097.13 DPWH
03-21-2018

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

09 MAR 2018

DEPARTMENT ORDER NO. 49 Series of 2018 03.21.18

SUBJECT: INCLUSION OF BRIDGE AESTHETICS IN ALL BRIDGE PLANS

It has been observed that bridges are designed without valuing the appearance and the integration of the structure into its context. In many cases design parameters for bridges have been on the "standard bridge"- typical bridge types that are followed in the design in different types of setting. In order to create a bridge that not only functions as a mere utility but also as a significant element in the environment, the following guidelines shall be observed:

- The ***DPWH Bridge Aesthetic Guidelines*** shall be incorporated in all DPWH bridge projects.
- An additional item – Aesthetics/Architectural details and perspective shall be included in all bridge plans. It should be composed of the following:
    - Conceptual Phase: (during Feasibility Study)
        - Site/Context Details including pictures
        - Conceptual/Schematic designs in 3D images
    - Design Phase: (during Detailed Engineering Design)
        - Perspective
        - Aesthetic/architectural design details
        - Materials specification for the finishes
- All proposed developments (replacement, widening, retrofitting, new construction) related to historical bridges and settings shall seek approval from the National Historical Commission of the Philippines (NHCP).

This Order shall take effect immediately.

MARK A. VILLAR
Secretary

5.1.4 AAC/BSR/ECM/LND

Department of Public Works and Highways
Office of the Secretary
WIN8R01455

BRIDGE AESTHETICS GUIDELINES

1st EDITION 2018

Republic of the Philippines
Department of Public Works and Highways
BUREAU OF DESIGN
Bridges Division

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FOREWORD

Bridges have been part of the human settlement since the beginning of time. It does more than just transportation as it functions socially, visually, and symbolically as significant structures in the community. Today, bridge designers all over the globe are creating refined bridges that are better, longer, larger, and spectacular than ever before. It is with deep pity that our country is far behind these innovations. Most of the Philippine bridges have been designed and constructed with the absence of Aesthetics for so many years which results in monotonous, massive, discordant, and visually unpleasant structures in the environment.

With the technology advancement, the public has become more mindful and concerned with the appearance of the bridge and the effects it contributes to the communities. The DPWH has prepared an instrument to address the demand for visually appealing bridges which is the ***Bridge Aesthetic Guidelines*** that will provide practical and easy to apply ideas aiming to improve the appearance of our bridges considering its integration to the natural and built environment.

The guideline indicates that aesthetically pleasing structures need not be costly nor a maintenance liability. All bridge designers and contractors both public and private will be guided through this guidebook in incorporating the values of aesthetics to produce attractive bridges which enhances the beauty and character of its context.

Our transportation environment deserves our best effort. Designers and builders should rediscover the lost practice of bridge aesthetics. Thus, this publication is intended to guide us towards making our bridges globally competitive.

MARK A. VILLAR
Secretary

Department of Public Works and Highways
Office of the Secretary

CHAPTER 1. INTRODUCTION

Bridge aesthetics is the use of applying accepted principles in the design and details of bridge construction so that its resulting appearance compliments the surrounding environment.

Aesthetic is a matter of taste and therefore, it is not possible to codify the rules which are to be followed in the design of bridges. However, a few basic criteria for general guidance are mentioned to this manual.

1.1 THE PURPOSE AND INTENT OF GUIDELINES

The purpose of this guideline is to assist bridge designers in the Philippines to produce bridges of aesthetic value. The term "**guideline**" in this document refers to the requirements, objectives, design principles, and processes in the design of bridges. In addition, this guideline will help Department of Public works and Highways (**DPWH**) along with other transport infrastructure consultants and construction companies

A good bridge design is a process requiring the use of three aspects, and it is the union of aesthetics, science and technology. Each of these features represents a part of making a bridge: science represents the design and function of the bridge, technology represents construction methodology of the bridge, and aesthetics represents the pleasing appearance of the bridge. Design excellence is achieved when these three elements are integrated in the design.

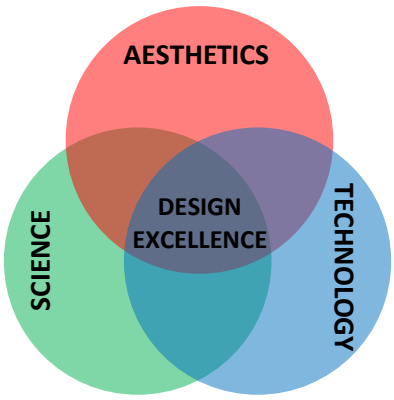


Figure 1. – Three Components of Design

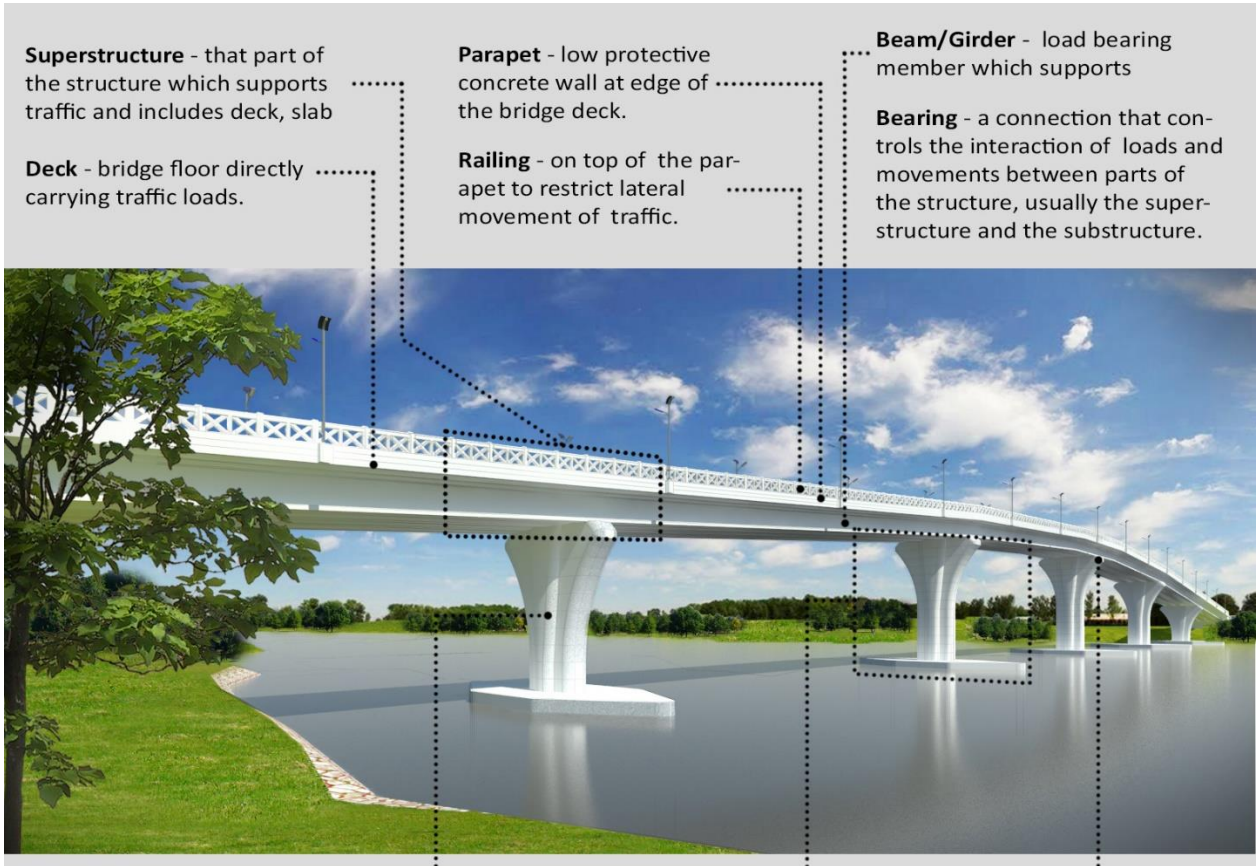
The intent of these guidelines is to:

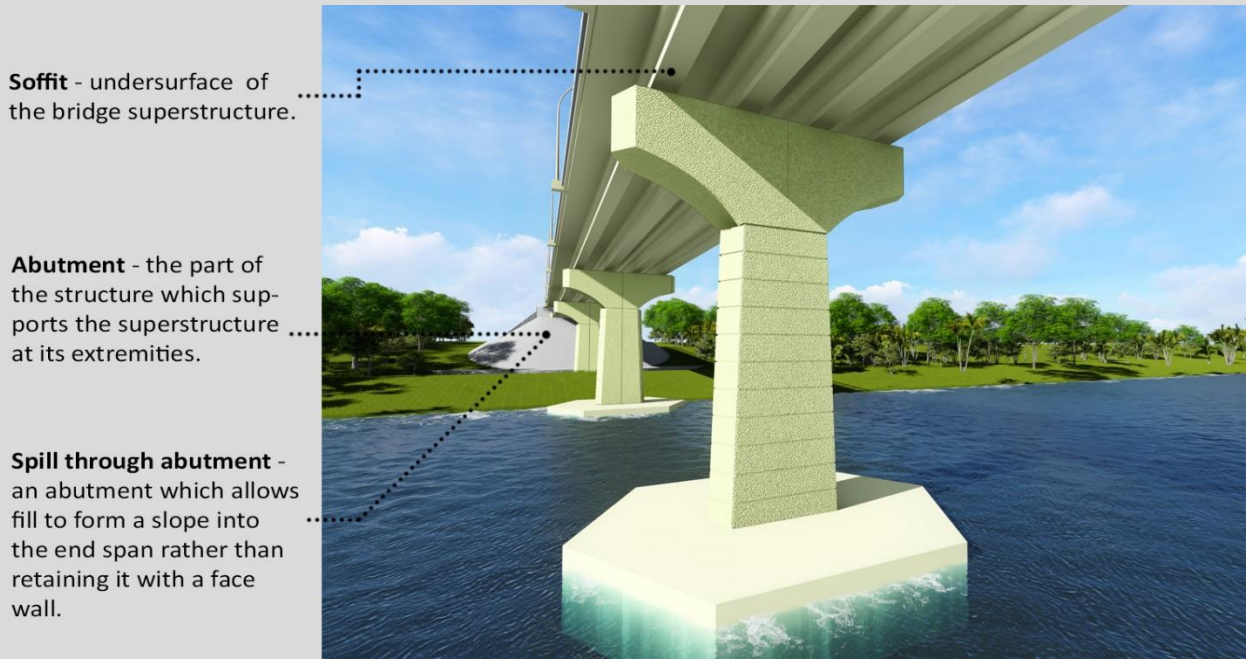
- Raise the level of awareness regarding visual, architectural, and aesthetic values that influence the appearance of bridges.
- Provide a ready reference for use during the design process.
- Provide both general observations and specific suggestions for designing bridges.
- Encourage bridge designers to include aesthetics along with science and technology in the design of bridges.

Within this manual, comparative examples are classified as "**ordinary**", representing designs that can be improved aesthetically, and "**better**", illustrating designs that are markedly improved by the application of aesthetic principles. Each section is accompanied by design recommendations and general considerations regarding the underlying principles that may improve the visual qualities of bridges. These better examples were selected because they are good illustrations of an underlying principle.

1.2 BRIDGE TERMINOLOGY

The following annotated photographs set down the terminology used in this guideline.





