 KN/m^3)	=	2.222	KN/m
		• Total Uniform Load of Girder, w	=	13.784	KN/m
		• Total Uniform Dead Load of Girder, w_{DL}	=	11.008	KN/m
		• Total Uniform Superimposed Dead Load of Girder, w_{SDL}	=	2.776	KN/m

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	LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

B.2.2 LOAD DEMAND CALCULATIONS AT MIDSPAN AND SUPPORT

The carriageway width is 7.35m curb to curb. Thus, the bridge can carry 2-lanes of traffic.

The distribution of wheel loads for two traffic lanes shall be taken as S/1.676

- Number of live load wheel line = 2.02 / 1.829 = 1.104
- Impact factor, I = 15.24 / (27.00 + 38.00) = 0.234

Conducting a Structural Analysis, the load demands for the SIG Continuous should be obtained separately and input the necessary lo

Description	At Midspan	At Pier Support
	10.8 m	27.0 m
Dead load moments, KN-m	546.52	-1016.85
Dead load shears, KN	-4.24	-184.41
Additional Dead load moments, KN-m	27.65	-51.45
Additional Dead load shears, KN	-0.21	-9.93
MS18 max. positive moment, KN-m	1060.52	0.00
MS18 max. negative moment, KN-m	-273.15	-957.00
MS18 max. positive Shear force, KN	83.28	0.00
MS18 max. negative Shear force, KN	-84.40	-198.35

B.3 LOAD STRESS CALCULATIONS

B.3.1 Properties at Midspan and Pier Support

AT MIDSPAN

	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
For Dead Load	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701
For Add. DL / Live Load	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967

AT PIER SUPPORT

	Total AREA (m2)	Web AREA (m2)	Iz (m4)	Yb (m)	Yt (m)	S_{BOT} (m^3)	S_{TOP} (m^3)
For Dead Load	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
For Add. DL / Live Load	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

B.4 LOAD STRESS CALCULATIONS

The resulting stresses due to bending and shear are calculated using the given load demands and the appropriate section properties at given section locations under consideration. The stress results are shown in the table below.

Estimated Stress Demands at Girder Sections In Mpa

LOADING	At Midspan 10.80 m	At Pier Support 27.00 m
Dead Load Moment, Top	77.95	-63.28
Dead Load Moment, Bottom	-45.67	63.28
SDL Moment, Top	0.56	-0.87
SDL Moment, Bottom	-1.76	2.69
Live Load Moment, Top	21.35	-16.13
Live Load Moment, Bottom	-67.55	50.01
Dead Load Shear	0.55	23.96
SDL Shear	0.03	1.29
Live Load Shear	10.82	25.78

-ve : tension
+ve : compression

C. LOAD RATING BY ALLOWABLE STRESS METHOD (ASM)

C.1 ALLOWABLE STRESS CALCULATIONS

C.1.1 Allowable Stresses for Concrete and Steel

Concrete : f'c = fc / 0.40 = 8.3 / 0.4 = 20.7 Mpa
(fc = 8.27 Mpa) (After 1959, f'c= 20.7 Mpa)

Steel : fs = 137.9 Mpa => fy = 248.2 Mpa
(after 1963)

C.1.2 Compression and Tensile Stresses

Note that the section is fully braced at this location.

i. Allowable compressive stress at inventory 0.55 fy = 137.9 Mpa

ii. Allowable comp./tensile stress at operating 0.75 fy = 186.2 Mpa

iii. Allowable tensile stress at inventory 0.55 fy = 137.9 Mpa

C.1.3 Allowable Shear Stress

i. Allowable shear stress at inventory fy/3 = 82.7 Mpa

ii. Allowable shear stress at operating (0.45 fy) = 110.3 Mpa

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

C.2 LOAD RATING CALCULATIONS

The rating factor (RF) in the Allowable Stress Method (ASD) is given by:

$$RF = \frac{R - A_1 D}{A_2 L (1 + I)}$$

Where : $A_1 = 1.0$

$A_2 = 1.0$

and substituting the values will give us the results as presented in the table below:

RATING FACTOR CALCULATIONS USING ALLOWABLE STRESS METHOD

Section	Description	INVENTORY RATING		OPERATING RATING	
At Midspan	Stress at top Fiber	(137.9 - (77.95+0.56)) / 21.35	= 2.78	(186.2 - (77.95+0.56)) / 21.35	= 5.04
	Stress at Bot Fiber	(-137.9 - (-45.67-1.76)) / -67.55	= 1.34	(-186.2 - (-45.67-1.76)) / -67.55	= 2.05
	Shear	(82.7 - (0.55+0.03)) / 10.82	= 7.59	(110.3 - (0.55+0.03)) / 10.82	= 10.14
At Support	Stress at top Fiber	(-137.9 - (-63.28-0.87)) / -16.13	= 4.57	(-186.2 - (-63.28-0.87)) / -16.13	= 7.57
	Stress at Bot Fiber	(137.9 - (63.28+2.69)) / 50.01	= 1.44	(186.2 - (63.28+2.69)) / 50.01	= 2.40
	Shear	(82.7 - (23.96+1.29)) / 25.78	= 2.23	(110.3 - (23.96+1.29)) / 25.78	= 3.30

LOAD RATING CALCULATIONS
(Rating Live Load = MS18 W=33 Metric Tons

Section	Description	INVENTORY RATING (Tons)	OPERATING RATING (Tons)
At Midspan	Moment	1.34 x 33 = **44.2**	2.05 x 33 = 67.8
	Shear	7.59 x 33 = 250.4	10.14 x 33 = 334.6
At Support	Moment	1.44 x 33 = **47.5**	2.40 x 33 = 79.3
	Shear	2.23 x 33 = 73.5	3.30 x 33 = 108.9

Rating Factors at sections At Support, Sect. B, and At Midspan have values over than 1, thus Posting Loads is not necessary.

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

D. LOAD POSTING BY ALLOWABLE STRESS METHOD (ASM)

The live load moments and shears can be separately taken from conducting a structural analysis corresponding to Types 1-1, 1-2 and 12-2 Posting Vehicles.

For 2-span continuous (2@27.0m) bridge, the Posting Live Load demands are:

D1. POSTING VEHICLE DEMAND FORCES

Vehicle Type	LL Demand	At Midspan	At Pier Support
Type 1-1	Moment	657.5	-593.3
	Shear	45.8	-109.1
Type 1-2	Moment	869.3	-784.7
	Shear	65.0	-154.7
Type 12-2	Moment	859.0	-775.2
	Shear	64.1	-152.7

D2. POSTING VEHICLE DEMAND STRESSES

Vehicle Type	Demand forces	At Midspan	At Pier Support
Type 1-1	Top Fiber	13.24	-10.00
	Bottom Fiber	-41.88	31.00
	Shear	5.95	14.18
Type 1-2	Top Fiber	17.50	-13.22
	Bottom Fiber	-55.37	41.00
	Shear	8.45	20.10
Type 12-2	Top Fiber	17.29	-13.06
	Bottom Fiber	-54.71	40.51
	Shear	8.33	19.84

Using the capacities and dead load demand stresses calculated, the load posting values are obtained by substituting the posting live load stress demands in the rating equation.

D3. LOAD POSTING RATING FACTOR CALCULATIONS (1)

Vehicle Type		At Midspan		At Support	
		Inventory	Operating	Inventory	Operating
Type 1-1	Top Fiber	4.49	8.13	7.38	12.21
	Bottom Fiber	2.16	3.31	2.32	3.88
	Shear	13.80	18.43	4.05	6.00
Type 1-2	Top Fiber	3.39	6.15	5.58	9.23
	Bottom Fiber	1.63	2.51	1.75	2.93
	Shear	9.72	12.99	2.86	4.23
Type 12-2	Top Fiber	3.43	6.23	5.65	9.34
	Bottom Fiber	1.65	2.54	1.78	2.97
	Shear	9.86	13.17	2.89	4.29

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

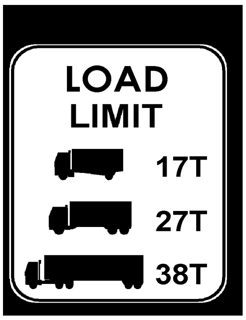
E. LOAD POSTING BY ALLOWABLE STRESS METHOD (ASM)

LOAD POSTING RATING FACTOR CALCULATIONS AT MIDSPAN

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	**33.0**	1.34	44.2	7.59	250.4	2.05	67.8	10.14	334.62	**33**
Type 1-1	**17.0**	2.16	36.7	13.80	234.6	3.31	56.3	18.43	313.41	**17**
Type 1-2	**27.0**	1.63	44.1	9.72	262.5	2.51	67.7	12.99	350.73	**27**
Type 12-2	**38.0**	1.65	62.8	9.86	374.6	2.54	96.4	13.17	500.46	**38**

LOAD POSTING RATING FACTOR CALCULATIONS AT PIER SUPPORT

Vehicle Type	Vehicle Weight (Metric Tons)	INVENTORY RATING				OPERATING RATING				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	**33.0**	1.44	47.5	2.23	73.5	2.40	79.3	3.30	108.9	**33**
Type 1-1	**17.0**	2.32	39.4	4.05	68.9	3.88	65.9	6.00	102.0	**17**
Type 1-2	**27.0**	1.75	47.4	2.86	77.1	2.93	79.2	4.23	114.21	**27**
Type 12-2	**38.0**	1.78	67.5	2.89	110.0	2.97	112.8	4.29	162.9	**38**



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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**SIG CONTINUOUS**

NOTES

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RATED BY :	DATE :	CHECKED BY :	DATE :

EXAMPLE 5

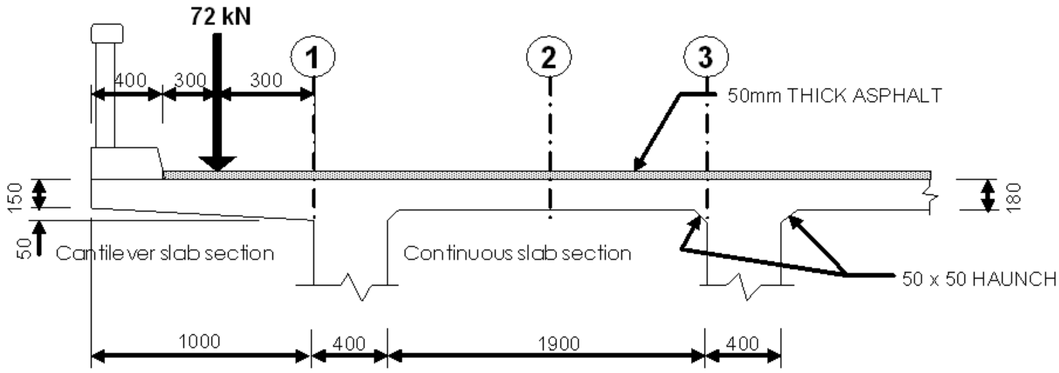
REINFORCED CONCRETE DECK SLAB

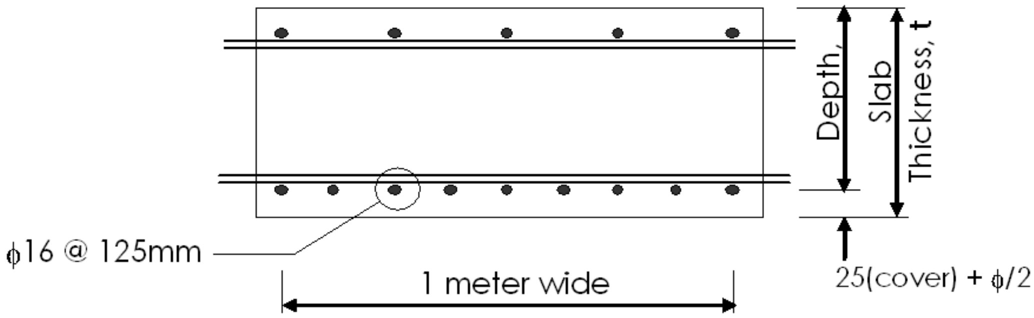
RC DECK SLAB

A. SLAB LAYOUT

BACK TO MENU

A. SLAB LAYOUT AND REBAR SCHEDULE





NEXT

B. DEMAND FORCES

B0. INPUT		
Assumption	Weight of barrier rail Wbr =	4.2
	Concrete Unit Weight Wu =	24.0
	Asphalt Unit Weight Wa =	22.0
FOR DEAD LOAD	**CONTINUOUS SALB**	
	Slab thickness ts (m)	0.18
	Asphalt overlay thickness tas (m	0.05
	Slab span (Ls) (m)	1.90
	CANTILEVER SALB	
	Slab thickness ts (m)	0.15
	Slab thickness of hunch ts' (m)	0.05
	Asphalt overlay thickness tas (m	0.05
	Slab span (Ls) (m)	1.0
	Width of Asphalt (Las) (m)	0.6
	Width of Curb (Lcu) (m)	0.4
FOR LIVE LOAD	**LIVE LOAD**	
	Live Load (LL) (KN)	72.0
	Impact (I)	0.3
	Wheel load position from Curb(Lcu)(m)	0.3
	Distributed over a length (E) (m)	1.383

B1. DEAD LOAD CALCULATIONS		
Moment due to dead load (KN-m/m)	Continuous Slab	**1.96**
	Cantilever Slab	**5.56**

B2. LIVE LOAD CALCULATIONS		
Moment due to Live load (KN-m/m)	Continuous Slab	**19.30**
	Cantilever Slab	**20.30**

NEXT

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)

C1. CAPACITY CALCULATIONS

C1.1. INPUT				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.30
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
Rebar area per meter strip As (mm^2)		Diameter (mm)		16
		Spacing (mm)		125
		Rebar area As (mm2)		1608.50
Ultimate capacity factor (Uf)	Nominal Factor			0.9
	Reduction factor	due to Concrete Section Loss		1.0
		due to Rebar Section Loss		1.0
	Applicable reduction factor			0.9
Slab thickness (mm)		Continuous slab (tscon)		180
		Cantilever slab (tscan)		200
Cover (mm) (c)				25
Rebar diameter (mm) (Φ)				16
Concrete rectangular stress block (a) (mm)				25.21
Depth d (mm)		Continuous slab (dcon) (mm)		147.0
		Cantilever slab (dcan) (mm)		167.0

C1.2. CAPACITY CALCULATIONS		
The Moment Ultimate Capacity	Continuous slab (Mucon) (KN-m/	**53.70**
	Cantilever slab (Mucan) (KN-m/	**61.69**

NEXT

C2. LOAD RATING CALCULATIONS

C2.1. INPUT	
Load factor for dead load	1.3
Load factor for live load in Inventory Rating	2.17
Load factor for live load in Operating Rating	1.3
Moment Ultimate Capacity at Continuous Slab	53.70
Dead Load Moment at Continuous Slab	1.96
Live Load Moment at Continuous Slab	19.30
Moment Ultimate Capacity at Cantilever Slab (KN-m/m)	61.69
Dead Load Moment at Cantilever Slab	5.56
Live Load Moment at Cantilever Slab	20.30
Rating Live Load	33.0

C2.2. CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating (tons)
Rating Factor and Load Rating	Continuous Slab	Inventory Rating	1.22	40.32
		Operating Rating	2.04	67.30
	Cantilever Slab	Inventory Rating	1.24	40.79
		Operating Rating	2.06	68.09

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Return to LAYOUT

Click following the above instruction

Return to LAYOUT

Load Posting

D. LOAD POSTING BY LOAD FACTOR METHOD

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES				
Description		Posting Vehicles		Demand Forces
		Type	Wheel Load	
Moment due to Live load (KN-m/m)	Continuous Slab	Type 1-1	66.8	17.90
		Type 1-2	73.9	19.81
		Type 12-2	65.9	17.66
	Cantilever Slab	Type 1-1	66.8	18.84
		Type 1-2	73.9	20.84
		Type 12-2	65.9	18.58

D2. POSTING RATING FACTOR CALCULATIONS

D2.1. POSTING RATING FACTOR CALCULATIONS			
Load factor for dead load			1.3
Load factor for live load in Inventory Rating			2.17
Load factor for live load in Operating Rating			1.3
At Continuous Slab	Moment Ultimate Capacity at Continuous Slab		53.70
	Dead Load Moment at Continuous Slab		1.96
	Live Load Moment at Continuous Slab	Type 1-1	17.90
		Type 1-2	19.81
		Type 12-2	17.66
At Cantilever Slab	Moment Ultimate Capacity at Cantilever Slab (KN-m/m)		61.69
	Dead Load Moment at Cantilever Slab		5.56
	Live Load Moment at Cantilever Slab	Type 1-1	18.84
		Type 1-2	20.84
		Type 12-2	18.58
Rating Live Load			33.0

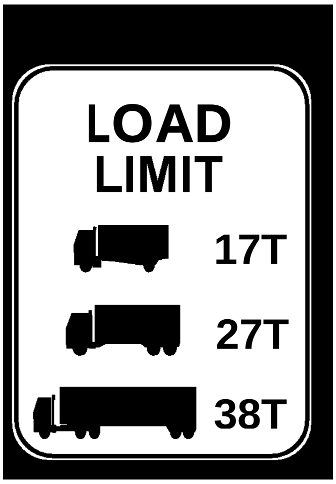
D2.2. RATING FACTOR AND LOAD RATING CALCULATIONS				Rating Factor	Load Rating (tons)
Rating Factor and Load Rating	Continuous Slab	Type 1-1	Inventory Rating	1.32	43.45
			Operating Rating	2.20	72.54
		Type 1-2	Inventory Rating	1.19	39.28
			Operating Rating	1.99	65.57
		Type 12-2	Inventory Rating	1.33	44.05
			Operating Rating	2.23	73.53
	Cantilever Slab	Type 1-1	Inventory Rating	1.25	41.30
			Operating Rating	2.09	68.94
		Type 1-2	Inventory Rating	1.13	37.33
			Operating Rating	1.89	62.31
		Type 12-2	Inventory Rating	1.27	41.86
			Operating Rating	2.12	69.88

NEXT

E. SUMMARY OF LOAD POSTING

		Inventory		Operating		Posting (Metric Tons)
		RF	LR	RF	LR	
(1) CONTINUOUS SLAB						
MS18	33.0	1.22	40.3	2.04	67.3	**33**
Type 1-1	17.0	1.32	22.4	2.20	37.4	**17**
Type 1-2	27.0	1.19	32.1	1.99	53.6	**27**
Type 12-2	38.0	1.33	50.7	2.23	84.7	**38**
(2) CANTILEVER SLAB						
MS18	33.0	1.24	40.8	2.06	68.1	**33**
Type 1-1	17.0	1.25	21.3	2.09	35.5	**17**
Type 1-2	27.0	1.13	30.5	1.89	51.0	**27**
Type 12-2	38.0	1.27	48.2	2.12	80.5	**38**

LOAD POSTING	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**



BACK TO LAYOUT

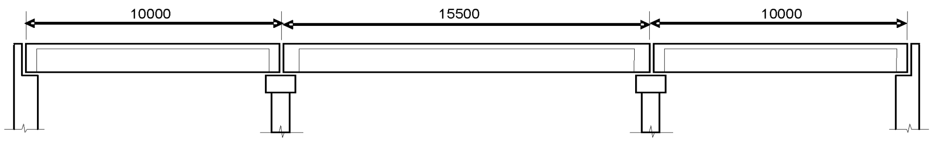
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

A. GENERAL

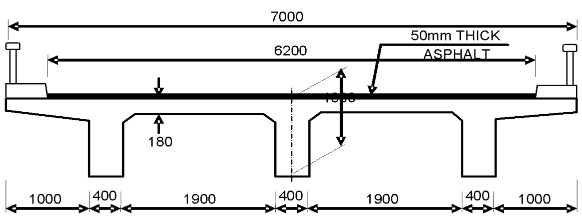
A.1 BRIDGE DESCRIPTION

- Bridge Location : None (Standard Bridge)
- Bridge Type : 3-span Continuous Reinforced Concrete T-Beams
- Br. Width / No. of Lanes : 6.10m curb to curb / Two-lanes
- Bridge Length : 10.0m + 15.5m +10.0m = 35.5m
- Year Built : 1961
- Structure
  - Girders : Multiple Girders per span (3-Girders), Monolithic with deck slab
    : Girder spacing at 2.30m on center
  - Substructure : Wall Type RC Pier and RC Cantilever Abutments
- Wearing Course : None
- Material Properties : fc = 8.3 Mpa , fs = 137.9 Mpa
  : f'c = 20.7 Mpa , fy = 275.8 Mpa
- Assumption : Weight of barrier rail = 4.2 KN/m
  : Concrete unit weight = 24.0 KN/m^3
  : Asphalt unit weight = 22.0 KN/m^3
- Others : Rating Live Load is AASHTO MS18 (HS20-44)
  Reqirement : Perform load rating for the reinforced concrete deck slab shown below using AASHTO MS18 as the rating live load.

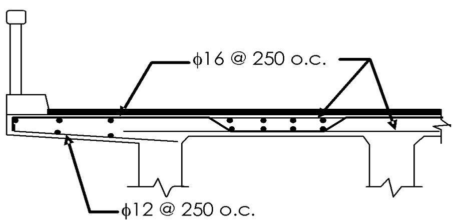
A2.BRIDGE LAYOUT AND SECTION



BRIDGE ELEVATION



DECK SECTION



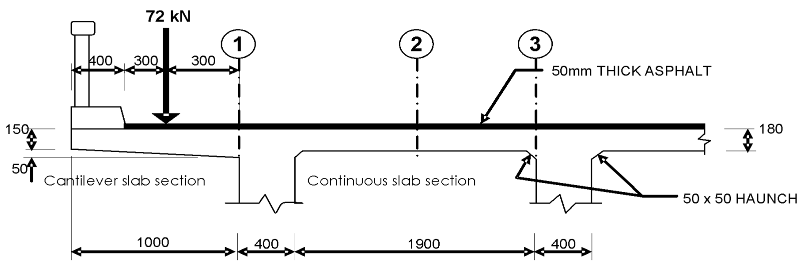
DECK REINFORCEMENT

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

NOTES

B. DEMAND FORCES



B1. DEAD - LOAD CALCULATIONS

The dead loads considered in the calculations include deck slab self-weight, barrier/railing and asphalt overlay.

a. Continuous slab

- Slab Self-weight = (0.18) (1.0) (24KN/m³) = 4.32 kN/m
- Asphalt overlay = (0.05) (1.0) (22KN/m³) = 1.10 kN/m
- Total Uniform Load per meter of slab, w_s = 5.42 kN/m

Using a clear span of S = 1.9m and 0.8 continuity factor, the moment due to dead load becomes:

$$M_{DLs} = (w_s S^2 / 10) = (5.42)\ (1.9^2 / 10) = 1.96 \text{ kN-m/m}$$

b. Cantilever Slab

- Self-weight of cantilever = (0.175) (1.0) (24KN/m³) = 4.20 kN/m
- Asphalt overlay = (0.05) (1.0) (22KN/m³) = 1.10 kN/m
- Barrier Rail = 4.20 kN/m

The dead load demand moments for the cantilever slab is taken at the edge of the exterior beam as:

$$M_{DLc} = \underbrace{(0.15)(1.0)(24)(0.5)}_{\text{Cant Slab}} + \underbrace{½(0.05)(1.0)(24)(1.0/3)}_{\text{Cant Slab}} + \underbrace{(1.1)(0.6)(0.3)}_{\text{AC overlay}}$$

$$+ \underbrace{(4.2)(0.8)}_{\text{Barrier Rail}}$$

$$= 5.56 \text{ kN-m/m}$$

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

NOTES

B2. LIVE - LOAD CALCULATIONS

a. Sections 2 and 3

The live load moments for are calculated as (use 0.8 continuiuty factor):

DPWH Guide Sect. 3.4.2.3

$$M_{LLs} = \frac{S + 0.61}{9.74}(72)(0.8)(1{+}0.3) = \frac{(1.9 + 0.61)}{9.74} 72\,(0.8)\quad(1.3)$$

Impact, $I = 15.24/(S{+}38)$ = 38%
USE I = 30%

$$= 19.30 \quad \text{kN-m/m}$$

b. Section 1

Live load moment at cantilever slab is taken when the wheel load is 0.30m from the curb and distributed over a length:

Distance $x = 300 > d = 167$

$E = 0.8X + 1.143 = 0.8(0.3) + 1.143 = 1.383$ m

$M_{LLs} = (72)(0.30)(1.3) = 28.08$ kN-m @ 1.383m spread

Therefore live load moment per meter width becomes

$M_{LLs} = 28.08 / 1.383 = 20.30$ kN-m/m

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)

C1. CAPACITY CALCULATIONS

Material Properties

	Allowable Stress				Strength			
Concrete	fc	=	8.30	MPa	f'c	=	20.70	MPa
Rebar	fs	=	137.90	MPa	fy	=	275.80	MPa

$A_s = \phi 16$ @ 125 = 1608.50 mm^2/m - Rebar area per meter strip

The concrete rectangular stress block is calculated as:

DPWH Guide Sect. 8.16.3

$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(1608.50)\ (275.80)}{(0.85)\quad(20.70)\quad(1000)}$$

$$= 25.21 \quad \text{mm}$$

The moment ultimate capacity is then calculated as:

$$M_U = \phi A_s f_y (d - a/2) \qquad \text{where } \phi = 0.90 \text{ for flexure}$$

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

NOTES

a. For Section 2 and 3,

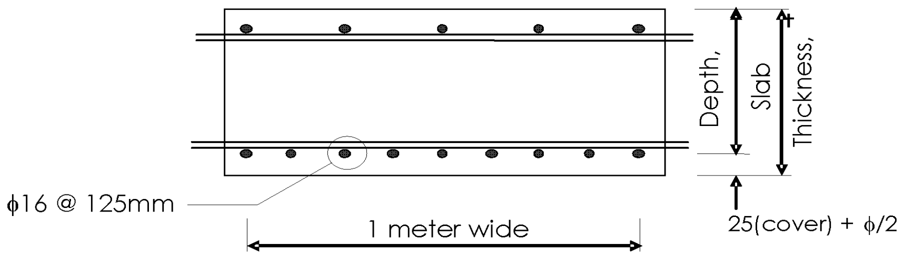
The depth, d = 180 - 25(cover) - $\phi/2$ = 180 - 25 - 16/2

d = 147.0 mm

Therefore,

M_U = 0.9 (1608.50) (275.80) (147 - 25/2)

= 53.70 kN-m/m



b. For Section 1,

The depth, d = 200 - 25(cover) - $\phi/2$ = 200 - 25 - 16/2

d = 167.0 mm

Therefore,

M_U = 0.9 (1608.50) (275.80) (167 - 25/2)

= 61.69 kN-m/m

C2. LOAD RATING CALCULATIONS

Using Load Factor Method (LFM) Eq. 3.2-4:

$$RF = \frac{\phi Rn - \gamma_D D}{\gamma_L L(1+I)}$$

where: γ_D = 1.30

γ_L = 2.17 (Inventory)

γ_L = 1.30 (Operating)

RATING FACTOR CALCULATIONS (LFM)

Location	Description	Inventory Rating		Operating Rating	
Section 1	Cantilever Slab	$\frac{61.64-1.3(5.56)}{2.17(20.3)}$ =	**1.24**	$\frac{61.64-1.3(5.56)}{1.3(20.3)}$ =	**2.06**
Section 2 or 3	Continuous Slab	$\frac{53.66-1.3(1.96)}{2.17(19.3)}$ =	**1.22**	$\frac{53.66-1.3(1.96)}{1.3(19.3)}$ =	**2.04**

RATED BY :	DATE :	CHECKED BY :	DATE :

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
LOAD RATING CALCULATIONS	BRIDGE NAME : RC DECK SLAB	

NOTES

Using the MS18 rating live load, the load rating for Inventory and Operating Levels are calculated below.

LOAD RATING CALCULATIONS (LFM)
(Rating Live Load = MS18 W = 33 Metric Tons)

Location	Description	Inventory Rating (Tons)		Operating Rating (Tons)		Notes
Section 1	Cantilever Slab	1.24 x 33	= **40.79**	2.06 x 33	= **67.30**	This Manual Eq. 3.1-5
Section 2 or 3	Continuous Slab	1.22 x 33	= **40.32**	2.04 x 33	= **68.09**	This Manual Eq. 3.1-5

Since both the Inventory and Operating Level Ratings are more than MS18 rating live load (33 metric tons), load posting analysis is not necessary.

D. Demand Forces for Load Posting Live Vehicles

Posting Live Vehicle's Forces is calculated as same as the section B2. Live- Load Calculations based on the Wheel Load of Posting live Load as follows.

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

Description		Posting Vehicles Type	Posting Vehicles Wheel Load	Demand Forces
Moment due to Live load (KN-m/m)	Continuous Slab	Type 1-1	66.8	17.90
		Type 1-2	73.9	19.81
		Type 12-2	65.9	17.66
	Cantilever Slab	Type 1-1	66.8	18.84
		Type 1-2	73.9	20.84
		Type 12-2	65.9	18.58

Posting Rating Factor is also calculated as same as the section C as follows.

D2.1. POSTING RATING FACTOR CALCULATIONS

Load factor for dead load			1.3
Load factor for live load in Inventory Rating			2.17
Load factor for live load in Operating Rating			1.3
At Continuous Slab	Moment Ultimate Capacity at Continuous Slab		53.70
	Dead Load Moment at Continuous Slab		1.96
	Live Load Moment at Continuous Slab	Type 1-1	17.90
		Type 1-2	19.81
		Type 12-2	17.66
At Cantilever Slab	Moment Ultimate Capacity at Cantilever Slab (KN-m/m)		61.69
	Dead Load Moment at Cantilever Slab		5.56
	Live Load Moment at Cantilever Slab	Type 1-1	18.84
		Type 1-2	20.84
		Type 12-2	18.58
Rating Live Load			33.0

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

NOTES

D2.2. RATING FACTOR AND LOAD RATING CALCULATIONS				Rating Factor	Load Rating (tons)
Rating Factor and Load Rating	Continuous Slab	Type 1-1	Inventory Rating	1.32	43.45
			Operating Rating	2.20	72.54
		Type 1-2	Inventory Rating	1.19	39.28
			Operating Rating	1.99	65.57
		Type 12-2	Inventory Rating	1.33	44.05
			Operating Rating	2.23	73.53
	Cantilever Slab	Type 1-1	Inventory Rating	1.25	41.30
			Operating Rating	2.09	68.94
		Type 1-2	Inventory Rating	1.13	37.33
			Operating Rating	1.89	62.31
		Type 12-2	Inventory Rating	1.27	41.86
			Operating Rating	2.12	69.88

Load Posting is summarized as follows.