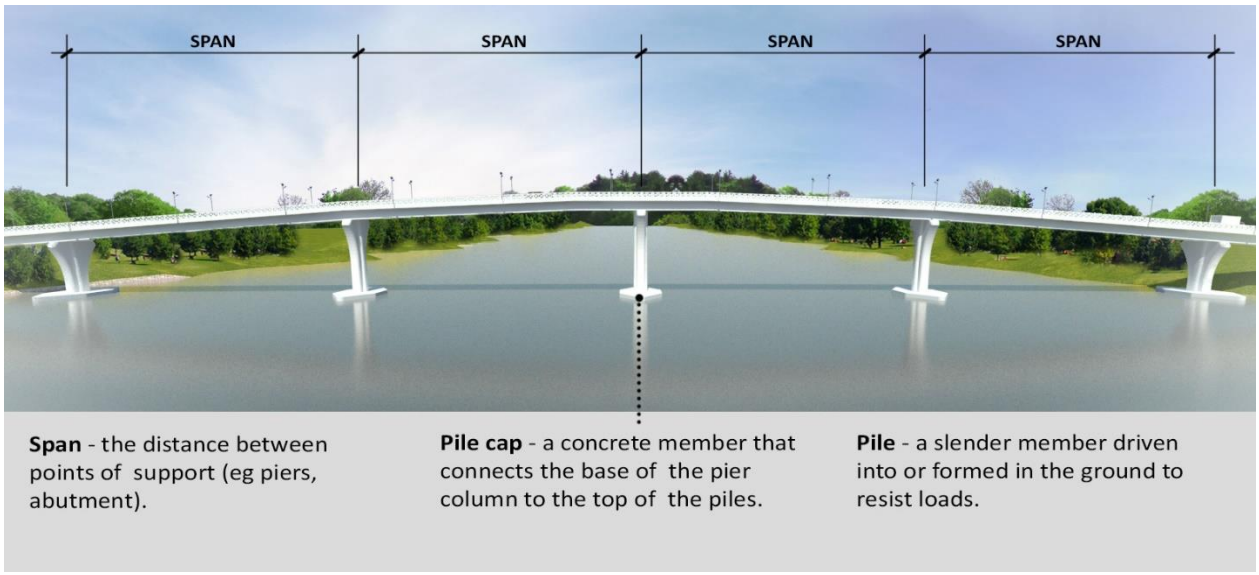
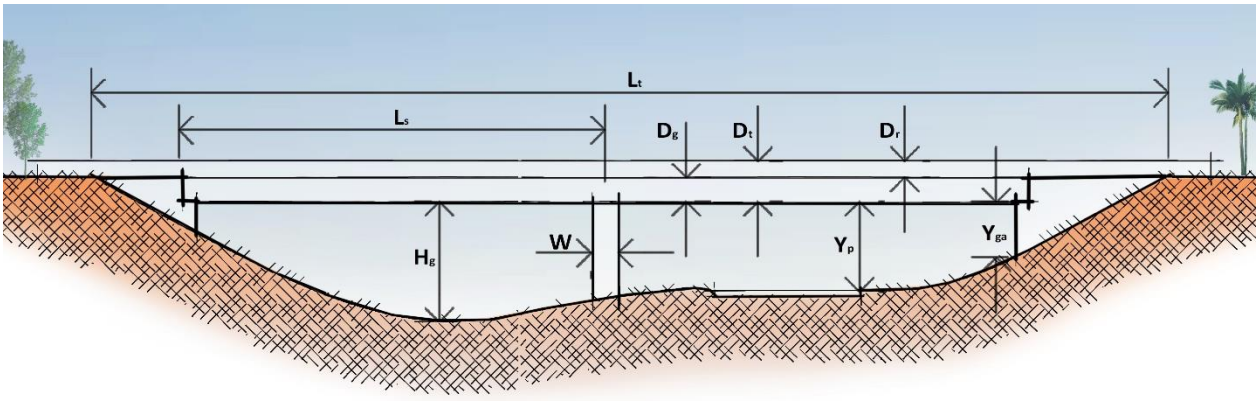


Figure 2. – Visual Glossary

1.3 NOMENCLATURE

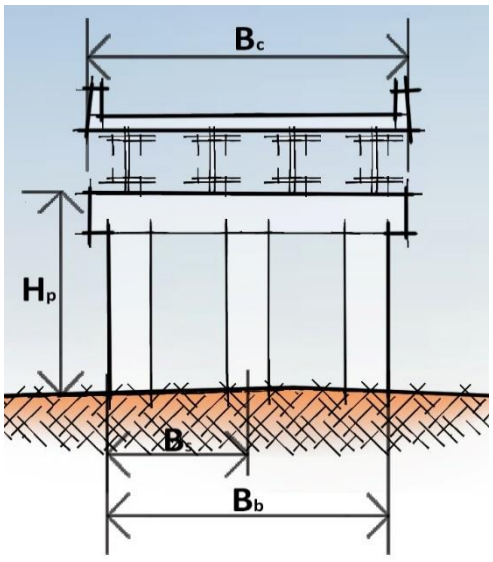
Throughout these guidelines, specific letters will be used to denote physical aspect of bridge elements are shown below.

Figure 3. – Guideline nomenclature



Nomenclature abbreviations:

L_t – Total bridge length
L_s – Span length
H_g – Vertical clearance to the ground
Y_p – Vertical clearance at pavement edge
Y_{ga} – Dist. bottom of girder to bot
W – Pier width
D_t – Total superstructure depth
D_g – Girder depth
D_r – Rail/Barrier height, top rail to bot. of deck
D_p – Depth of parapet
H_p – Pier height
B_s – Spacing of columns
B_b – Pier length at base
B_c – Pier length at cap or top
P_s – Pier spacing



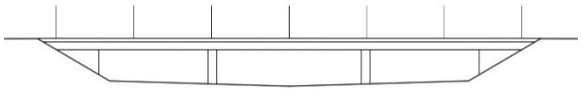
CHAPTER 2. THE BRIDGE AND ITS SETTING

The bridge and its setting are considered as a whole of the framework. Indeed, we have to understand that all design requirements and considerations should be established by understanding its context. In the pursuit of design excellence, the designers are presented with the following principles:

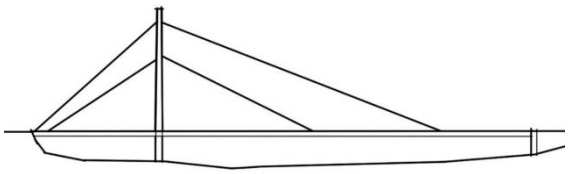
2.1 FUNDAMENTALS OF AESTHETIC DESIGN

Fundamental of aesthetics design refers to the external shape or appearance of a bridge and this broadly relates to the bridge type, how the parts are arranged relative to one another and the order or rhythm of elements to create an overall visual result.

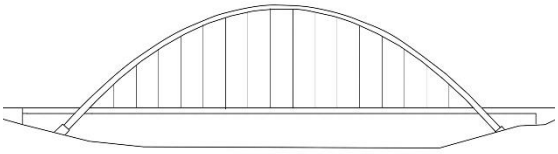
The two visual concepts used to develop, describe, and express visual form ideas are: **visual design elements** and **principles of design**. The bridge designer, through a creative design process, can integrate the fundamentals of aesthetics with sound structural design and function to create a bridge form that is both visually attractive and compatible with its environment.



Vertical and horizontal lines are considered formal & stable elements.



Oblique lines are considered dynamic elements.



Curve lines can be considered dynamic or tranquil elements.

Figure 4. – Dominant line themes

2.1.1 Visual Design Elements

There are noticeable elements that the eye and mind seek to identify which apply to any type of structures. The perception of form and space consist of five major elements; line, shape, form, color, and texture. The following terms are borrowed from other visual design fields applied to bridge design.

Line

A line is a continuous extent of length, straight or curved. For bridges, lines are seen in the profiles of spans, piers, abutments, wingwalls, noisewalls and railings. Line has different meaning and psychological influence on the viewer.

Shape

A shape is a two-dimensional surface, the outline of an area or figure. Shape will distinguish when an object is clearly separated from the background.

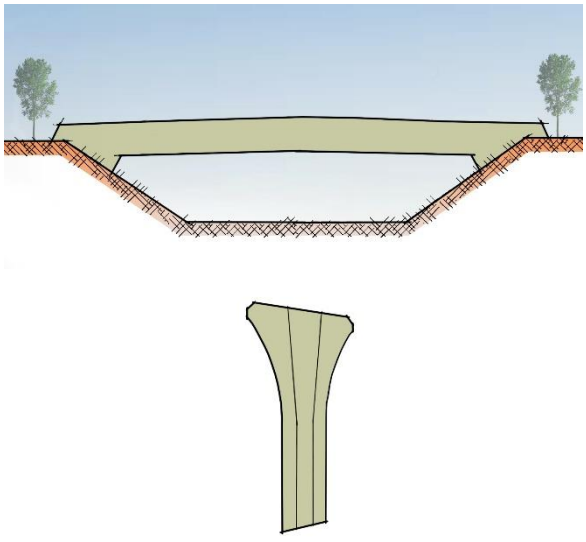


Figure 5. – Shape concept

Form

A form is a three-dimensional arrangement of an object, adding depth to the shape. The visual experience of moving under or over a bridge is primarily influenced by the form of the bridge, its geometry, span arrangement, horizontal alignment, vertical profile, and relation to adjacent structures and its relationship to the space or sets of spaces that create its environment.

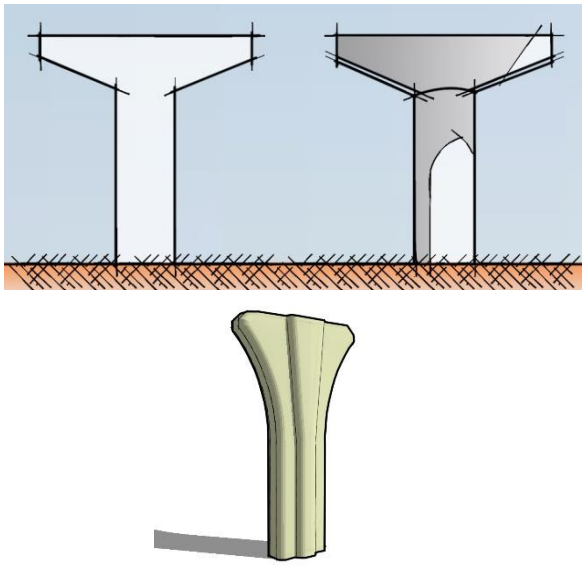
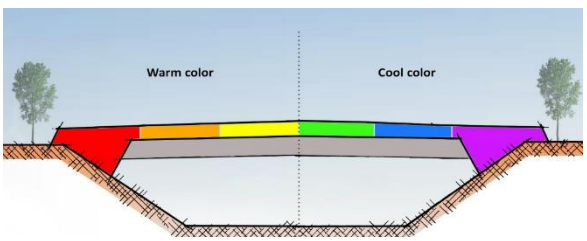


Figure 6. – Form concept

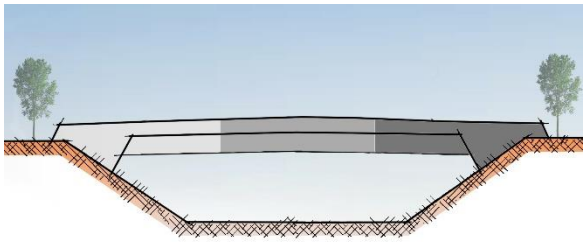
Color

Colors do not always mean for cosmetic purposes; when used with understanding it can define, clarify, modify, accentuate, or subdue the visual effects of structural elements. Colors are also influenced by its setting or it depends to designer's intention. Each color has a different characteristics and it gives psychological impacts to the viewer.



***Warm colors such as reds, yellows, browns** tend to emphasize the presence and size of forms, whereas Cool colors (blues, greens, purples) diminish the visual importance of elements to which they are applied*

Figure 7. – Color spectrum characteristics



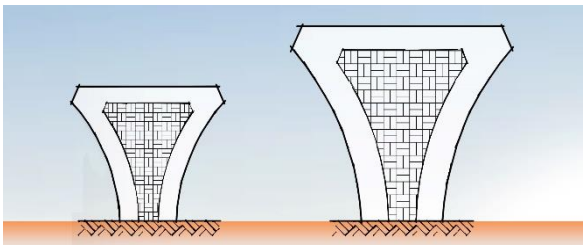
Value refers to the lightness or darkness of a color. In daytime, light color gives less visual importance in the object while dark color has a tendency to accentuate the object.