E. SUMMARY OF LOAD POSTING

		Inventory		Operating		Posting (Metric Tons)
		RF	LR	RF	LR	
(1) CONTINUOUS SLAB						
MS18	33.0	1.22	40.3	2.04	67.3	**33**
Type 1-1	17.0	1.32	22.4	2.20	37.4	**17**
Type 1-2	27.0	1.19	32.1	**1.99**	53.6	**27**
Type 12-2	38.0	1.33	50.7	2.23	84.7	**38**
(2) CANTILEVER SLAB						
MS18	33.0	1.24	40.8	2.06	68.1	**33**
Type 1-1	17.0	1.25	21.3	2.09	35.5	**17**
Type 1-2	27.0	1.13	30.5	1.89	51.0	**27**
Type 12-2	38.0	1.27	48.2	2.12	80.5	**38**

LOAD POSTING	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**

RATED BY :	DATE :	CHECKED BY :	DATE :

	DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS	BRIDGE ID :	PAGE :
	LOAD RATING CALCULATIONS	BRIDGE NAME :	**RC DECK SLAB**

NOTES

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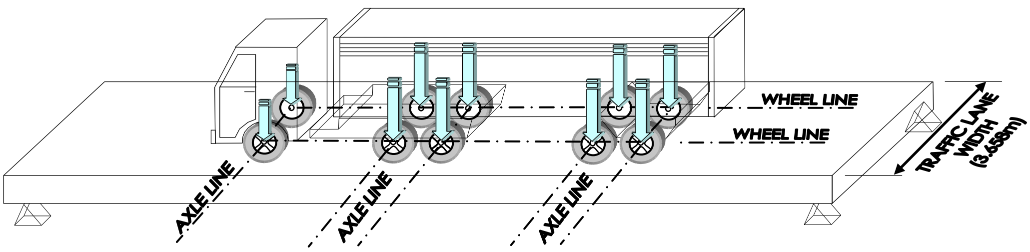
RATED BY :	DATE :	CHECKED BY :	DATE :

APPENDIX III

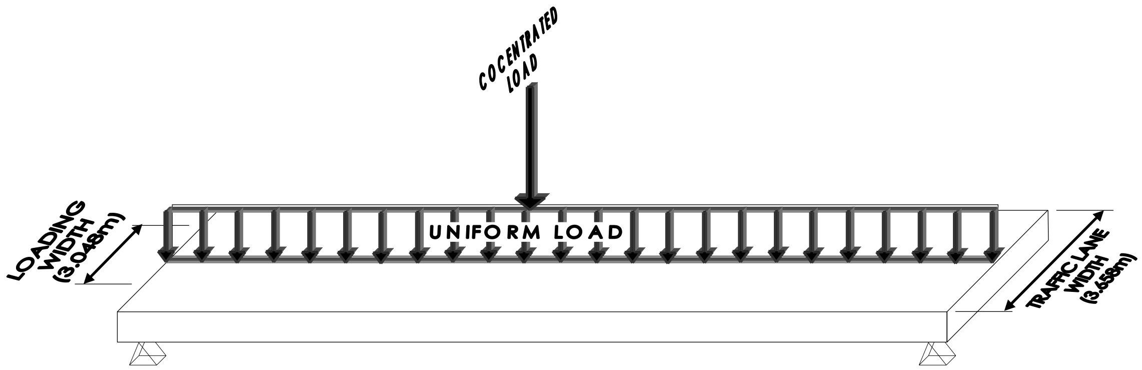
RATING CALCULATION AIDS

APPENDIX III - A

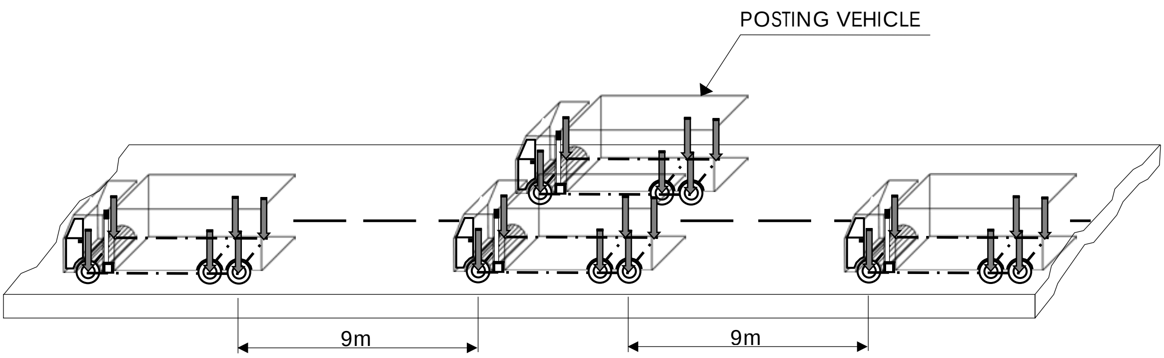
LIVE LOAD LAYOUT IN TRAFFIC LANES



ONE-LANE TRUCK LOADING PATTERN (RATING LIVE LOAD)



ONE-LANE LANE LOADING PATTERN



NOTE:

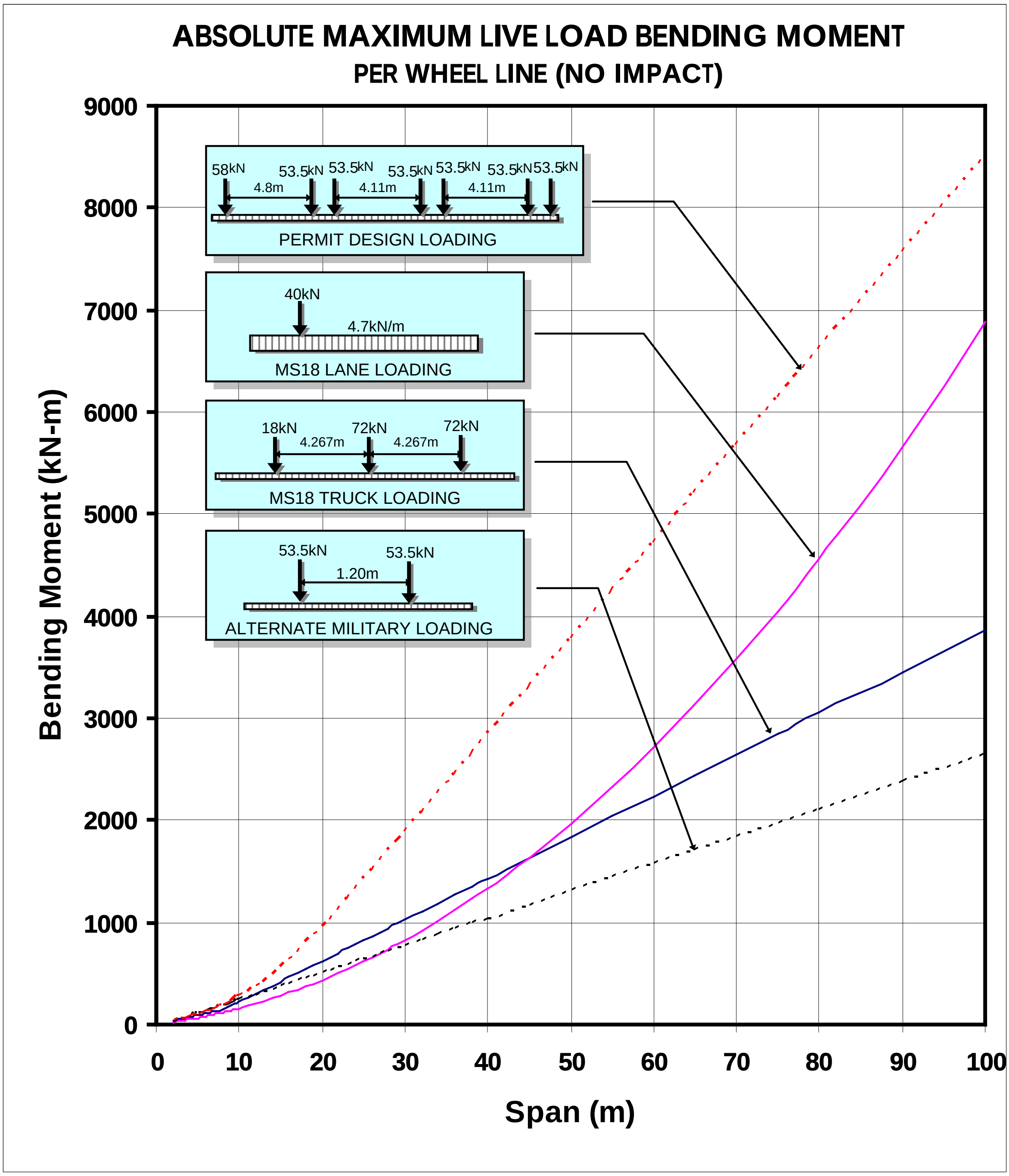
THIS LOAD PATTERN IS USED FOR SPANS OVER 60m IN LENGTH TO SIMULATE TRAIN OF VEHICLES SPACED AT 9m CLEAR IN ONE LANE AND A SINGLE VEHICLE LOAD IN THE ADJACENT LANES

TWO-LANE TRUCK TRAIN LOADING PATTERN (POSTING LIVE LOAD)

APPENDIX III - B.1

DPWH DESIGN GUIDELINES DESIGN LIVE LOAD BENDING MOMENT FOR SIMPLE SPANS

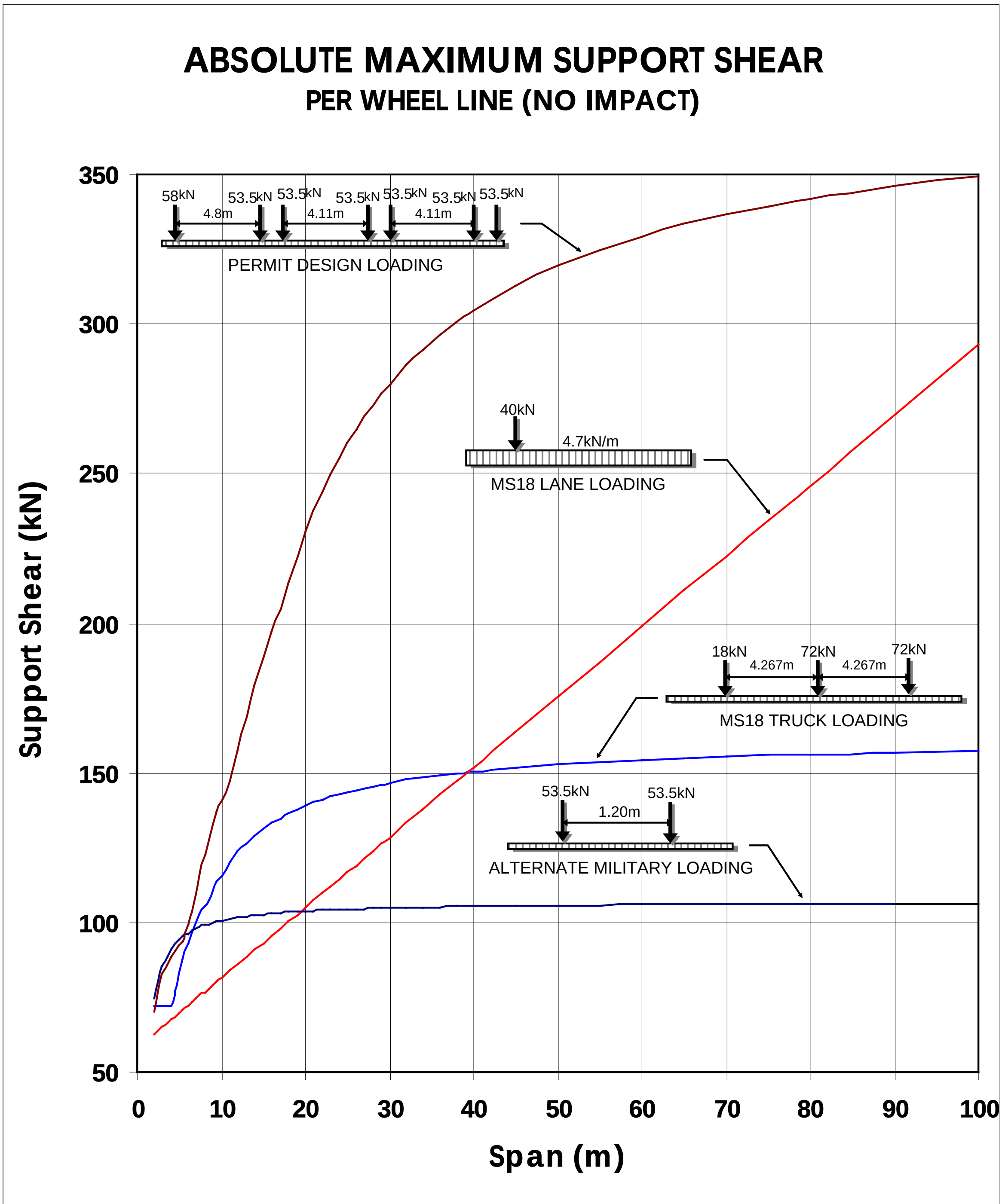
(PER WHEEL LINE, NO IMPACT)



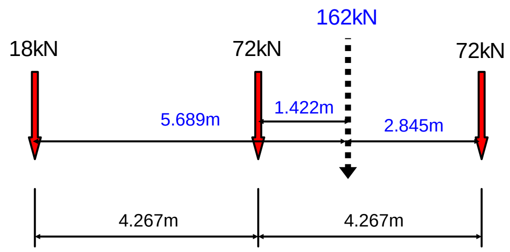
APPENDIX III - B.2

DPWH DESIGN GUIDELINES DESIGN LIVE LOAD SUPPORT SHEAR FOR SIMPLE SPANS

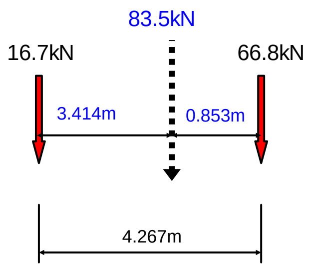
(PER WHEEL LINE, NO IMPACT)



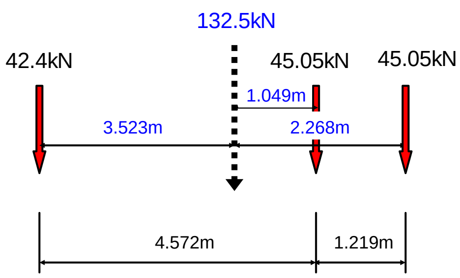
APPENDIX III - C
MAGNITUDE AND LAYOUT OF WHEEL LOADS FOR LOAD RATING AND LOAD POSTING
(PER WHEEL LINE)



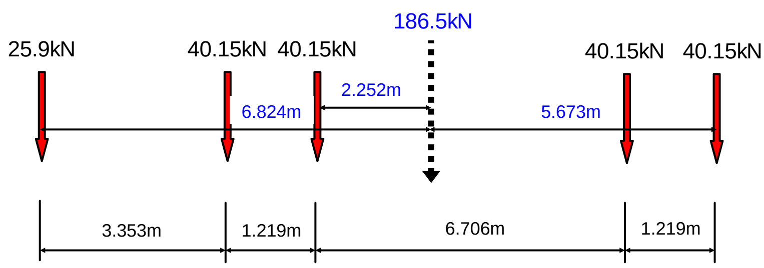
MS18 RATING LIVE LOAD



TYPE 1-1 POSTING LIVE LOAD



TYPE 1-2 POSTING LIVE LOAD



TYPE 12-2 POSTING LIVE LOAD

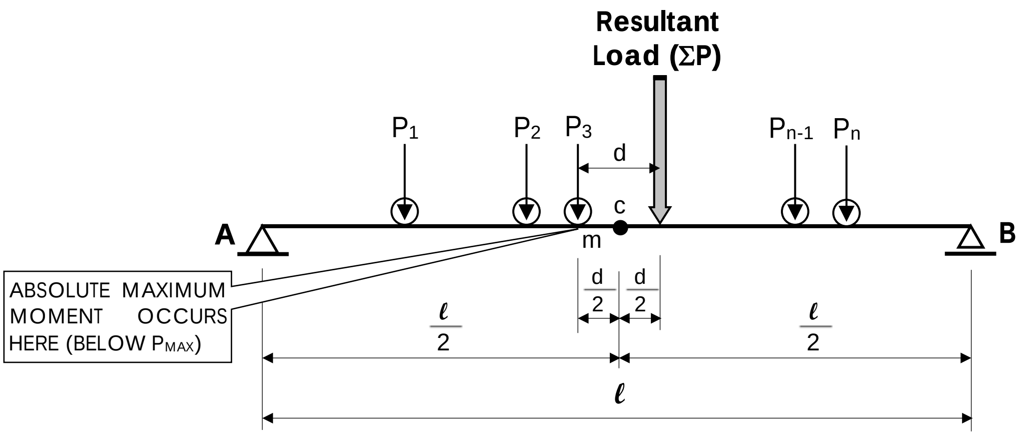
APPENDIX III - D

MAXIMUM ABSOLUTE LIVE LOAD MOMENT FOR SIMPLE BEAM

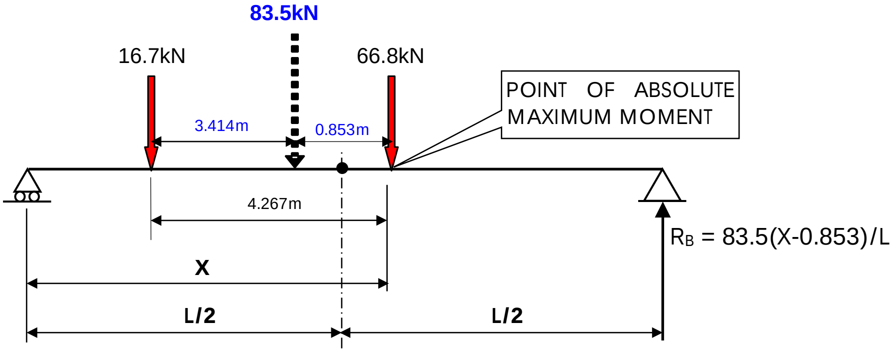
Basic Principles:

1 - The absolute maximum bending moment due to a series of concentrated wheel loads moving on a simple span beam always occur near the center of the span directly under one of these loads (in this case, wheel P_3 at point m).

2 - The loading pattern producing the absolute maximum moment in the simple beam is when the center of the beam (point c) is between the resultant load (ΣP) and one of the maximum adjacent concentrated wheel load (in this case, wheel P_3), as shown below.



D.1 CASE OF TRUCK LOADING TYPE 1-1



Case 1 (when L < 8.10m) - Consider only ONE wheel, P = 66.8kN

$M_p = 66.8(X)(L-X)/L$ .... [D.1-1]

$dM_p/dX = 66.8(L-2X)/L = 0,$ **t** $X = L/2$

$\mathbf{M_{pmax} = 66.8(L)/4}$ .... [D.1-2]

Case 2 (when L ≥ 8.10m) - Full Truck

$M_p = 83.5(X-0.853)(L-X)/L$ .... [D.1-3]

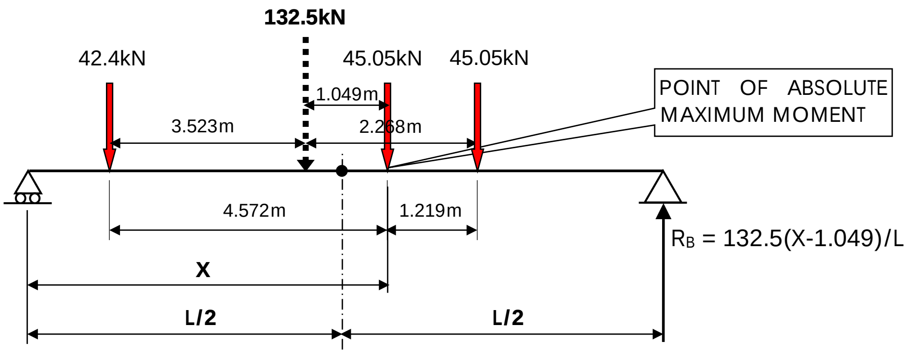
$dM_p/dX = 83.5(L-2X+0.853)/L = 0,$ **t** $X = (L+0.853)/2$

$\mathbf{M_{pmax} = (83.5/L)[(L-0.853)/2]^2}$ .... [D.1-4]

Example:

1. When L = 4m, $M_p max = 66.8(4)/4$ = 66.8 kN-m
2. When L = 20m, $M_p max = (83.5/20)[(20-0.853)/2]^2$ = 382.65 kN-m

D.2 CASE OF TRUCK LOADING TYPE 1-2



Case 1 (when L < 8.62m) - Consider only TWO wheels, P = 2 @ 45.05kN

$M_p = 90.1(X-1.219/2)(L-X)/L$ .... [D.2-1]

$dM_p/dX = 90.1(L-2X+0.6095)/L = 0$, **t** $X = (L+0.6095)/2$

$\mathbf{M_{pmax} = (90.1/L)[(L-0.6095)/2]^2}$ .... [D.2-2]

Case 2 (when L ≥ 8.62m) - Full Truck

$M_p = 132.5(X-1.049)(L-X)/L - (45.05)(1.219)$ .... [D.2-3]

$dM_p/dX = 132.5(L-2X+1.049)/L = 0$, **t** $X = (L+1.049)/2$

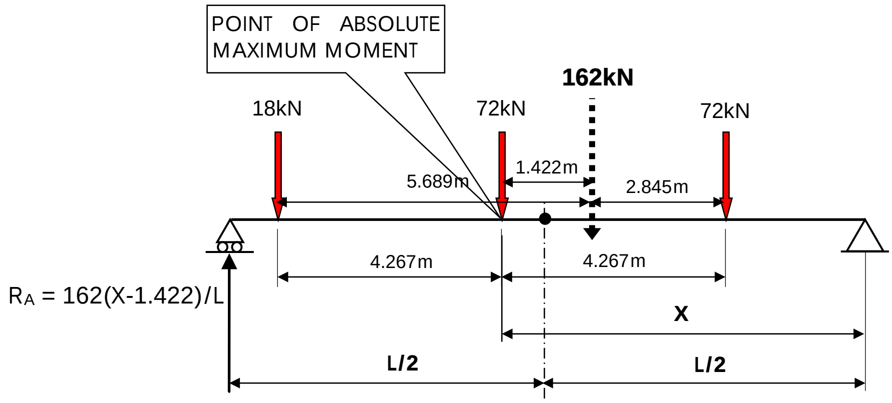
$\mathbf{M_{pmax} = (132.5/L)[(L-1.049)/2]^2 - 54.92}$ .... [D.2-4]

Example:

1. When L = 4m, $M_p max = (90.1/4)[(4-0.6095)/2]^2$ = 64.73
kN-m

2. When L = 20m, $M_p max = (132.5/20)[(20-1.049)/2]^2 - 54.92 = 539.91$ kN-m

D.3 CASE OF TRUCK LOADING TYPE MS18



Case 1 (when L < 7.47m) - Consider only ONE wheel, P = 72kN

$M_p = 72(X)(L-X)/L$ .... [D.3-1]

$dM_p/dX = 72(L-2X)/L = 0,$ **t** $X = L/2$

$\mathbf{M_{pmax} = 72(L)/4}$ .... [D.3-2]

Case 2 (when 7.47 ≤ L < 10.67m) - Consider only TWO wheels, P = 2 @ 72kN

$M_p = 144(X-2.134)(L-X)/L$ .... [D.3-3]

$dM_p/dX = 144(L-2X+2.134)/L = 0,$ **t** $X = (L+2.134)/2$

$\mathbf{M_{pmax} = (144/L)[(L-2.134)/2]^2}$ .... [D.3-4]

Case 3 (when L ≥ 10.67m) - Full Truck

$M_p = 162(X-1.422)(L-X)/L - (18)(4.267)$ .... [D.3-5]

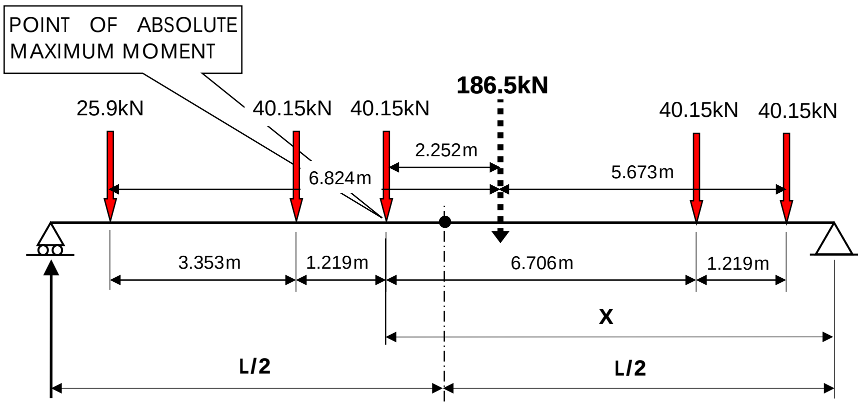
$dM_p/dX = 162(L-2X+1.422)/L = 0,$ **t** $X = (L+1.422)/2$

$\mathbf{M_{pmax} = (162/L)[(L-1.422)/2]^2 - 76.81}$ .... [D.3-6]

Example:

1. When L = 4m, $M_p max = 72(4)/4$ = 72 kN-m
2. When L = 10m, $M_p max = (144/10)[(10-2.134)/2]^2$ = 222.75 kN-m
3. When L = 20m, $M_p max = (162/20)[(20-1.422)/2]^2 - 76.81$ = 622.10 kN-m

D.4 CASE OF TRUCK LOADING TYPE 12-2



Case 1 (when L < 6.53m) - Consider only TWO wheel, P = 2 @ 40.15 kN

$M_p = 80.3(X-0.6095)(L-X)/L$ .... [D.4-1]

$dM_p/dX = 80.3(L-2X+0.6095)/L = 0,$ t $X = (L+0.6095)/2$

$\mathbf{M_{pmax} = (80.3/L)[(L-0.6095)/2]^2}$ .... [D.4-2]

Case 2 (when 6.53≤ L<14.72m) - Consider THREE wheels, P = 2 @ 40.15kN + 25.9kN

$M_p = 106.2(X-0.357)(L-X)/L - (40.15)(1.219)$ .... [D.4-3]

$dM_p/dX = 106.2(L-2X+0.357)/L = 0,$ t $X = (L+0.357)/2$

$\mathbf{M_{pmax} = (106.2/L)[(L-0.357)/2]^2 - 48.94}$ .... [D.4-4]

Case 3 (when L ≥ 14.72m) - Full Truck

$M_p = 186.5(X-2.252)(L-X)/L - (40.15)(1.219) - (25.9)(4.572)$ .... [D.4-5]

$dM_p/dX = 186.5(L-2X+2.252)/L = 0,$ t $X = (L+2.252)/2$

$\mathbf{M_{pmax} = (186.5/L)[(L-2.252)/2]^2 - 167.36}$ .... [D.4-6]

Example:

1. When L = 4m, $M_p max = (80.3/4)[(4-0.6095)/2]^2$ = 57.69 kN-m
2. When L = 10m, $M_p max = (106.2/10)[(10-0.357)/2]^2 - 48.94$ = 197.94 kN-m
3. When L = 20m, $M_p max = (186.5/20)[(20-2.252)/2]^2 - 167.36$ = 566.96 kN-m

APPENDIX III - D.5

LIVE LOAD MOMENTS ON LONGITUDINAL STRINGERS OR GIRDERS

FOR SIMPLE SPANS PER WHEEL LINE, WITHOUT IMPACT

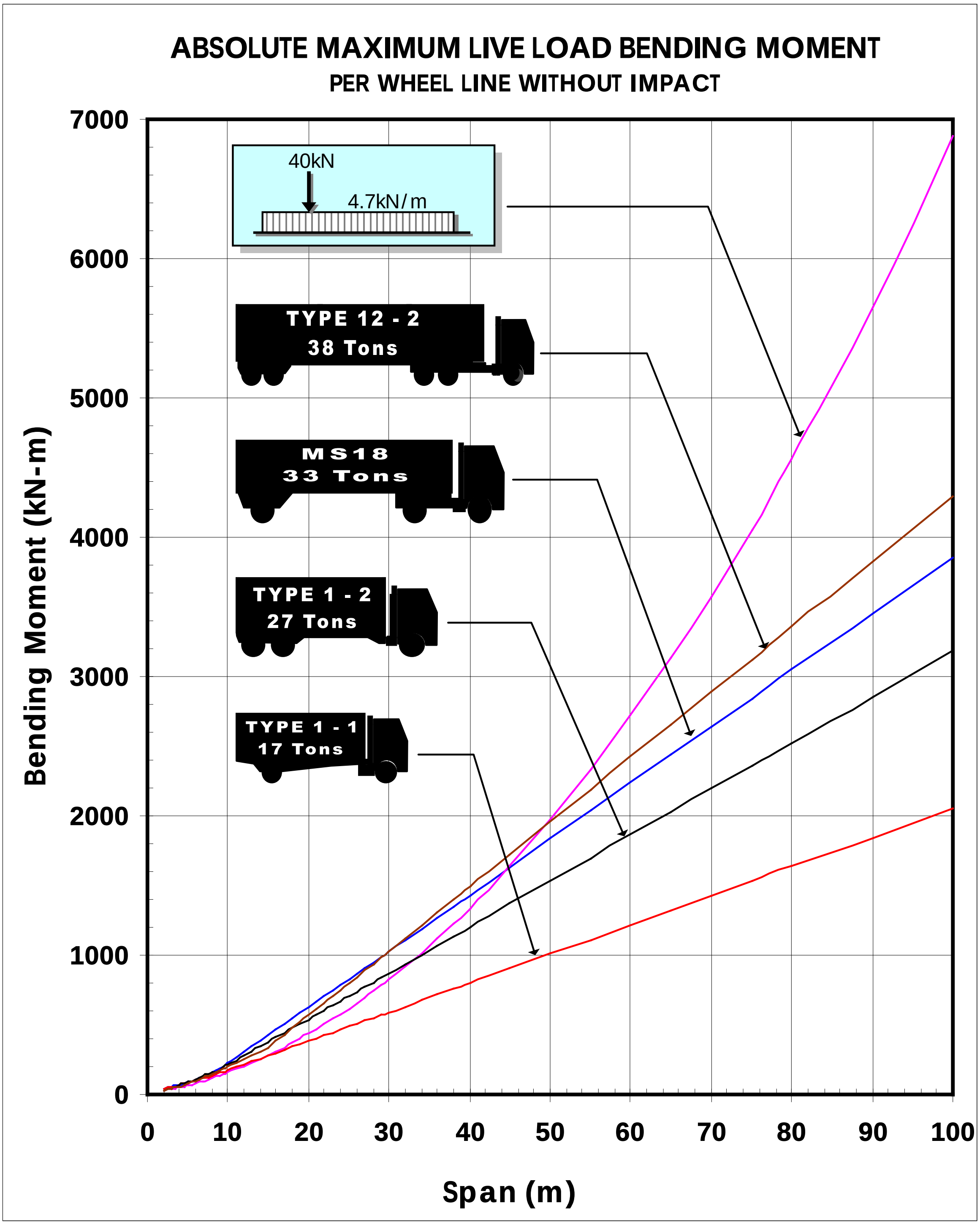
SPAN (m)	IMPACT (%)	LIVE LOAD MOMENT IN KILONEWTON-METER PER WHEEL LINE			
		MS18 (HS20)	TYPE 1-1	TYPE 1-2	TYPE 12-2
2.0	30	36.0	33.4	22.6	20.1
3.0	30	54.0	50.1	43.0	38.3
3.5	30	63.0	58.5	53.8	48.0
4.0	30	72.0	66.8	64.8	57.7
4.5	30	81.0	75.2	75.8	67.6
5.0	30	90.0	83.5	86.9	77.4
5.5	30	99.0	91.9	98.0	87.3
6.0	30	108.0	100.2	109.1	97.3
6.5	30	117.0	108.6	120.3	107.2
7.0	30	126.0	116.9	131.5	118.5
7.5	30	138.3	125.3	142.6	131.7
8.0	30	154.9	133.6	153.8	145.0
8.5	30	171.7	143.7	165.0	158.2
9.0	30	188.6	154.0	177.8	171.5
9.5	30	205.7	164.3	194.2	184.7
10.0	30	222.8	174.7	210.5	198.0
11.0	30	261.0	195.4	243.3	224.5
12.0	30	300.9	216.2	276.2	251.0
13.0	30	340.9	237.0	309.1	277.6
14.0	29	380.9	257.8	342.0	304.1
15.0	29	421.0	278.6	374.9	337.8
16.0	28	461.2	299.4	407.9	383.5
17.0	28	501.4	320.2	440.9	429.2
18.0	27	541.6	341.0	473.9	475.1
19.0	27	581.9	361.9	506.9	521.0
20.0	26	622.2	382.7	540.0	567.0
21.0	26	662.5	403.5	573.0	613.1
22.0	25	702.8	424.4	606.0	659.2
23.0	25	743.1	445.2	639.1	705.3
24.0	25	783.5	466.1	672.2	751.5
25.0	24	823.8	486.9	705.2	797.8
26.0	24	864.2	507.8	738.3	844.0
27.0	23	904.6	528.6	771.4	890.3
28.0	23	945.0	549.5	804.4	936.6
29.0	23	985.4	570.3	837.5	983.0
30.0	22	1025.8	591.2	870.6	1029.3
32.0	22	1106.6	632.9	936.8	1122.1
34.0	21	1187.5	674.6	1003.0	1214.9
36.0	21	1268.3	716.4	1069.1	1307.8
38.0	20	1349.2	758.1	1135.3	1400.7
40.0	20	1430.1	799.8	1201.5	1493.6
45.0	18	1639.7*	904.1	1367.1	1726.1
50.0	17	1968.8*	1008.5	1532.6	1958.7
55.0	16	2327.2*	1112.8	1698.2	2191.4
60.0	16	2715.0*	1217.2	1863.7	2424.1
65.0	15	3132.2*	1321.5	2029.3	2657.0
70.0	14	3578.8*	1425.9	2194.9	2889.8
75.0	13	4054.7*	1530.3	2360.5	3122.7
80.0	13	4560.0*	1634.6	2526.1	3355.6
90.0	12	5658.8*	1843.4	2857.3	3821.6
100.0	11	6875.0*	2052.1	3188.5	4287.6

NOTES:

1. * MS18 Lane Loading governs at these spans.
2. Shaded values indicate load effects greater than the MS18 rating live load. However, Section 3.2.4 of the DPWH Design Guidelines requires design using load effects by Alternate Military Loading and Permit Design Load, which is greater than the shaded values.

MAXIMUM LIVE LOAD MOMENT FOR SIMPLE SPANS (RATING AND POSTING VEHICLES)

PER WHEEL LINE WITHOUT IMPACT



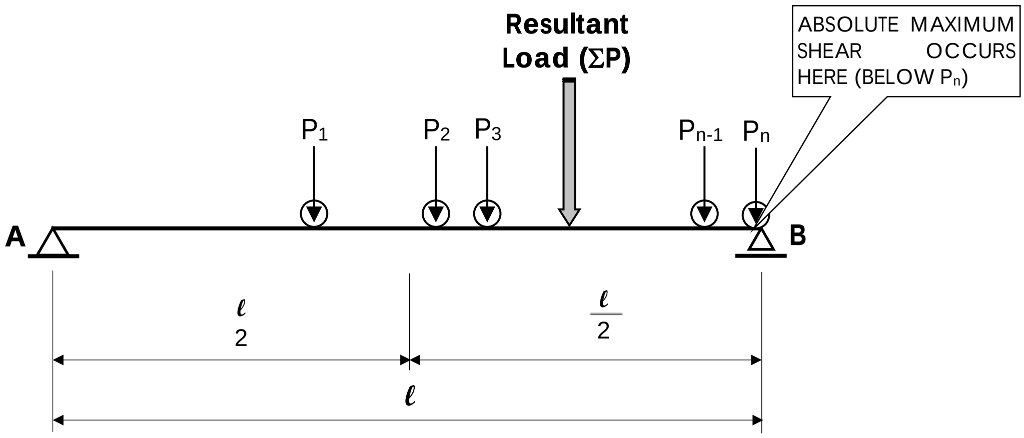
APPENDIX III - E

MAXIMUM ABSOLUTE LIVE LOAD SHEAR FOR SIMPLE BEAM

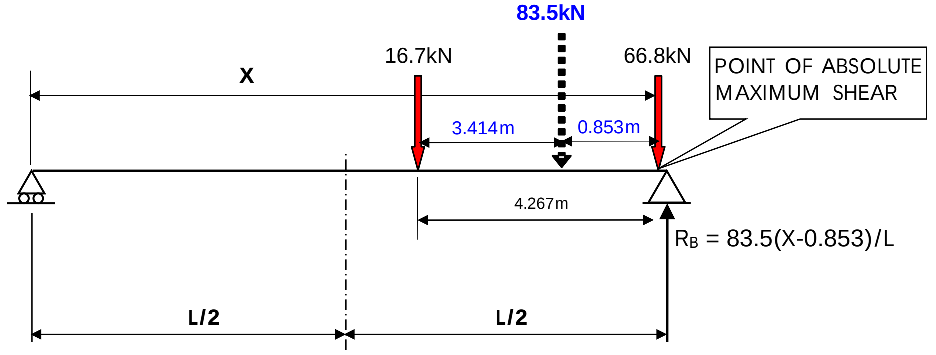
Basic Principles:

1 - The absolute maximum shear to the left of the support due to a series of concentrated wheel loads moving on a simple span beam always occur at the left of the support directly under last heavier wheel (in this case, wheel P_n at point B).

2 - The loading pattern producing the absolute maximum shear in the simple beam is when the last heavier wheel is at an infinitesimal distance from the support (in this case, wheel P_n), as shown below.



E.1 CASE OF TRUCK LOADING TYPE 1-1



Case 1 (when L ≤ 4.267) - Consider only ONE wheel, P = 66.8kN

$V_p = 66.8(X)/L$ .... [E.1-1]

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$X \rightarrow L$

$\mathbf{V_{pmax} = 66.8\ kN}$ .... [E.1-2]

Case 2 (when L > 4.267m) - Full Truck

$V_p = 83.5(X-0.853)/L$ .... [E.1-3]

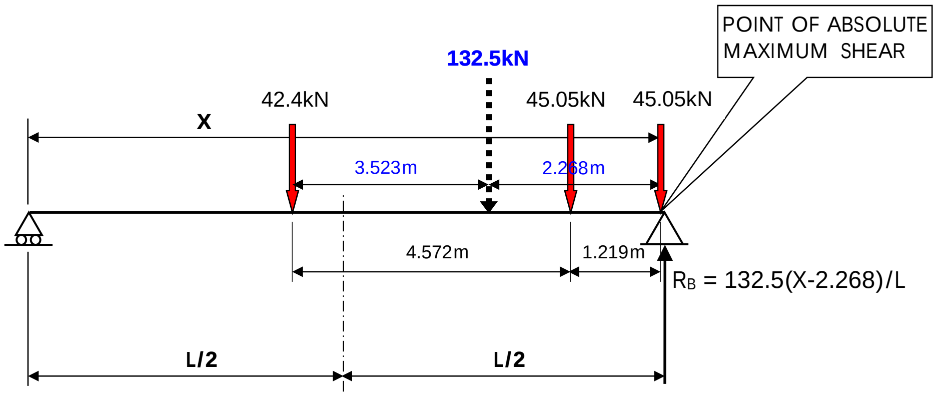
$X \rightarrow L$

$\mathbf{V_{pmax} = 83.5(1-0.853/L)}$ (in kN) .... [E.1-4]

Example:

1. When L = 4m, $V_p max$ = 66.8 kN
2. When L = 20m, $V_p max$ = 83.5(1-0.853/20) = 79.94 kN

E.2 CASE OF TRUCK LOADING TYPE 1-2



Case 1 (when L ≤ 5.791m) - Consider only TWO wheels, P = 2 @ 45.05kN

V_p = 90.1(X-1.219/2)/L .... [E.2-1]

X → L

V_{pmax} = 90.1(1-0.6095/L) (in kN) .... [E.2-2]

Case 2 (when L > 5.791m) - Full Truck

V_p = 132.5(X-2.268)/L ....
[E.2-3]

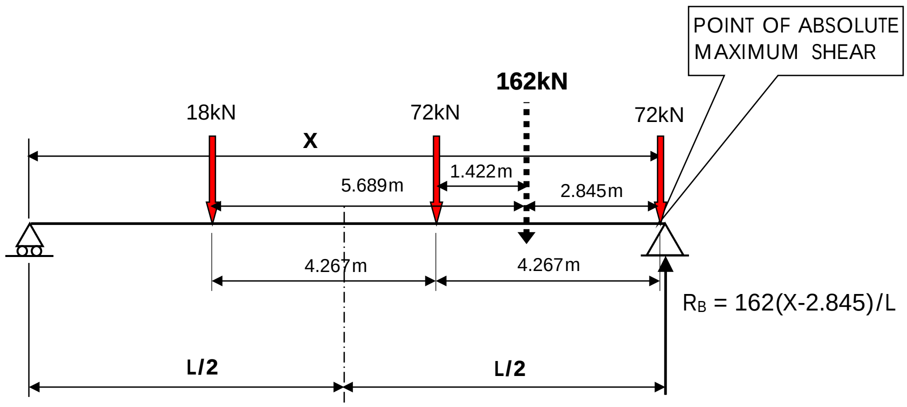
X → L

V_{pmax} = 132.5(1-2.268/L) (in kN) .... [E.2-4]

Example:

1. When L = 4m, $V_p$max = 90.1(1-0.6095/4) = 76.37 kN-m
2. When L = 20m, $V_p$max = 132.5(1-2.268/20) = 117.47 kN-m

E.3 CASE OF TRUCK LOADING TYPE MS18



Case 1 (when L ≤ 4.267m) - Consider only ONE wheel, P = 72kN

$V_p = 72(X)/L$ .... [E.3-1]

$X \rightarrow L$

$\mathbf{V_{pmax} = 72\ kN}$ .... [E.3-2]

Case 2 (when 4.267 < L ≤ 8.534m) - Consider only TWO wheels, P = 2 @ 72kN

$V_p = 144(X-4.267/2)/L$ .... [E.3-3]

$X \rightarrow L$

$\mathbf{V_{pmax} = 144(1-2.134/L)}$ (in kN) .... [E.3-4]

Case 3 (when L > 8.534m) - Full Truck

$V_p = 162(X-2.845)/L$ .... [E.3-5]

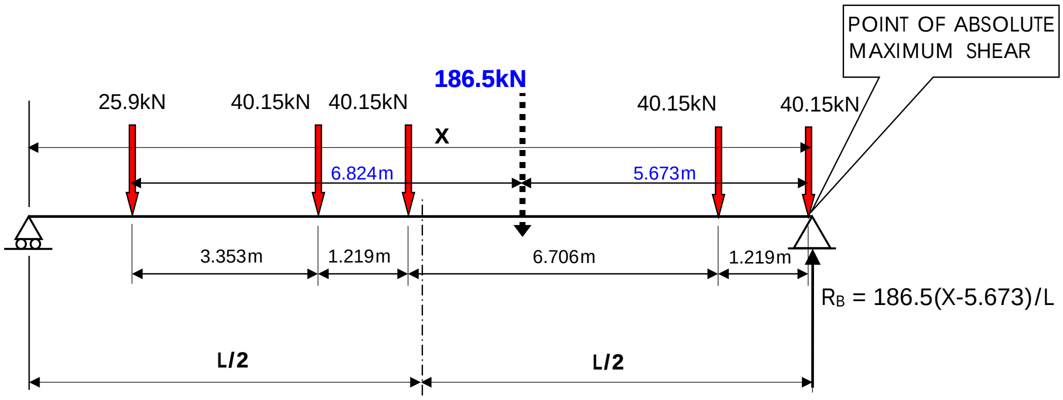
$X \rightarrow L$

$\mathbf{V_{pmax} = 162(1-2.845/L)}$ (in kN) .... [E.3-6]

Example:

1. When L = 4m, $V_p max$ = 72 kN
2. When L = 8m, $V_p max$ = 144(1-2.134/8) = 105.59 kN
3. When L = 20m, $V_p max$ = 162(1-2.845/20) = 138.96 kN

E.4 CASE OF TRUCK LOADING TYPE 12-2



Case 1 (when L ≤ 4.572m) - Consider only TWO wheel, P = 2 @ 40.15 kN

$V_p = 80.3(X-1.219/2)/L$ .... [E.4-1]

$X \rightarrow L$

$\mathbf{V_{pmax} = 80.3(1-0.6095/L)}$ (in kN) .... [E.4-2]

Case 2 (when 4.572 < L ≤ 12.497m) - Consider THREE wheels, P = 2 @ 40.15kN + 25.9kN

$V_p = 106.2(X-1.576)/L$ .... [E.4-3]

$X \rightarrow L$

$\mathbf{V_{pmax} = 106.2(1-1.576/L)}$ (in kN) .... [E.4-4]

Case 3 (when L > 12.497m) - Full Truck

$V_p = 186.5(X-5.673)/L$ .... [E.4-5]

$X \rightarrow L$

$\mathbf{V_{pmax} = 186.5(1-5.673/L)}$ (in kN) .... [E.4-6]

Example:

1. When L = 4m, $V_p max = 80.3 (1-0.6095/4)$ = 68.06 kN
2. When L = 10m, $V_p max = 106.2(1-1.576/10)$ = 89.46 kN
3. When L = 20m, $V_p max = 186.5(1-5.673/20)$ = 133.60 kN

APPENDIX III - E.5

LIVE LOAD SHEARS ON LONGITUDINAL STRINGERS OR GIRDERS

FOR SIMPLE SPANS PER WHEEL LINE, WITHOUT IMPACT

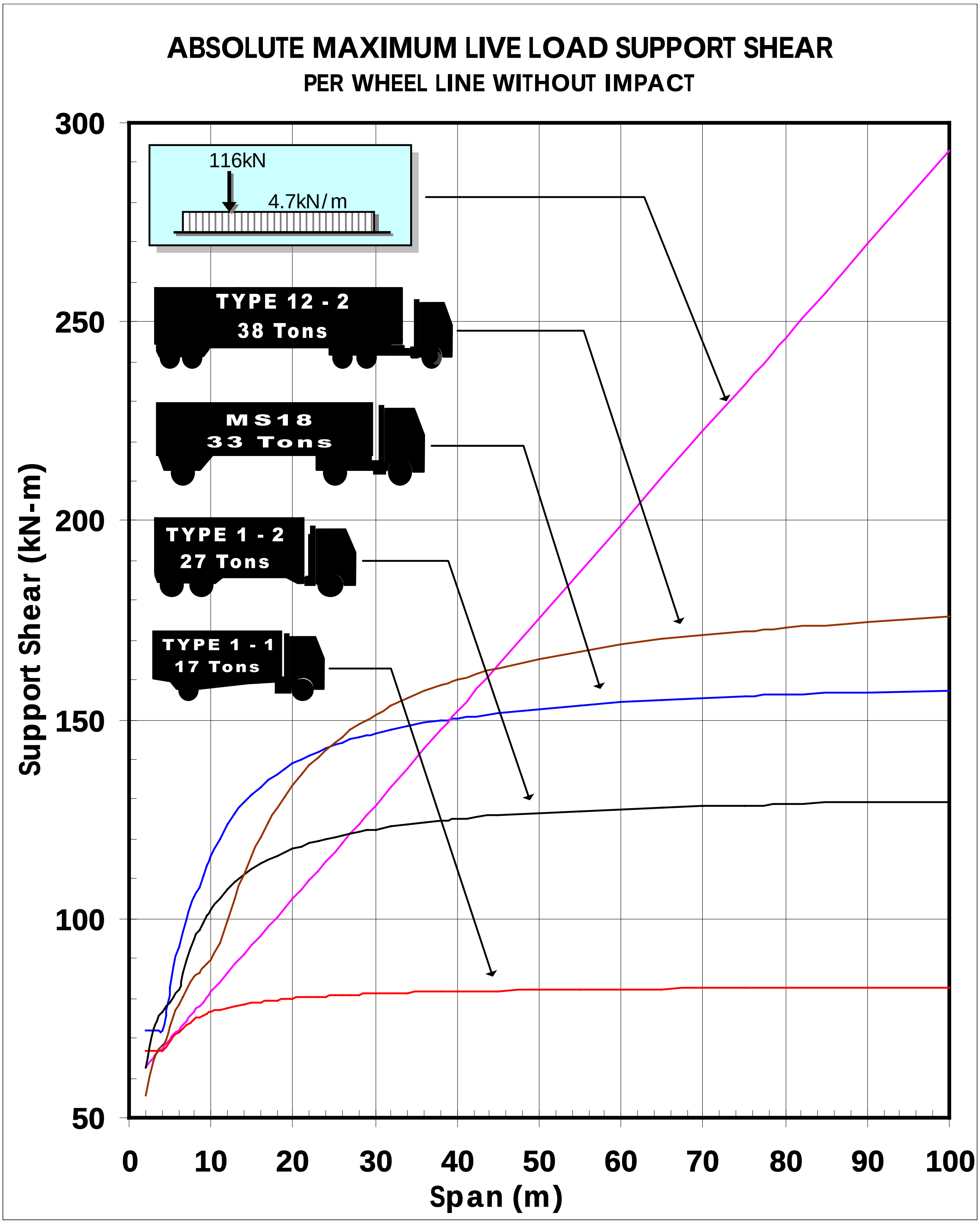
SPAN (m)	IMPACT (%)	LIVE LOAD SUPPORT SHEAR IN KN PER WHEEL LINE			
		MS18 (HS20)	TYPE 1-1	TYPE 1-2	TYPE 12-2
2.0	30	72.0	66.8	62.7	55.9
3.0	30	72.0	66.8	71.8	64.0
3.5	30	72.0	66.8	74.5	66.4
4.0	30	72.0	66.8	76.4	68.1
4.5	30	75.8	67.7	77.9	69.5
5.0	30	82.6	69.3	79.2	72.8
5.5	30	88.2	70.6	80.2	75.8
6.0	30	92.8	71.7	82.5	78.4
6.5	30	96.8	72.6	86.3	80.5
7.0	30	100.2	73.4	89.6	82.3
7.5	30	103.1	74.1	92.5	83.9
8.0	30	105.6	74.6	95.0	85.3
8.5	30	107.8	75.2	97.2	86.6
9.0	30	110.8	75.6	99.2	87.7
9.5	30	113.5	76.1	100.9	88.6
10.0	30	116.0	76.4	102.5	89.5
11.0	30	120.2	77.1	105.2	93.9
12.0	30	123.6	77.6	107.5	99.5
13.0	30	126.6	78.1	109.4	105.2
14.0	29	129.1	78.5	111.1	111.0
15.0	29	131.3	78.8	112.5	116.0
16.0	28	133.2	79.1	113.8	120.4
17.0	28	134.9	79.4	114.9	124.3
18.0	27	136.4	79.6	115.9	127.8
19.0	27	137.8	79.8	116.7	130.9
20.0	26	139.0	80.0	117.5	133.6
21.0	26	140.1	80.2	118.2	136.2
22.0	25	141.1	80.3	118.9	138.5
23.0	25	142.0	80.5	119.5	140.6
24.0	25	142.8	80.6	120.0	142.5
25.0	24	143.6	80.7	120.5	144.2
26.0	24	144.3	80.8	121.0	145.9
27.0	23	145.0	80.9	121.4	147.4
28.0	23	145.6	81.0	121.8	148.8
29.0	23	146.2	81.1	122.2	150.1
30.0	22	146.7	81.2	122.5	151.3
32.0	22	147.6	81.3	123.2	153.5
34.0	21	148.5	81.5	123.7	155.4
36.0	21	149.2	81.6	124.2	157.2
38.0	20	149.9	81.7	124.6	158.7
40.0	20	152.0*	81.8	125.0	160.1
45.0	18	163.8*	82.0	125.9	163.0
50.0	17	175.5*	82.1	126.5	165.4
55.0	16	187.3*	82.3	127.1	167.3
60.0	16	199.0*	82.4	127.5	168.9
65.0	15	210.8*	82.5	127.9	170.3
70.0	14	222.5*	82.5	128.3	171.4
75.0	13	234.3*	82.6	128.5	172.4
80.0	13	246.0*	82.7	128.8	173.3
90.0	12	269.5*	82.8	129.2	174.8
100.0	11	293.0*	82.8	129.5	176.0

NOTES:

3. * MS18 Lane Loading governs at these spans.
4. Shaded values indicate load effects greater than the MS18 rating live load. However, Section 3.2.4 of the DPWH Design Guidelines requires design using load effects by Alternate Military Loading and Permit Design Load, which is greater than the shaded values.

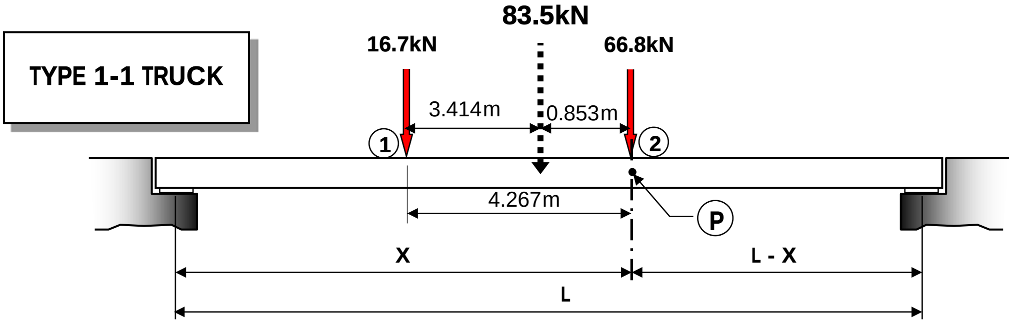
MAXIMUM LIVE LOAD SUPPORT SHEARS FOR SIMPLE SPANS (RATING AND POSTING VEHICLES)

PER WHEEL LINE WITHOUT IMPACT



APPENDIX III - F.1

MAXIMUM MOMENT & SHEAR AT ANY POINT ON SPAN FOR TYPE 1-1 POSTING VEHICLE (SIMPLE SPAN ONLY)



BENDING MOMENT AT POINT "P" (M_P) in kN-m PER WHEEL LINE (NO IMPACT)

Case 1 $$M_P = \frac{66.8\,(X)(L - X)}{L} \qquad \text{when} \quad L < 4.267\text{m}$$

Case 2 $$M_P = \frac{83.5\,(L - X)(X - 0.853)}{L} \qquad \text{when} \quad X \geq 4.267\text{m}$$

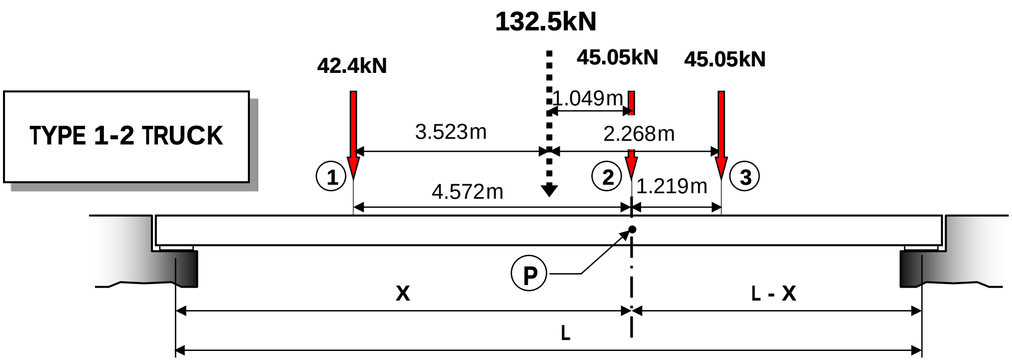
SHEAR AT RIGHT OF POINT "P" (V_P) in kN PER WHEEL LINE (NO IMPACT)

Case 1 $$V_P = \frac{66.8\,(X)}{L} \qquad \text{when} \quad L < 4.267\text{m}$$

Case 2 $$V_P = \frac{83.5\,(X - 0.853)}{L} \qquad \text{when} \quad X \geq 4.267\text{m}$$

APPENDIX III - F.2

MAXIMUM MOMENT & SHEAR AT ANY POINT ON SPAN FOR TYPE 1-2 POSTING VEHICLE (SIMPLE SPAN ONLY)



BENDING MOMENT AT POINT "P" (M_P) in kN-m PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	FORMULA FOR MAXIMUM MOMENT AT POINT "P" (M_P)	Minimum L-X (m)	Minimum X (m)	AXLE NO. @ PANEL POINT "P"	TRUCK TRAVEL DIRECTION
1	0 - 0.340	$M_P = \frac{132.5\,(X - 2.268)(L - X)}{L}$	0	5.791	3	R - L
2	0.340 - 0.500	$M_P = \frac{132.5\,(X - 1.049)(L - X)}{L} - 54.92$	1.219	4.572	2	R - L

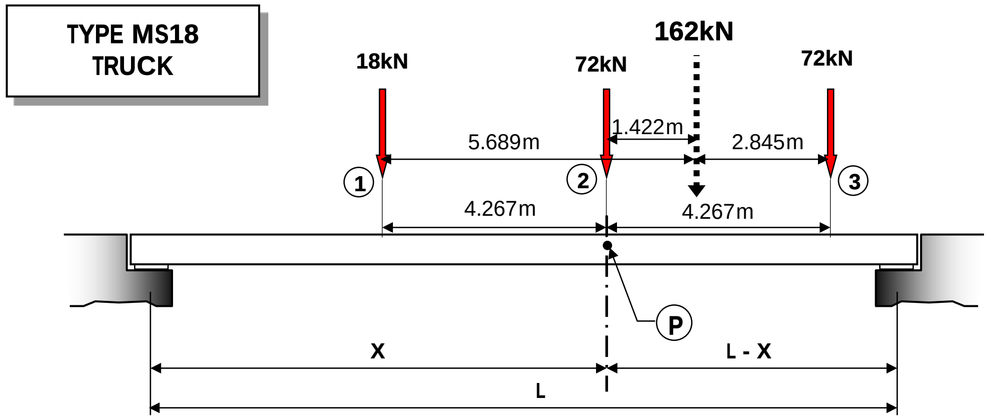
SHEAR AT RIGHT OF POINT "P" (V_P) in kN PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	FORMULA FOR MAXIMUM SHEAR AT POINT "P" (V_P)	Minimum L-X (m)	Minimum X (m)	AXLE NO. @ PANEL POINT "P"	TRUCK TRAVEL DIRECTION
1	0 - 0.500	$V_P = \frac{132.5\,(X - 2.268)}{L}$	0	5.791	3	R - L

NOTE : Shear formula is applicable when dimension "X" exceeds the total length of truck. When "X" is less than the minimum, determine shears by statics.

APPENDIX III - F.3

MAXIMUM MOMENT & SHEAR AT ANY POINT ON SPAN FOR MS18 RATING VEHICLE (SIMPLE SPAN ONLY)



NOTE : *The following formulas are applicable when the entire truck is within the span.

**Lane Load governs when L > 44.05m

***Truck loading does not govern shear beyond this length specified. Use lane loading.

BENDING MOMENT AT POINT "P" (M_P) in kN-m PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	FORMULA FOR MAXIMUM MOMENT AT POINT "P" (M_P)	Minimum		Max L* (m)
			L-X (m)	X (m)	
1	0 - 0.333	$M_P = \dfrac{162\,(X - 2.845)(L - X)}{L}$	0	8.534	-
2	0.333 - 0.500	$M_P = \dfrac{162\,(X - 1.422)(L - X)}{L} - 76.81$	4.267	4.267	44.05

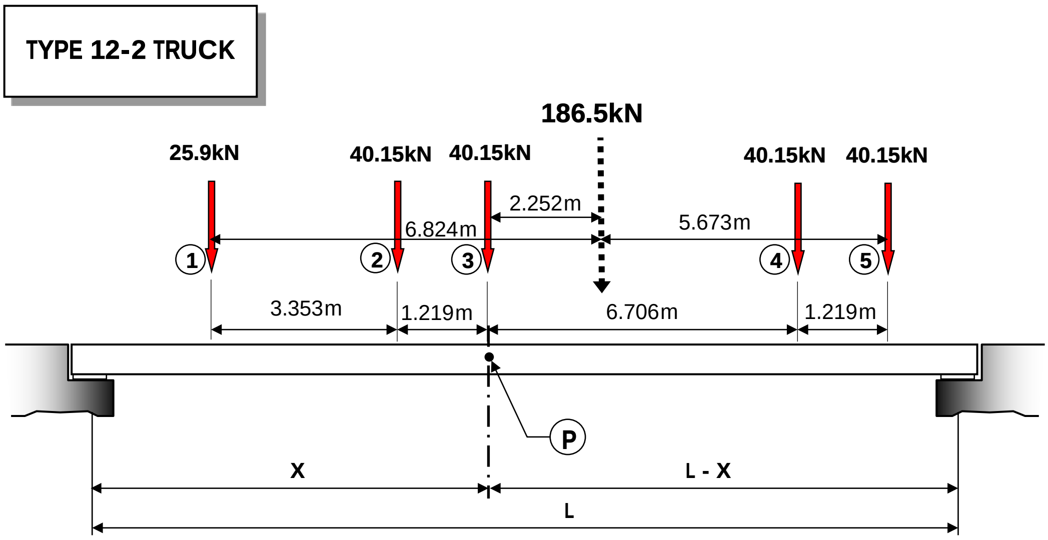
SHEAR AT RIGHT OF POINT "P" (V_P) in kN PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	Use for Girder Lengths	FORMULA FOR MAXIMUM SHEAR AT POINT "P" (V_P)	Minimum	
				L-X (m)	X (m)
1	0 - 0.500	Under 12.80m	$V_P = \dfrac{162\,(X - 1.422)}{L} - 18$	4.267	4.267
2		12.8m -	$V_P =$ 162 (X - 2.845)	0	8.534

		36.6m***	L		

APPENDIX III - F.4

MAXIMUM MOMENT & SHEAR AT ANY POINT ON SPAN FOR TYPE 12-2 POSTING VEHICLE (SIMPLE SPAN ONLY)



NOTE : The following formulas are applicable when the entire truck is within the span.

BENDING MOMENT AT POINT "P" (M_P) in kN-m PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	FORMULA FOR MAXIMUM MOMENT AT POINT "P" (M_P)	Minimum		AXLE NO. @ PANEL POINT "P"	TRUCK TRAVEL DIRECTION
			L-X (m)	X (m)		
1	0 - 0.211	$M_P = \frac{186.5\,(X - 5.673)(L - X)}{L}$	0	12.497	5	R - L
2	0.211 - 0.354	$M_P = \frac{186.5\,(X - 3.471)(L - X)}{L} - 86.84$	3.353	9.144	2	L - R
3	0.354 - 0.500	$M_P = \frac{186.5\,(X - 2.252)(L - X)}{L} - 167.36$	4.572	7.925	3	L - R

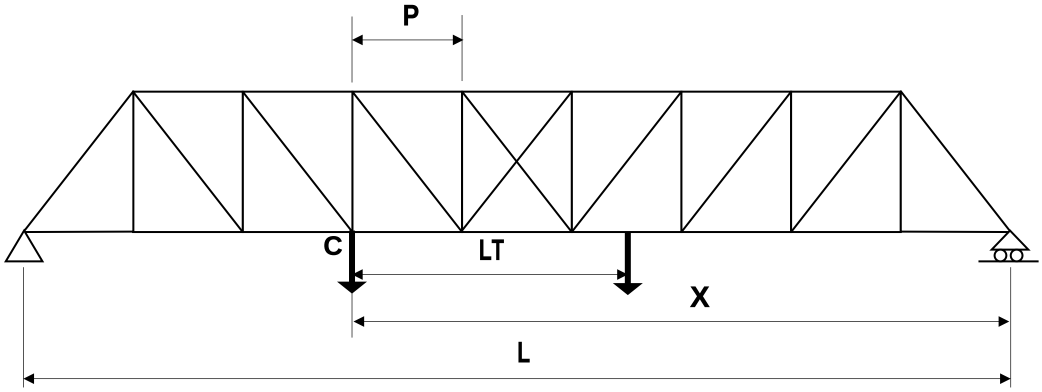
SHEAR AT RIGHT OF POINT "P" (V_P) in kN PER WHEEL LINE (NO IMPACT)

LOAD CASE	L-X/L	FORMULA FOR MAXIMUM SHEAR AT POINT "P" (V_P)	Minimum		AXLE NO. @ PANEL POINT "P"	TRUCK TRAVEL DIRECTION
			L-X (m)	X (m)		
1	0 - 0.500	$V_P = 186.5\,(X - 5.673)$	0	12.497	5	R - L

		L				

APPENDIX III - G

MAXIMUM SHEAR AT ANY PANEL POINT



L	:	Length of Truss
LT	:	Axle Spacing/Distance
P	:	Length of Panel
X	:	Distance from Panel Point to End of Truss

SHEAR AT PANEL POINT (V_C) IN kN PER WHEEL LINE (NO IMPACT)

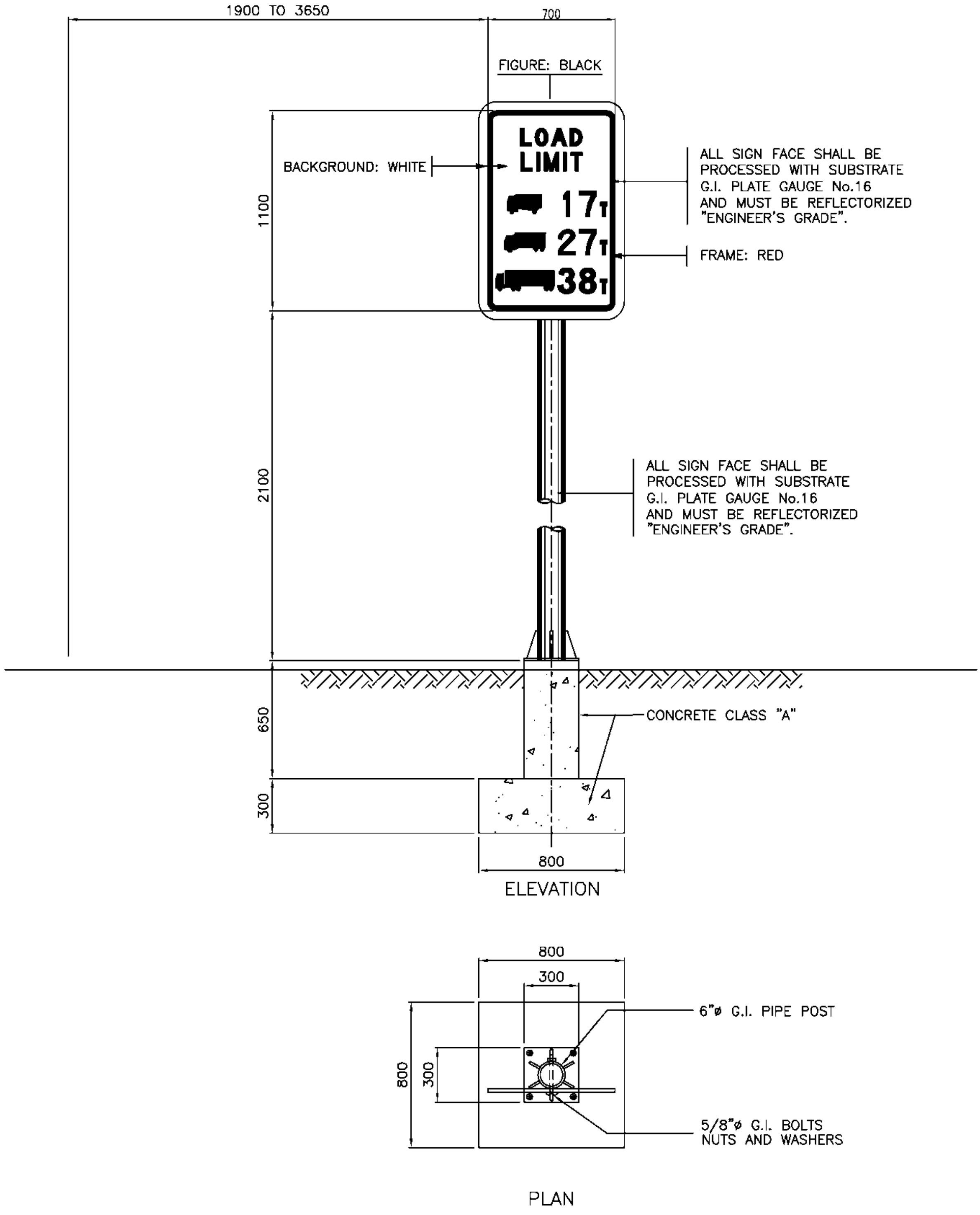
LOAD TYPE	LT (m)	MIN "X" (m)	FORMULA	USE FOR TRUSS WITH NO. OF PANELS	AXLE NO. @ PANEL POINT	TRUCK TRAVEL DIRECTION
TYPE 1-2	5.791	5.791	$V_P = \dfrac{132.5\ (X - 2.268)}{L}$	ALL	3	L - R
TYPE 12-2	12.497	12.497	$V_P = \dfrac{186.5\ (X - 5.673)}{L}$	5 OR MORE	5	L - R
		9.144	$V_P = \dfrac{186.5\ (X - 3.471)}{L} - \dfrac{86.84}{P}$	3, 4	2	R - L
		7.925	$V_P = \dfrac{186.5\ (X - 2.252)}{L} - \dfrac{167.35}{P}$	2	3	R - L

NOTES:

- Applicable only when entire truck is within the span
- See Appendix IV - F for shears resulting from Type 1-1 and MS18
- Truck Travel Direction : L - R - Truck moving from Left to Right
  R - L - Truck moving from Right to Left