Figure 8. – Values of color

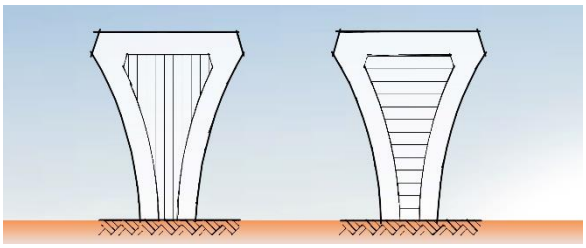
Texture

Texture is found on the surface of all objects and is closely related to form. Texture helps define form through subtle surface variations and shadings. It can be used to soften or reduce imposing scale, add visual interest, and introduce human scale to large objects such as piers, abutments, and tall retaining walls.

Distance alters our perception of texture. When viewed from a distance, fine textures blend into a single tone and appear flat. As a rule, the greater the distance or the larger the object, the coarser or larger the texture should be.



Texture directly proportional to the object



Texture illusions, vertical texture makes the object slimmer while horizontal makes wider

Figure 9. – Texture Concept

2.1.2 Aesthetic qualities

Aesthetic qualities of design are intangible, perceived qualities arising from the relationships of design elements. The properties of aesthetic qualities are **proportion, rhythm, order, harmony, balance, contrast, scale**, and **unity**. These properties are basic elements of creative design compositions common to all fine arts as well as bridge architecture.

Proportion

Proportion is a method of creating a sense of order by assigning appropriate relative sizes to the various elements. The goal is appropriate proportions between the various parts of a structure – comparing its height, width and depth; comparing solids and voids; and comparing areas of sunlight and shadow.

The concept of proportion may be thought of as a mathematical relationship. A graphical example of such a relationship is the Golden Rectangle. The Golden Rectangle is a logarithmic spiral constructed from the convergence of a mathematical series of proportions referred to as the Fibonacci series. This series is based on the proportion of a: b, b :(a+b), etc.

In design, the most obvious proportional relationships are based on relative size and shape of the elements. There can also be proportional degrees of surface texture and color. Proportion may become a system of planned order that contributes to the unity of a design. Appropriate proportion must exist between the various parts of a structure: between its height, width, and depth; between solids and voids; between surfaces and openings; and between areas of sunlight and shadow.

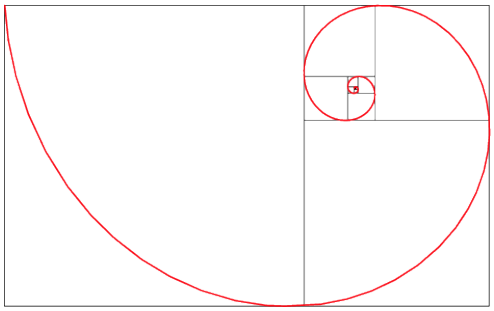


Figure 10. – Golden Rectangle

The designer needs to think about proportion.

A random, thoughtless approach to the proportion between different elements of a bridge is unlikely to lead to an aesthetically valued structure.

The two most important governing principles are:

- Using excessively imbalanced proportions between significant elements should be considered carefully.
- Repeating similar proportions or ratios throughout a structure can lead to a harmonious structure.

Once a bridge type has been selected the most important factors in creating a well-proportioned bridge are:

- The slenderness ratio.
- The relationship between the bridge height and span.
- The relationship between pier thickness and superstructure.
- The relationship between deck overhang and parapet depth.

The Slenderness Ratio

The proportion between depths of superstructure and bridge span is an important ratio. It is referred to as the slenderness of the bridge and defined as the span length divided by the superstructure depth.

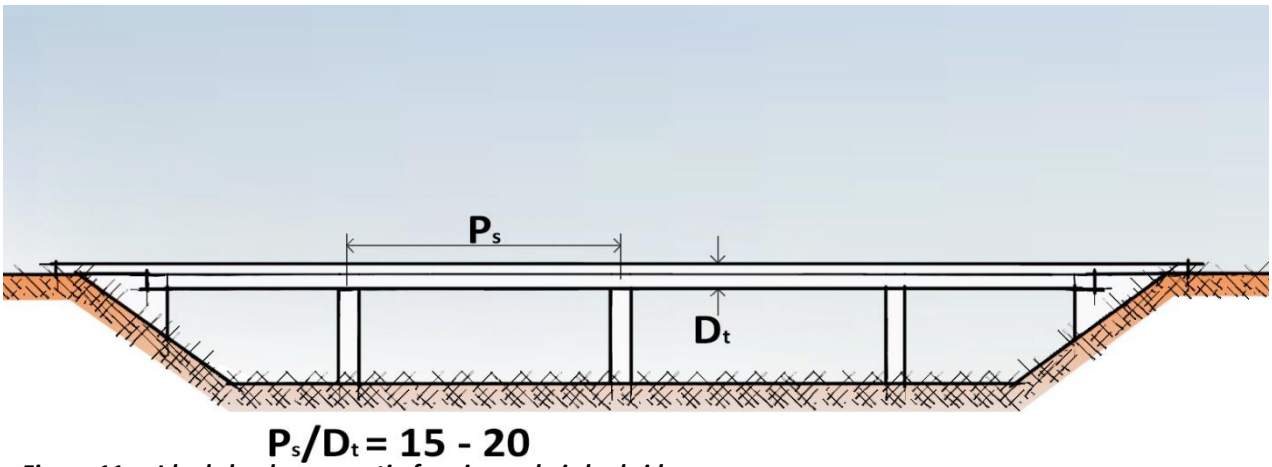


Figure 11. – Ideal slenderness ratio for pier and girder bridges

Common ratios can vary from 5 to 35. A slenderness ratio of 5 refers to a situation where additional elements are superimposed on the bridge, such as noise walls creating a very chunky bridge. A ratio of 30 can result in a very slender bridge. For common pier and girder bridges, ratios should generally vary between 15 and 20.

It is important to differentiate between the slenderness ratio and the visual slenderness of a bridge. A high slenderness ratio does not necessarily indicate a good appearance, since the visual slenderness of a bridge can be affected by solid parapets and opaque noise walls on top of the superstructure, making the bridge appear chunkier than is necessary. The setting and scale of the bridge can also influence whether a bridge appears slender or chunky and, indeed, whether slenderness or chunkiness is appropriate. It is for these reasons that the slenderness ratio should be understood as a guide only.

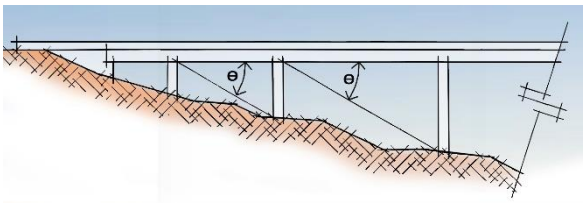
The proportions of this bridge, the large depth at the abutments compared to the depth at the crown, give it a very slender appearance.

Captain Cook Bridge over the Georges River has a ratio of 1:18 and together with its gentle vertical curve has a very slender appearance.

Figure 12. – Example of Slenderness ratio

The relationship between bridge height and span

The ratio between bridge height and span is also important. As a general rule the higher the bridge the wider the span. However, in bridges with a variable height, such as over valleys, it is generally not practical to vary span with height unless two or more superstructure types are used.



Preferably in pier and girder bridges, the higher the bridge the wider span of two piers.

Figure 13. – Relationship between bridge height and span

The relationship between pier thickness and superstructure depth

The ratio of pier width to superstructure depth should also be considered carefully. Bridges with tall thin piers relative to superstructure depth can appear odd, as can the opposite.

The pier widths used on this bridge next to the old wool road appear too thin and almost spindly in comparison to the depth of the girder and parapet.

Figure 14. – Pier thickness and superstructure depth

The relationship between deck overhang and parapet depth

The ratio of deck overhang relative to parapet depth is also considered a significant aesthetic proportion.

This guideline adopted proportioning of deck overhang and parapet depth from the Cardiff University School of engineering, as depicted in the diagram below and illustrated by the associated bridge example.

c > d and c > b/2
c = 2a to 4a
d = 2a to 4a

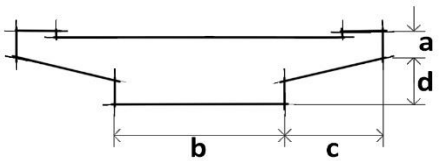


Figure 15. – Deck overhang and parapet depth ratio

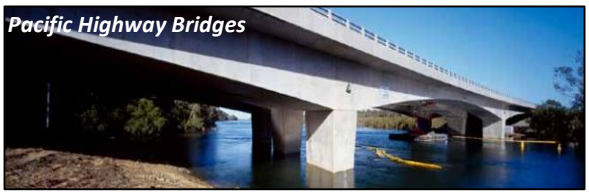


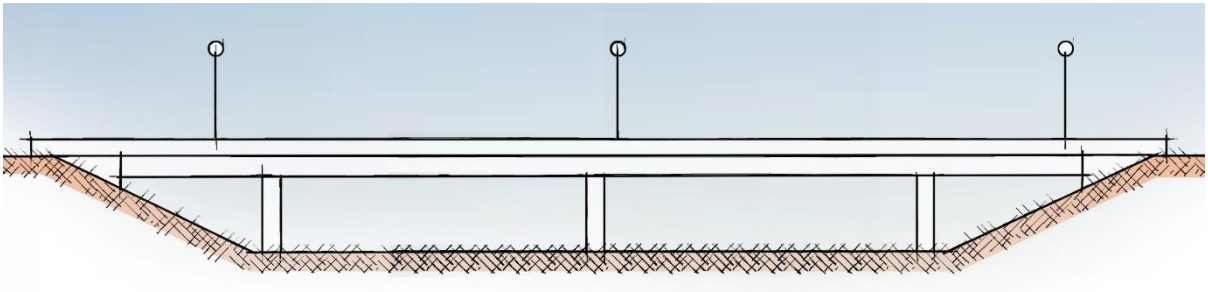
Figure 16. – Examples of deck overhang and parapet

Order and Rhythm

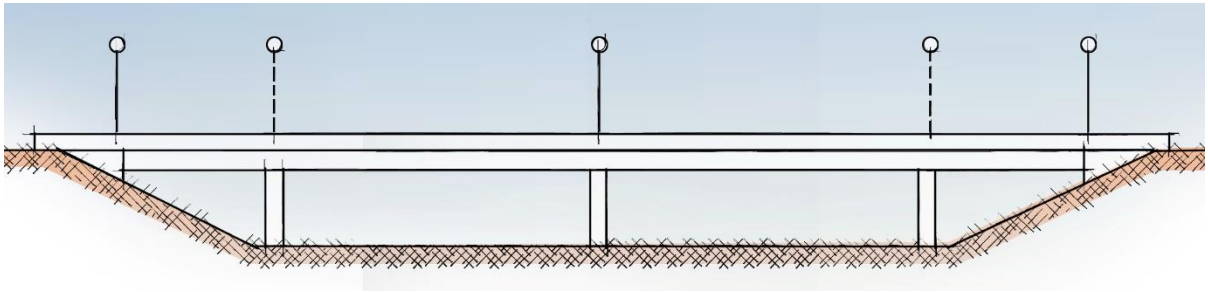
Rhythm is the regular recurrence of any like elements in, on, or around a structure. It requires that the elements have some similarity of visual characteristics in addition to a modulated placement. In bridges, for example, major rhythms are created by the repetition of similar pier shapes. Minor rhythms may be created by the spacing of light poles, post spacing within a railing, or even the horizontal rustication on a pier. Modulating the placement of these elements can create visual flow or movement across the scene. A good example of this is when pier spacing gradually increases near the main span when a bridge crosses a wide river or lake.

Order refers to arrangement. It is the arrangement of design elements so that they work together as a unit without visual confusion. The whole arrangement works as a unit with each element having a proper place and function. The selection of a constant girder depth throughout the structure is an element of good order. Order is also achieved by limiting the lines and edges of a structure to only a few directions. Under the rule of order, the regular recurrence of similar elements in a composition creates a natural flow, known as rhythm that is satisfying to the eye.

For example, spans should match where possible, or at least demonstrate a consistent order. The cumulative effect of all bridge elements including lighting columns, barrier supports and piers should be considered.

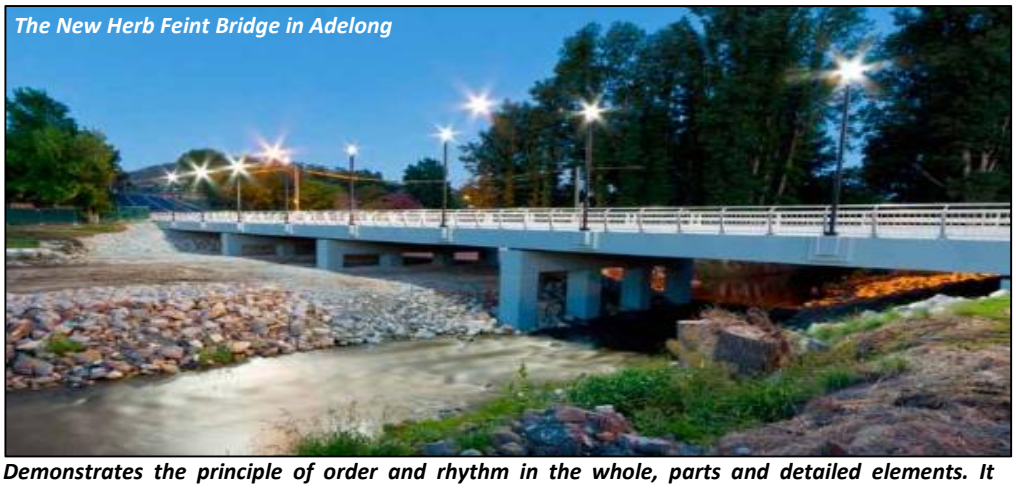


With rhythm in bridge elements, yet without an order, it appears discordant bridge.



Rearranging the parts provides an ordered and pleasing whole.

Figure 17. – Illustrations of bridge with order and rhythm



Demonstrates the principle of order and rhythm in the whole, parts and detailed elements. It responds well to the setting of Adelong creek as a central landmark within the town.

Figure 18. – Actual sample of bridge with order and rhythm

Harmony

Harmony is the relationship of the elements of a design based on similarity of their visual characteristics. The relationship must be complementary. If the planes or lines in a design have more dissimilar characteristics than they have similar characteristics, they are not likely to be perceived as harmonious. This is most readily achieved by using the **Law of the Same** or the **Law of the Similar**.

Law of the Same: Harmony may be perceived or created in a structure or composition of structures that attains order through the repetition of the *same* elements, forms, or spaces.

Law of the Similar: Harmony may be perceived or created in a composition that attains order through the repetition of *similar* elements, forms, or spaces.

Harmony depicted as a function of shape, size, direction, and color

Figure 19. – Harmony themes

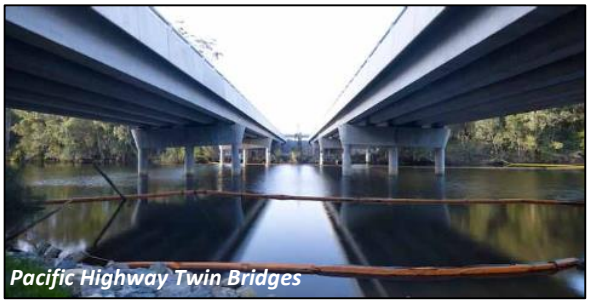
The shapes of these piers are similar, and thus harmonious, even though their sizes are different.

Figure 20. – Example of harmony by similar in form and elements

Balance

Visual balance is the perceived equilibrium of design elements around an axis or focal point. Rather than a physical balance, it may also refer to equilibrium of abstract elements of the design such as masses, visual weights, texture, etc. Visual balance is fundamental to all successful compositions.

Figure 21. - Symmetrical and Asymmetrical compositions



These Pacific Highway Twin Bridges at Bonville have a perfectly balanced composition

Figure 22. – Symmetrical composition

Contrast

One principle of contrast is the dynamic relationship among parts of a design based on complementary opposition of visual characteristics. Contrast relieves the monotony of simple harmony by complementing the harmonious characteristics of some design elements with their opposites, thus adding a heightened awareness of each other.

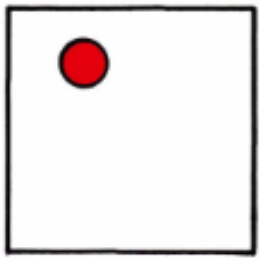
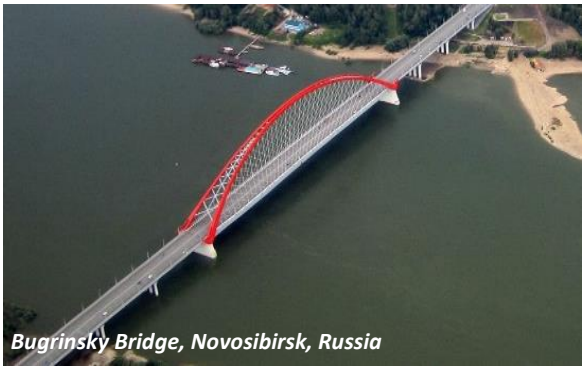


Figure 23. – Contrast in shape, size, color, and scale

A second principle of contrast is that of dominance. This concept relates to one of two contrasting elements commanding the visual attention over the other. One becomes the feature and the other becomes the supporting background. In terms of design, a dominant theme is essential in organizing the design into a pleasing aesthetic experience.



Contrast in color brings out the shape of tied arch bridge over bodies of water.

Figure 24. – Contrast in color

Scale

Scale refers to the size relationship among various features of the structure and between the total structure and its surroundings. Since design concerns itself with things that are to be used by people, a connection exists between the human body and designed objects. We often refer to structures that respond to the size of the human form as having human scale.

This would be particularly true for a pedestrian bridge or any bridge with high pedestrian usage. When a bridge becomes exceptionally large, many of the component elements lose their human scale. Elements such as piers, pylons, or superstructure members may take on monumental scale.

Here it becomes more important that the structure be in scale with the surrounding environment.

Unity

Unity is presented last because it encompasses the perfect application of all the other qualities. It refers to the combined effects of all other aesthetic qualities applied simultaneously. Unity is the condition, or state, of full resolution of the site and project functions. Unity implies harmony where all of the elements are in accord, producing an undivided total effect. Unity provides the observer with a sense of wholeness, generated by some central or dominating perception in the composition.

The deck-arch provides a central feature in the valley that complements in the environment, and inversely, the surrounding gives affirmative impressions to the bridge.
Figure 25. – Bridge with unity

2.2 INFLUENCE OF CONTEXT

The choice of bridge structure is affected by many contextual factors that include the following:

- Influence of span.
- The alignment of the bridge as part of the route option.
- Topography and geology.
- The nature of the load to be carried.
- The visual presence of the structure.
- The character of the area.

2.2.1 Influence of span

All these factors will have a powerful influence on the choice of bridge type, in particular the superstructure. In most instances, it is span length that is the most significant factor in determining the form (and cost) of a bridge.

The accepted approximate relationship between span and superstructure type is as follows:

- **Short span** (up to approximately **18m**): **pre-stressed concrete plank bridges**.
- **Short to medium span** (approximately **18-40m**): **pre-stressed concrete girders or posttensioned concrete voided slabs**.
- **Medium span** (approximately **40-60m**): **steel or post-tensioned concrete box girders** or **incrementally launched girders**.
- **Medium to long span** (up to approximately **300m**): **balanced cantilever**.
- **Long span** (up to approximately **800m**): **cable stay**.
- **Very long span** (longer than **800m**): **Suspension bridges**.

2.2.2 The alignment of the bridge as a part of the route option

To maximize innovation and minimize cost the vertical and horizontal alignment of the bridge, as part of a route option, should be straight or follow a constant radius where possible. This allows for a wide range of bridge types to be used. For example, by their nature incrementally launched bridges can only be used where the alignment is straight or has a constant radius as they are cast and pushed out from one point.

2.2.3 Topography and geology

The nature of the topography and geology can dictate bridge type. For example, in terms of topography, certain bridges require particular space configurations for casting yards or access. In terms of geology, a robust sound bedrock can create a suitable foundation for a sprung arch bridge.

2.2.4 The nature of the load to be carried

Bridges serve a whole range of purposes and the load required to be supported has an influence on bridge type. For example, pedestrian bridges can exploit greater variation in bridge type opportunities than say bridges catering for freight or rail, at the other extreme.

2.2.5 The visual presence of the structure

On occasion, bridge type can be influenced by the visibility and visual presence of a bridge. For example, large or high bridges within urban areas can be designed to make a visual statement in the city and this will have an effect on the choice of bridge type.

2.2.6 The character of the area

The local character of the area can also have an influence on bridge type. For example, heritage areas can influence the form and materials adopted for a bridge.

2.3 AESTHETIC DESIGN HIERARCHY

The bridge as a whole composed of the pier, deck, superstructure and abutment establishes the important visual properties of the bridge. In short, the general physical characteristics create the visual personality of the bridge. Ornamental railings, lightings, paint color are considered high level of aesthetic treatment, thus should not define the visual statement of the bridge.

2.3.1 Principle Aesthetic Design Factors

To find the best design solution, designers must consider and concentrate on developing the best design of the following factors:

- Superstructure Type and Shape
- Vertical and Horizontal Geometry and their setting relationship
- Pier Placement and Shape
- Abutment Placement and Shape

2.3.2 Secondary Aesthetic Design Factors

The secondary aesthetic designs factors help emphasize the positive qualities that have been created with the principle aesthetic design factors. The following should be considered in defining the principle aesthetic design factors:

- Railing details
- Surface colors and textures
- Lightings

2.4 THE SITE / ENVIRONMENT INTEGRATION

The **bridge site** is the most important feature that will influence the configuration and the aesthetic design of a bridge. Bridges designed to work with and complement a site, will be both functionally and aesthetically successful.

- Consider the relationship to the surrounding natural and built landscape. Bridges on the one hand are part of site and locale and so need to be in harmony with their context while, on the other, they can make or define a place.

- The dimensions of the structure must relate to human scale when pedestrians are involved, as pedestrians are uneasy and uncomfortable with heavy, brutal forms.
- Bridges should make a positive contribution to the immediate environment in which they are placed.
- Familiarize the bridge site, visit in different times of day and night. Sometimes the appearance at night is as important as during daytime.
- Consider the type of traffic the bridge is expected to carry or traverse. Bridges that carry pedestrian traffic will require appurtenances scaled to people more than a bridge that carries only interstate highway traffic.
- Nearby land used must be considered. A bridge in an industrial area may warrant a different level of aesthetic design than a bridge located in a park or public place. Adjacent buildings and structures might lend existing architectural features that can be echoed in the bridge.
- Consider the involvement of all concerned parties (communities, elected officials, potential stakeholders, businesses, public agencies) which may affect the design and configuration of a bridge.

2.4.1 Bridges in Rural Setting considerations:

- Natural vegetation should be protected and augmented.
- Minimize the complexity of a bridge in rural setting.
- The built and natural environment should be made as visible as possible through the bridge.

A traditional or bare stone arch bridge beautifully matches an area where stones are available in abundance and where stone out-crops is visible in the locality.

The Khaju Bridge in Isfahan, Iran reflects a strong cultural influence.

Deck type arch bridge with a high rise span ratio is most suitable in a narrow gorge with a beautiful background.
Figure 26. – Examples of bridges designed to complement natural environment/area features

2.4.2 Bridges in Urban Setting considerations:

- Create a landmark structure that complements or contrast with its visual catchment. More people see the bridge at slower speeds.
- Maximize the view from and through the bridge.
- Respect locally valued structures and their curtilages.
- Ensure the spaces under the bridge are not dark, degraded, and unsafe. These criteria are often neglected in design of viaducts/flyovers over at grade roads.
- Consider the volumes of traffic.