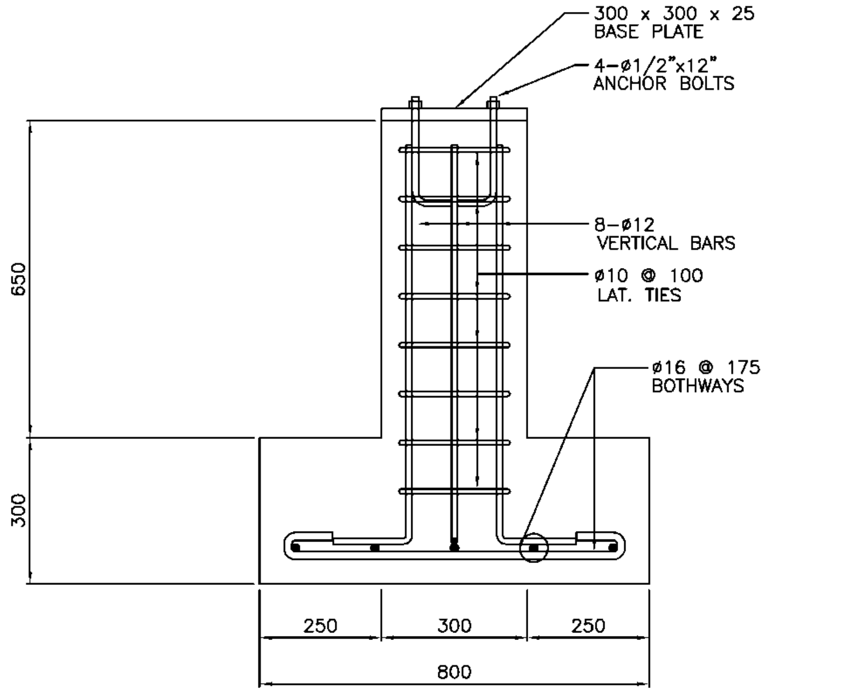
APPENDIX IV

LOAD POSTING SIGN

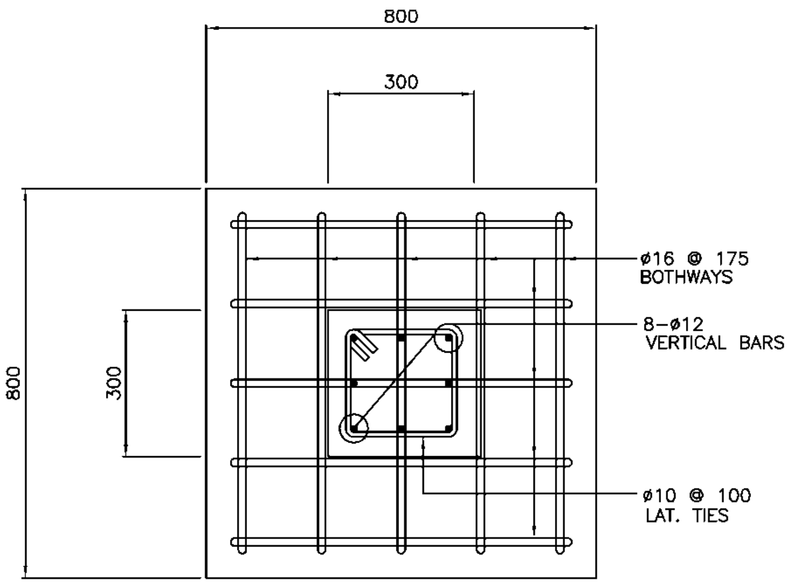


DETAILS OF INSTALLATION

SCALE 1:20

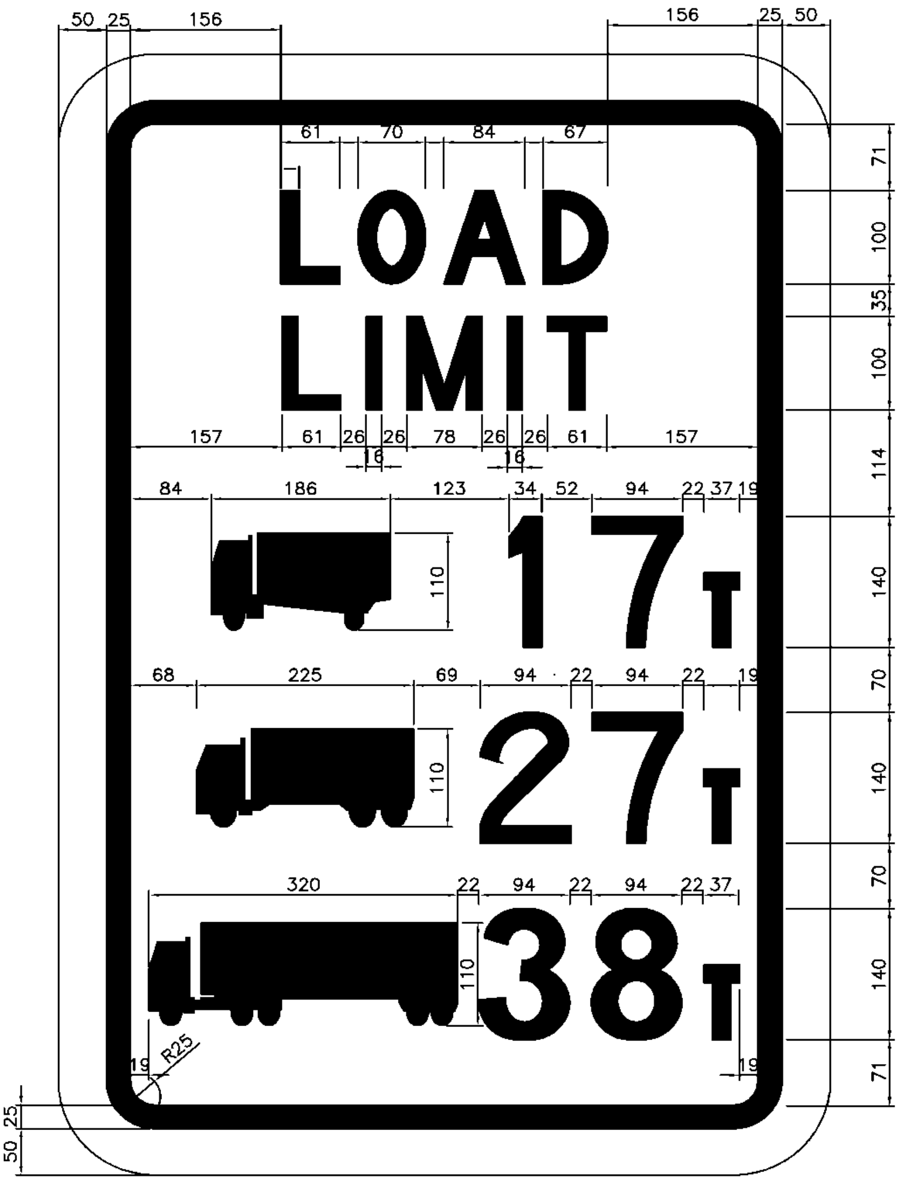


ELEVATION



PLAN

DETAILS OF PEDESTAL
SCALE **1:10**



DETAILS OF SERIES 120DN LETTERS & NUMERICAL DIMENSIONS
SCALE 1:5

Manual For Load Rating Of Bridges

3rd Edition

LOAD RATING

COMPUTER-BASED PROGRAM

USER ' S MANUAL

Appendix V

User's Manual for Load Rating Computer-Based Program

Table of Contents

User's Manual of Computer-Based Program on Load Rating

1. General

This User's Manual is divided into 6 sections showing the detail procedure for Load Rating.
DPWH through the assistance of JICA developed Manual for Load Rating of Bridges (MLRB) 2nd Edition on March, 2009. In addition, a Computer-based Program on Load Rating of Bridges (CBPLR) has been developed to complement MLRB. This 3_{rd} Edition 2014, retains the original CBPLR established in 2009.

This Program has the following advantages:

(1) It is easy to calculate the Load Rating for Major Bridge Types.
(2) This Program provides 4 Bridge Types including RC Deck Slab, not only Simple and Continuous Bridges but also Interior and Exterior Girder. (refer to Section 5)
(3) DPWH Engineers can save time to determine the appropriate Load Rating
(4) DPWH Engineers can avoid inappropriate Load Rating Calculations

However, the pilot Bridges for Load Rating example have some unknown factors, therefore the User should carefully give the Input Data with appropriate engineering judgements in this Program as follows.

(1) To determine and measure appropriate Bridge Layout and Dimensions
(2) To determine and assume appropriate Rebar/PC Tendon Schedule inside concrete components of Bridges
(3) To determine and assume appropriate Material Properties.
(4) To determine the appropriate evaluation for Bridge Current Condition (Damage).

2. Function of this Program

This Program provides Load Rating Calculations of Bridges.

3. Installation of Software

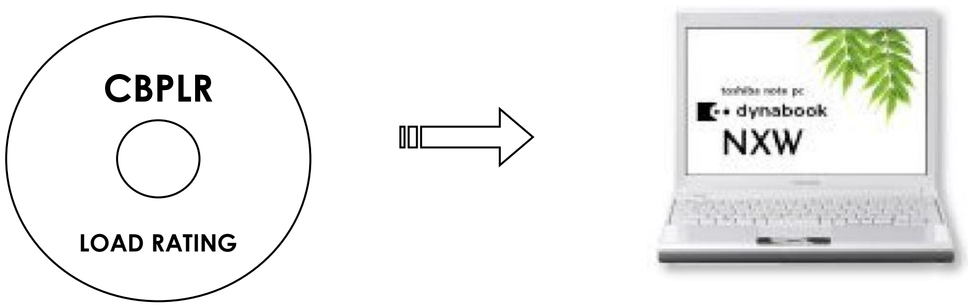
This Program requires the following softwares which should be installed in your computer.
Microsoft Excel 2003 or 2007 or 2010
Microsoft Windows XP or Vista or Windows 7

4. Installing and Uninstalling Procedures of CBPLR

4.1 Installing

(1) Start your computer
(2) Insert the CBPLR set up CD. Then you can see the program files and folder as shown below.
(3) "Copy" the Program "CBPLR".
(4) "Paste" it to your computer root directory C:

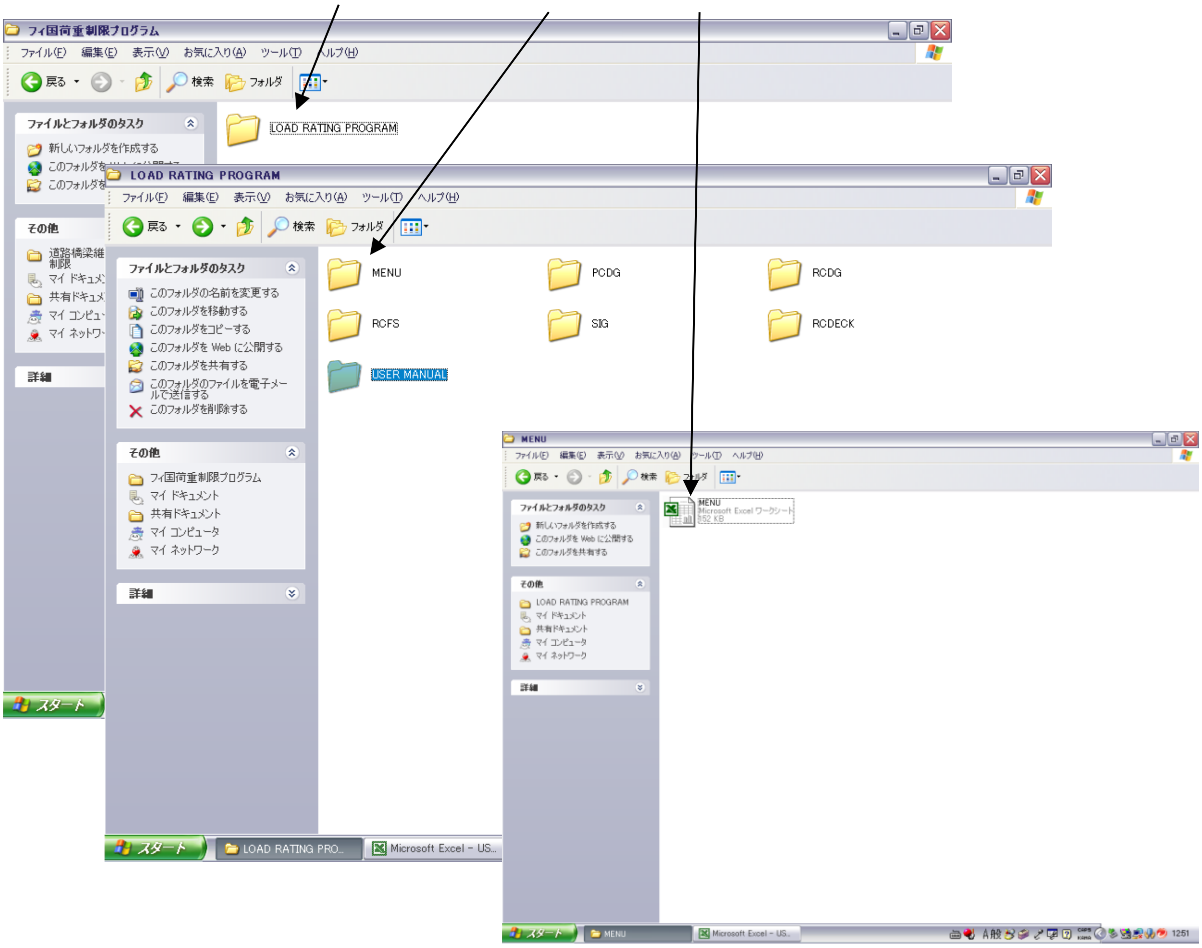
Program CD **Insert Program CD to your PC**



4.1.1 Copy to your computer directory C: drive

4.1.2 Starting

Double click folder **"Load Rating Program" and "MENU" then Excel file "MENU"**



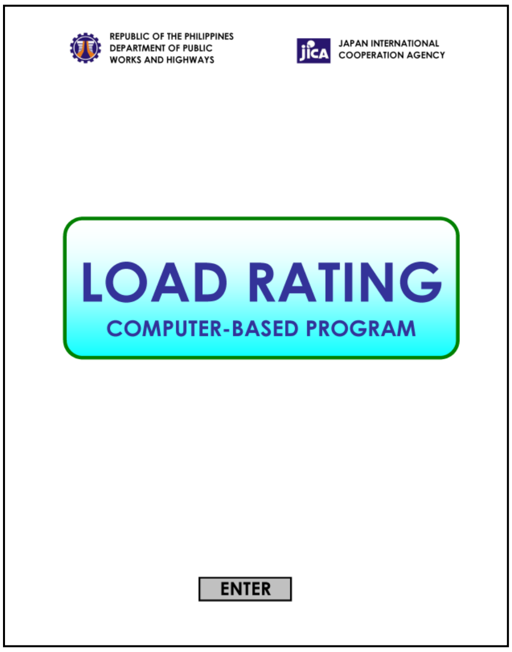
4.2 Uninstalling

Delete "CBPLR" from Directory C:

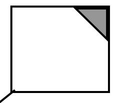
5. Procedure of "MENU" in this Program

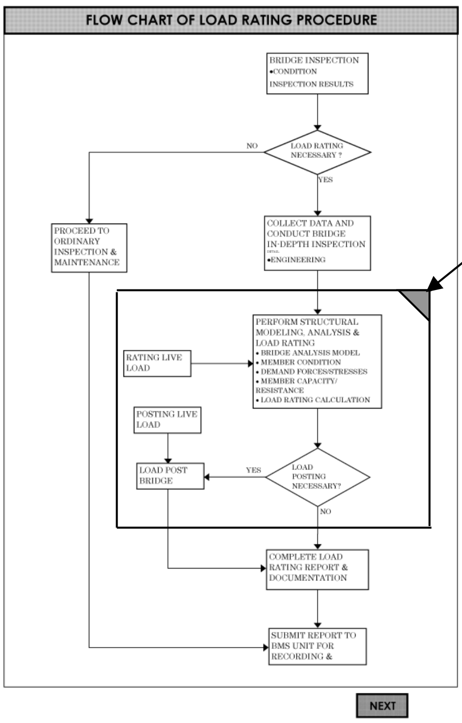
5.1 TITLE

After opening the Excel file **"Menu"**, then click button ENTER on this screen.



5.2 Flowchart of Load rating Procedure

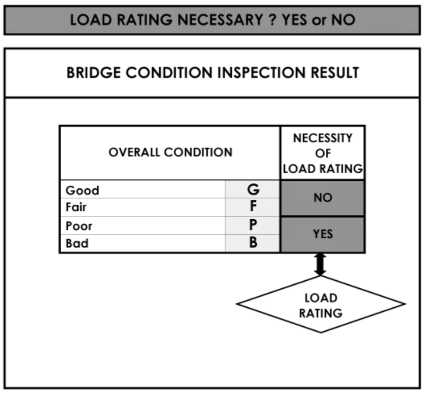
Flow Chart of Load Rating Procedure is shown below. This Program covers  part.



After reconfirming the Flowchart, click **"NEXT"** button.

5.3 Bridge Condition Inspection Results

The overall condition state G, F, P and B of the bridge should be determined by the Accredited Bridge Engineer. User should select the actual overall condition state based on the Condition Inspection Survey or Engineering Inspection Survey in Bridge Management System.
In case of selecting P and B, click button **"Yes"** then directly proceed to the next screen **"MENU"**



5.4 Menu of Load Rating

This screen links with all Excel programs for each Bridge types. The User can use the directory and proceed in selecting the bridge type by **clicking cell of the objective bridge types**. They are;

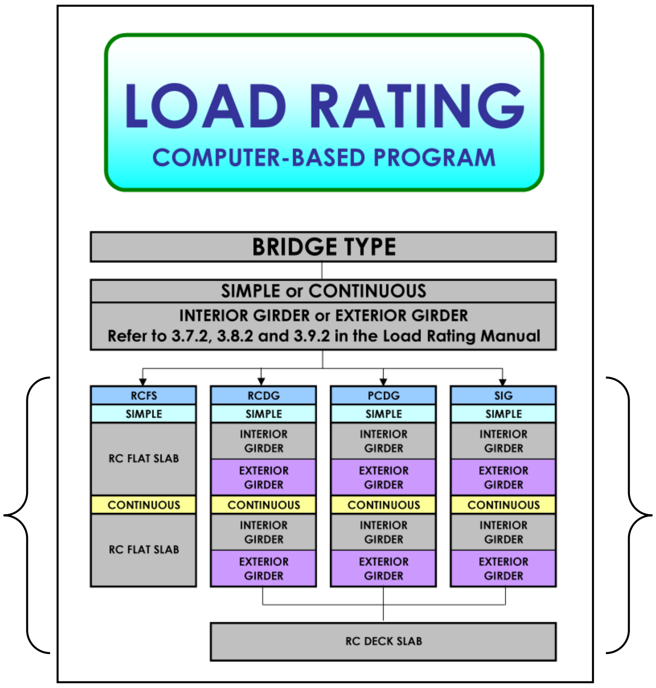
RCFS (Reinforced Concrete Flat Slab Bridge) : Simple RC Flat Slab
Continuous RC Flat Slab

RCDG (Reinforced Concrete Deck Girder Bridge) : Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

PCDG (Prestressed Concrete Deck Girder Bridge) : Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

SIG (Steel I Girder Bridge) : Simple Interior and Exterior Girder
Continuous Interior and Exterior Girder

RCDECK (Reinforced Concrete Deck Slab)



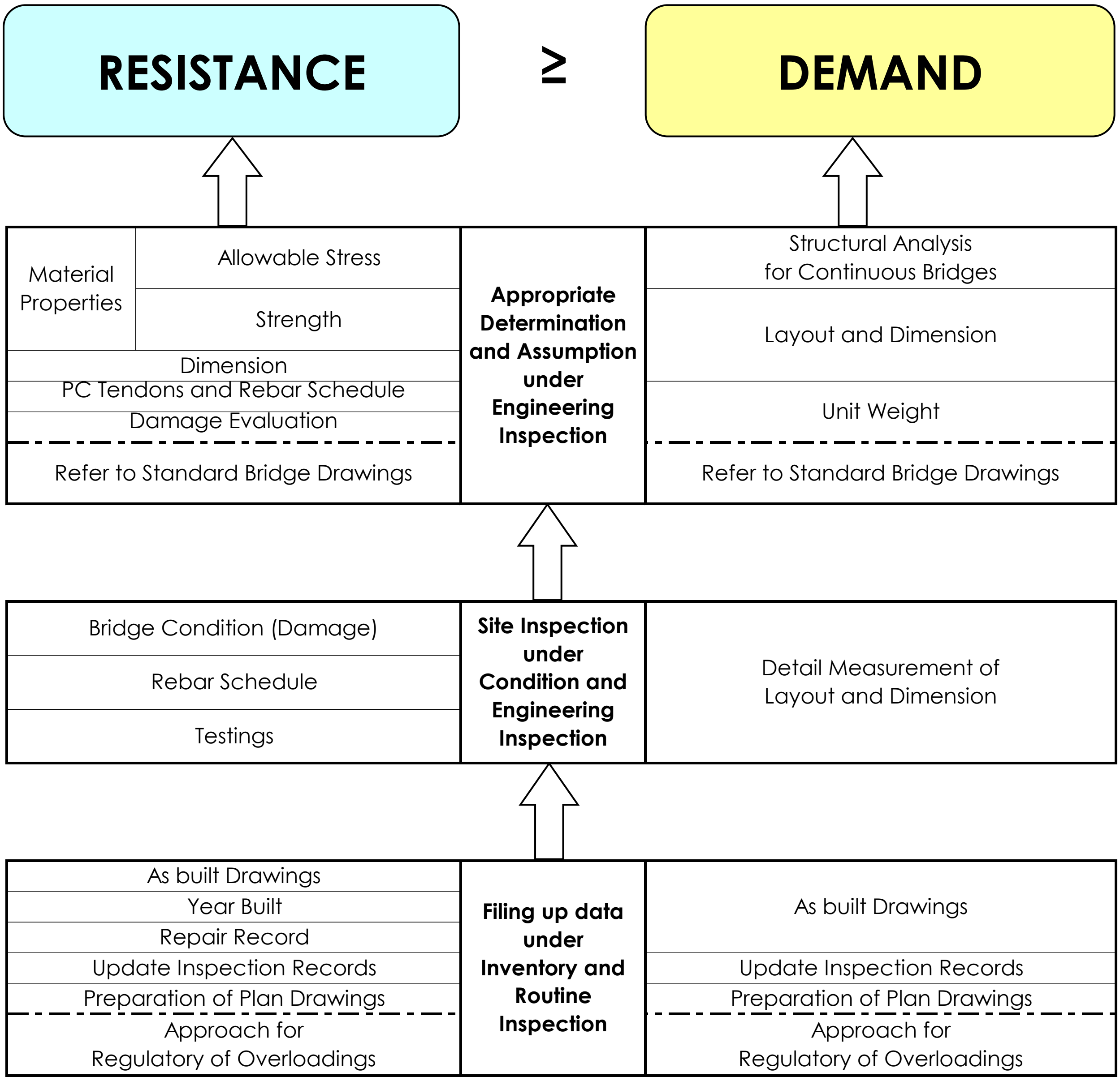
Cells of each Bridge Types

6. Procedure of "Load Rating Program of each bridge type" in this Program

6.1 General

6.1.1 Load Rating Principles

When operating the Load Rating Program, Load Rating Principles should be kept through many activities as follows

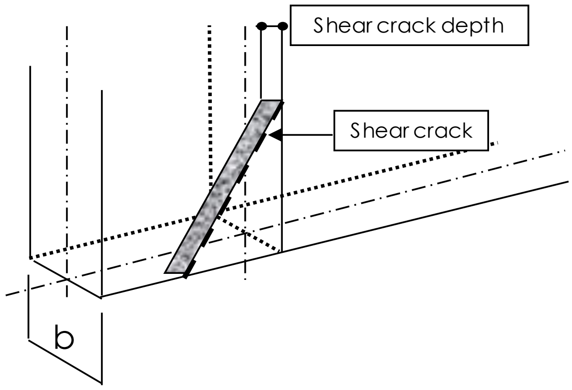


6.1.2 Damage Evaluation

Damage evaluation is considered in this Program as follows:

<table>
<tr><th colspan="3">Condition State
2-Poor or 3-Bad</th></tr>
<tr><td rowspan="9">Severity
of
defect
At Midspan
At Support</td><td>Location (Section)</td><td>2-Poor or more at near Support or near Midspan
where loaded maximum demand forces</td></tr>
<tr><td colspan="2">For Concrete Girder</td></tr>
<tr><td>Cracking</td><td>greater than 0.3mm and its spacing
smaller than 500mm</td></tr>
<tr><td>Rebar exposure</td><td>greater than 50 cm^2 exposed and corroded</td></tr>
<tr><td colspan="2">For Concrete Deck Slab</td></tr>
<tr><td>Cracking</td><td>greater than 0.3mm, 2 directions,
and its spacing smaller than 500mm</td></tr>
<tr><td>Rebar exposure</td><td>greater than 50 cm^2 exposed and corroded</td></tr>
<tr><td colspan="2">For Steel Girder</td></tr>
<tr><td>Corrosion</td><td>greater than 10% section loss
stratified rust with pitting of metal surface</td></tr>
</table>

Damage evaluation method is as follows:

<table>
<tr><td rowspan="7">Concrete
Girder and
Deck Slab</td><td rowspan="2">Cracking
due to Moment</td><td>Not consider concrete section loss of tension fiber</td></tr>
<tr><td>Consider only by rebar exposure of tension fiber</td></tr>
<tr><td rowspan="3">Cracking
due to Shear</td><td>Consider by reduction factor (Φ) according to shear crack depth (Cw)
as mentioned below
Cw = > 0.5 b applying Φ= 1.0
then Shear resistance due to Concrete Vc = 0
Cw < 0.5 b then Φ= Cw / b
then Shear resistance due to Concrete Vc^{*} = (1- Φ) x Vc</td></tr>
<tr><td>For example, b = 400mm and shear crack depth 150mm
Vc^{*} = (1-150 / 400) x Vc = 0.625 Vc</td></tr>
<tr><td>
</td></tr>
<tr><td rowspan="2">Rebar Exposure</td><td>Section loss of main Rebar (%) based on exposed Area</td></tr>
<tr><td>Section loss of stirrups (%) based on exposed Area</td></tr>
<tr><td>Steel
Girder</td><td>Corrosion</td><td>Actual section loss should be applied to steel girder dimension,
and then calculate section properties considering section loss</td></tr>
</table>

6.1.3 Program Contents

MENU			1	TITLE	Cover Page
			2	FLOW	Flow Chart of Load Rating Procedure
			3	BCIR	Bridge Condition Inspection Results
			4	MENU	Menu of Bridge Load Rating
RCFS: REINFORCED CONCRETE FLAT SLAB BRIDGE					
RCFS	SIMPLE and CONTINUOUS		1	GENERAL	A1. General Bridge Description
			2	LAYOUT	A2. Bridge Layout and Dimension
			3	DFDLLL	B. Demand Forces Calculation for DL and LL
			4	CCLFM	C1. Capacity Calculations for Moment and Shear
			5	LRLFM	C2. Load Rating Calculations by LFM
			6	POSTLL	D1.Demand Forces for Load Posting Vehicles
			7	POSTLFM	D2. Posting Rating Calculations by LFM
			8	CCASM	E1. Moment and Shear Capacity Calculations
			9	LRASM	E2. Load Rating Calculations by ASM
			10	POSTASM	F. Load Posting by ASM
			11	POSTSUM	G. Summary of Load Posting
RCDG: REINFORCED CONCRETE DECK SLAB GIRDER BRIDGE					
RCDG	SIMPLE and CONTINUOUS	INTERIOR GIRDER and EXTERIOR GIRDER	1	GENERAL	A1. General Bridge Description
			2	LAYOUT	A2. Bridge Layout and Dimension
			3	DFDLLL	B. Demand Forces Calculation for DL and LL
			4	CCLFM	C1. Capacity Calculations for Moment and Shear
			5	LRLFM	C2. Load Rating Calculations by LFM
			6	POSTLL	D1.Demand Forces for Load Posting Vehicles
			7	POSTLFM	D2. Posting Rating Calculations by LFM
			8	CCASM	E1. Moment and Shear Capacity Calculations
			9	LRASM	E2. Load Rating Calculations by ASM
			10	POSTASM	F. Load Posting by ASM
			11	POSTSUM	G. Summary of Load Posting
PCDG: PRESTRESSED CONCRETE I GIRDER BRIDGE					
PCDG	SIMPLE and CONTINUOUS	INTERIOR GIRDER and EXTERIOR GIRDER	1	GENERAL	A1. General Bridge Description
			2	LAYOUT	A2. Bridge Layout and Dimension
			3	DFDLLL	B. Demand Forces Calculation for DL and LL
			4	DSC	B3. Demand Stresses Calculations
			5	CCMS	C. Capacity Calculations for Moment and Shear
			6	LRC	C1. Load Rating Calculations
			7	LRSUM	C2.3 Summary of Rating Factor and Load Rating
			8	POSTLL	D1. Demand Forces for Load Posting Vehicles
			9	POSTLR1	D2. Posting Rating Calculations
			10	POSTLR2	D3.1 Posting Load Rating Calculations
			11	POSTSUM	D3.3 Summary of Posting Rating Factor and Load Rating
			12	SUMMARY	E. Summary of Load Posting
SIG: STEEL I-GIRDER BRIDGE					
SIG	SIMPLE and CONTINUOUS	INTERIOR GIRDER and EXTERIOR GIRDER	1	GENERAL	A1. General Bridge Description
			2	LAYOUT	A2. Bridge Layout and Dimension
			3	DFDLLL	B1. Demand Forces Calculations for DL and LL
			4	DSDLLL	B5. Demand Stresses Calculations for DL and LL
			5	LRASM	C. Load Rating Calculations by ASM
			6	POSTASM	D. Load Posting by ASM
			7	POSTSUM	E. Posting Load Rating Calculations
RCDECK			1	LAYOUT	A. Bridge Layout and Dimension
			2	DFDLLL	B. Demand Forces Calculations
			3	CCLFM	C1. Capacity Calculations
			4	LRLFM	C2. Load Rating Calculations by LFM
			5	POSTLL	D. Load Posting by LFM
			6	POSTSUM	E.. Summary of Load Posting

6.1.4 Differences Between Interior Girder and Exterior Girder

Interior Girder	Demand Forces	Slab Dimension only intermediate continuous slab
		Live load distribution factor = S / 1.829
	Resistance	According to Slab Dimension
Exterior Girder	Demand Forces	Slab Dimension composed continuous and cantilever slab
		Live load distribution factor = (S - 1.829) / S
	Resistance	According to Slab Dimension

6.1.5 Differences Between Simple Girder and Continuous Girder

(1) RCFS (Reinforced Concrete Flat Slab Brdige)

Simple Girder	Demand Forces	All Demand Forces can be calculated in this Program
	Resistance	Section for Load Rating is only at Midspan calculating for Moment
Continuous Girder	Demand Forces	Superimposed Dead Load and Live Load supported on Continuous Girder should be given by separate analysis with appropriate structural model
	Resistance	Sections for Load Rating are at Midspan and Pier Support calculating only for Moment Longitudinal Rebar Schedule at Pier Support should be additionally given

(2) RCDG (Reinforced Concrete Deck Slab Girder Bridge) and PCDG (Prestressed Concrete I Girder Bridge)

Simple Girder	Demand Forces	All Demand Forces can be calculated in this Program
	Resistance	Sections for Load Rating are at Midspan and Support calculating for Moment and Shear
Continuous Girder	Demand Forces	Superimposed Dead Load and Live Load supported on Continuous Girder should be given by separate analysis with appropriate structural model
	Resistance	Section for Load Rating is at Midspan and Pier Support calculating for Moment and Shear Longitudinal Rebar Schedule at Pier Support should be additionally given

(3) SIG (Steel I Girder Bridge)

Simple Girder	Demand Forces	All Demand Forces can be calculated in this Program Three (3) sections are prepared for calculation of forces
	Resistance	Sections for Load Rating are also prepared three (3) sections at Midspan, Support and severe damaged section calculating for Moment and Shear
Continuous Girder	Demand Forces	Superimposed Dead Load and Live Load supported on Continuous Girder should be given by separate analysis with appropriate structural model
	Resistance	Sections for Load Rating are two (2) sections at Midspan and Pier Support calculating for Moment and Shear Longitudinal Rebar Schedule at Pier Support should be additionally given

6.1.6 Meaning of Colored Cells

Light Blue Cells	Original Input
Yellow Cells	Calculated Figures by Original Input/Calculated Figure
Orange Cells	Load Factor and Load Rating calculated by original input/calculated figures
Glay Cells	Linked Cells
White Cells	Specified Figures/Letters

Note : User can modify Light Blue Cells only.
Other cells have calculation formulas which are protected and can be not changed or altered.

6.1.7 Drawings Attached for Each Bridge Types

The drawings attached for each bridge types in this Program are just references based on initial data of Load Rating.

Properly, the drawings of an objective bridge should be individually prepared to obtain accurate input data such as bridge layout, dimensions, Rebar schedule, PC tendons schedule and others.

6.2 RCFS (Reinforced Concrete Flat Slab Bridge)

6.2.1 Simple RCFS

Sheet 1 (GENERAL) : Input data of Bridge Description

RCFS SIMPLE

A. GENERAL

BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION	VII					
Bridge Name							
Bridge Type	Simple or Continuous	Simple					
	Number of Span	1					
Bridge of Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		8.000					=8.000m
Year Built		1958					
Structure	Superstructure	Reinforced Concrete Slab					
	Substructure	Wall Type RC Piers and RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	6.9	Mpa	fs=	137.9	Mpa
		f'c=	17.2	Mpa	fy=	275.8	Mpa
Assumption		Weight of barrier rail Wbr =			18.5	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

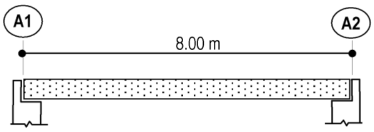
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

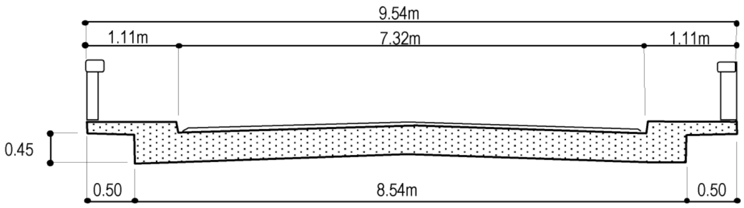
Note	
Input Data	Light blue cells should be filled up.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input Data of Bridge Layout and Dimension

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



DECK SECTION

BRIDGE LAYOUT AND DIMENSION	
Overall width (m)	9.540
Carriageway Width (m)	7.320
Slab width bw(m)	8.540
Slab thickness h (m)	0.450
Span Length L(m)	8.000

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Girder Dimension : Overall Width - Slab Dimension : Width and Thickness - Span Length
Drawings	Drawings (Elevation and Cross Section) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B0. INPUT		
FOR DEAD LOAD	Slab width bw(m)	8.540
	Slab thickness h (m)	0.450
	Span Length L(m)	8.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Slab		10.800
	Barrier Rail		2.708
	Asphalt Overlay		0.943
	Total		14.450
Dead Load	Moment (KN-m/m)	M_{DL}	115.60
	Shear (KN)	V_{DL}	57.80

B2. LIVE-LOAD CALCULATIONS			
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD	
Number of live load wheel line	0.589		
Impact factor	0.300		
span	8.000		
Max.MS18 moment for 8.00m span /wheel line	without Impact	M_L	154.84
	with Impact	M_{LL}	118.46
Max.MS18 shear at a distance "d" from the support/wheel line	without Impact	V_L	105.59
	with Impact	V_{LL}	80.78

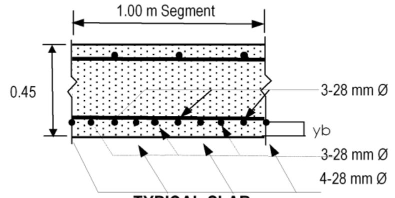
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 128 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Slab Width	Slab Width for Load Rating Calculations is applied 1m width.		
Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III (refer to Table shown in the next pages of this Sheet 3)		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	= A x W
		M_{DL}	= 1/8 x W_{DL} x L^2
		V_{DL}	= 1/2 x W_{DL} x L
	Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 4 (CCLFM): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



TYPICAL SLAB REINFORCEMENT

Total area of Rebar	
Nos of Rebar	10
Dia. (mm)	28
As(mm2)	6158
yb (mm)	61

C1. CAPACITY CALCULATIONS

C1. INPUT				
(1) Common Input Data				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	6.9
		Strength	f'c	17.2
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
(2) Input Data for Moment Capacity				
Total Area of Steel As(mm^2)	10 x (28mm rebar)			6158
Section Loss (%)				10
Total Assumed Area of Steel As(mm2)				5542
Centroid of rebars from bottom of deck , d (mm)				61
Centroid of rebars from top of deck , d (mm)				389
Effective width of deck , b_{eff} (mm)				1000
Ultimate capacity factor (Uf)				0.90

C1. MOMENT CAPACITY AT MIDSPAN	
Rectangular stress block depth a (mm)	105.0
The Moment Capacity Mu (kN-m)	462.9

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 129 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar	Main Reinforcements Schedule
	Damage Evaluation	Secton Losses due to Rebar exposure caused by Moment
Drawings	Drawings (Rebar Schedule) for the objective bridge should be prepared as shown in this screen.	
Applied Equation in Output	Ultimate Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)

Sheet 5 (LRLFM) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		
Load factor for dead load		1.3
Load factor for live load	Inventory	2.17
	Operating	1.3
Moment Ultimate Capacity at Midspan (kN-m)		462.92
Dead Load Moment at Midspan (kN-m)		115.60
Live Load Moment at Midspan (kN-m)		118.46
Rating Live Load (Tons)		33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	1.22	40.26
		Operating Rating	2.03	66.99

Depend on the minimum value of Rating Factor > 1 or <1 , instruction is automatically shown below

Return to GENERAL

Click following the above instruction

Return to GENERAL

LOAD POSTING

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 130 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces Calculations for Load Posting Vehicles (Type 1-1, Type 1-2 and Type 12-2)

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	0.589			
Impact factor	0.300			
span	8.00			
Type 1-1 moment for 8.00m span /wheel line		without Impact	M_L	133.60
		with Impact	M_{LL}	102.21
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	74.60
		with Impact	V_{LL}	57.07
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 8.00m span /wheel line		without Impact	M_L	153.79
		with Impact	M_{LL}	117.66
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	94.94
		with Impact	V_{LL}	72.64
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 8.00m span /wheel line		without Impact	M_L	144.93
		with Impact	M_{LL}	110.88
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	85.28
		with Impact	V_{LL}	65.24

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 130 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Posting Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III. (refer to Table shown in the next pages of this Sheet 6)		
Applied Equation in Output	Posting Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 7 (POSTLFM) : Postina Ratina Calculations

D2. POSTING RATING CALCULATIONS

D2.1 INPUT			
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
		Moment	
Moment Ultimate Capacity		462.92	
Dead Load		115.60	
		Moment	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	118.46	33.0
	Type 1-1	102.21	17.0
	Type 1-2	117.66	27.0
	Type 12-2	110.88	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating		Operating Rating		Posting (Metric Tons)
		Moment		Moment		
		RF	LR	RF	LR	
MS18	33.0	1.22	40.1	2.03	67.0	33
Type 1-1	17.0	1.41	24.0	2.35	40.0	17
Type 1-2	27.0	1.22	33.1	2.04	55.2	27
Type 12-2	38.0	1.30	49.4	2.17	82.4	38

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 131 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 8 (CCASM) : Moment and Shear Capacity Calculations by ASM

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				
Year Built				1958
Material Properties	Concrete	fc	Inventory	6.9
			Operating	10.3
		f'c		17.2
	Rebar	fs	Inventory	137.9
			Operating	193.1
Total Assumed Area of Steel As(mm^2)				5542
Centroid of rebars from top of deck , d (mm)				389
Effective width of deck , beff (mm)				1000
Rebar Ratio ρ = As / (beff x d)				0.01425
Modular Ratio of Elasticity n = Es / Ec				12
k = $\sqrt{\ }$ [2ρn + (ρn)^2] - ρn				0.4383
kd				170.5
j				0.8539
jd				332.2

E1.2 MOMENT CAPACITY CALCULATIONS			
Moment (kN-m)	Capacity by concrete allowable stress	Inventory	195.37
		Operating	291.65
	Capacity by rebar allowable stress	Inventory	253.87
		Operating	355.49

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 131, 132 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Moment Capacity	Mc = (Compression zone resultant force "C") x fc x jd
		Ms = As x fs x jd
		Mu is governing smaller figure either Mc or Ms

Sheet 9 (LRASM) : Load Ratina Calculations bv ASM

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		
Load factor for dead load		1.0
Load factor for live load		1.0
Moment Capacity at Midspan (kN-m)	Inventory	195.37
	Operating	291.65
Dead Load Moment at Midspan (kN-m)		115.60
Live Load Moment at Midspan (kN-m)		118.46
Rating Live Load (Tons)		33.0

E2.2. RATING FACTOR CALCULATIONS (ASM)			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.67	22.11
		Operating Rating	1.49	49.17

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 132 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x 33.0 (Vehicle Wejght)

Sheet 10 (POSTASM) : Load Posting Calculations by ASM

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

F1. INPUT			
Load factor for dead load		1.0	
Load factor for live load		1.0	
		Moment	
Moment Capacity	Inventory	195.37	
	Operating	291.65	
Dead Load		115.60	
		Moment	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	118.46	33.0
	Type 1-1	102.21	17.0
	Type 1-2	117.66	27.0
	Type 12-2	110.88	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)

Vehicle Type	Vehicle Weight (Metric Tons)	Moment				Posting (Metric Tons)
		Inventory Rating		Operating Rating		
		RF	LR	RF	LR	
MS18	33.0	0.67	22.2	1.49	49.0	22
Type 1-1	17.0	0.78	13.3	1.72	29.3	13
Type 1-2	27.0	0.68	18.3	1.50	40.4	18
Type 12-2	38.0	0.72	27.3	1.59	60.3	27

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

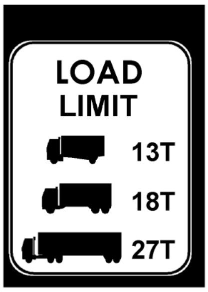
NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 133 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Each Posting Vehicle Wejght)

Sheet 11 (POSTSUM) : Summary of Load Posting

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.67	22.2	1.22	40.1	22T
Type 1-1	17.0	0.78	13.3	1.41	24.0	13T
Type 1-2	27.0	0.68	18.3	1.22	33.1	18T
Type 12-2	38.0	0.72	27.3	1.30	49.4	27T



After confirmation of this sheet, click "BACK TO GENERAL" button then proceed directly to the next screen.

BACK TO GENERAL

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 133 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.2.2 Continuous RCFS

Sheet 1 (GENERAL) : Input Data of Bridge Description

RCFS CONTINUOUS

A. GENERAL BACK TO MENU

A1. BRIDGE DESCRIPTION								
Bridge Location	REGION	VII						
Bridge Name								
Bridge Type	Simple or Continuous	C						
	Number of Span	3						
Bridge of Width (curb to curb) (m)		7.32						
Number of Lanes		2						
Bridge Length (m)		8.000	8.000	8.000			=24.000m	
Year Built		1982						
Structure	Superstructure	Reinforced Concrete Slab						
	Substructure	Wall Type RC Piers and RC Cantilever Abutments						
Wearing Course	thickness (mm)	50						
	material	Asphalt						
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa	
		f'c=	20.7	Mpa	fy=	275.8	Mpa	
Assumption		Weight of barrier rail Wbr =			18.5	KN/m		
		Concrete Unit Weight Wu =			24.0	KN/m^3		
		Asphalt Unit Weight Wa =			22.0	KN/m^3		
Others		Rating Live Load is AASHTO MS18 (HS20-44)						

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

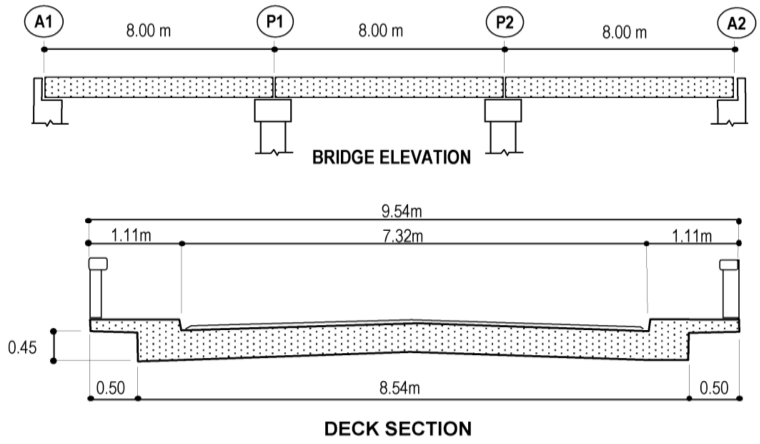
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

Note	
Input Data	Light blue cells should be filled up.
Differences compared with Simple RCFS	Simple or Continuous, Number of Span and Bridge Length.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input Data of Bridge Layout and Dimension

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE LAYOUT AND DIMENSION	
Overall width (m)	9.540
Carriageway Width (m)	7.320
Slab width bw(m)	8.540
Slab thickness h (m)	0.450
Span Length L(m)	8.000

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

<table>
<tr><th colspan="2">Note</th></tr>
<tr><td>Input Data</td><td>Light blue cells should be filled up, these are;
- Girder Dimension : Overall Width
- Slab Dimension : Width and Thickness
- Span Length</td></tr>
<tr><td>Differences compared with Simple RCFS</td><td>Drawing of Bridge Elevation.</td></tr>
<tr><td>Drawings</td><td>Drawings (Elevation and Cross Section) for the objective bridge should be prepared as shown in this screen.</td></tr>
</table>

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B0. INPUT		
FOR DEAD LOAD	Slab width bw(m)	8.540
	Slab thickness h (m)	0.450
	Span Length L(m)	8.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Slab		10.800
	Barrier Rail		2.708
	Asphalt Overlay		0.943
	Total		14.450
Dead Load	Moment (KN-m/m)	M_{DL}	115.60
	Shear (KN)	V_{DL}	57.80

B2. LOAD DEMAND MIDSPAN AND SUPPORT OF RCS

Conducting a Structural Analysis, the load demands for the RCS should be obtained separately and input the necessary load demands in the Table below.

LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD
Number of live load wheel line	0.589	
Impact factor	0.300	
span	8.000	

Description	At Midspan	At Pier Support
Dead load moments, KN-m	115.60	-66.30
Additional Dead load moments, KN-m	7.65	-7.45
MS18 max. positive moment, KN-m	152.50	-
MS18 max. negative moment, KN-m	-	-109.10

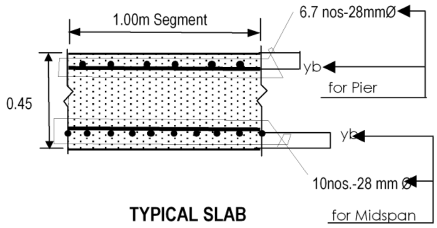
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 146 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Load Demands on continuous bridge should be given.		
Differences compared with Simple RCFS	Load demands should be separately analized with appropriate structural Model.		
Slab Width	Slab Width for Load Rating Calculations is applied 1m width.		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	$= A \times W$
		M_{DL}	$= 1/8 \times W_{DL} \times L^2$
		V_{DL}	$= 1/2 \times W_{DL} \times L$

Sheet 4 (CCLFM): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



TYPICAL SLAB REINFORCEMENT

Total area of Rebar		
	Midspan	At Pier
Nos of Rebar	10	6.7
Dia. (mm)	28	28
As(mm2)	6158	4126
yb (mm)	61	64

C1. CAPACITY CALCULATIONS

C1. INPUT

(1) Common Input Data				At Midspan	At Pier
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3	
		Strength	f'c	20.7	
	Rebar	Allowable Stress	fs	137.9	
		Strength	fy	275.8	

(2) Input Data for Moment Capacity		At Midspan	At Pier
Total Area of Steel As(mm^2)	10 x (28mm rebar)	6158	4126
Section Loss (%)		0	0
Total Assumed Area of Steel As(mm2)		6158	4126
Centroid of rebars from bottom of deck , d (mm)		61	64
Centroid of rebars from top of deck , d (mm)		389	386
Effective width of deck , b_{eff} (mm)		1000	1000
Ultimate capacity factor (Uf)		0.90	0.90

C1. MOMENT CAPACITY AT MIDSPAN	At Midspan	At Pier
Rectangular stress block depth a (mm)	97.0	65.0
The Moment Capacity Mu (kN-m)	520.4	362.0

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 146, 147 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar	Main Reinforcements Schedule
	Damage Evaluation	Secton Losses due to Rebar exposure caused by Moment
Differences compared with Simple RCFS	Rebar schedule at Pier should be added.	
Drawings	Drawings (Rebar Schedule) for the objective bridge should be prepared as shown in this screen.	
Applied Equation in Output	Ultimate Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)

Sheet 5 (LRLFM) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
Moment Ultimate Capacity at Midspan (kN-m)		520.43	-362.00
Dead Load Moment at Midspan (kN-m)		123.25	-73.75
Live Load Moment at Midspan (kN-m)		152.50	-109.10
Rating Live Load (Tons)		33.0	33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.09	35.97
			Operating Rating	1.82	60.06
		At Pier	Inventory Rating	1.12	36.96
			Operating Rating	1.88	62.04

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 148 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces Calculations for Load Posting Vehicles

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the RCS should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	105.2	-83.9
	Shear	-	-23.1
Type 1-2	Moment	137.7	-109.2
	Shear	-	-31.2
Type 12-2	Moment	142.8	-115.9
	Shear	-	-30.4

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 149 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Load Demands loaded on continuous bridge should be given.
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier
	Load demands should be separately analized with appropriate structural Model.

Sheet 7 (POSTLFM) : Posting Rating Calculations

D2. POSTING RATING CALCULATIONS

D2.1 INPUT				
Load factor for dead load		1.3		
Load factor for live load	Inventory	2.17		
	Operating	1.3		
		Midspan	At Pier	
Moment Ultimate Capacity		520.43	362.00	
Dead Load		123.25	-73.75	
		Midspan	At Pier	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	152.50	-109.10	33.0
	Type 1-1	105.20	-83.90	17.0
	Type 1-2	137.70	-109.20	27.0
	Type 12-2	142.80	-115.90	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM						
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating		Operating Rating		**Posting (Metric Tons)**
		Moment		Moment		
		RF	LR	RF	LR	
(1) AT MIDSPAN						
MS18	33.0	1.09	35.9	1.82	60.0	**33**
Type 1-1	17.0	1.58	26.8	2.63	44.8	**17**
Type 1-2	27.0	1.21	32.5	2.01	54.3	**27**
Type 12-2	38.0	1.16	44.2	1.94	73.7	**38**
(2) AT PIER						
MS18	33.0	1.12	37.1	1.88	61.9	**33**
Type 1-1	17.0	1.46	24.8	2.44	41.5	**17**
Type 1-2	27.0	1.12	30.3	1.87	50.6	**27**
Type 12-2	38.0	1.06	40.2	1.77	67.1	**38**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 149 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 8 (CCASM) : Moment and Shear Capacity Calculations by ASM

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				At Midspan	At Pier
Year Built				1982	
Material Properties	Concrete	fc	Inventory	8.3	
			Operating	13.1	
		f'c		20.7	
	Rebar	fs	Inventory	137.9	
			Operating	193.1	
Total Assumed Area of Steel As(mm	8 x (28mm rebar)			6158	4126
Centroid of rebars from top of deck , d (mm)				389	386
Effective width of deck , beff (mm)				1000	1000
Rebar Ratio ρ = As / (beff x d)				0.01583	0.01069
Modular Ratio of Elasticity n = Es / Ec				12	12
$k = \sqrt{[2\rho n + (\rho n)^2]} - \rho n$				0.4550	0.3942
kd				177.0	152.2
j				0.8483	0.8686
jd				330.0	335.3

E1.2 MOMENT CAPACITY CALCULATIONS			At Midspan	At Pier
Moment (kN-m)	Capacity by concrete allowable stress	Inventory	242.40	211.72
		Operating	382.59	334.16
	Capacity by rebar allowable stress	Inventory	280.21	190.74
		Operating	392.38	267.10

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 150, 151, 152 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Moment Capacity	Mc = (Compression zone resultant force "C") x fc x jd
		Ms = As x fs x jd
		Mu is governing smaller figure either Mc or Ms

Sheet 9 (LRASM) : Load Rating Calculations by ASM

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.0	
Load factor for live load		1.0	
Moment Capacity at Midspan (kN-m)	Inventory	242.40	190.74
	Operating	382.59	267.10
Dead Load Moment at Midspan (kN-m)		123.25	-73.75
Live Load Moment at Midspan (kN-m)		152.50	-109.10
Rating Live Load (Tons)		33.0	

E2.2. RATING FACTOR CALCULATIONS (ASM)				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment ( )	Midspan	Inventory Rating	0.78	25.74
			Operating Rating	1.70	56.10
		At Pier	Inventory Rating	1.07	35.31
			Operating Rating	1.77	58.41

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 152 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Vehicle Wejght)

Sheet 10 (POSTASM) : Load Posting Calculations by ASM

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

F1. INPUT				
Load factor for dead load		1.0		
Load factor for live load		1.0		
		Moment		
		Midspan	At Pier	
Moment Capacity	Inventory	242.40	-190.74	
	Operating	382.59	-267.10	
Dead Load		123.25	-73.75	
		Moment		Vehicle
		Midspan	At Pier	Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	152.50	-109.10	33.0
	Type 1-1	105.20	-83.90	17.0
	Type 1-2	137.70	-109.20	27.0
	Type 12-2	142.80	-115.90	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)						
Vehicle Type	Vehicle Weight (Metric Tons)	Moment				Posting (Metric Tons)
		Inventory Rating		Operating Rating		
		RF	LR	RF	LR	
(1) AT MIDSPAN						
MS18	33.0	0.78	25.8	1.70	56.1	26
Type 1-1	17.0	1.13	19.3	2.47	41.9	17
Type 1-2	27.0	0.87	23.4	1.88	50.9	23
Type 12-2	38.0	0.83	31.7	1.82	69.0	32
(2) AT PIER						
MS18	33.0	1.07	35.4	1.77	58.5	33
Type 1-1	17.0	1.39	23.7	2.30	39.2	17
Type 1-2	27.0	1.07	28.9	1.77	47.8	27
Type 12-2	38.0	1.01	38.4	1.67	63.4	38

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

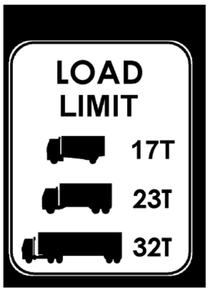
NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 153 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCFS	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Each Posting Vehicle Wejght)

Sheet 11 (POSTSUM) : Summary of Load Posting

G. SUMMARY OF RESULTS FOR LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.78	25.8	1.09	35.9	26T
Type 1-1	17.0	1.13	19.3	1.46	24.8	17T
Type 1-2	27.0	0.87	23.4	1.12	30.3	23T
Type 12-2	38.0	0.83	31.7	1.06	40.2	32T



After confirmation of this sheet, click "BACK TO GENERAL" button then proceed directly to the next screen.

BACK TO GENERAL

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 154 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.3 RCDG (Reinforced Concrete Deck Girder Bridge)

6.3.1 Simple RCDG

Sheet 1 (GENERAL) : Input Data of Bridge Description

INTERIOR RCDG SIMPLE

A. GENERAL BACK TO MENU

A1. BRIDGE DESCRIPTION								
Bridge Location	REGION	XI						
Bridge Name		Sample Bridge						
Bridge Type	Simple or Continuous	S	Reinforced Concrete T-beams					
	Number of Span	1						
Bridge of Width (curb to curb) (m)		7.32						
Number of Lanes		2						
Bridge Length (m)		10.400					=10.400m	
Year Built		1987						
Structure	Nos. of Girder	4	Multiple monotholic with deck slab.					
	Girder Spacing (m)	2.400	on centers					
	Substructure	Concrete bents and Abutments						
Wearing Course	thickness (mm)	50						
	material	Asphalt						
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa	
		f'c=	20.7	Mpa	fy=	275.8	Mpa	
Assumption		Weight of barrier rail Wbr =		3.6	KN/m			
		Concrete Unit Weight Wu =		24.0	KN/m^3			
		Asphalt Unit Weight Wa =		22.0	KN/m^3			
Others		Rating Live Load is AASHTO MS18 (HS20-44)						

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

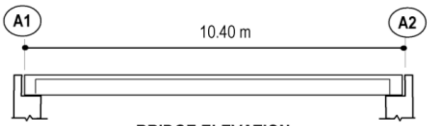
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

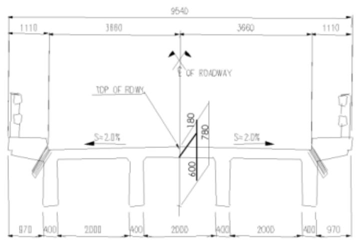
Note	
Input Data	Light blue cells should be filled up.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input Data of Bridge Layout and Dimension

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

BRIDGE LAYOUT AND DIMENSION	
Girder width bw(m)	0.400
Girder Web height h (m)	0.600
Fillet/Haunch width wf(m)	0.100
Fillet/Haunch height hf(m)	0.100
Slab thickness ts (m)	0.180
Span Length L(m)	10.400

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Girder Dimension : Width and Web Height - Slab Dimension : Fillet/Hunch Width and Height, and Slab Thickness - Span Length
Drawings	Drawings (Elevation and Cross Section) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B0. INPUT		
FOR DEAD LOAD	Girder width bw(m)	0.400
	Girder Web height h (m)	0.600
	Fillet/Haunch width wf(m)	0.100
	Fillet/Haunch height hf(m)	0.100
	Slab thickness ts (m)	0.180
	Slab width ws (m)	2.400
	Span Length L(m)	10.400

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder		5.760
	Fillet/Haunch		0.240
	Slab Weight	Continuous	10.368
	Barrier Rail		1.800
	Asphalt Overlay		2.640
	Total		20.810
Dead Load	Moment (KN-m/m)	M_{DL}	281.4
	Shear (KN)	V_{DL}	108.2

B2. LIVE-LOAD CALCULATIONS			
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD	
Number of live load wheel line	1.312		
Impact factor	0.300		
span	10.400		
Max.MS18 moment for 10.40m span /wheel line	without Impact	M_L	236.5
	with Impact	M_{LL}	403.5
Max.MS18 shear at a distance "d" from the support/wheel line	without Impact	V_L	117.7
	with Impact	V_{LL}	200.7

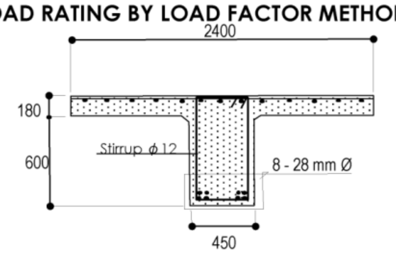
NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 168 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Live Load Forces	They are calculated based on the Load Rating Manual Appendix III (refer to Table shown in the next pages of this Sheet 3)		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	$= A \times W$
		M_{DL}	$= 1/8 \times W_{DL} \times L^2$
		V_{DL}	$= 1/2 \times W_{DL} \times L$
	Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 4 (CCLFM): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)



GIRDER AND SLAB DETAILS

Total area of Rebar	
Nos of Rebar	8
Dia. (mm)	28
As(mm2)	4926
yb (mm)	102

Stirrups	
Dia. (mm)	12
As(mm2)	113.1
Spacing (mm)	200

C1. CAPACITY CALCULATIONS

C1. INPUT				
(1) Common Input Data				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
(2) Input Data for Moment Capacity				
Total Area of Steel As(mm^2)				4926
Section Loss due to Rebar Exposure (%)				0
Total Assumed Area of Steel As(mm2)				4926
Centroid of rebars from bottom of deck , d (mm)				102
Centroid of rebars from top of deck , d (mm)				678
Effective width of deck , b_{eff} (mm		12ts + bw		2560
		Span Length / 4		2600
		beff		2400
Ultimate capacity factor (Uf)				0.90
(3) Input Data for Shear Capacity				
Girder width bw(mm)				400
Depth of Shear Cracks (mm)				199
The Reduction Factor due to Shear Cracks				0.50
Centroid of rebars from top of deck , d (mm)				678
Area of rebar Av(mm^2)				113.1
Section Loss due to Stirrups Exposure (%)				0
Total Assumed Area of Steel As(mm2)				113.1
Spacing of stirrups S (mm)				200
Ultimate capacity factor (Uf)				0.85

C1.1 MOMENT CAPACITY AT MIDSPAN	
Rectangular stress block depth a (mm)	32.2
The Moment Capacity Mu (kN-m)	809.3
C1.2 SHEAR CAPACITY AT SUPPORT	
The shear **FULL capacity** due to concrete section Vc (kN)	206.1
The shear **capacity** due to concrete section Vc (kN)	103.5
The shear **FULL capacity** due to shear reinforcement Vs (kN)	211.5
The shear **capacity** due to Stirrups Vs (kN)	211.5
The total shear capacity Vu (kN)	267.8

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 169, 170 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar	Main Reinforcements Schedule
		Stirrups Schedule
	Damage Evaluation	Secton Losses due to Rebar exposure caused by Moment
		Depth of Shear Cracks
		Secton Losses due to Stirrups exposure caused by Shear
Drawings	Drawings (Rebar Schedule) for the objective bridge should be prepared as shown in this screen.	
Applied Equation in Output	Ultimate Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)
	Ultimate Shear Capacity V_U	VU = Φ x (Vc + Vs) where, Vc = 0.167 x Sqrt (f'c) x b x d Vs = 2 x Av' x fy x deff / S

Sheet 5 (LRLFM) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		
Load factor for dead load		1.3
Load factor for live load	Inventory	2.17
	Operating	1.3
Moment Ultimate Capacity at Midspan (kN-m)		809.3
Dead Load Moment at Midspan (kN-m)		281.4
Live Load Moment at Midspan (kN-m)		403.5
Shear Ultimate Capacity at Support (KN)		267.8
Dead Load Shear at Support (KN)		108.2
Live Load Shear at Support (KN)		200.7
Rating Live Load (Tons)		33.0

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.51	16.7
		Operating Rating	0.85	27.9
	Shear (At Support)	Inventory Rating	0.29	9.6
		Operating Rating	0.49	16.1

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Load Posting

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 170, 171 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces Calculations for Load Posting Vehicles (Type 1-1, Type 1-2 and Type 12-2)

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.312			
Impact factor	0.300			
span	10.40			
Type 1-1 moment for 10.40m span /wheel line		without Impact	M_L	183.0
		with Impact	M_{LL}	312.1
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	76.7
		with Impact	V_{LL}	130.8
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 10.40m span /wheel line		without Impact	M_L	223.6
		with Impact	M_{LL}	381.4
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	103.6
		with Impact	V_{LL}	176.7
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 10.40m span /wheel line		without Impact	M_L	208.6
		with Impact	M_{LL}	355.8
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	90.1
		with Impact	V_{LL}	153.7

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 171 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary any input data.		
Posting Live Load Forces	They are calculated based on the Load Rating Manual Appendix III. (refer to Table shown in the next pages of this Sheet 6)		
Applied Equation in Output	Posting Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 7 (POSTLFM) : Posting Rating Calculations

D2. POSTING RATING CALCULATIONS

D2.1 INPUT				
Load factor for dead load		1.3		
Load factor for live load	Inventory	2.17		
	Operating	1.3		
		Moment	Shear	
Moment Ultimate Capacity		809.3	267.8	
Dead Load		281.4	108.2	
		Moment	Shear	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	403.5	200.7	33.0
	Type 1-1	312.1	130.8	17.0
	Type 1-2	381.4	176.7	27.0
	Type 12-2	355.8	153.7	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.51	16.7	0.29	9.6	0.85	27.9	0.49	16.1	**10**
Type 1-1	17.0	0.65	11.1	0.45	7.6	1.09	18.6	0.75	12.7	**8**
Type 1-2	27.0	0.54	14.5	0.33	8.9	0.89	24.2	0.55	14.9	**9**
Type 12-2	38.0	0.57	21.8	0.38	14.5	0.96	36.4	0.64	24.2	**14**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 171 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	$RF = (\Phi \times Rn - \gamma_D \times DL) / (\gamma_{LL} \times (LL + I))$
	Load Rating LR	$LR = RF \times$ (Vehicle Weight)

Sheet 8 (CCASM) : Moment and Shear Capacity Calculations by ASM

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				
Material Properties	Concrete	fc	Inventory	8.3
			Operating	13.1
		f'c		20.7
	Rebar	fs	Inventory	137.9
			Operating	193.1
Total Assumed Area of Steel As(mm^2)				4926
Area of rebar Av(mm^2)				113.1
Spacing of stirrups S (mm)				200
Centroid of rebars from top of deck , d (mm)				678
Effective width of deck , beff (mm)				2400
Girder width bw(m)				400
Rebar Ratio ρ = As / (beff x d)				0.00303
Modular Ratio of Elasticity n = Es / Ec				12
k = $\sqrt{}$ [2pn + (ρn)^2] - ρn				0.2357
j				0.9214
kd				159.8
Slab thickness ts (mm)				180.0
k				0.2357
z				53.26
jd				624.74

Calculation of kd					
n	As	d	b	ts	bw
12	4926	678	2400	180.0	400
nAs	nAsd	bts	1/2bts^2	bwy	y/2+ts
59112	40077936	432000	38880000	0	180.0
ts+y	$Y_{calculate}$				Y_{input}
180.0	0.0				0.0

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS				
Moment (kN-m)	Capacity by concrete allowable stress Mc		Inventory	994.18
			Operating	1569.13
	Capacity by rebar allowable stress Ms		Inventory	424.38
			Operating	594.26
Shear (kN)	Capacity due to concrete section	Vc	Inventory	49.60
			Operating	74.40
	Capacity due to rebar	Vs	Inventory	105.74
			Operating	148.07
	Shear capacity	Vu	Inventory	155.34
			Operating	222.47

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 172, 173, 174 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Only Allowable Stress of Rebar should be given.	
	Yinput should be given as same value with Ycalculate. By giving an initial value of Yinput, then User can get a value of Ycalculate. Repeating to apply Ycalculate as a Yinput, Yinput as same value with Ycalculate will be taken. In case Y is within slab thickness, Ycalculate and Yinput will be equal to zero (0).	
Applied Equation in Output	Moment Capacity	Mc = (Compression zone resultant force "C") x fc x jd
		Ms = As x fs x jd
		Mu is governing smaller figure either Mc or Ms
	Shear Capacity	Vc = 0.08 x Sqrt (f'c) x bw x d (for Inventory)
		Vc = 0.12 x Sqrt (f'c) x bw x d (for Operating)
		Vs = (2 x Av x fs x ds) / S
		Vu = Vc + Vs

Sheet 9 (LRASM) : Load Rating Calculations by ASM

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		
Load factor for dead load		1.0
Load factor for live load		1.0
Moment Capacity at Midspan (kN-m)	Inventory	424.4
	Operating	594.3
Dead Load Moment at Midspan (kN-m)		281.4
Live Load Moment at Midspan (kN-m)		403.5
Shear Capacity at Support (KN)	Inventory	155.3
	Operating	222.5
Dead Load Shear at Support (KN)		108.2
Live Load Shear at Support (KN)		200.7
Rating Live Load (Tons)		33.0

E2.2. RATING FACTOR CALCULATIONS (ASM)			Rating Factor	Load Rating
Rating Factor and Load Rating	Moment (Midspan)	Inventory Rating	0.35	11.7
		Operating Rating	0.78	25.6
	Shear (At Support)	Inventory Rating	0.23	7.7
		Operating Rating	0.57	18.8

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 174 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x 33.0 (Vehicle Wejght)

Sheet 10 (POSTASM) : Load Posting Calculations by ASM

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

F1. INPUT				
Load factor for dead load		1.0		
Load factor for live load		1.0		
		Moment	Shear	
Moment and Shear Capacity	Inventory	424.4	155.3	
	Operating	594.3	222.5	
Dead Load		281.4	108.2	
		Moment	Shear	Vehicle Weight
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	403.5	200.7	33.0
	Type 1-1	312.1	130.8	17.0
	Type 1-2	381.4	176.7	27.0
	Type 12-2	355.8	153.7	38.0

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
MS18	33.0	0.35	11.7	0.23	7.7	0.78	25.6	0.57	18.8	8
Type 1-1	17.0	0.46	7.8	0.36	6.1	1.00	17.0	0.87	14.9	6
Type 1-2	27.0	0.38	10.1	0.27	7.2	0.82	22.2	0.65	17.5	7
Type 12-2	38.0	0.40	15.3	0.31	11.7	0.88	33.4	0.74	28.2	12

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 174, 175 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Each Posting Vehicle Wejght)

Sheet 11 (POSTSUM) : Summary of Load Posting

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.23	7.7	0.29	9.6	8T
Type 1-1	17.0	0.36	6.1	0.45	7.6	6T
Type 1-2	27.0	0.27	7.2	0.33	8.9	7T
Type 12-2	38.0	0.31	11.7	0.38	14.5	12T

After confirmation of this sheet, click button "END GO TO RC DECK SLAB" then proceed directly to the next screen.