These bridges create an impression of the culture, economy and character of the place
Figure 27. – Bridges as Landmarks

CHAPTER 3. THE PARTS OF THE BRIDGE

(Principal Aesthetic Design Factors)

The design components of a bridge comprise superstructure types and shapes including parapet, railings, and overhangs, pier placement and span arrangements, pier/support shapes, abutment placement and shape, and other detail components. The objective of bridge aesthetic is to integrate all facets - environmental, structural, functional, and visual into a design solution which all the conditions are simultaneously resolved. This chapter shows ideas and considerations to the parts of the bridge - the superstructure, substructure and bridge curtilages.

3.1 SUPERSTRUCTURE

This section addresses the aesthetic considerations associated with superstructure design. While the section attempts to treat the superstructure individually, the designer should remember that all elements of a bridge must be considered in relation to the whole and the whole bridge in relation to its site location.

Slant leg pier: Richmond Hill Bridge, Colorado, USA

Delta frames: Shenandoah River Bridge, Eastern Panhandle, West Virginia, USA

Guidelines to consider:

- Achieve a slender superstructure while maintaining continuity and proportions.
- In the case of single point interchanges, continuous multi-span structures may be helpful in reducing
- The impression of massiveness than simple span structures.
- Slant leg piers or delta frames may be suitable for providing continuity with supports and creating geometric openings beneath a bridge. This approach may be particularly attractive at the crest of a vertical curved alignment to frame the view.

3.1.1 Type

Girder Bridge

The girder seen in elevation and its cross sectional shape are important considerations.

Haunched Girders

Principles of haunch girder design in elevation

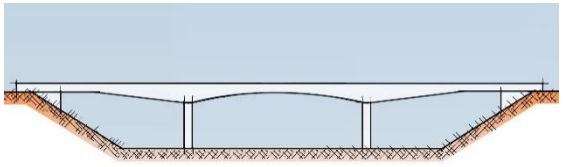


Figure 28. – Ideal no. of haunch

- Three or five span haunches are generally aesthetically very elegant, balanced structure.

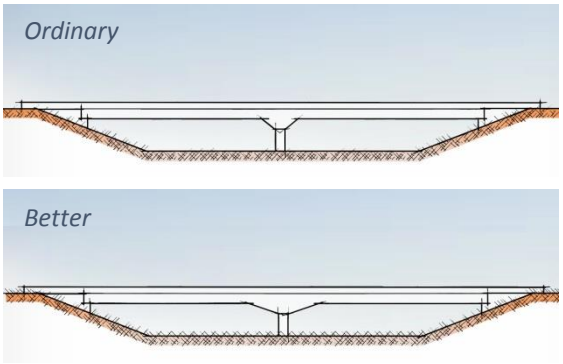
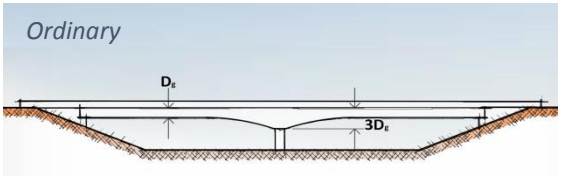
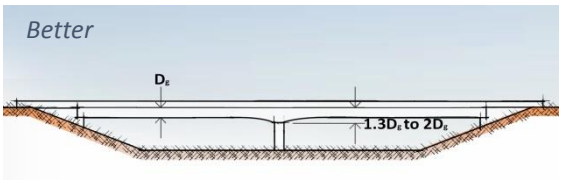


Figure 29. – Configuration of haunch girder

- Long haunches smoothly tapering out are much more graceful and responsive than short abrupt haunches.
- Provide parabolic haunches rather than circular linear haunches.
- Avoid the use of haunches on tall piers when the openings are predominantly vertical.
- Provide a substantial pier beneath the haunches. This element should provide a corresponding strong visual support for the concentrated loads at that point.



$3D_g$



$1.33D_g1 < D_g2 < 2D_g1$

Figure 30. –Suggested dimensions of haunch depth

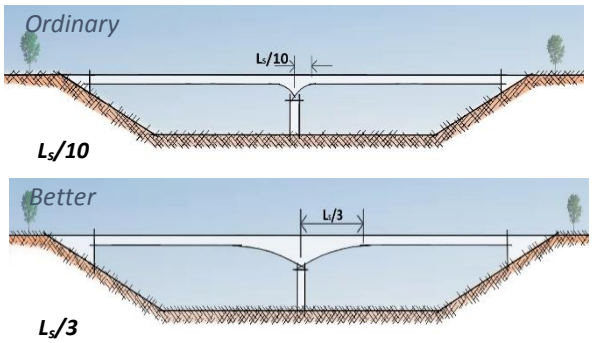


Figure 31. –Suggested dimensions of haunch length

- Limit the depth of haunches to twice the midspan depth.

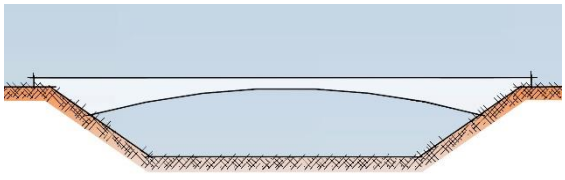


Figure 32. – Curving girder

- Even with single spans, curving the girder can provide an expression of elegance.

- Limit the angle subtended by the haunch to between 135 and 165 degrees; otherwise the bearing point will look too delicate to support the girder. Avoid sharp angle between haunch and beam.

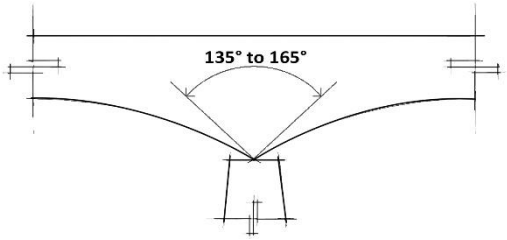


Figure 33. – Ideal angle for haunch girder

Ordinary

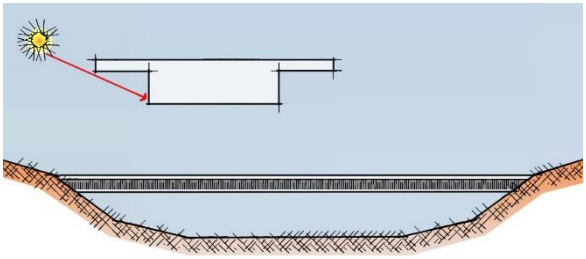
Better

Figure 34. – Actual sample of haunch design

Box Girders

Principles of box girder design in cross section

- A right angled connection can catch the light and a double line may be visible; maximising the overhang will increase the duration of shadow.



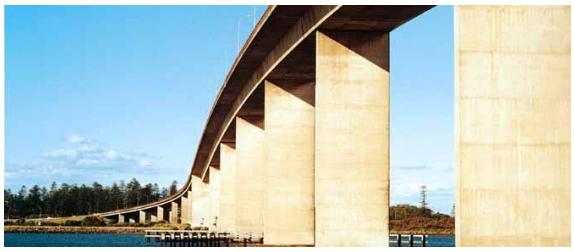


Figure 35. – Box girder in right angled connection

- An angled connection will minimise this effect.

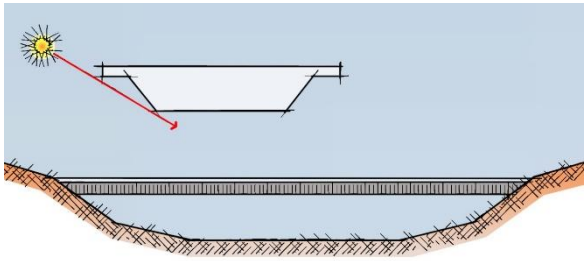


Figure 36. – Box girder in angled connection

- A very acute angle provides a deep shadow nearly all of the time.

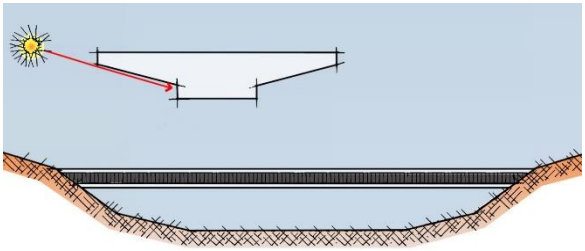
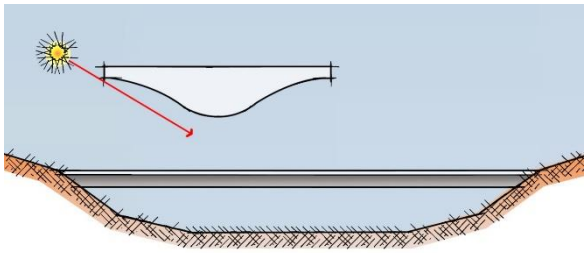


Figure 37. – Box girder in very acute angle connection

- A curved soffit will provide a gradation of tone and minimise a sharp line at the base of the beam.



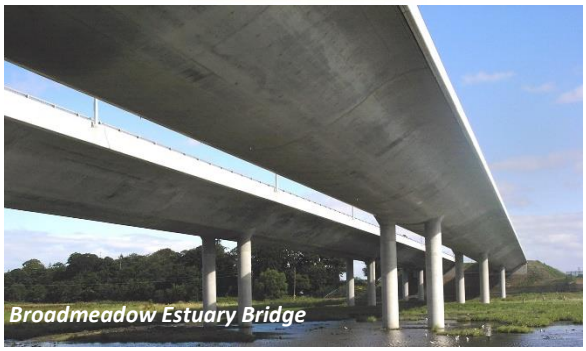


Figure 38. – Curved soffit box girder

Rigid Frame Bridges

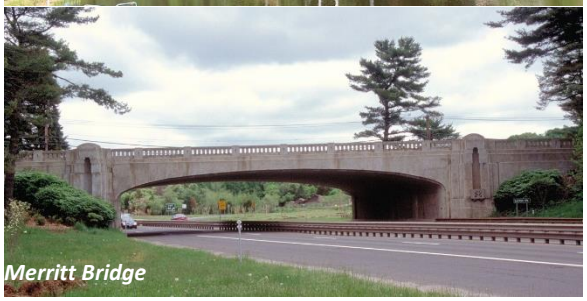


Figure 39. – Rigid frame bridges

- Use rigid frames where there are strong land forms at the ends to contain the visual thrusts.
- Slant the legs enough to maximize their length and develop the visual illusion of additional bridge length.
- Rigid Frame Bridge is appropriate for single- or two-span bridges. Combined with haunching to provide a shallow arch opening beneath the bridge.

Arch Bridges

Figure 40. – Arch bridge sample

- The arch should be stronger (thicker) than the deck and the supporting walls or spandrel piers.
- Deck supports should be uniform in size and shape and continue the same column spacing over the entire length of the bridge.
- Consider arches where strong land forms contain the visual thrust of the arch, as in valley or highway cuts.
- Minimize sway bracing and floor system members. Develop a simple arrangement for these elements to promote a clear and consistent relationship to the main members.
- Provide continuity with approach structures. For example, use arch floor system stringers the same depth as the approach girders.
- Allow an open spandrel between the deck and the crown of arch on steep arches with spandrel columns.
- Hold the number of spandrel columns to a maximum of 3 in the transverse direction.