END GO TO RC DECK SLAB

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 175 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.3.2 Continuous RCDG

Sheet 1 (GENERAL) : Input a Bridge Description for Load Rating

INTERIOR RCDG CONTINUOUS

A. GENERAL

BACK TO MENU

A1. BRIDGE DESCRIPTION

Bridge Location	REGION						
Bridge Name		STANDARD BRIDGE					
Bridge Type	Simple or Continuous	C	Reinforced Concrete T-beams				
	Number of Span	3					
Bridge of Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		15.000	15.000	15.000			=45.000m
Year Built		2000					
Structure	Nos. of Girder	4	Multiple monotholic with deck slab.				
	Girder Spacing (m)	2.400	on centers				
	Substructure	Wall Type RC Piers and RC Cantilever Abutments					
Wearing Course	thickness (mm)	0					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa
		f'c=	20.7	Mpa	fy=	275.8	Mpa
Assumption		Weight of barrier rail Wbr =			13.0	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

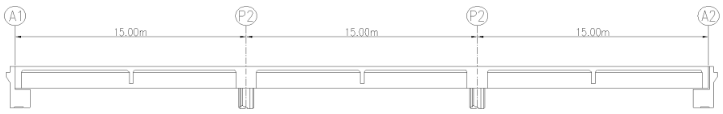
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

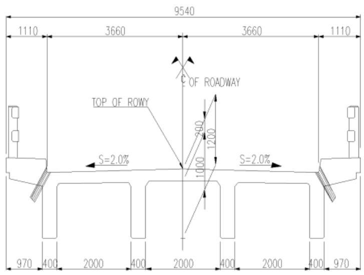
Note	
Input Data	Light blue cells should be filled up.
Differences compared with Simple RCDG	Simple or Continuous, Number of Span and Bridge Length.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input Data of Bridge Layout and Dimension

A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION

BRIDGE LAYOUT AND DIMENSION	
Girder width bw(m)	0.400
Girder Web height h (m)	1.000
Fillet/Haunch width wf(m)	0.100
Fillet/Haunch height hf(m)	0.100
Slab thickness ts (m)	0.200
Span Length L(m)	15.000

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Girder Dimension : Width and Web Height - Slab Dimension : Fillet/Hunch Width and Height, and Slab Thickness - Span Length
Differences compared with Simple RCDG	Drawing of Bridge Elevation.
Drawings	Drawings (Elevation and Cross Section) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B0. INPUT		
FOR DEAD LOAD	Girder width bw(m)	0.400
	Girder Web height h (m)	1.000
	Fillet/Haunch width wf(m)	0.100
	Fillet/Haunch height hf(m)	0.100
	Slab thickness ts (m)	0.200
	Slab width ws (m)	2.400
	Span Length L(m)	15.000

B1. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder		9.600
	Fillet/Haunch		0.240
	Slab Weight	Continuous	11.520
	Barrier Rail		6.500
	Asphalt Overlay		0.000
	Total Load		27.860
	Total DeadLoad		21.360
	Total Superimposed Dead Load		6.500

B2. LOAD DEMAND MIDSPAN AND SUPPORT OF RCDG		
Conducting a Structural Analysis, the load demands for the RCDG should be obtained		
Description	At Midspan	At Pier Support
	0.4L	1.0L
Dead load moments, KN-m	496.7	-620.1
Dead load shears, KN	-	-248.2
MS18 max. positive moment, KN-m	536.3	0.0
MS18 max. negative moment, KN-m	-	-416.4
MS18 max. negative Shear force, KN	-	-334.5

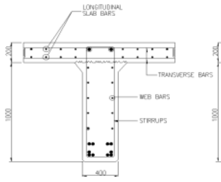
NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

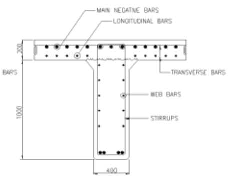
Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 188 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Load Demands on continuous bridge should be given.
Differences compared with Simple RCDG	Load demands should be separately analized with appropriate structural Model.

Sheet 4 (CCLFM): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING CALCULATIONS



SECTION AT MIDSPAN



SECTION AT PIER SUPPORT

Total area of Rebar	Midspan	Pier
Nos of Rebar	10	13
Dia. (mm)	36	28
As(mm2)	10179	8005
yb (mm)	126	63

Stirrups	At Pier
Dia. (mm)	16
As(mm2)	201.1
Spacing (mm)	150

C1. CAPACITY CALCULATIONS

C1. INPUT

(1) Common Input Data				At Midspan	At Pier
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3	
		Strength	f'c	20.7	
	Rebar	Allowable Stress	fs	137.9	
		Strength	fy	275.8	

(2) Input Data for Moment Capacity		At Midspan	At Pier
Total Area of Steel As(mm^2)		10179	8005
Section Loss due to Rebar Exposure (%)		0	0
Total Assumed Area of Steel As(mm2)		10179	8005
Centroid of rebars from bottom of deck , yb (mm)		126	63
Centroid of rebars from top of deck , d (mm)		1074	1137
Effective width of deck , b_{eff} (mm	12ts + bw	2800	-
	Span Length / 4	3750	-
	beff	2400	400
Ultimate capacity factor (Uf)		0.90	0.90

(3) Input Data for Shear Capacity	At Midspan	At Pier
Girder width bw(mm)	-	400
Depth of Shear Cracks (mm)	-	0
The Reduction Factor due to Shear Cracks	-	1.00
Centroid of rebars from top of deck , d (mm)	-	1137
Area of rebar Av(mm^2)	-	201.1
Section Loss due to Stirrups Exposure (%)	-	0
Total Assumed Area of Steel As(mm2)	-	201.1
Spacing of stirrups S (mm)	-	150
Ultimate capacity factor (Uf)	-	0.85

C1.1 MOMENT CAPACITY AT MIDSPAN	At Midspan	At Pier
Rectangular stress block depth a (mm)	66.5	313.7
The Moment Capacity Mu (kN-m)	2629.6	1947.6

C1.2 SHEAR CAPACITY AT SUPPORT	At Midspan	At Pier
The shear **FULL capacity** due to concrete section Vc (kN)	-	345.6
The shear **capacity** due to concrete section Vc (kN)	-	345.6
The shear **FULL capacity** due to shear reinforcement Vs (kN)	-	840.7
The shear **capacity** due to Stirrups Vs (kN)	-	840.7
The total shear capacity Vu (kN)	-	1008.3

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 189, 190 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar	Main Reinforcements Schedule
		Stirrups Schedule at Pier
	Damage Evaluation	Secton Losses due to Rebar exposure caused by Moment
		Depth of Shear Cracks
		Secton Losses due to Stirrups exposure caused by Shear
Differences compared with Simple RCDG	Rebar schedule at Pier should be added.	
Drawings	Drawings (Rebar Schedule) for the objective bridge should be prepared as shown in this screen.	
Applied Equation in Output	Ultimate Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)
	Ultimate Shear Capacity V_U	VU = Φ x (Vc + Vs) where, Vc = 0.167 x Sqrt (f'c) x b x d Vs = 2 x Av' x fy x deff / S

Sheet 5 (LRLFM) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 INPUT		At Midspan	At Pier
Load factor for dead load		1.3	
Load factor for live load	Inventory	2.17	
	Operating	1.3	
Moment Ultimate Capacity at Midspan (kN-m)		2629.6	-1947.6
Dead Load Moment at Midspan (kN-m)		496.7	-620.1
Live Load Moment at Midspan (kN-m)		536.3	-416.4
Shear Ultimate Capacity at Support (KN)		-	-1008.3
Dead Load Shear at Support (KN)		-	-248.2
Live Load Shear at Support (KN)		-	-334.5
Rating Live Load (Tons)		33.0	

C2.2 CALCULATIONS OF RATING FACTOR AND LOAD RATING				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.70	56.3
			Operating Rating	2.85	93.9
		At Pier	Inventory Rating	1.26	41.7
			Operating Rating	2.11	69.6
	Shear	At Pier	Inventory Rating	0.94	31.2
			Operating Rating	1.58	52.0

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Load Posting

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 191 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces Calculations for Load Posting Vehicles (Type 1-1, Type 1-2 and Type 12-2)

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the RCDG should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	382.8	-205.0
	Shear	-	-130.0
Type 1-2	Moment	492.6	-303.4
	Shear	-	-188.1
Type 12-2	Moment	450.5	-392.6
	Shear	-	-201.1

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 192 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Load demands should be separately analyzed with appropriate structural Model.
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier

Sheet 7 (POSTLFM) : Posting Rating Calculations

D2. POSTING RATING CALCULATIONS

D2.1 INPUT					
Load factor for dead load		1.3			
Load factor for live load	Inventory	2.17			
	Operating	1.3			
		Moment		Shear	
		Midspan	At Pier	At Pier	
Moment Ultimate Capacity		2629.6	1947.6	1008.3	
Dead Load		496.7	620.1	248.2	
		Moment		Shear	Vehicle Weight
		Midspan	At Pier		
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	536.3	416.4	334.5	33.0
	Type 1-1	382.8	205.0	130.0	17.0
	Type 1-2	492.6	303.4	188.1	27.0
	Type 12-2	450.5	392.6	201.1	38.0

D2.2 LOAD POSTING RATING FACTOR CALCULATIONS BY LFM										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) At Midspan										
MS18	33.0	1.70	56.3	-	-	2.85	93.9	-	-	**33**
Type 1-1	17.0	2.39	40.6	-	-	3.99	67.8	-	-	**17**
Type 1-2	27.0	1.86	50.1	-	-	3.10	83.6	-	-	**27**
Type 12-2	38.0	2.03	77.1	-	-	3.39	128.7	-	-	**38**
(2) At Pier Support										
MS18	33.0	1.26	41.7	0.94	31.2	2.11	69.6	1.58	52.0	**31**
Type 1-1	17.0	2.57	43.6	2.43	41.3	4.28	72.8	4.06	69.0	**17**
Type 1-2	27.0	1.73	46.8	1.68	45.4	2.89	78.1	2.80	75.7	**27**
Type 12-2	38.0	1.34	50.9	1.57	59.7	2.24	85.0	2.62	99.7	**38**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 192 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor RF	$RF = (\Phi \times Rn - \gamma_D \times DL) / (\gamma_{LL} \times (LL + I))$
	Load Rating LR	LR = RF x (Vehicle Weight)

Sheet 8 (CCASM) : Moment and Shear Capacity Calculations by ASM

E. Load Rating by Allowable Stress Method

E1. MOMENT AND SHEAR CAPACITY CALCULATIONS

E1.1 Input				Midspan	At Pier
Material Properties	Concrete	fc	Inventory	8.3	
			Operating	13.1	
		f'c		20.7	
	Rebar	fs	Inventory	137.9	
			Operating	193.1	
Total Assumed Area of Steel As(mm^2)				10179	8005
Area of rebar Av(mm^2)				201.1	201.1
Spacing of stirrups S (mm)				150	150
Centroid of rebars from top of deck , d (mm)				1074	1137
Effective width of deck , beff (mm)				2400	400
Girder width bw(m)				400	400
Rebar Ratio ρ = As / (beff x d)				0.00395	0.01760
Modular Ratio of Elasticity n = Es / Ec				12	12
k = $\sqrt{\ }$ [2ρn + (ρn)^2] - ρn				0.2641	0.4722
j				0.9120	0.8426
kd				294.6	536.9
Slab thickness ts (mm)				200.0	200.0
k				0.2743	-
z				98.20	-
jd				975.80	958.04

Calculation of kd					
n	As	d	b	ts	bw
12	10179	1074	2400	200.0	400
nAs	nAsd	bts	1/2bts^2	bwy	y/2+ts
122148	131186952	480000	48000000	37840	247.3
ts+y	$Y_{calculate}$				Y_{input}
294.6	94.6				94.6

E1.2 MOMENT AND SHEAR CAPACITY CALCULATIONS				Midspan	At Pier
Moment (kN-m)	Capacity by concrete allowable stress Mc		Inventory	2617.2	-853.8
			Operating	4130.8	-1347.6
	Capacity by rebar allowable stress Ms		Inventory	1369.7	-1057.6
			Operating	1918.0	-1480.9
Shear (kN)	Capacity due to concrete section	Vc	Inventory	-	165.5
			Operating	-	248.3
	Capacity due to rebar	Vs	Inventory	-	420.3
			Operating	-	588.6
	Shear capacity	Vu	Inventory	-	585.9
			Operating	-	836.9

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 193 - 196 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Only Allowable Stress of Rebar should be given.	
	Yinput should be given as the same value with Ycalculate. By giving a initial value of Yinput, then the User can get a value of Ycalculate. Repeating to apply Ycalculate as a Yinput, Yinput as same value with Ycalculate will be taken. In case Y is within the slab thickness, Ycalculate and Yinput will be applied as zero (0).	
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Moment Capacity	Mc = (Compression zone resultant force "C") x fc x jd
		Ms = As x fs x jd
		Mu is governing smaller figure either Mc or Ms
	Shear Capacity	Vc = 0.08 x Sqrt (f'c) x bw x d (for Inventory)
		Vc = 0.12 x Sqrt (f'c) x bw x d (for Operating)
		Vs = (2 x Av x fs x ds) / S
		Vu = Vc + Vs

Sheet 9 (LRASM) : Load Rating Calculations by ASM

E2. LOAD RATING CALCULATIONS

E2.1 INPUT		Midspan	At Pier
Load factor for dead load		1.0	
Load factor for live load		1.0	
Moment Capacity at Midspan (kN-m)	Inventory	1369.71	-853.82
	Operating	1918.0	-1347.6
Dead Load Moment at Midspan (kN-m)		496.7	-620.1
Live Load Moment at Midspan (kN-m)		536.3	-416.4
Shear Capacity at Support (KN)	Inventory	-	-585.9
	Operating	-	-836.9
Dead Load Shear at Support (KN)		-	-248.2
Live Load Shear at Support (KN)		-	-334.5
Rating Live Load (Tons)		33.0	

E2.2. RATING FACTOR CALCULATIONS (ASM)				Rating Factor	Load Rating
Rating Factor and Load Rating	Moment	Midspan	Inventory Rating	1.63	53.72
			Operating Rating	2.65	87.46
		At Pier	Inventory Rating	0.56	18.52
			Operating Rating	1.75	57.65
	Shear	At Pier	Inventory Rating	1.01	33.31
			Operating Rating	1.76	58.08

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 197 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x 33.0 (Vehicle Wejght)

F. LOAD POSTING BY ALLOWABLE STRESS METHOD

F1. INPUT						
Load factor for dead load		1.0				
Load factor for live load		1.0				
		Moment		Shear		
		Midspan	At Pier	At Pier		
Moment and Shear Capacity	Inventory	1369.7	-853.8	-585.9		
	Operating	1918.0	-1347.6	-836.9		
Dead Load		496.7	-620.1	-248.2		
		Moment		Shear	Vehicle Weight	
		Midspan	At Pier	At Pier		
Live Load Moment at Midspan (kN-m) Live Load Shear at Support (KN)	MS18	536.3	-416.4	-334.5	33.0	
	Type 1-1	382.8	-205.0	-130.0	17.0	
	Type 1-2	492.6	-303.4	-188.1	27.0	
	Type 12-2	450.5	-392.6	-201.1	38.0	

F2. LOAD POSTING RATING FACTOR CALCULATIONS (ASM)										
Vehicle Type	Vehicle Weight (Metric Tons)	Inventory Rating				Operating Rating				**Posting (Metric Tons)**
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) AT MIDSPAN										
MS18	33.0	1.63	53.7	-	-	2.65	87.5	-	-	**33**
Type 1-1	17.0	2.28	38.8	-	-	3.71	63.1	-	-	**17**
Type 1-2	27.0	1.77	47.9	-	-	2.89	77.9	-	-	**27**
Type 12-2	38.0	1.94	73.6	-	-	3.15	119.9	-	-	**38**
(2) AT PIER SUPPORT										
MS18	33.0	0.56	18.5	1.01	33.3	1.75	57.7	1.76	58.1	**19**
Type 1-1	17.0	1.14	19.4	2.60	44.2	3.55	60.3	4.53	77.0	**17**
Type 1-2	27.0	0.77	20.8	1.80	48.5	2.40	64.7	3.13	84.5	**21**
Type 12-2	38.0	0.60	22.6	1.68	63.8	1.85	70.4	2.93	111.2	**23**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 197, 198 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple RCDG	Load Rating calculations should be done not only at Midspan but also at Pier	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Each Posting Vehicle Wejght)

Sheet 11 (POSTSUM) : Summary of Load Posting

G. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	Allowable Stress (ASM)		Load Factor (LFM)		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	0.56	18.5	0.94	31.2	19T
Type 1-1	17.0	1.14	19.4	2.39	40.6	17T
Type 1-2	27.0	0.77	20.8	1.68	45.4	21T
Type 12-2	38.0	0.60	22.6	1.34	50.9	23T

After confirmation of this sheet, click button "END GO TO RC DECK SLAB" then directly proceed to the next screen.

END AND GO TO DECK SLAB

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 198 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.4 PCDG (Prestressed Concrete Deck Girder Bridge)

6.4.1 Simple PCDG

Sheet 1 (GENERAL) : Input Data of Bridge Description

INTERIOR PCDG SIMPLE

A. GENERAL BACK TO MENU

A1. BRIDGE DESCRIPTION				
Bridge Location	REGION			
Bridge Name				
Bridge Type	Simple or Continuous	S	Precast, Prestressed I Girder Bridge	
	Number of Span	1		
Bridge Width (curb to curb) (m)		7.32		
Number of Lanes		2		
Bridge Length (m)		35.000		=35.000 m
Year Built		2003		
Structure	Nos. of Girder	4		
	Girder Spacing (m)	2.100	on centers	
	Substructure	Concrete bents and abutments		
Wearing Course	thickness (mm)	50		
	material	Asphalt		
Notes on Plans	f'c (Girder)	38	MPa	
	f'c (Slab)	24.2	MPa	
	Ultimate Strength of Tendons fu	1860	MPa	
	Working Force	5270	kN (Effective after losses)	
	Centroid of PC Tendons	100	mm (from soffit at Midspan)	
		824	mm (from soffit at Anchorage)	
Assumption	Weight of barrier rail Wbr =	13.0	KN/m	
	fy (Reinforcing Bars)	415	Mpa	
	Concrete Unit Weight Wu =	24.0	KN/m^3	
	Asphalt Unit Weight Wa =	22.0	KN/m^3	
Others	Rating Live Load is AASHTO MS18 (HS20-44)			

NEXT

Material	Year of Construction	f'c or fy	fc or fs			
			Inventory	Operating	Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

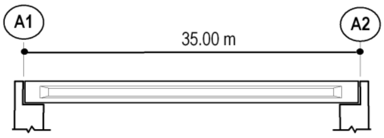
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

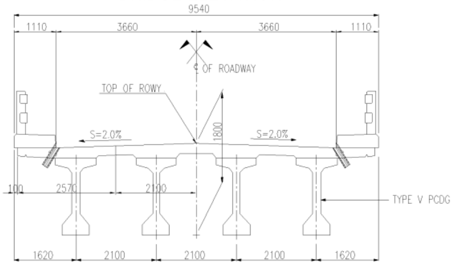
Note	
Input Data	Light blue cells should be filled up.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input a Bridge Layout and Dimension for Load Rating

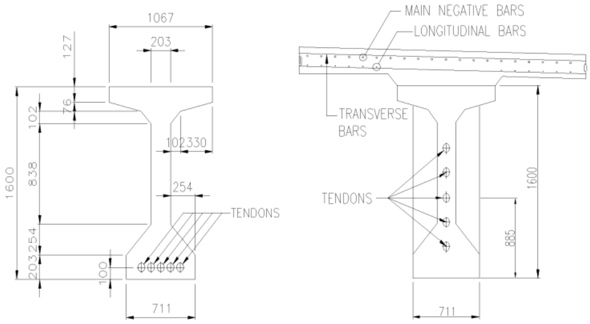
A2. BRIDGE LAYOUT AND DIMENSION



BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION



GIRDER SECTION		
Girder Height	1.600	
Dimension	b	h
Slab	2.100	0.2
Uflg	1.067	0.127
	0.330	0.076
	0.102	0.076
	0.102	0.102
Web	0.203	1.270
Lflg	0.254	0.254
	0.711	0.203

*1.00 (Modulas Ratio)

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Girder Dimension : Girder Height, and Width and Height for Upper/Lower Flange and Web - Slab Dimension : Slab Width and Slab Thickness
Drawings	Drawings (Elevation, Cross Section and Girder Details) for the objective bridge should be prepared as shown in this screen.

B. DEMAND FORCES

B1. DEAD LOAD CALCULATIONS

B1.1 INPUT		
FOR DEAD LOAD	Area of Girder (m^2)	0.645
	Span Length (m)	35.0
	Composite Girder Height (m)	1.800
	Girder Height (m)	1.600
	Slab thickness (m)	0.200
	Slab Spacing (m)	2.100
	Weight of Diaphram (kN/m)	1.5
	Weight of Barrier Rail (kN/m)	13
	Number of Girder (nos.)	4

B1.2 DEAD LOAD CALCULATIONS		
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	15.49
	Slab weight	10.08
	Weight of Diaphram	1.50
	Barrier Rail	6.50
	Asphalt Overlay	2.31
	Total	35.88
	Total of Dead Load	27.07
	Total of Superimposed Dead Load	8.81
Dead Load Moment at Midspan M_{DL}(kN-m)		4145.0
Superimposed Dead Load Moment at Midspan M_{SDL} (kN-m)		1349.0
Dead Load Shear at Support V_{DL} (kN)		473.7
Superimposed Dead Load Shear at Support V_{SDL} (kN)		154.2

B2. LIVE LOAD CALCULATIONS

B2. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.148			
Impact factor	0.209			
span	35.00			
Max.MS18 moment for 35.00m span /wheel line		without Impact	M_L	1227.9
		with Impact	M_{LL}	1704.1
Max.MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	148.8
		with Impact	V_{LL}	206.6

B2. FORCE DEMAND CALCULATIONS		
Description	Moment C (0.5L)	Shear At Support
Dead load (kN-m)	4145.0	473.7
Superimposed Dead load (kN-m)	1349.0	154.2
MS18 moment with Impact (kN-m)	1704.1	206.6

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 213, 214 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Weight of Diaphram should be given.		
Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III (refer to Table shown in the next pages of this Sheet 3)		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	$= A \times W$
		M_{DL}	$= 1/8 \times W_{DL} \times L^2$
		V_{DL}	$= 1/2 \times W_{DL} \times L$
	Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 4 (DSC) : Demand Stresses Calculations

B3. SECTION PROPERTIES CALCULATION					
Load Condition	A (m^2)	Iz (m^4)	Y_b (m)	Y_t (m)	Y_t slab (m)
For Dead Loads	0.645	0.214	0.804	0.796	NA
For Superposed Dead Load and Live Loads	1.065	0.419	1.157	0.443	0.643

B4. STRESS CALCULATIONS			
(1) Stress at Midspan			
Loading	Stresses in the PCI Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.44	-15.61	6.85
Prestress (Pef=5270kN)	-5.66	22.14	2.03
Superimposed Dead Load	1.42	-3.73	0.00
Live Load	1.80	-4.71	0.00

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 214, 215 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Applied Equation in Output	Stresses	Moment	= M / Sx (= Y / Iz x M)

Sheet 5 (CCMS): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)

C1. CAPACITY CALCULATIONS

C1.1 MOMENT CAPACITY at MIDSPAN		
Assumed total prestressing loss σ_{LOSS} (Mpa)	158.1	
Ultimate Strength of Tendons fu (Mpa)	1860	
Web Width bw (mm)	203	
Φ	1.00	
Prestressing Steel Area As* (mm^2)	4261	
Section Loss (%)	0	
Total Assumed Area of Steel As(mm2)	4261	
Effective width of deck , beff (mm)	2100	
Centroid of Prestressing Steel from top of deck , d (mm)	1700	
Yield Strength of Tendons fy (Mpa)	1570	
k=2(1.04-fy/fu)	0.39	C_{input}
Neutral axis location (mm)	231.2	231.2
Moment Capacity at Midspan R (kN-m)	12007	

C1.2 SHEAR CAPACITY at SUPPORT	
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	0
The Reduction Factor due to Shear Cracks	1.00
Diameter of Stirrups (mm)	12
Area of Stirrups Φs (mm^2)	113.1
Spacing of Stirrups (mm)	200
Section Loss due to Stirrups Exposure (%)	0
Total Assumed Area of Steel As(mm2)	113.1
Nominal Shear Capacity Factor Φc	0.85
Nominal Shear Strength provided by concrete Vc (kN)	109.5
Nominal Shear Strength provided by Rebar Vs (kN)	1642.7
Shear Capacity Vu	1489.4

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 216, 217 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Prestressing Steel	Section Losses (%)
		Yield strength fy
	Cinput should be given as the same value with Neutral axis location in the left side cell of Cinput. By giving a initial value of Cinput, then the User can get a value of Neutral axis location. Repeating to apply Neutral axis location as a Cinput, Cinput as same value with Neutral axis location will be taken.	
	Rebar	Diameter of Stirrups
		Spacing of Stirrups
	Damage Evaluation	Depth of Shear Cracks
		Secton Losses due to Stirrups exposure caused by Shear
Applied Equation in Output	Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)
	Shear Capacity V_U	VU = Φ x (Vc + Vs) where, Vc = 0.05 x Sqrt (f'c) x b x d x Φ Vs = 2 x Av' x fy x deff / S

Sheet 6 (LRC) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 LOAD RATING BASED ON SERVICEABILITY LIMIT STATE	
(1) USING COMPRESSIVE STRESS	
For Strength Factor	0.6
For Strength Factor	0.4
For Dead Load Factor	0.5
Concrete Compressive Stress	38
Dead Load Stress	16.87
Prestress after all losses	-5.66
Secondary Prestress	0.00
Live Load stresses including Impact	1.80
Using Compressive Stress Under All Load Combination	6.44
Using Compressive Stress Under Live Load	5.33
(2) USING ALLOWABLE TENSION STRESS	
Dead Load Stress	-19.33
Prestress after all losses	22.14
Secondary Prestress	0.00
Live Load stresses including Impact	-4.71
Using the Allowable Tension in Concrete	1.25

C2.2 LOAD RATING BASED ON STRENGTH LIMIT STATE			
Dead Load Factor		1.3	
Live Load factors	Inventory	2.17	
	Operating	1.3	
		Section C (at Midspan)	Section B (Support)
		Moment	Shear
Moment and Shear Capacity		12006.6	1489.4
Moment and Shear due to Dead Load		4145.0	473.7
Moment and Shear due to Superimposed Dead Load		1349.0	154.2
Moment and Shear due to Live Load		1704.1	206.6

C2.3 LOAD RATING CALCULATIONS				
Description	Moment		Shear	
	Inventory	Operating	Inventory	Operating
Rating Factor	1.32	2.20	1.50	2.51
Rating Live Load (MS18) (Metic Tons)	33.0			
Load Rating Calculations	43.4	72.5	49.6	82.7

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note					
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 217, 218 in the Manual for Load Rating of Bridges.				
Verification	Results of calculations should be verified.				
Input Data	Unnecessary.				
Applied Equation in Output	Rating Factor (RF)	Under SLS	Compression	All Load	= 0.6 x f'c - (Fd + Fp + Fs) / Fl
				Live Load	= 0.4 x f'c - 0.5 x (Fd + Fp + Fs) / Fl
			Tension		= 0.5 x sqrt (f'c) - (Fd + Fp + Fs) / Fl
		Under Strength Limit State			= (Φ x Rn - γD x DL) / (γLL x (LL + I))
	Load Rating (LR)				LR = RF x 33.0 (Vehicle Weight)

Sheet 7 (LRSUM) : Summary of Rating Factor and Load Rating

C2.3 SUMMARY OF RATING FACTOR AND LOAD RATING

Weight of Vehicle (Metric Tons)				33	At Midspan		At Support	
					RF	LR	RF	LR
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load		6.44	212.6	-	-
			Live Load		5.33	176.0	-	-
		Allowable Tension			1.25	41.3	-	-
	Strength Limit State	Moment	Inventory		1.32	43.4	-	-
			Operating		2.20	72.5	-	-
		Shear	Inventory		-	-	1.50	49.6
			Operating		-	-	2.51	82.7
Minimum Rating Factor and Load Rating					1.25	41.3	1.50	49.6

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 217, 218 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

Sheet 8 (POSTLL) : Demand Forces Calculations for Load Posting Vehicles (Type 1-1, Type 1-2 and Type 12-2)

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES				
(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.148			
Impact factor	0.209			
span	35.00			
Type 1-1 moment for 35.00m span /wheel line		without Impact	M_L	695.45
		with Impact	M_{LL}	965.19
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	81.46
		with Impact	V_{LL}	113.06
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 35.00m span /wheel line		without Impact	M_L	1036.00
		with Impact	M_{LL}	1437.83
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	123.91
		with Impact	V_{LL}	171.97
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 35.00m span /wheel line		without Impact	M_L	1261.27
		with Impact	M_{LL}	1750.48
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	156.27
		with Impact	V_{LL}	216.88

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 219 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Posting Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III. (refer to Table shown in the next pages of this Sheet 8)		
Applied Equation in Output	Posting Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact

Sheet 9 (POSTLR1) : Posting Load Rating Calculations (1)

D2. POSTING RATING CALCULATIONS

D2.1 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE			
(1) USING COMPRESSIVE STRESS			
Description		At Midspan	At Support
For Strength Factor		0.6	
For Strength Factor		0.4	
For Dead Load Factor		0.5	
Concrete Compressive Stress		38	
Dead Load Stress		16.87	-
Prestress after all losses		-5.66	-
Secondary Prestress		0.00	-
Live Load stresses including Impact	Type 1-1	1.02	-
	Type 1-2	1.52	-
	Type 12-2	1.85	-
Using Compressive Stress Under All Load Combination	Type 1-1	11.37	-
	Type 1-2	7.64	-
	Type 12-2	6.27	-
Using Compressive Stress of Live Load	Type 1-1	9.42	-
	Type 1-2	6.32	-
	Type 12-2	5.19	-
(2) USING ALLOWABLE TENSION STRESS			
Dead Load Stress		-19.33	-
Prestress after all losses		22.14	-
Secondary Prestress		0.00	-
Live Load stresses including Impact	Type 1-1	-2.67	-
	Type 1-2	-3.97	-
	Type 12-2	-4.83	-
Using the Allowable Tension in Concrete	Type 1-1	2.21	-
	Type 1-2	1.48	-
	Type 12-2	1.22	-

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note					
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 219, 220 in the Manual for Load Rating of Bridges.				
Verification	Results of calculations should be verified.				
Input Data	Unnecessary.				
Applied Equation in Output	Stresses for Posting Live Load				= M / Sx (= Y / Iz x M)
	Rating Factor (RF)	Under SLS	Compression	All Load	= 0.6 x f'c - (Fd + Fp + Fs) / Fl
				Live Load	= 0.4 x f'c - 0.5 x (Fd + Fp + Fs) / Fl
			Tension		= 0.5 x sqrt (f'c) - (Fd + Fp + Fs) / Fl

Sheet 10 (POSTLR2) : Posting Load Rating Calculations (2)

D3. LOAD RATING CALCULATIONS

D3.1 POSTING RATING BASED ON STRENGTH LIMIT STATE			
Dead Load Factor		1.3	
Live Load factors	Inventory	2.17	
	Operating	1.3	
Description		Moment at Midspan	Shear at Support
Moment and Shear Capacity		12007	1489
Moment and Shear due to Dead Load		4145.0	473.7
Moment and Shear due to Superimposed Dead Load		1349.0	154.2
Moment and Shear due to Live Load	Type 1-1	965.2	113.1
	Type 1-2	1437.8	172.0
	Type 12-2	1750.5	216.9

D3.2 POSTING RATING CALCULATIONS						
Description			Moment at Midspan		Shear at Support	
			Inventory	Operating	Inventory	Operating
Rating Factor		Type 1-1	2.32	3.88	2.74	4.58
		Type 1-2	1.56	2.60	1.80	3.01
		Type 12-2	1.28	2.14	1.43	2.39
Postting Live Load (Metic Tons)	Weight of vehicle	Type 1-1	17.0			
		Type 1-2	27.0			
		Type 12-2	38.0			
Load Rating Calculations		Type 1-1	39.5	65.9	46.6	77.9
		Type 1-2	26.5	70.3	30.7	81.3
		Type 12-2	21.8	81.2	24.3	90.7

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 220 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Each Posting Vehicle Weight)

Sheet 11 (POSTSUM) : Summary of Posting Rating Factor and Load Rating

D3.3 SUMMARY OF POSTING RATING FACTOR AND LOAD RATING				At Midspan		At Support	
				RF	LR	RF	LR
(1) POSTING VEHICLE TYPE 1-1				Weight of Vehicle		17 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	11.37	193.4	-	-
			Live Load	9.42	160.1	-	-
		Allowable Tension		2.21	37.6	-	-
	Strength Limit State	Moment	Inventory	2.32	39.5	-	-
			Operating	3.88	65.9	-	-
		Shear	Inventory	-	-	2.74	46.6
			Operating	-	-	4.58	77.9
Minimum Rating Factor and Load Rating				2.21	37.6	2.74	46.6
(2) POSTING VEHICLE TYPE 1-2				Weight of Vehicle		27 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	7.64	206.2	-	-
			Live Load	6.32	170.7	-	-
		Allowable Tension		1.48	40.1	-	-
	Strength Limit State	Moment	Inventory	1.56	42.1	-	-
			Operating	2.60	70.3	-	-
		Shear	Inventory	-	-	1.80	48.7
			Operating	-	-	3.01	81.3
Minimum Rating Factor and Load Rating				1.48	40.1	1.80	48.7
(3) POSTING VEHICLE TYPE 12-2				Weight of Vehicle		38 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	6.27	238.3	-	-
			Live Load	5.19	197.3	-	-
		Allowable Tension		1.22	46.3	-	-
	Strength Limit State	Moment	Inventory	1.28	48.7	-	-
			Operating	2.14	81.2	-	-
		Shear	Inventory	-	-	1.43	54.4
			Operating	-	-	2.39	90.7
Minimum Rating Factor and Load Rating				1.22	46.3	1.43	54.4

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

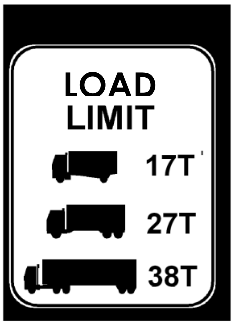
NEXT

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 219, 220, 221 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

Sheet 12 (SUMMARY) : Summary of Load Posting

E. SUMMARY OF LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	AT MIDSPAN		AT SUPPORT		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.25	41.3	1.50	49.6	33T
Type 1-1	17.0	2.21	37.6	2.74	46.6	17T
Type 1-2	27.0	1.48	40.1	1.80	48.7	27T
Type 12-2	38.0	1.22	46.3	1.43	54.4	38T



After confirmation of this sheet, click button "END GO TO RC DECK SLAB" then proceed directly to the next screen.

END AND GO TO DECK SLAB

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 221 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.4.2 Continuous PCDG

Sheet 1 (GENERAL) : Input Data of Bridge Description

INTERIOR PCDG CONTINUOUS

A. GENERAL

BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location		REGION	II				
Bridge Name							
Bridge Type	Simple or Continuous		C	Precast, Prestressed PC I Girder Bridge			
	Number of Span		3				
Bridge Width (curb to curb) (m)			7.32				
Number of Lanes			2				
Bridge Length (m)			35.000	35.000	35.000		=105.000m
Year Built			2000				
Structure	Nos. of Girder		4	Superstructure made continuous for live loading			
	Girder Spacing (m)		2.100	on centers			
	Substructure		Concrete bents and abutments				
Wearing Course	thickness (mm)		50				
	material		Asphalt				
Notes on Plans		f'c (Girder)		38	MPa		
		f'c (Slab)		24.2	MPa		
		Ultimate Strength of Tendons fu		1860	MPa		
		Working Force		6750	kN (Effective after losses)		
		Centroid of PC Tendons		100	mm (from soffit at Midspan)		
				885	mm (from soffit at Anchorage)		
Assumption		Weight of barrier rail Wbr =		13.0	KN/m		
		fy (Reinforcing Bars)		415	Mpa		
		Concrete Unit Weight Wu =		24.0	KN/m^3		
		Asphalt Unit Weight Wa =		22.0	KN/m^3		
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	137.9	224.1	137.9	*pc
	Grade 60	413.7	165.5	248.2	165.5	*pc

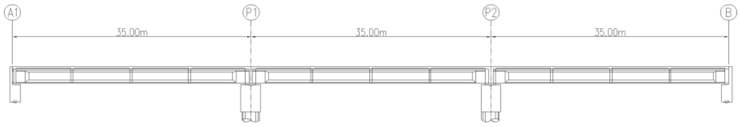
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

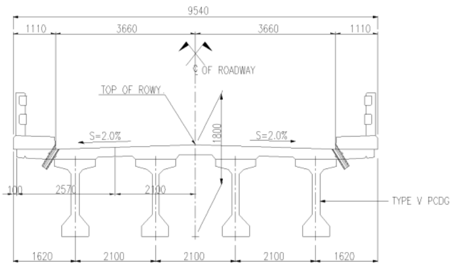
Note	
Input Data	Light blue cells should be filled up.
Differences compared with Simple PCDG	Simple or Continuous, Number of Span and Bridge Length.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input a Bridge Layout and Dimension for Load Rating

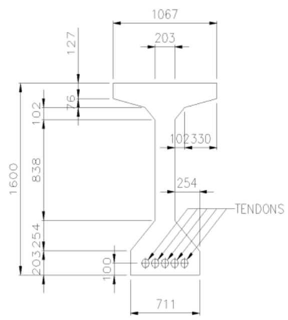
A2. BRIDGE LAYOUT AND SECTION



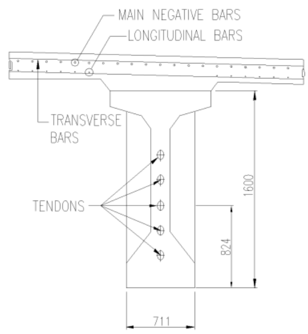
BRIDGE ELEVATION



SUPERSTRUCTURE CROSS SECTION



SECTION AT MIDSPAN



SECTION AT PIER SUPPORT

GIRDER SECTION			
Girder Height	1.600		
Dimension	b	h	
Slab	2.100	0.2	*1.00 (Modulas Ratio)
Uflg	1.067	0.127	
	0.330	0.076	
	0.102	0.076	
	0.102	0.102	
Web	0.203	1.270	
Lflg	0.254	0.254	
	0.711	0.203	

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Girder Dimension : Girder Height, and Width and Height for Upper/Lower Flange and Web - Slab Dimension : Slab Width and Slab Thickness
Differences compared with Simple PCDG	Drawing of Bridge Elevation.
Drawings	Drawings (Elevation, Cross Section and Girder Details) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B1. DEAD LOAD CALCULATIONS

B1.1 INPUT		
FOR DEAD LOAD	Area of Girder (m^2)	0.653
	Span Length (m)	35.000
	Composite Girder Height (m)	1.80
	Girder Height (m)	1.60
	Slab thickness (m)	0.200
	Slab Spacing (m)	2.100
	Weight of Diaphram (kN/m)	1.5
	Weight of Barrier Rail (kN/m)	13
	Number of Girder (nos.)	4

B1.2 DEAD LOAD CALCULATIONS	
Dead Load Moment at Midspan M_{DL}(kN-m)	4173.5
Dead Load Shear at Support V_{DL} (kN)	477.0

B2. FORCE DEMAND CALCULATIONS

B2.1 INPUT	
Number of Lanes	2
Fraction DF	1.148

B2.2 FORCE DEMAND CALCULATIONS

Conducting a Structural Analysis, the load demands for the PCDG should be obtained separately and input the necessary load demands in the Table below.

Description		C (0.5L)	At Pier Support
Moments	Dead load (kN-m)	4173.5	0.0
	Superimposed Dead load (kN-m)	594.7	-792.9
	MS18 moment with Impact (kN-m)	2441.4	-2770.7
Shears	Dead load (kN)	0.0	-477.0
	Superimposed Dead load (kN)	0.0	-135.9
	MS18 max. positive shear force (kN)	202.9	67.0
	MS18 max. negative shear force (kN)	-202.9	-465.3
	MS18 max. positive moment for shear (kN-m)	2319.3	457.9
	MS18 max. negative moment for shear (kN-m)	-2319.3	-449.8

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 235, 236 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Weight of Diaphram should be given. Load Demands on continuous bridge should be given.		
Differences compared with Simple PCDG	Load demands should be separately analyzed with appropriate structural Model.		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	$= A \times W$
		M_{DL}	$= 1/8 \times W_{DL} \times L^2$
		V_{DL}	$= 1/2 \times W_{DL} \times L$

Sheet 4 (DSC) : Demand Stresses Calculations

B3. SECTION PROPERTIES CALCULATION

Load Condition	A (m^2)	Iz (m^4)	Y_b (m)	Y_t (m)	Y_t slab (m)
For Dead Loads	0.653	0.217	0.812	0.788	NA
For Live Loads	1.073	0.420	1.159	0.441	0.641

B4. STRESS CALCULATIONS

(1) Stress at Midspan

Loading	Stresses in the PC Girder (Mpa)		
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite
Dead Load (Self + Slab)	15.17	-15.63	6.69
Prestress (Pef=6750kN)	-7.13	28.32	2.63
Superimposed Dead Load	0.62	-1.64	0.00
Live Load	2.56	-6.74	0.00
Live Load Moment for Shear	2.43	-6.40	0.00

(2) Stress at Pier Support

Loading	Stresses in the PC Girder (Mpa)			
	Top Concrete Fiber	Bottom Concrete Fiber	Centroid of Composite	Top of Slab
Dead Load (Self + Slab)	0.00	0.00	0.00	0.00
Prestress (Pef=6750kN)	12.13	8.48	11.13	0.00
Superimposed Dead Load	-0.83	2.19	0.00	-1.21
Live Load	-2.91	7.65	0.00	-4.23
Live Load Moment for Shear	-0.47	1.24	0.00	-0.69

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 236, 237 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.		
Applied Equation in Output	Stresses	Moment	= M / Sx (= Y / Iz x M)

Sheet 5 (CCMS1): Capacity Calculations for Moment at Midspan and Shear at Support

C. LOAD RATING BY LOAD FACTOR METHOD

C1. CAPACITY CALCULATIONS

C1.1 MOMENT CAPACITY at MIDSPAN		
Assumed total prestressing loss including creep σ_{LOSS} (Mpa)	204.6	
Ultimate Strength of Tendons fu (Mpa)	1860	
Web Width bw (mm)	203	
Prestressing Steel Area As* (mm^2)	5670	
Section Loss (%)	0	
Total Assumed Area of Steel As(mm2)	5670	
Effective width of deck , beff (mm)	2100	
Centroid of Prestressing Steel from top of deck , d (mm)	1700	
Yield Strength of Tendons fy (Mpa)	1570	
k=2(1.04-fy/fu)	0.39	C_{input}
Neutral axis location (mm)	560.6	560.6
Moment Capacity at Midspan R (kN-m)	14284	

C1.2 MOMENT CAPACITY at PIER SUPPORT	
Ultimate Strength of Rebar fy (Mpa)	415
Number of Rebars (nos.)	15
Diameter of Main Rebar (mm)	36
Area of one main rebar Φs (mm2)	1017
Concrete Cover (mm)	38
Resistance Reduction Factor	0.90
Rebars Area As (mm^2)	15255
Section Loss (%)	10
Total Assumed Area of Steel As(mm2)	13730
Centroid of Rebar from top of compression fiber, d (mm)	1744
Web Width bw (mm)	711.0
Rebar Ratio ρ = As / (beff x d) ρ	0.01107
Neutral axis location (mm)	608.1
Moment Capacity at Face of Support R (kN-m)	8045

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 238, 239 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Prestressing Steel at Midspan	Assumed prestressing loss including creep loss (Mpa)
		Section Losses (%)
		Yield strength fy
	Cinput should be given as the same value with Neutral axis location in the left side cell of Cinput. By giving a initial value of Cinput, then the User can get a value of Neutral axis location. Repeating to apply Neutral axis location as a Cinput, Cinput as same value with Neutral axis location will be taken.	
	Rebar at Pier Support	Number of main rebar
		Diameter of main rebar
		Concrete cover
	Damage Evaluation	Secton Losses due to main rebar exposure caused by Moment
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)

Sheet 6 (CCMS2): Capacity Calculations for Moment at Midspan and Shear at Support

C1. CAPACITY CALCULATIONS

C1.3 SHEAR CAPACITY at MIDSPAN	
Diameter of Stirrups (mm)	12
Area of Stirrups (mm^2)	113
Spacing of Stirrups (mm)	250
Nominal Shear Capacity Factor Φ	0.85
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	40
The Reduction Factor due to Shear Cracks	0.80
Cracking Moment (kN-m)	3775.4
Factored Total Moment Mmax (kN-m)	11231.6
Factored Shear Force Vi (kN)	440.3
Nominal Shear Strength Vci (kN)	254.4
Nominal Shear Strength Vcw (kN)	1474.5
Nominal Shear Strength provided by concrete Vc (kN)	204.2
Nominal Shear Strength provided by Rebar Vs (kN)	637.8
Shear Capacity Vu = Φ (Vc + Vs) (kN)	715.7

C1.4 SHEAR CAPACITY at PIER B	
Diameter of Stirrups (mm)	12
Area of Stirrups (mm^2)	113
Spacing of Stirrups (mm)	150
Nominal Shear Capacity Factor Φ	0.85
Web Width bw (mm)	203
Depth of Shear Cracks (mm)	30
The Reduction Factor due to Shear Cracks	0.85
Cracking Moment (kN-m)	-819.2
Factored Total Moment Mmax (kN-m)	-2006.8
Factored Shear Force Vi (kN)	-1806.4
Nominal Shear Strength Vci (kN)	1350.4
Nominal Shear Strength Vcw (kN)	1836.5
Nominal Shear Strength provided by concrete Vc (kN)	1150.9
Nominal Shear Strength provided by Rebar Vs (kN)	1090.5
Shear Capacity Vu	1905.1

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 240, 241 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar both at Midspan and at Pier Support	Diameter of stirrups
		Spacing of stirrups
	Damage Evaluation	Depth of Shear Cracks
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Shear Capacity V_U	VU = Φ x (Vc + Vs) where, Vc = 0.05 x Sqrt (f'c) x b x d x Φ Vs = 2 x Av' x fy x deff / S

Sheet 7 (LRC) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1 LOAD RATING BASED ON SERVICEABILITY LIMIT STATE		
(1) USING COMPRESSIVE STRESS		
	Section C	Pier Support B
For Strength Factor	0.6	
For Strength Factor	0.4	
For Dead Load Factor	0.5	
Concrete Compressive Stress	38	
Dead Load Stress	15.80	2.19
Prestress after all losses	-7.13	8.48
Secondary Prestress	0.00	0.00
Live Load stresses including Impact	2.56	7.65
Using Compressive Stress Under All Load Combination	5.52	1.59
Using Compressive Stress of Live Load	4.24	1.29
(2) USING ALLOWABLE TENSION STRESS		
Dead Load Stress	-17.27	-0.83
Prestress after all losses	28.32	12.13
Secondary Prestress	0.00	0.00
Live Load stresses including Impact	-6.74	-2.91
Using the Allowable Tension in Concrete	2.10	4.95

C2.2 LOAD RATING BASED ON STRENGTH LIMIT STATE					
Dead Load Factor		1.3			
Live Load factors	Inventory	2.17			
	Operating	1.3			
		Section C (at Midspan)		Section B (Support)	
		Moment	Shear	Moment	Shear
Moment and Shear Capacity		14284	716	-8045	-1905
Moment and Shear due to Dead Load		4174	0.00	0.00	-477
Moment and Shear due to Superimposed Dead Load		595	0.00	-793	-136
Moment and Shear due to Live Load		2441	203	-2771	-465

C2.3 LOAD RATING CALCULATIONS					
Description		Moment		Shear	
		Inventory	Operating	Inventory	Operating
Rating Factor	Section C (Midspan)	1.53	2.55	1.63	2.71
	Pier B (Support)	1.51	1.95	1.10	1.83
Rating Live Load (MS18) (Metic Tons	Weight of vehicle	33.0			
Load Rating Calculations	Section C (Midspan)	50.4	84.1	53.6	89.5
	Pier B (Support)	49.8	64.3	36.2	60.5

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note				
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 242, 243 in the Manual for Load Rating of Bridges.			
Verification	Results of calculations should be verified.			
Input Data	Unnecessary.			
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.			
Applied Equation in Output	Rating Factor (RF)	Under SLS	Compression — All Load	= 0.6 x f'c - (Fd + Fp + Fs) / Fl
			Compression — Live Load	= 0.4 x f'c - 0.5 x (Fd + Fp + Fs) / Fl
			Tension	= 0.5 x sqrt (f'c) - (Fd + Fp + Fs) / Fl
		Under Strength Limit State		= (Φ x Rn - γD x DL) / (γLL x (LL + I))
	Load Rating (LR)			LR = RF x 33.0 (Vehicle Weight)

Sheet 8 (LRSUM) : Summary of Rating Factor and Load Rating

C2.3 SUMMARY OF RATING FACTOR AND LOAD RATING							
Weight of Vehicle (Metric Tons)			33	Section C		Pier Support B	
				RF	LR	RF	LR
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	5.52	182.1	1.59	52.3
			Live Load	4.24	140.0	1.29	42.5
		Allowable Tension		2.10	69.2	4.95	163.2
	Strength Limit State	Moment	Inventory	1.53	50.4	1.51	49.8
			Operating	2.55	84.1	1.95	64.3
		Shear	Inventory	1.63	53.6	1.10	36.2
			Operating	2.71	89.5	1.83	60.5
Minimum Rating Factor and Load Rating				1.53	50.4	1.10	36.2

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 242, 243 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.

Sheet 9 (POSTLR1) : Posting Load Rating Calculations (1)

D. LOAD POSTING BY LOAD FACTOR METHOD

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES				
Conducting a Structural Analysis, the load demands for the PCDG should be obtained separately and input the necessary load demands in the Table below.				
Description			Section C	Pier Support B
Posting Vehicle Moment and Shear	Moment	Type 1-1	822.1	-448.7
		Type 1-2	1219.9	-702.9
		Type 12-2	1447.3	-934.3
	Shear	Type 1-1	60.3	-123.2
		Type 1-2	85.5	-191.8
		Type 12-2	84.1	-248.8

D2. POSTING RATING CALCULATIONS

D2.1 POSTING RATING BASED ON SERVICEABILITY LIMIT STATE			
(1) USING COMPRESSIVE STRESS			
Description		Section C	Pier Support B
For Strength Factor		0.6	
For Strength Factor		0.4	
For Dead Load Factor		0.5	
Concrete Compressive Stress		38	
Dead Load Stress		15.80	2.19
Prestress after all losses		-7.13	8.48
Secondary Prestress		0.00	0.00
Live Load stresses including Impact	Type 1-1	0.86	1.24
	Type 1-2	1.28	1.94
	Type 12-2	1.52	2.58
Using Compressive Stress Under All Load Combination	Type 1-1	16.38	9.79
	Type 1-2	11.04	6.25
	Type 12-2	9.31	4.70
Using Compressive Stress of Live Load	Type 1-1	12.60	7.96
	Type 1-2	8.49	5.08
	Type 12-2	7.16	3.82
(2) USING ALLOWABLE TENSION STRESS			
Dead Load Stress		-17.27	-0.83
Prestress after all losses		28.32	12.13
Secondary Prestress		0.00	0.00
Live Load stresses including Impact	Type 1-1	-2.27	-0.47
	Type 1-2	-3.37	-0.74
	Type 12-2	-4.00	-0.98
Using the Allowable Tension in Concrete	Type 1-1	6.23	30.54
	Type 1-2	4.20	19.50
	Type 12-2	3.54	14.67

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note					
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 244, 245 in the Manual for Load Rating of Bridges.				
Verification	Results of calculations should be verified.				
Input Data	Load demands should be separately analyzed with appropriate structural Model.				
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.				
Applied Equation in Output	Stresses for Posting Live Load				= M / Sx (= Y / Iz x M)
	Rating Factor (RF)	Under SLS	Compression	All Load	= 0.6 x f'c - (Fd + Fp + Fs) / Fl
				Live Load	= 0.4 x f'c - 0.5 x (Fd + Fp + Fs) / Fl
			Tension		= 0.5 x sqrt (f'c) - (Fd + Fp + Fs) / Fl

Sheet 10 (POSTLR2) : Posting Load Rating Calculations (2)

D2. LOAD RATING CALCULATIONS

D2.2 POSTING RATING BASED ON STRENGTH LIMIT STATE					
Dead Load Factor		1.3			
Live Load factors	Inventory	2.17			
	Operating	1.3			
		Section C (at Midspan)		Section B (Support)	
		Moment	Shear	Moment	Shear
Moment and Shear Capacity		14284	716	-8045	-1905
Moment and Shear due to Dead Load		4174	0.00	0.00	-477
Moment and Shear due to Superimposed Dead Load		595	0.00	-792.9	-136
Moment and Shear due to Live Load	Type 1-1	822	60	-449	-123
	Type 1-2	1220	86	-703	-192
	Type 12-2	1447	84	-934	-249

D2.3 POSTING RATING CALCULATIONS						
Description			Moment		Shear	
			Inventory	Operating	Inventory	Operating
Rating Factor	Section C (Midspan)	Type 1-1	4.53	7.57	5.47	9.13
		Type 1-2	3.05	5.10	3.86	6.44
		Type 12-2	2.57	4.30	3.92	6.55
	Pier B (Support)	Type 1-1	7.20	12.02	4.15	6.92
		Type 1-2	4.60	7.68	2.66	4.45
		Type 12-2	3.46	5.77	2.05	3.43
Postting Live Load (Metic Tons)	Weight of vehicle	Type 1-1	17.0			
		Type 1-2	27.0			
		Type 12-2	38.0			
Load Rating Calculations	Section C (Midspan)	Type 1-1	77.0	128.6	93.0	155.2
		Type 1-2	82.5	137.7	104.2	173.9
		Type 12-2	97.8	163.3	149.0	248.8
	Pier B (Support)	Type 1-1	122.5	204.4	70.5	117.6
		Type 1-2	124.2	207.3	71.9	120.0
		Type 12-2	131.5	219.4	78.0	130.2

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 246, 247 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x (Each Posting Vehicle Weight)

Sheet 11 (POSTSUM) : Summary of Posting Rating Factor and Load Rating

D2.3 SUMMARY OF POSTING RATING FACTOR AND LOAD RATING				Section C		Pier Support B	
				RF	LR	RF	LR
(1) POSTING VEHICLE TYPE 1-1				Weight of Vehicle		17 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	16.38	278.5	9.79	166.4
			Live Load	12.60	214.1	7.96	135.3
		Allowable Tension		6.23	105.9	30.54	519.3
	Strength Limit State	Moment	Inventory	4.53	77.0	7.20	122.5
			Operating	7.57	128.6	12.02	204.4
		Shear	Inventory	5.47	93.0	4.15	70.5
			Operating	9.13	155.2	6.92	117.6
Minimum Rating Factor and Load Rating				4.53	77.0	4.15	70.5
(2) POSTING VEHICLE TYPE 1-2				Weight of Vehicle		27 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	11.04	298.1	6.25	168.7
			Live Load	8.49	229.2	5.08	137.2
		Allowable Tension		4.20	113.3	19.50	526.5
	Strength Limit State	Moment	Inventory	3.05	82.5	4.60	124.2
			Operating	5.10	137.7	7.68	207.3
		Shear	Inventory	3.86	104.2	2.66	71.9
			Operating	6.44	173.9	4.45	120.0
Minimum Rating Factor and Load Rating				3.05	82.5	2.66	71.9
(3) POSTING VEHICLE TYPE 12-2				Weight of Vehicle		38 (Metoric Tons)	
Rating Factor and Load Rating	Serviceability Limit State	Compression	All Load	9.31	353.7	4.70	178.6
			Live Load	7.16	271.9	3.82	145.3
		Allowable Tension		3.54	134.4	14.67	557.4
	Strength Limit State	Moment	Inventory	2.57	97.8	3.46	131.5
			Operating	4.30	163.3	5.77	219.4
		Shear	Inventory	3.92	149.0	2.05	78.0
			Operating	6.55	248.8	3.43	130.2
Minimum Rating Factor and Load Rating				2.57	97.8	2.05	78.0

NEXT

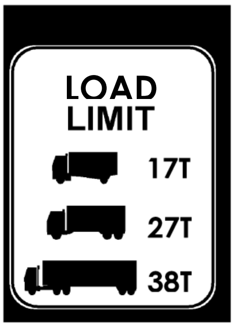
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 246, 247 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.
Differences compared with Simple PCDG	Load Rating calculations should be done not only at Midspan but also at Pier.

Sheet 12 (SUMMARY) : Summary of Load Posting

E. SUMMARY OF RESULTS FOR LOAD POSTING

SUMMARY OF RESULTS FOR LOAD POSTING						
Vehicle Type	Vehicle Weight (Metric Tons)	SECTION C		PIER SUPPORT B		Load Posting (Tons)
		Rating Factor	Load Rating	Rating Factor	Load Rating	
MS18	33.0	1.53	50.4	1.10	36.2	33T
Type 1-1	17.0	4.53	77.0	4.15	70.5	17T
Type 1-2	27.0	3.05	82.5	2.66	71.9	27T
Type 12-2	38.0	2.57	97.8	2.05	78.0	38T



After confirmation of this sheet, click "END GO TO RC DECK SLAB" button then proceed directly to the next

END AND GO TO DECK SLAB

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 247 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

6.5 SIG (Steel I Girder Bridge)

6.5.1 Simple SIG

Sheet 1 (GENERAL) : Input Data of Bridge Description

INTERIOR SIG SIMPLE

A. GENERAL BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION	VII					
Bridge Name		MANANGA II Bridge					
Bridge Type	Simple or Continuous	S	Steel I-Girder Bridge				
	Number of Span	4					
Bridge Width (curb to curb) (m)		7.32					
Number of Lanes		2					
Bridge Length (m)		35.000	35.000	35.000	35.000		=140.000m
Year Built		1970					
Structure	Nos. of Girder	3	Multiple Girder composite for live load				
	Girder Spacing (m)	3.200	on centers				
	Substructure	RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	8.3 Mpa		fs=	265.0 Mpa	
		f'c=	20.7 Mpa		fy=	482.0 Mpa	
Assumption		Weight of barrier rail Wbr =			4.600	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m^3	
		Steel Girder Unit Weight Ws =			77.0	KN/m^3	
		Asphalt Unit Weight Wa =			22.0	KN/m^3	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Structural Steel Bending	**Prior to 1905**	179.3	96.5	134.4	96.5	
	1905 to 1936	206.8	110.3	155.1	110.3	
	1936 to 1963	227.5	124.1	168.9	124.1	
	after 1963	248.2	137.9	186.2	137.9	
Structural Steel Web Shear	**Prior to 1905**	179.3	58.6	79.3	58.6	
	1905 to 1936	206.8	65.5	93.1	65.5	
	1936 to 1963	227.5	75.8	103.4	75.8	
	after 1963	248.2	82.7	110.3	82.7	
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	189.8	224.1	137.9	*pc
	Grade 60	413.7	227.5	248.2	165.5	*pc
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc

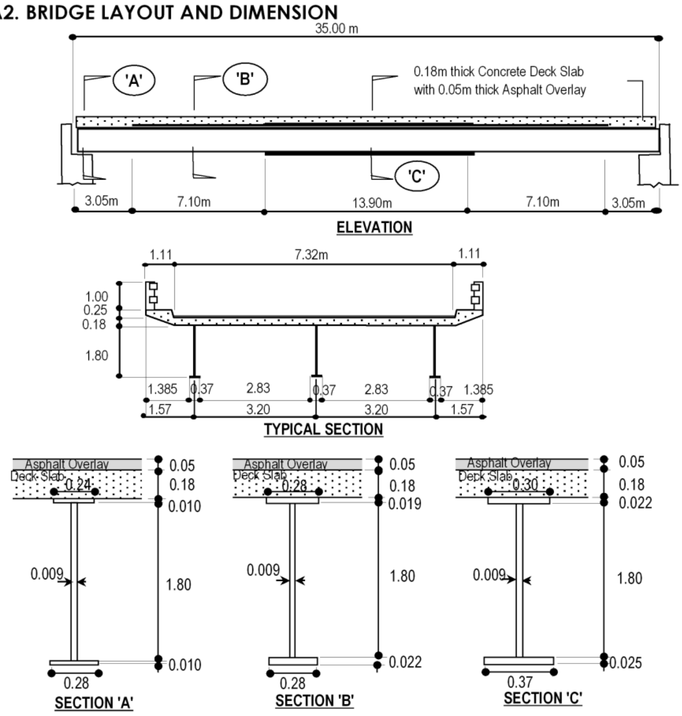
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

Note	
Input Data	Light blue cells should be filled up.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input a Bridge Layout and Dimension for Load Rating

A2. BRIDGE LAYOUT AND DIMENSION



GIRDER SECTION

SECTION	SECTION A (At Support)		SECTION B (Dummy)		SECTION C (At Midspan)	
Location (m)	0.010		1.000		17.500	
Dimension	b (m)	h (m)	b (m)	h (m)	b (m)	h (m)
Slab	thickness = 0.180 m					
	0.320	0.180	0.320	0.180	0.320	0.180
Uflg	0.240	0.010	0.280	0.019	0.300	0.022
	0.000	0.000	0.000	0.000	0.000	0.000
Web	0.009	1.800	0.009	1.800	0.009	1.800
	0.000	0.000	0.000	0.000	0.000	0.000
Lflg	0.280	0.010	0.280	0.022	0.370	0.025
	0.000	0.000	0.000	0.000	0.000	0.000
Length	6.100		14.200		13.900	

* Only figure should be given (in case of this screen, give the "0.180" only)

*10 (Modular Ratio)

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Location of objective section - Slab Dimension : Slab Thickness (Only figure should be given) - Girder Dimension : Width and Height for Upper/Lower Flange and Web - Length of objective section
Drawings	Drawings (Elevation, Cross Section and Steel Girder Details) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B.1 INPUT AND SECTION PROPERTIES

B0. INPUT	
Slab thickness ts (m)	0.180
Slab width ws (m)	3.200
Span Length L(m)	35.000

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) UNDER DEAD LOAD (NON-COMPOSIE GIRDER)							
SECTION	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
A (At Support)	0.02140	0.01620	0.00863	0.89308	0.92692	0.00966	0.00931
B (Dummy)	0.02768	0.01620	0.01387	0.89407	0.94693	0.01551	0.01464
C (At Midspan)	0.03205	0.01620	0.01737	0.84924	0.99776	0.02045	0.01741
(2) UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (COMPOSIE GIRDER)							
A (At Support)	0.07900	0.01620	0.02492	1.63453	0.18547	0.01524	0.13435
B (Dummy)	0.08528	0.01620	0.03412	1.59443	0.24657	0.02140	0.13840
C (At Midspan)	0.08965	0.01620	0.04189	1.54813	0.29887	0.02706	0.14016

Standard Section Area of "SECTION A"	
Original Section Area (m^2)	0.0214

B.2 DEAD LOAD CALCULATIONS

B2. DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	Section A (At Support)	0.287
		Section B (Dummy)	0.865
		Section C (At Midspan)	0.980
		Stiffener and Bracing	0.267
	Slab Weight	Continuous	13.824
	Barrier Rail		3.067
	Asphalt Overlay		3.520
	Total Load		22.809
	Total DeadLoad		16.223
	Total Superimposed Dead Load		6.587
Dead Load	Moment (KN-m/m)	M_{DL}	2484.1
	Shear (KN)	V_{DL}	283.9
Superimposed Dead Load	Moment (KN-m/m)	M_{DL}	1008.6
	Shear (KN)	V_{DL}	115.3

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 258 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Original section area of section "A" should be given. This data is prepared in case section losses are observed in steel girder.		
Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III (refer to Table shown in the next pages of this Sheet 3)		
Applied Equation in Output	Dead Load	Uniform Load W_{DL}	$= A \times W$
		M_{DL}	$= 1/8 \times W_{DL} \times L^2$
		V_{DL}	$= 1/2 \times W_{DL} \times L$

Sheet 4 (DSDLLL) : Demand Forces and Stresses Calculations

B3. LIVE LOAD CALCULATIONS

B3. LIVE-LOAD CALCULATIONS				
LIVE-LOAD Type	MS18(HS20)	INPUT FOR LIVE LOAD		
Number of live load wheel line	1.750			
Impact factor	0.209			
span	35.00			
Max.MS18 moment for 35.00m span /wheel line		without Impact	M_L	819.75
		with Impact	M_{LL}	1733.65
Max.MS18 shear at a distance "d" from the support/wheel line		without Impact	V_L	143.49
		with Impact	V_{LL}	303.46

B4. LOAD DEMANDS ON DIFFERENT SECTIONS OF STEEL GIRDER

B4. LOAD DEMAND MIDSPAN AND SUPPORT OF STEEL GIRDER			
Loading	At Support	Section B (Dummy)	At Midspan
	0.01m	1.00m	17.50m
Dead load moments, KN-m	2.8	275.8	2484.1
Dead load shears, KN	283.7	267.7	0.0
SDL moments, KN-m	1.2	112.0	1008.58
SDL shears, KN	115.2	108.7	0.0
LL moment + Impact, KN-m	3.1	305.0	1733.6
LL shear + Impact, KN	314.7	305.0	118.7

B5. LOAD STRESS CALCULATIONS

ESTIMATED STRESS DEMANDS AT GIRDER SECTIONS				
Loading	Location	At Support	Section B (Dummy)	At Midspan
DL moment	Top	**0.30**	**18.83**	**142.69**
	Bottom	**-0.29**	**-17.78**	**-121.45**
SDL moment	Top	**0.01**	**0.81**	**7.20**
	Bottom	**-0.08**	**-5.23**	**-37.27**
LL+I moment, $\sigma_{LL+I}{}^{t}$	Top	**0.02**	**2.20**	**12.37**
	Bottom	**-0.21**	**-14.25**	**-64.07**
DL shear, v_{DL}		**17.51**	**16.52**	**0.00**
SDL shear, v_{SDL}		**7.11**	**6.71**	**0.00**
LL+I shear, v_{LL+I}		**19.42**	**18.83**	**7.33**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 259, 260 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Live Load Forces	They are calculated based on the Load Rating Manual Appendix III (refer to Table shown in the next pages of this Sheet 3)		
Applied Equation in Output	Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact
	Stresses	Moment	= M / Sx (= Y / Iz x M)
		Shear	= (Shear forces) / (Web Area)

Sheet 5 (LRASM) : Load Rating Calculations by ASM

C. LOAD RATING BY ALLOWABLE STRESS METHOD

C1. ALLOWABLE STRESS CALCULATIONS

C.1.1 ALLOWABLE STRESSES FOR CONCRETE AND STEEL				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	265.0
		Strength	fy	482.0

C.1.2 COMPRESSION AND TENSILE STRESSES		
Allowable compressive stress	Inventory	265.0
	Operating	361.5
Allowable tensile stress	Inventory	265.0

C.1.3 ALLOWABLE SHEAR STRESS		
Allowable Shear Stress	Inventory	160.7
	Operating	216.9

C2. LOAD RATING CALCULATIONS

C2.1 RATING FACTOR CALCULATIONS USING ASM

Section	Description	Inventory	Operating
At Support	Stress at Top Fiber	11301.38	15421.66
	Stress at Bottom Fiber	1282.08	1749.61
	Shear	7.01	9.90
B (Dummy)	Stress at Top Fiber	111.34	155.14
	Stress at Bottom Fiber	16.98	23.75
	Shear	7.30	10.29
At Midspan	Stress at Top Fiber	9.31	17.11
	Stress at Bottom Fiber	1.66	3.17
	Shear	21.94	29.61