- The arch and deck should merge on shallow structures

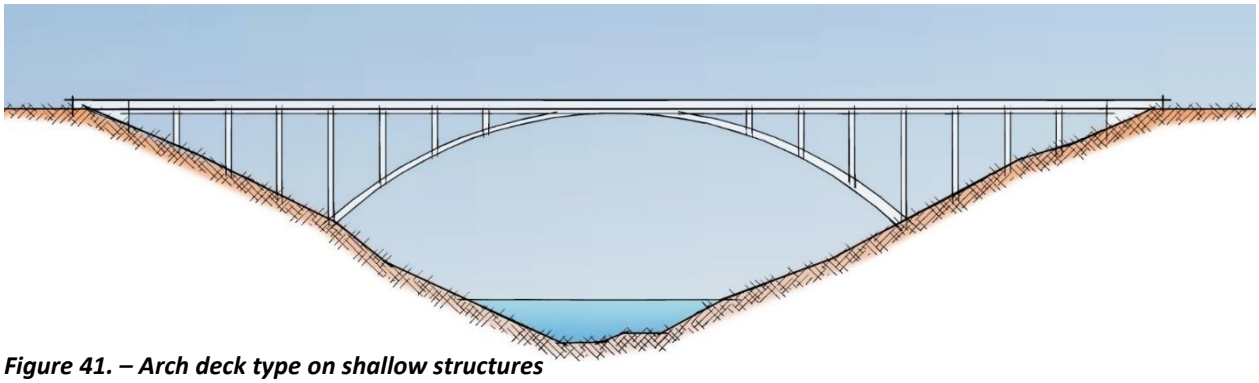


Figure 41. – Arch deck type on shallow structures

- Steep arch bridges should maintain separate arch and deck elements

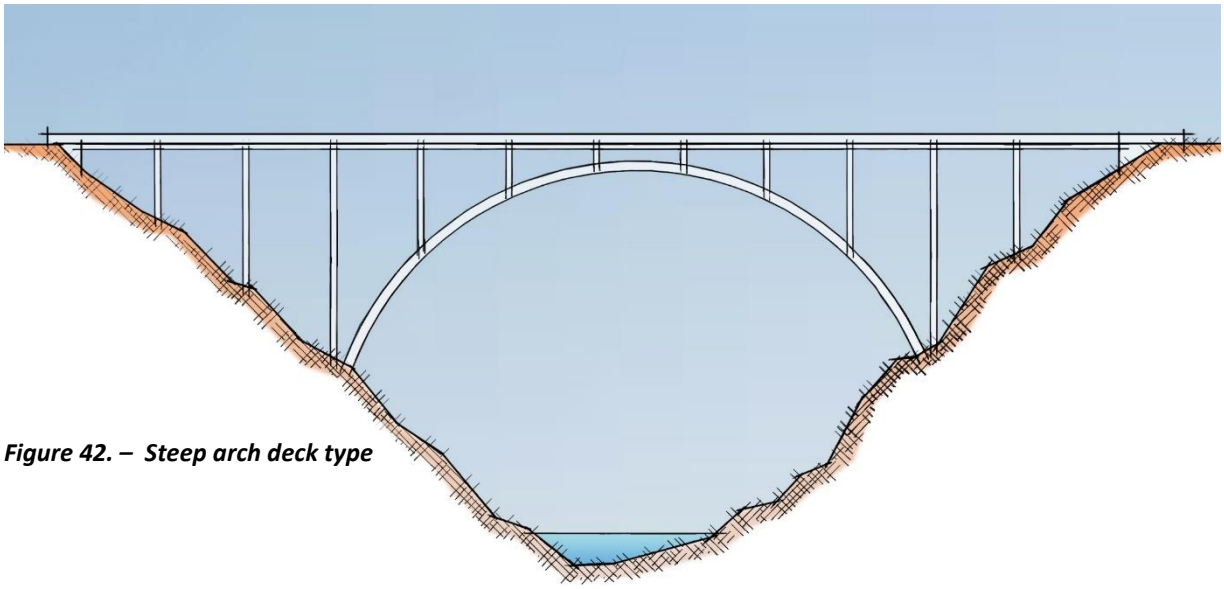
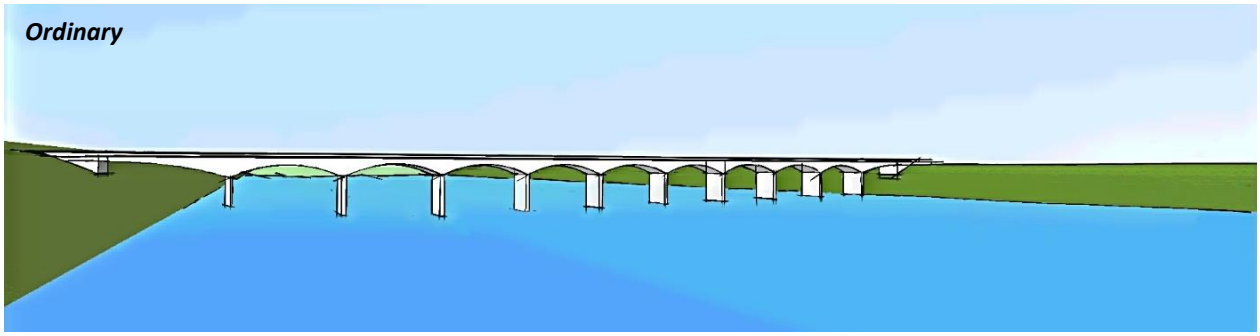
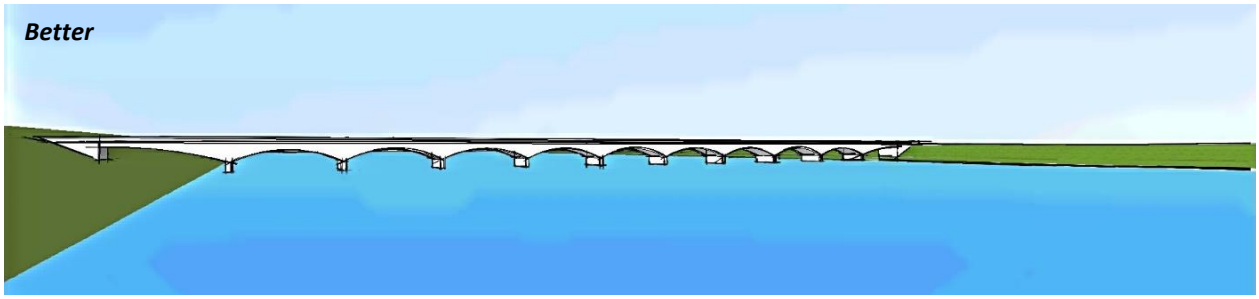


Figure 42. – Steep arch deck type

- A series of shallow arches can be attractive at a low level, especially over water. At high levels they become monotonous.



Ordinary, piers conflict with rhythm of arches



Better; low-level arch produces pleasing appearance

Figure 43. – Series of Arches

Consideration for Structure depth:

- The apparent depth of a bridge is the combined depth of the girder, deck slab and edge railing. If this dimension becomes too large, the bridge may appear bulky and more of a barrier than a crossing.
- Thinner structures with longer spans are more visually transparent and pleasing than deeper structures or structures with shorter span.
- Continuous girders will provide a slenderer structure than simple spans.
- Steel girders will provide a slenderer structure than precast concrete I-beams.
- Concrete slab bridges often look very light because of their minimal structure depth.
- Pay special attention to proportions when the depth of a girder is less than the rail height.

Consideration for Structure consistency:

- Use of different structure types over the length of a bridge should be avoided as it often interrupts the visual line created by the superstructure and is contrary to developing a sense of unity and integrity.
- It is preferable to use the same depth of girder for the entire bridge length and not change girder depths based on the length of each individual span.
- When a series of bridges is seen as a group, such as an interchange or a corridor, it is preferable to use the same structure type

Figure 44. – Lack of superstructure consistency

Figure 45. – Superstructure consistency example

3.1.2 Shape

Parapet and Railings

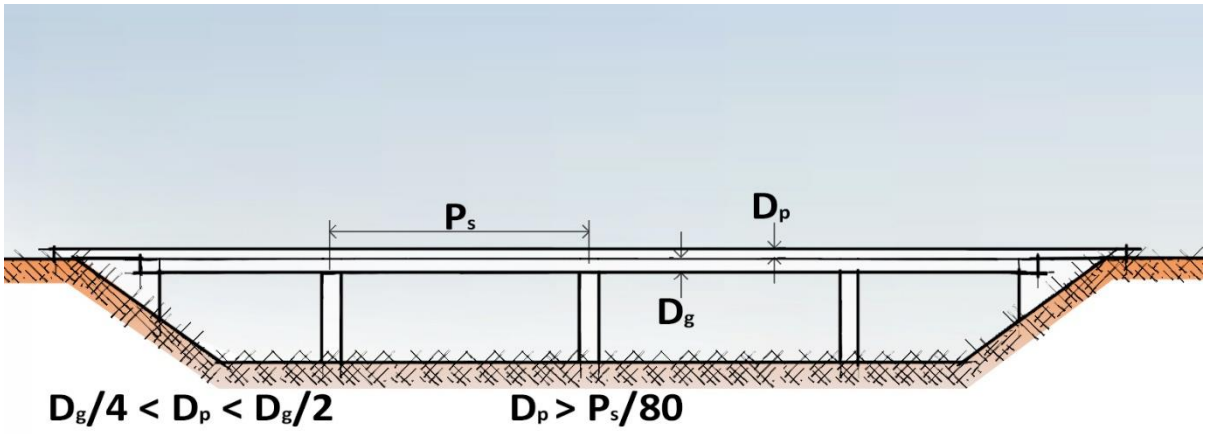


Figure 46. – Desirable Proportions of parapet

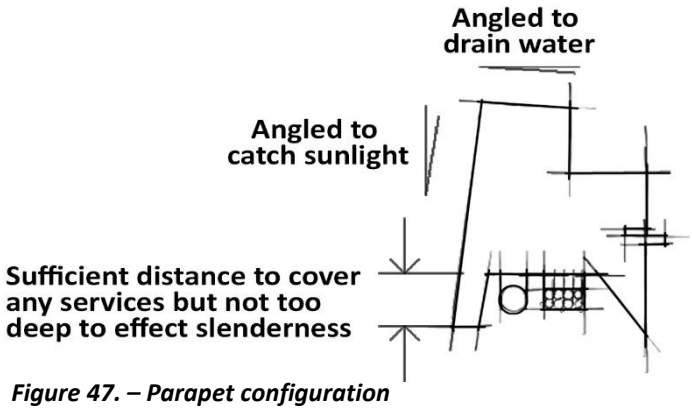


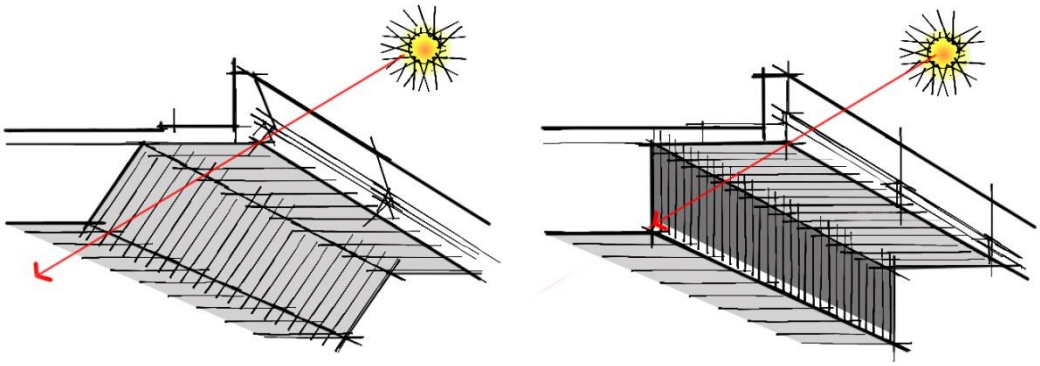
Figure 47. – Parapet configuration

- While parapets are typically solid concrete surfaces, their exterior face presents an opportunity for surface articulation. The use of horizontal rustications, textured surfaces, color or other aesthetic enhancements may be appropriate to consider.
- They should appear as a continuous uninterrupted face, extending the full length of the bridge with a generous overlap of the abutments.
- A continuous neat, sharp edge will help define them against the background.
- The proportions between their depth, the deck overhang and the girder depth should be carefully considered. Shaping the parapet if it is too deep can assist in visually balancing proportions.
- Maximizing the shadow cast on the girder and superstructure will further accentuate and express their form.
- The outer face should generally be a smooth single plane surface on a continuous curve (if the bridge is not straight) and slanted slightly outwards towards the bottom to better catch the sunlight.
- The top should angle towards the road, to channel rainwater onto the bridge, minimizing staining of the outside face.
- Consideration should be given to extending the parapet below the deck soffit to hide drainage pipes.