C2.2 LOAD RATING CALCULATIONS

Section	Description	Rating Live Load (Metric Tons)			33.0
		Inventory		Operating	
At Support	Moment	1282.08	42308.7	1749.61	57737.0
	Shear	7.01	231.2	9.90	326.7
B (Dummy)	Moment	16.98	560.4	23.75	783.9
	Shear	7.30	241.0	10.29	339.5
At Midspan	Moment	1.66	54.7	3.17	104.4
	Shear	21.94	723.9	29.61	977.1

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown

Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 260, 261 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Allowable compression stress, tensile stress and shear stress under inventory and operating should be given.	
Applied Equation in Output	Rating Factor RF	$RF = (\Phi \times Rn - \gamma_D \times DL) / (\gamma_{LL} \times (LL + I))$
	Load Rating LR	LR = RF x 33.0 (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces and Stresses Calculations for Load Posting Vehicles (Type 1-1, Type 1-2 and Type 12-2)

D. LOAD POSTING BY ALLOWABLE STRESS (ASM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.1 DEMAND FORCES FOR LOAD POSTING VEHICLES

(1) POSTING VEHICLE Type 1-1				
LIVE-LOAD Type	Type1-1			
Number of live load wheel line	1.750			
Impact factor	0.209			
span	35.00			
Type 1-1 moment for 35.00m span /wheel line		without Impact	M_L	695.45
		with Impact	M_{LL}	1470.77
Type 1-1 shear at a distance "d" from the support/wheel line		without Impact	V_L	80.64
		with Impact	V_{LL}	170.54
(2) POSTING VEHICLE Type 1-2				
LIVE-LOAD Type	Type1-2			
Type 1-2 moment for 35.00m span /wheel line		without Impact	M_L	1036.00
		with Impact	M_{LL}	2190.98
Type 1-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	120.43
		with Impact	V_{LL}	254.69
(3) POSTING VEHICLE Type 12-2				
LIVE-LOAD Type	Type12-2			
Type 12-2 moment for 35.00m span /wheel line		without Impact	M_L	1261.27
		with Impact	M_{LL}	2667.39
Type 12-2 shear at a distance "d" from the support/wheel line		without Impact	V_L	144.01
		with Impact	V_{LL}	304.56

D1.2 POSTING VEHICLE DEMAND FORCES AT MIDSPAN, SUPPORT

Posting Vehicle	Demand Forces	At Support	B (Dummy)	At Midspan
		0.01m	1.00m	17.50m
Type 1-1	Moment	1.72	167.24	1470.77
	Shear	172.24	167.24	83.99
Type 1-2	Moment	2.62	254.05	2190.98
	Shear	261.98	254.05	121.95
Type 12-2	Moment	3.30	319.22	2667.39
	Shear	330.38	319.22	133.28

D1.3 POSTING VEHICLE DEMAND STRESSES AT MIDSPAN, SUPPORT

Posting Vehicle	Demand Forces	At Support	B (Dummy)	At Midspan
Type 1-1	Top Fiber	0.01	1.21	10.49
	Bottom Fiber	-0.11	-7.81	-54.35
	Shear	10.63	10.32	5.18
Type 1-2	Top Fiber	0.02	1.84	15.63
	Bottom Fiber	-0.17	-11.87	-80.97
	Shear	16.17	15.68	7.53
Type 12-2	Top Fiber	0.02	2.31	19.03
	Bottom Fiber	-0.22	-14.92	-98.58
	Shear	20.39	19.70	8.23

NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 262 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Posting Live Load Forces	They are calculated besed on the Load Rating Manual Appendix III. (refer to Table shown in the next pages of this Sheet 6)		
Applied Equation in Output	Posting Live Load	ML	Refer to Load Rating Manual Appendix III
		MLL	= ML x D.F x Impact
		VL	Refer to Load Rating Manual Appendix III
		VLL	= ML x D.F x Impact
	Stresses	Moment	= M / Sx (= Y / Iz x M)
		Shear	= (Shear forces) / (Web Area)

Sheet 7 (POSTLFM) : Posting Rating Calculations

E. POSTING LOAD RATING FACTOR CALCULATIONS

E1. LOAD POSTING RATING FACTOR CALCULATIONS (1)

Posting Vehicle		At Supprot		B (Dummy)		At Midspan	
		Inventory	Operating	Inventory	Operating	Inventory	Operating
Type 1-1	Top Fiber	19138.80	26666.17	203.04	282.89	10.97	20.17
	Bott Fiber	2141.82	2995.94	30.97	43.32	1.96	3.73
	Shear	12.80	18.08	13.32	18.76	31.00	41.84
Type 1-2	Top Fiber	12582.61	17531.41	133.66	21.80	7.36	13.54
	Bott Fiber	1408.12	1969.65	20.39	28.51	1.31	2.50
	Shear	8.41	11.89	8.77	12.35	21.35	28.81
Type 12-2	Top Fiber	9977.65	13901.90	106.37	148.21	6.05	11.12
	Bott Fiber	1116.60	1561.88	16.22	22.69	1.08	2.06
	Shear	6.67	9.43	6.98	9.83	19.53	26.36

E2. LOAD POSTING RATING FACTOR CALCULATIONS (2)

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory				Operating				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) AT SUPPORT										
MS18	33.0	1,282.08	42308.7	7.01	231.2	1,749.61	57737.0	9.90	326.7	**33**
Type 1-1	17.0	2,141.82	36410.9	12.80	217.6	2,995.94	50931.0	18.08	307.4	**17**
Type 1-2	27.0	1,408.12	38019.1	8.41	227.2	1,969.65	53180.5	11.89	321.0	**27**
Type 12-2	38.0	1,116.60	42430.6	6.67	253.6	1,561.88	59351.3	9.43	358.3	**38**
(2) SECTION B (Dummy)										
MS18	33.0	16.98	560.4	7.30	241.0	23.75	783.9	10.29	339.5	**33**
Type 1-1	17.0	30.97	526.4	13.32	226.4	43.32	736.4	18.76	318.9	**17**
Type 1-2	27.0	20.39	550.4	8.77	236.7	21.80	588.6	12.35	333.4	**27**
Type 12-2	38.0	16.22	616.5	6.98	265.1	22.69	862.3	9.83	373.5	**38**
(3) AT MIDSPAN										
MS18	33.0	1.66	54.7	21.94	723.9	3.17	104.4	29.61	977.1	**33**
Type 1-1	17.0	1.96	33.2	31.00	526.9	3.73	63.4	41.84	711.2	**17**
Type 1-2	27.0	1.31	35.4	21.35	576.4	2.50	67.6	28.81	778.0	**27**
Type 12-2	38.0	1.08	41.0	19.53	742.2	2.06	78.2	26.36	1001.8	**38**

Load Posting	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**

After confirmation of this sheet, click"END GO TO RC DECK SLAB" button then proceed directly to the next screen.

END AND GO TO DECK SLAB

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 263 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I)) a = (As' * fy) / (0.85 *f'c * beff)
	Load Rating LR	LR = RF x (Vehicle Weight)

6.5.2 Continuous SIG

Sheet 1 (GENERAL) : Input Data of Bridge Description

INTERIOR SIG CONTINUOUS

A. GENERAL

BACK TO MENU

A1. BRIDGE DESCRIPTION							
Bridge Location	REGION						
Bridge Name							
Bridge Type	Simple or Continuous	C	Steel I-Girder Bridge				
	Number of Span	2					
Bridge Width (curb to curb) (m)		24.00					
Number of Lanes		6					
Bridge Length (m)		27.000	27.000				=54.000m
Year Built		1967					
Structure	Nos. of Girder	13	Multiple Girder composite for live load				
	Girder Spacing (m)	2.020	on centers				
	Substructure	Wall Type RC Pier and RC Cantilever Abutments					
Wearing Course	thickness (mm)	50					
	material	Asphalt					
Material Properties		fc=	8.3	Mpa	fs=	137.9	Mpa
		f'c=	20.7	Mpa	fy=	248.2	Mpa
Assumption		Weight of barrier rail Wbr =			3.600	KN/m	
		Concrete Unit Weight Wu =			24.0	KN/m³	
		Steel Girder Unit Weight Ws =			77.0	KN/m³	
		Asphalt Unit Weight Wa =			22.0	KN/m³	
Others		Rating Live Load is AASHTO MS18 (HS20-44)					

NEXT

Material	Year of Construction	f'c or fy	fc or fs Inventory	fc or fs Operating	fc or fs Posting	
Structural Steel Bending	**Prior to 1905**	179.3	96.5	134.4	96.5	
	1905 to 1936	206.8	110.3	155.1	110.3	
	1936 to 1963	227.5	124.1	168.9	124.1	
	after 1963	248.2	137.9	186.2	137.9	
Structural Steel Web Shear	**Prior to 1905**	179.3	58.6	79.3	58.6	
	1905 to 1936	206.8	65.5	93.1	65.5	
	1936 to 1963	227.5	75.8	103.4	75.8	
	after 1963	248.2	82.7	110.3	82.7	
Rebar	**Prior to 1954**	227.5	124.1	172.4	124.1	
	after 1954	275.8	137.9	193.1	137.9	
	Grade 50	344.7	189.8	224.1	137.9	*pc
	Grade 60	413.7	227.5	248.2	165.5	*pc
Concrete	**Prior to 1959**	17.2	6.9	10.3	6.9	
	after 1959	20.7	8.3	13.1	8.3	
	1977 to 1981	27.6	11.0	16.5	11.0	*pc
	after 1981	31.0	12.4	18.6	12.4	*pc

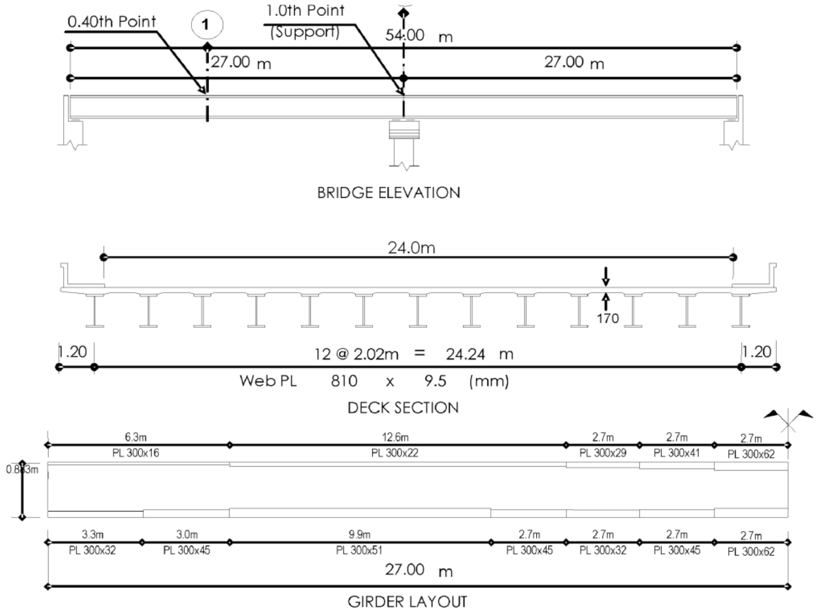
After confirmation of this sheet, click "NEXT" button then proceed directly to the next

*pc: for Prestressed Concrete

Note	
Input Data	Light blue cells should be filled up.
Differences compared with Simple SIG	Simple or Continuous, Number of Span and Bridge Length.
Material Properties	It should be taken from GENERAL NOTE in the as built drawings or in the Standard Bridge Design. In case of non-availability of data, It should be taken based on the Bridge Year Built. (refer to Table shown in the above Table)

Sheet 2 (LAYOUT) : Input a Bridge Layout and Dimension for Load Rating

A2. BRIDGE LAYOUT AND SECTION



GIRDER SECTION						
SECTION	SECTION A (At Pier)		SECTION B (Dummy)		SECTION C (At Midspan)	
Location (m)	0.010		1.000		13.500	
Dimension	b (m)	h (m)	b (m)	h (m)	b (m)	h (m)
Slab	thickness = 0.170 m					
	0.202	0.170	0.202	0.170	0.202	0.170
Uflg	0.300	0.062	0.300	0.029	0.300	0.022
	0.000	0.000	0.000	0.000	0.000	0.000
Web	0.010	0.810	0.010	0.810	0.010	0.810
	0.000	0.000	0.000	0.000	0.000	0.000
Lflg	0.300	0.062	0.300	0.032	0.300	0.051
	0.000	0.000	0.000	0.000	0.000	0.000
Length	2.700		2.700		16.200	

* Only figure should be given (in case of this screen, give the "0.170" only)

*10 (Modular Ratio)

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Input Data	Light blue cells should be filled up, these are; - Location of objective section - Slab Dimension : Slab Thickness (Only figure should be given) - Girder Dimension : Width and Height for Upper/Lower Flange and Web - Length of objective section
Differences compared with Simple SIG	Drawing of Bridge Elevation.
Drawings	Drawings (Elevation, Cross Section and Steel Girder Details) for the objective bridge should be prepared as shown in this screen.

Sheet 3 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B.1 INPUT AND SECTION PROPERTIES

B0. INPUT	
Slab thickness ts (m)	0.170
Slab width ws (m)	2.020
Span Length L(m)	27.000

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) UNDER DEAD LOAD (NON-COMPOSIE GIRDER)							
SECTION	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
A (At Pier)	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
B (Dummy)	0.02600	0.00770	0.00365	0.42192	0.44908	0.00865	0.00813
C (At Midspan)	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701
(2) UNDER SUPERIMPOSED DEAD LOAD AND LIVE LOAD (COMPOSIE GIRDER)							
A (At Pier)	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934
B (Dummy)	0.06034	0.00770	0.00795	0.72590	0.14510	0.01095	0.05480
C (At Midspan)	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967

Standard Section Area of "SECTION A"	
Original Section Area (m^2)	0.0449

B.2 LOAD DEMAND CALCULATIONS

B2.1 DEAD LOAD CALCULATIONS			
Uniform Load per meter of Girder (KN/m)	Self-weight of Girder	Section A (At Pier)	0.691
		Section B (Dummy)	0.400
		Section C (At Midspar	1.367
		Stiffener and Bracing	0.307
	Slab Weight	Continuous	8.242
	Barrier Rail		0.554
	Asphalt Overlay		2.222
	Total Load		13.784
	Total DeadLoad		11.008
	Total Superimposed Dead Load		2.776

B2.2 LOAD DEMAND MIDSPAN AND SUPPORT OF STEEL GIRDER		
Conducting a Structural Analysis, the load demands for the SPG should be obtained separately and input the necessary load demands in the Table below.		
Description	At Midspan	At Pier Support
	10.8 m	27.0 m
Dead load moments, KN-m	546.52	-1016.85
Dead load shears, KN	-4.24	-184.41
Additional Dead load moments, KN-m	27.65	-51.45
Additional Dead load shears, KN	-0.21	-9.93
MS18 max. positive moment, KN-m	1060.52	0.00
MS18 max. negative moment, KN-m	-273.15	-957.00
MS18 max. positive shear force, KN	83.28	0.00
MS18 max. negative shear force, KN	-84.40	-198.35

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 272, 273 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Original section area of section "A" should be given. This data is prepared in case section losses are observed in steel girder. Load Demands on continuous bridge should be given.
Differences compared with Simple SIG	Load demands should be separately analyzed with appropriate structural Model.

Sheet 4 (DSDLLL) : Demand Forces and Stresses Calculations

B3. LOAD STRESS CALCULATIONS

B1. PROPERTIES OF STEEL GIRDER SECTIONS							
(1) At Midspan							
	Total Area	Web Area	Iz (m^4)	Y_b (m)	Y_t (m)	S_{xb} (m^3)	S_{xt} (m^3)
For Dead Load	0.02960	0.00770	0.00390	0.32621	0.55679	0.01197	0.00701
For Add.DL and Live Load	0.06394	0.00770	0.01053	0.67092	0.21208	0.01570	0.04967
(2) At Pier Support							
For Dead Load	0.04490	0.00770	0.00750	0.46700	0.46700	0.01607	0.01607
For Add.DL and Live Load	0.07924	0.00770	0.01352	0.70623	0.22777	0.01914	0.05934

ESTIMATED STRESS DEMANDS AT GIRDER SECTIONS			
Loading	Location	At Midspan	At Pier Support
DL moment	Top	**77.95**	**-63.28**
	Bottom	**-45.67**	**63.28**
SDL moment	Top	**0.56**	**-0.87**
	Bottom	**-1.76**	**2.69**
LL+I moment, σ_{LL+I}	Top	**21.35**	**-16.13**
	Bottom	**-67.55**	**50.01**
DL shear, v_{DL}		**0.55**	**23.96**
SDL shear, v_{SDL}		**0.03**	**1.29**
LL+I shear, v_{LL+I}		**10.82**	**25.78**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 273, 274in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Differences compared with Simple SIG	Load Rating calculations should be done not only at Midspan but also at Pier.		
Applied Equation in Output	Stresses	Moment	= M / Sx (= Y / Iz x M)
		Shear	= (Shear forces) / (Web Area)

Sheet 5 (LRASM) : Load Rating Calculations by ASM

C. LOAD RATING BY ALLOWABLE STRESS METHOD

C1. ALLOWABLE STRESS CALCULATIONS

C.1.1 ALLOWABLE STRESSES FOR CONCRETE AND STEEL				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.3
		Strength	f'c = fc/0.4	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy = fs/0.55	248.2
C.1.2 COMPRESSION AND TENSILE STRESSES				
Allowable compressive stress		Inventory		137.9
		Operating		186.2
Allowable tensile stress		Inventory		137.9
C.1.3 ALLOWABLE SHEAR STRESS				
Allowable Shear Stress		Inventory fy/3		82.7
		Operating 0.45fy		110.3

C2. LOAD RATING CALCULATIONS

C2.1 RATING FACTOR CALCULATIONS USING ASM			
Section	Description	Inventory	Operating
At Midspan	Stress at Top Fiber	2.78	5.04
	Stress at Bottom Fiber	1.34	2.05
	Shear	7.59	10.14
At Pier Support	Stress at Top Fiber	4.57	7.57
	Stress at Bottom Fiber	1.44	2.40
	Shear	2.23	3.30

C2.2 LOAD RATING CALCULATIONS					
Section	Description	Rating Live Load (Metric Tons)			33.0
		Inventory		Operating	
At Midspan	Moment	1.34	44.2	2.05	67.8
	Shear	7.59	250.4	10.14	334.6
At Pier Support	Moment	1.44	47.5	2.40	79.3
	Shear	2.23	73.5	3.30	108.9

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Return to GENERAL

Click following the above instruction

Return to GENERAL

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 274, 275 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Allowable compression stress, tensile stress and shear stress under inventory and operating should be given.	
Differences compared with Simple SIG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I))
	Load Rating LR	LR = RF x 33.0 (Vehicle Weight)

Sheet 6 (POSTLL) : Demand Forces and Stresses Calculations

D. LOAD POSTING BY LOAD FACTOR METHOD (LFM)

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES

D1.2 POSTING VEHICLE DEMAND FORCES			
Conducting a Structural Analysis, the load demands for the SPG should be obtained separately and input the necessary load demands in the Table below.			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Moment	657.5	-593.3
	Shear	45.8	-109.1
Type 1-2	Moment	869.3	-784.7
	Shear	65.0	-154.7
Type 12-2	Moment	859.0	-775.2
	Shear	64.1	-152.7

D1.3 POSTING VEHICLE DEMAND STRESSES			
Posting Vehicle	Demand Forces	At Midspan	At Pier Support
Type 1-1	Top Fiber	13.24	-10.00
	Bottom Fiber	-41.88	31.00
	Shear	5.95	14.18
Type 1-2	Top Fiber	17.50	-13.22
	Bottom Fiber	-55.37	41.00
	Shear	8.45	20.10
Type 12-2	Top Fiber	17.29	-13.06
	Bottom Fiber	-54.71	40.51
	Shear	8.33	19.84

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 276 in the Manual for Load Rating of Bridges.		
Verification	Results of calculations should be verified.		
Input Data	Unnecessary.		
Differences compared with Simple SIG	Load Rating calculations should be done not only at Midspan but also at Pier Load demands should be separately analized with appropriate structural Model.		
Applied Equation in Output	Stresses	Moment	= M / Sx (= Y / Iz x M)
		Shear	= (Shear forces) / (Web Area)

Sheet 7 (POSTLFM) : Posting Rating Calculations

E. LOAD POSTING RATING FACTOR CALCULATIONS

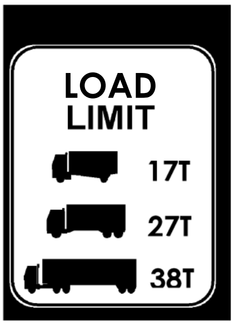
E1. LOAD POSTING RATING FACTOR CALCULATIONS (1)

Posting Vehicle		At Midspan		At Pier Support	
		Inventory	Operating	Inventory	Operating
Type 1-1	Top Fiber	4.49	8.13	7.38	12.21
	Bottom Fiber	2.16	3.31	2.32	3.88
	Shear	13.80	18.43	4.05	6.00
Type 1-2	Top Fiber	3.39	6.15	5.58	9.23
	Bottom Fiber	1.63	2.51	1.75	2.93
	Shear	9.72	12.99	2.86	4.23
Type 12-2	Top Fiber	3.43	6.23	5.65	9.34
	Bottom Fiber	1.65	2.54	1.78	2.97
	Shear	9.86	13.17	2.89	4.29

E2. LOAD POSTING RATING FACTOR CALCULATIONS (2)

Vehicle Type	Vehicle Weight (Metric Tons)	Inventory				Operating				Posting (Metric Tons)
		Moment		Shear		Moment		Shear		
		RF	LR	RF	LR	RF	LR	RF	LR	
(1) SECTION A										
MS18	33.0	1.34	44.2	7.59	250.4	2.05	67.8	10.14	334.6	**33**
Type 1-1	17.0	2.16	36.7	13.80	234.6	3.31	56.3	18.43	313.4	**17**
Type 1-2	27.0	1.63	44.1	9.72	262.5	2.51	67.7	12.99	350.7	**27**
Type 12-2	38.0	1.65	62.8	9.86	374.6	2.54	96.4	13.17	500.5	**38**
(2) SECTION B										
MS18	33.0	1.44	47.5	2.23	73.5	2.40	79.3	3.30	108.9	**33**
Type 1-1	17.0	2.32	39.4	4.05	68.9	3.88	65.9	6.00	102.0	**17**
Type 1-2	27.0	1.75	47.4	2.86	77.1	2.93	79.2	4.23	114.2	**27**
Type 12-2	38.0	1.78	67.5	2.89	110.0	2.97	112.8	4.29	162.9	**38**

Load Posting	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**



After confirmation of this sheet, click "END GO TO RC DECK SLAB" button then proceed directly to the next screen.

END AND GO TO DECK SLAB

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 276, 277 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Differences compared with Simple SIG	Load Rating calculations should be done not only at Midspan but also at Pier.	
Applied Equation in Output	Rating Factor RF	RF = (Φ x Rn - γ_D x DL) / (γ_{LL} x (LL + I)) a = (As' * fy) / (0.85 *f'c * beff)
	Load Rating LR	LR = RF x (Vehicle Weight)

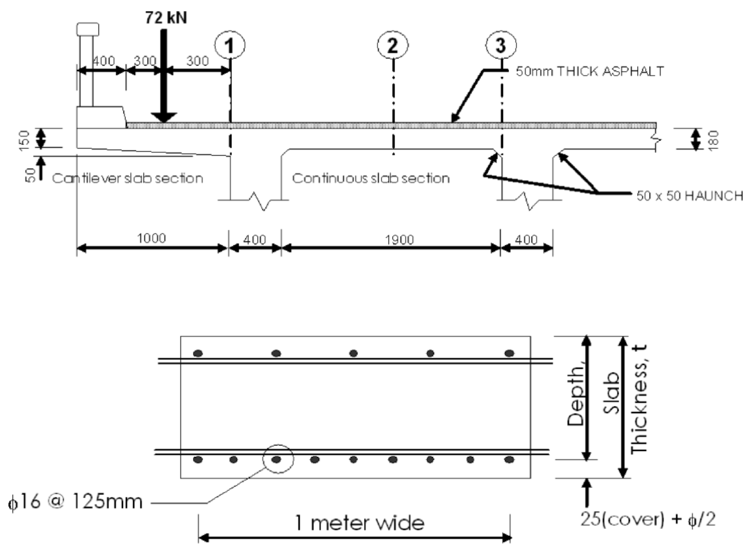
6.6 RCDECK (Reinforced Concrete Deck Slab)

Sheet 1 (LAYOUT) : Slab Layout and Rebar Schedule

RC DECK SLAB

A. SLAB LAYOUT **BACK TO MENU**

A. SLAB LAYOUT AND REBAR SCHEDULE



NEXT

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

Note	
Drawings	Drawings (Elevation and Cross Section) for the objective bridge should be prepared as shown in this screen.

Sheet 2 (DFDLLL) : Demand Forces Calculations

B. DEMAND FORCES

B0. INPUT		
Assumption	Weight of barrier rail Wbr =	4.2
	Concrete Unit Weight Wu =	24.0
	Asphalt Unit Weight Wa =	22.0
FOR DEAD LOAD	**CONTINUOUS SALB**	
	Slab thickness ts (m)	0.18
	Asphalt overlay thickness tas (m	0.05
	Slab span (Ls) (m)	1.90
	CANTILEVER SALB	
	Slab thickness ts (m)	0.15
	Slab thickness of hunch ts' (m)	0.05
	Asphalt overlay thickness tas (m	0.05
	Slab span (Ls) (m)	1.0
	Width of Asphalt (Las) (m)	0.6
	Width of Curb (Lcu) (m)	0.4
FOR LIVE LOAD	**LIVE LOAD**	
	Live Load (LL) (KN)	72.0
	Impact (I)	0.3
	Wheel load position from Curb(Lcu)(m)	0.3
	Distributed over a length (E) (m)	1.383

B1. DEAD LOAD CALCULATIONS		
Moment due to dead load (KN-m/m)	Continuous Slab	**1.96**
	Cantilever Slab	**5.56**

B2. LIVE LOAD CALCULATIONS		
Moment due to Live load (KN-m/m)	Continuous Slab	**19.30**
	Cantilever Slab	**20.30**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note			
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 287, 288 in the Manual for Load Rating of Bridges.		
Input Data	Light blue cells should be filled up and these Input data should be given the same as the objective Girder's Load rating.		
Applied Equation in Output	Dead Load	Continuous Slab	$= 1 / 10 \times W \times L_S{}^{\wedge 2}$
		Cantilever Slab	$= \Sigma \ (W \times l)$
	Live Load	Continuous Slab	$= (L_S + 0.61) / 9.74 \times LL$ x (Uniform Continuity = 0.8) x (1 + I)
		Cantilever Slab	= LL x l x (1 + I) / (E : Distribution Factor) where, E = 0.8 x (X) + 1.143 X : Wheel load distance from the curb

Sheet 3 (CCLFM): Capacity Calculations for Moment

C. LOAD RATING BY LOAD FACTOR METHOD (LFM)

C1. CAPACITY CALCULATIONS

C1.1. INPUT				
Material Properties (Mpa)	Concrete	Allowable Stress	fc	8.30
		Strength	f'c	20.7
	Rebar	Allowable Stress	fs	137.9
		Strength	fy	275.8
Rebar area per meter strip As (mm^2)		Diameter (mm)		16
		Spacing (mm)		125
		Rebar area As (mm2)		1608.50
Ultimate capacity factor (Uf)	Nominal Factor			0.9
	Reduction factor	due to Concrete Section Loss		1.0
		due to Rebar Section Loss		1.0
	Applicable reduction factor			0.9
Slab thickness (mm)		Continuous slab (tscon)		180
		Cantilever slab (tscan)		200
Cover (mm) (c)				25
Rebar diameter (mm) (Φ)				16
Concrete rectangular stress block (a) (mm)				25.21
Depth d (mm)		Continuous slab (dcon) (mm)		147.0
		Cantilever slab (dcan) (mm)		167.0

C1.2. CAPACITY CALCULATIONS		
The Moment Ultimate Capacity	Continuous slab (Mucon) (KN-m/	**53.70**
	Cantilever slab (Mucan) (KN-m/	**61.69**

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 288, 289 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Light blue cells should be filled up, these are;	
	Rebar	Rebar Schedule (Diameter, Spacing and Cover)
	Damage Evaluation	Secton Losses of Concrete Section
		Secton Losses due to Rebar exposure caused by Moment
	Material Properties	Should be given as same as the objective Girder's Load rating.
Applied Equation in Output	Moment Capacity M_U	M_U = Uf x As' x fy x (d - a) where, a = (As' x fy) / (0.85 x f'c x beff)

Sheet 4 (LRLFM) : Load Rating Calculations

C2. LOAD RATING CALCULATIONS

C2.1. INPUT	
Load factor for dead load	1.3
Load factor for live load in Inventory Rating	2.17
Load factor for live load in Operating Rating	1.3
Moment Ultimate Capacity at Continuous Slab	53.70
Dead Load Moment at Continuous Slab	1.96
Live Load Moment at Continuous Slab	19.30
Moment Ultimate Capacity at Cantilever Slab (KN-m/m)	61.69
Dead Load Moment at Cantilever Slab	5.56
Live Load Moment at Cantilever Slab	20.30
Rating Live Load	33.0

C2.2. CALCULATIONS OF RATING FACTOR AND LOAD RATING			Rating Factor	Load Rating (tons)
Rating Factor and Load Rating	Continuous Slab	Inventory Rating	1.22	40.32
		Operating Rating	2.04	67.30
	Cantilever Slab	Inventory Rating	1.24	40.79
		Operating Rating	2.06	68.09

Depend on the minimum value of Rating Factor > 1 or <1 , instruction in the below cell is automatically shown
Return to LAYOUT

Click following the above instruction

Return to LAYOUT

Load Posting

According to the Instruction shown in this screen, User have to click a gray coloured cell "Return to GENERAL" or "LOAD POSTING", then proceed directly to the next screen.

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 289, 290 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.

Sheet 5 (LRLFM) : Load Posting Calculations by LFM

D. LOAD POSTING BY LOAD FACTOR METHOD

D1. DEMAND FORCES FOR LOAD POSTING VEHICLES				
Description		Posting Vehicles Type	Posting Vehicles Wheel Load	Demand Forces
Moment due to Live load (KN-m/m)	Continuous Slab	Type 1-1	66.8	17.90
		Type 1-2	73.9	19.81
		Type 12-2	65.9	17.66
	Cantilever Slab	Type 1-1	66.8	18.84
		Type 1-2	73.9	20.84
		Type 12-2	65.9	18.58

D2. POSTING RATING FACTOR CALCULATIONS

D2.1. POSTING RATING FACTOR CALCULATIONS			
Load factor for dead load			1.3
Load factor for live load in Inventory Rating			2.17
Load factor for live load in Operating Rating			1.3
At Continuous Slab	Moment Ultimate Capacity at Continuous Slab		53.70
	Dead Load Moment at Continuous Slab		1.96
	Live Load Moment at Continuous Slab	Type 1-1	17.90
		Type 1-2	19.81
		Type 12-2	17.66
At Cantilever Slab	Moment Ultimate Capacity at Cantilever Slab (KN-m/m)		61.69
	Dead Load Moment at Cantilever Slab		5.56
	Live Load Moment at Cantilever Slab	Type 1-1	18.84
		Type 1-2	20.84
		Type 12-2	18.58
Rating Live Load			33.0

D2.2. RATING FACTOR AND LOAD RATING CALCULATIONS				Rating Factor	Load Rating (tons)
Rating Factor and Load Rating	Continuous Slab	Type 1-1	Inventory Rating	1.32	43.45
			Operating Rating	2.20	72.54
		Type 1-2	Inventory Rating	1.19	39.28
			Operating Rating	1.99	65.57
		Type 12-2	Inventory Rating	1.33	44.05
			Operating Rating	2.23	73.53
	Cantilever Slab	Type 1-1	Inventory Rating	1.25	41.30
			Operating Rating	2.09	68.94
		Type 1-2	Inventory Rating	1.13	37.33
			Operating Rating	1.89	62.31
		Type 12-2	Inventory Rating	1.27	41.86
			Operating Rating	2.12	69.88

After confirmation of this sheet, click "NEXT" button then proceed directly to the next

NEXT

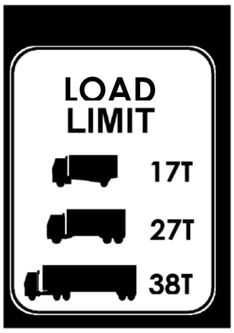
Note		
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 290, 291 in the Manual for Load Rating of Bridges.	
Verification	Results of calculations should be verified.	
Input Data	Unnecessary.	
Applied Equation in Output	Rating Factor	RF = (R - A1 x D) / (A2 x L (1 + I))
	Load Rating	LR = RF x (Each Posting Vehicle Wejght)

Sheet 6 (POSTSUM) : Summary of Load Posting

E. SUMMARY OF LOAD POSTING

		Inventory		Operating		Posting
		RF	LR	RF	LR	(Metric Tons)
(1) CONTINUOUS SLAB						
MS18	33.0	1.22	40.3	2.04	67.3	**33**
Type 1-1	17.0	1.32	22.4	2.20	37.4	**17**
Type 1-2	27.0	1.19	32.1	**1.99**	53.6	**27**
Type 12-2	38.0	1.33	50.7	2.23	84.7	**38**
(2) CANTILEVER SLAB						
MS18	33.0	1.24	40.8	2.06	68.1	**33**
Type 1-1	17.0	1.25	21.3	2.09	35.5	**17**
Type 1-2	27.0	1.13	30.5	1.89	51.0	**27**
Type 12-2	38.0	1.27	48.2	2.12	80.5	**38**

LOAD POSTING	
MS18	**33T**
Type 1-1	**17T**
Type 1-2	**27T**
Type 12-2	**38T**



After confirmation of this sheet, click "BACK TO LAYOUT" button then proceed directly to the next screen.

BACK TO LAYOUT

Note	
Reference	Refer to the manual calculation sheets as shown in the Appendix II "Load Rating Examples" page 291 in the Manual for Load Rating of Bridges.
Verification	Results of calculations should be verified.
Input Data	Unnecessary.