Considerations in the design of railing are the following:

- Railings visually lighten a structure by reducing the concrete edge height.
- The outboard face of crash-tested barriers may be architecturally treated for the aesthetic benefit of the structure.
- If crash-tested barriers are not required, consider treatment of the parapet and railing to complement the overall visual design theme of the bridge.
- Consider ending rail systems and pedestrian screens with tapers to avoid abrupt changes.
- Avoid connecting the guardrail to the rail system with through-bolts as the details clutter the appearance of the bridge.
- Avoid setting the outboard face of the rail system flush with deck fascia unless the interface of the rail system and the deck is detailed to address its visual appearance.
- Consider pitching the top of the rail system toward the roadway side where staining is less visible and easier to clean.

Overhangs



Orienting surfaces to create areas of shadow: Surfaces slanted backward is brighter than vertical surfaces slanted toward the ground.
Figure 48. – Overhang and girder effects

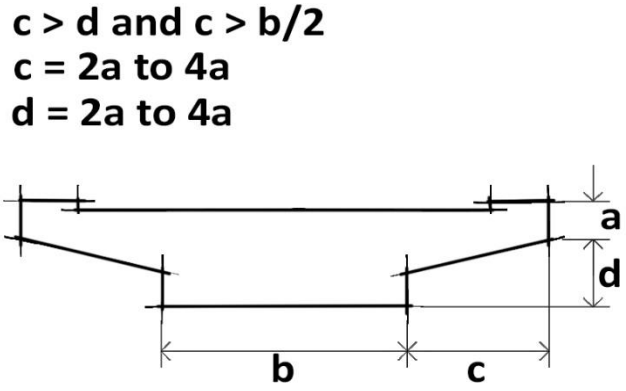


Figure 49. – Overhang proportioning

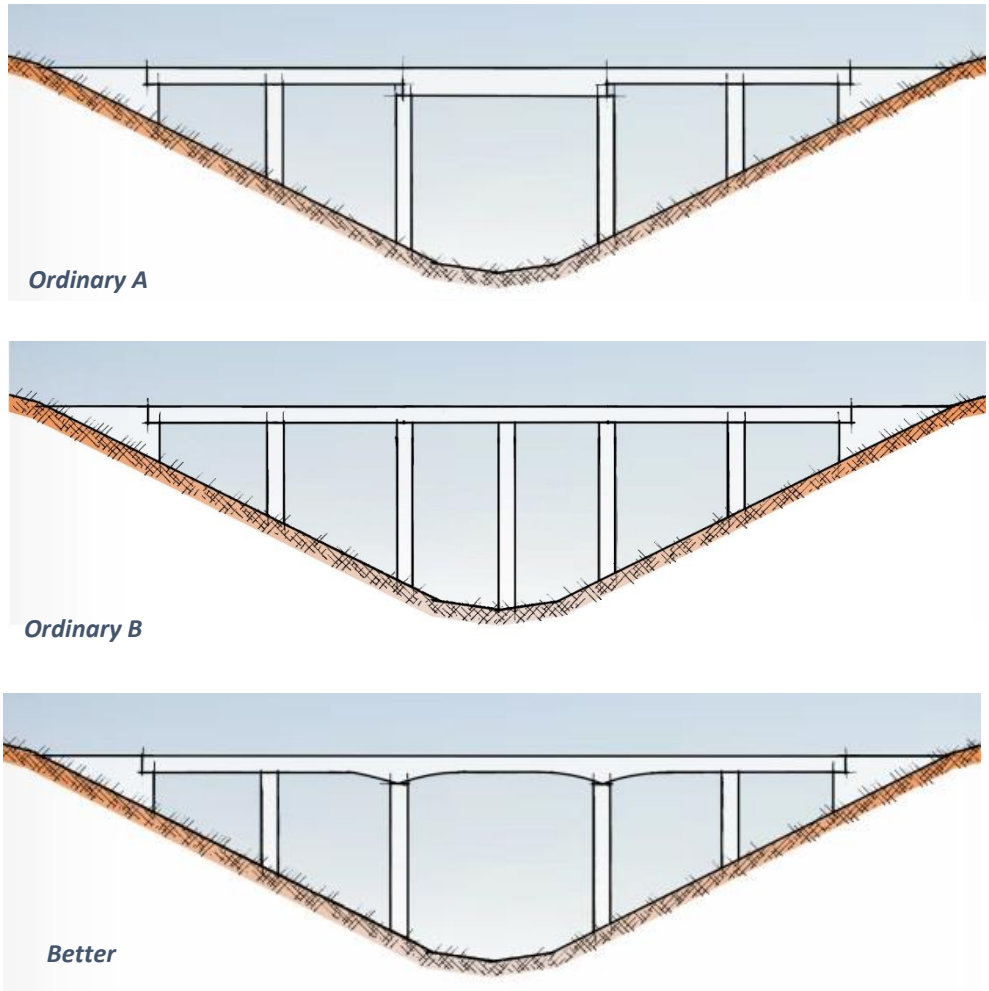
3.2 SUBSTRUCTURE

The substructure provides the visual, as well as literal, base for the bridge. The visual appeal of bridge forms is greatly influenced by the substructure units' prominence. The placement and size of the substructure units will inspire the viewers 'perception of scale and proportion, along with order and balance. The shape of the substructure units will affect the viewers' perception of line and mass. The surface treatment of the units will impact the continuity of the structure. Collectively, the substructure units will influence the visual appeal of the structure as much as any other aspect of the bridge.

Pier

Consideration for aesthetically pleasing bridges:

- Topographic features
- Sightlines through the substructure
- The ratio of span of lengths to pier heights



Discontinuous superstructure and an even number of spans detract from the appearance of the superstructure.

Figure 50. – Pier Span Arrangement

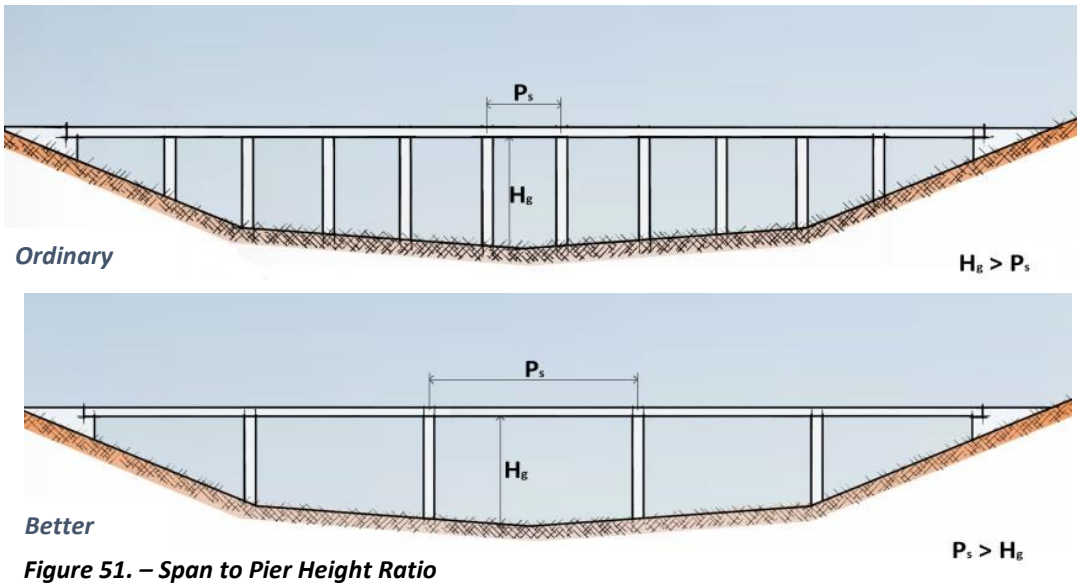


Figure 51. – Span to Pier Height Ratio

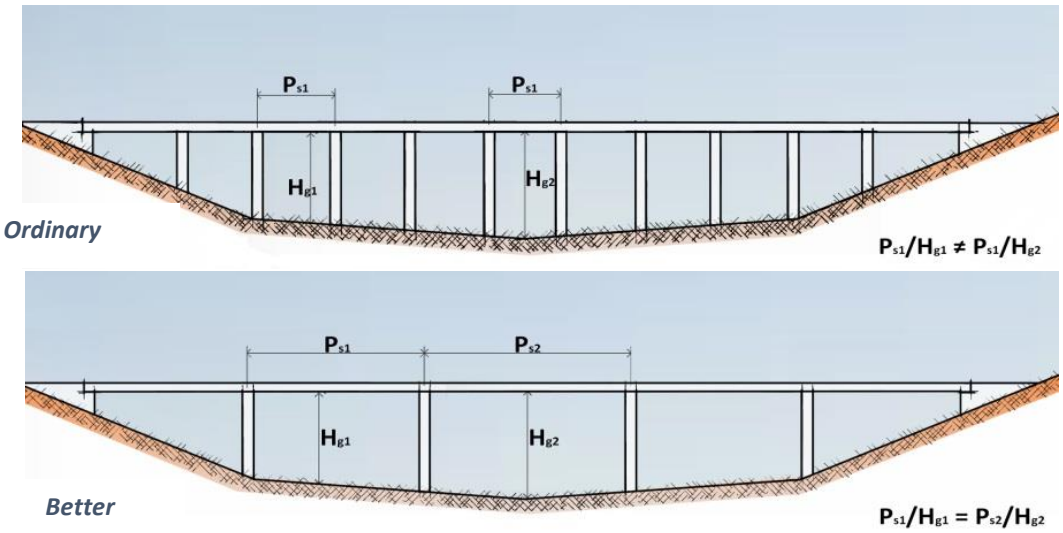


Figure 52. – Consistent Proportions of Span

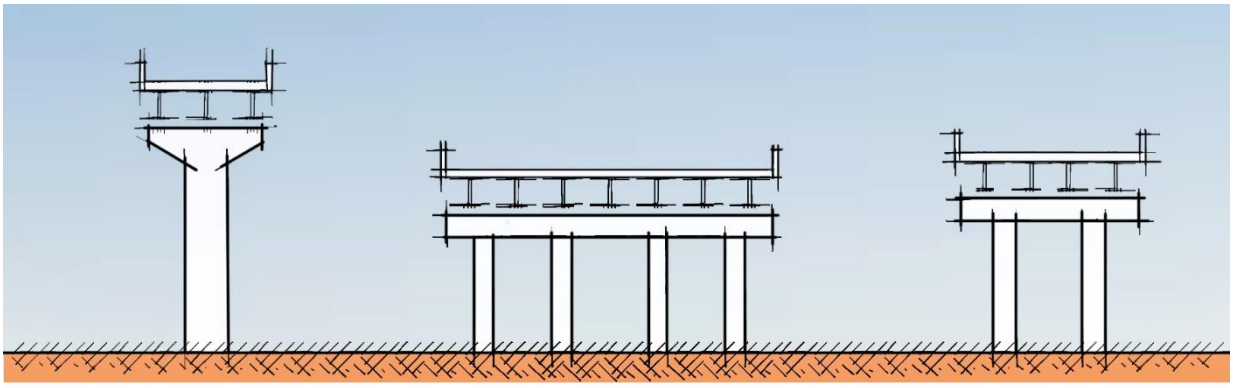
Relationship of the span layout to the site:

- Strong long-span sculptural elements that contrast with, but do not dominate the landscape.
- Slender elements that minimize the silhouette and are as transparent as possible may be preferable to reduce the visual impact of the project.
- Examine the ratio of the span to vertical clearance or height. It may be appropriate to hold this ratio constant throughout the bridge. As the vertical clearance diminishes going away from the main span of the bridge, smaller side spans may be warranted. In general, the span should be greater than the height.
- Longer spans require deeper superstructures, which can have a major visual impact. This is particularly true for bridges with minimal under clearance or long span single point interchange bridges.
- Examine the fit of more classic approaches to structure composition and proportioning. An odd number of spans may be more preferable with the center span longer than the other spans and may also provide a more optimum structure design.

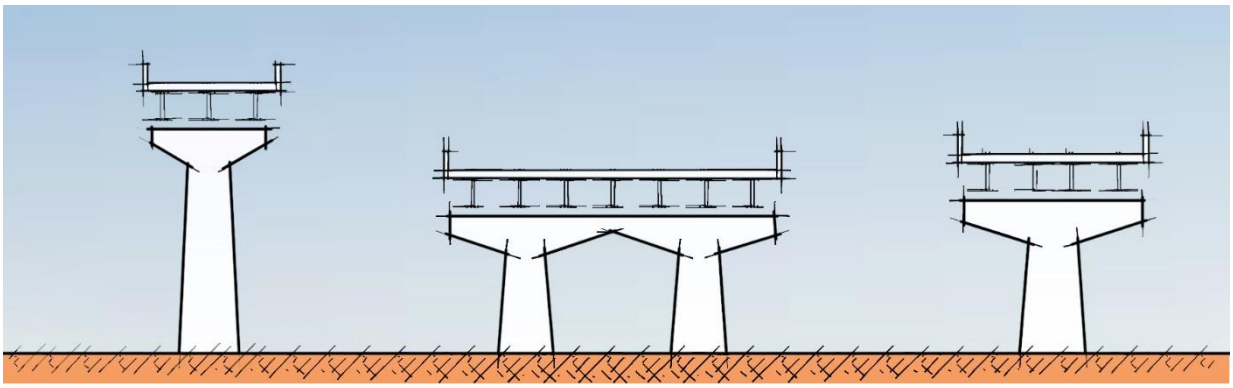
- Depending on the site topography, it may be appropriate to vary the span length with the height above grade.
- Linearly taper the column cross section dimensions over the column height or use curved flares at the column capitals.
- Place the exterior columns at the outside face of the cap and eliminate the cap cantilevers to emphasize the vertical lines of the columns.

Pier Families

- Create a family of pier designs that look good individually and as a group.



Ordinary



Better

Figure 53. – Family of piers that vary by width

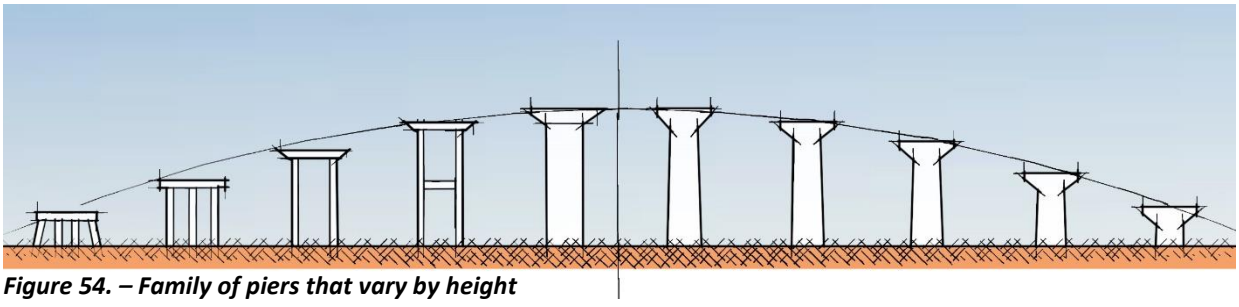


Figure 54. – Family of piers that vary by height

Pier Columns

- The designer can use the principle of light reflection to slim down a massive column.
- Use of V, X, Y shapes or any desired shapes (aside from the typical square and round column) to achieve a desired visual effect.
- The end elevations of piers should be narrow and chamfered or rounded.
- Pier width should relate to superstructure depth (superstructure depth/4<pier width< superstructure depth/2)

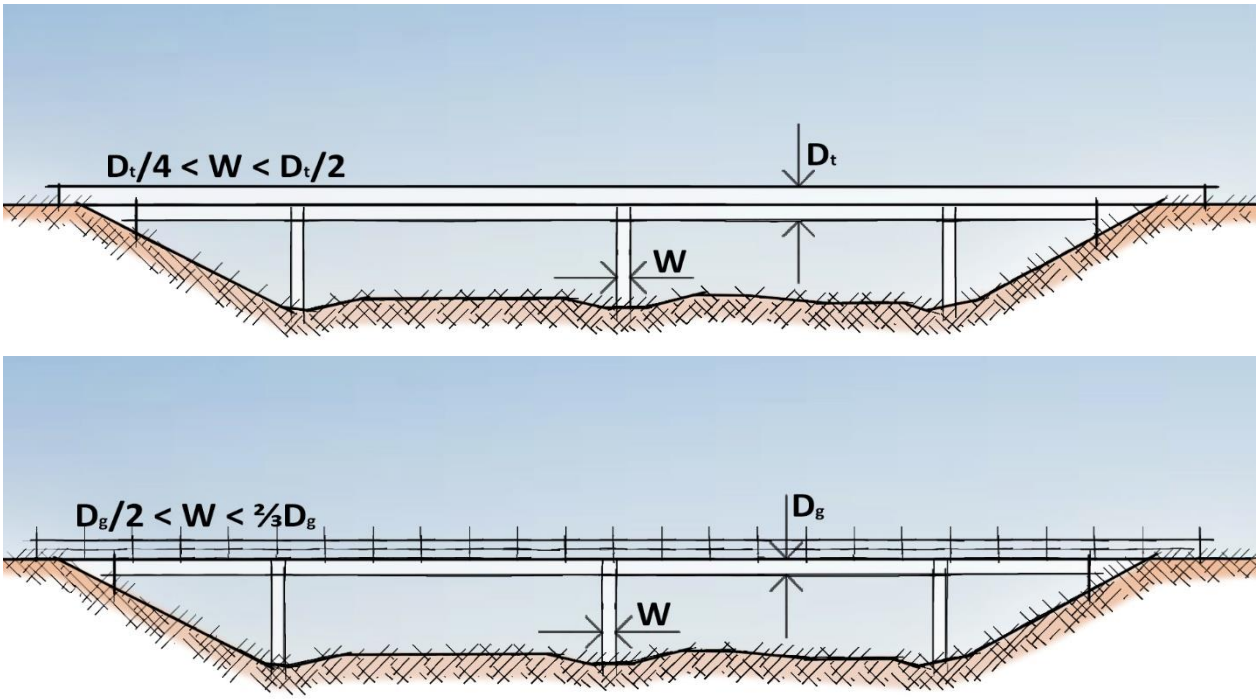


Figure 55. – Pier width to Superstructure Depth Ratio

Short and Tall Piers

Short Piers are piers with lengths (Bc) that exceed their height

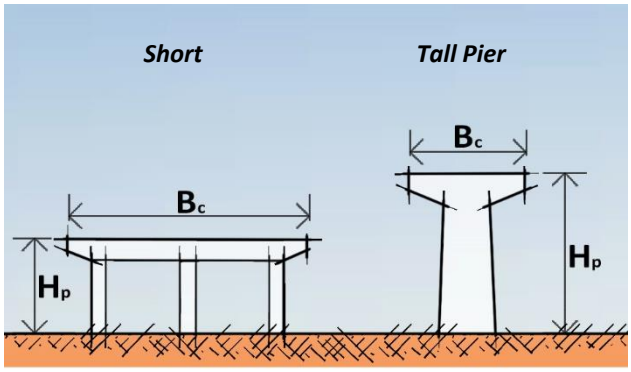


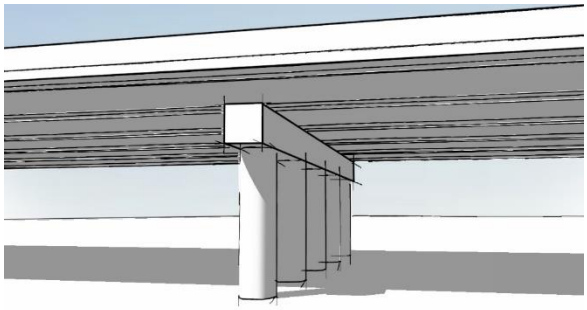
Figure 56. – Short & Tall pier classification

Consideration for short piers should include the following:

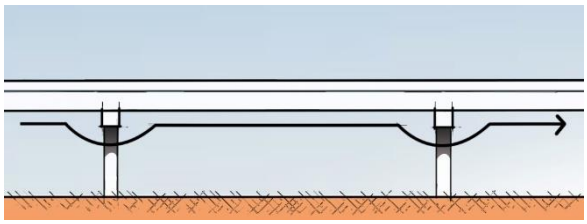
- Avoid using short hammerhead piers because the pier cap makes the large portion of the total pier.
- Should eliminate or minimize the pier cap and the pier cap ends.

Pier Caps

Cap beam and particularly their end elevations are distracting elements that make the superstructure seem deeper.



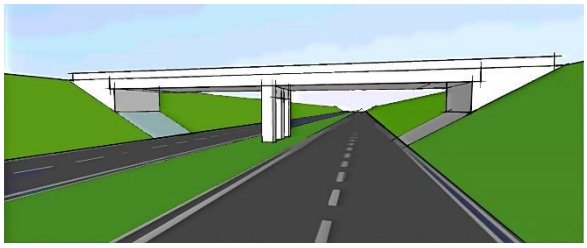
Pier cap end creates disturbing visual hot pot



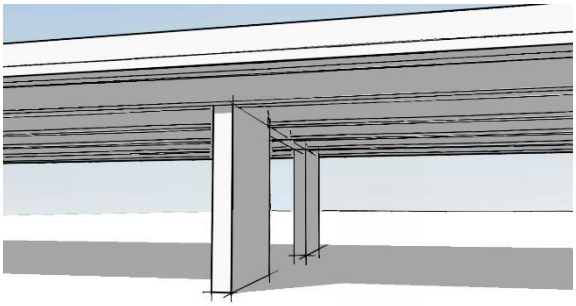
Prominence of the pier cap end surface

Figure 57. – Undesirable pier cap treatment

Eliminating or minimizing pier caps considerations:



- Incorporation of the pier cap into the columns (integrated pier cap)



- Incorporation of the pier cap into the superstructure (integral pier cap)
- Use multiple columns without a pier cap

Figure 58. – Pier Cap considerations

End of pier cap can be minimized by:

- Reducing its mass and reflective surface.
- Beveling or tapering the surface of the pier cap end.
- Minimizing the height of the pier cap.

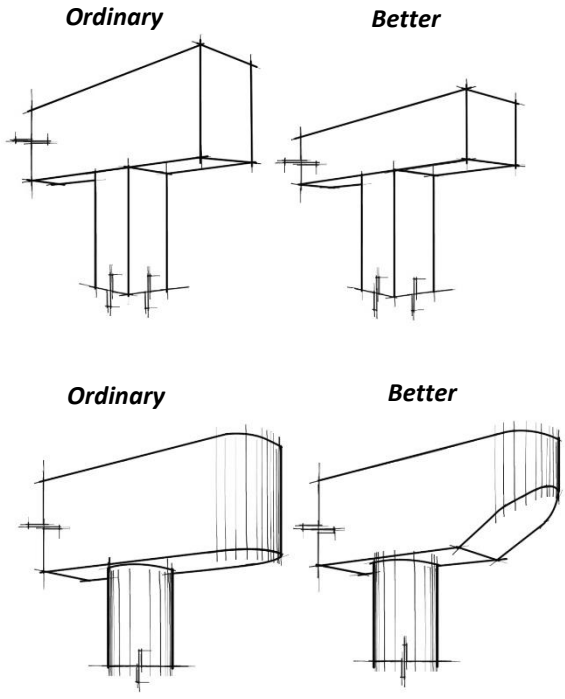


Figure 59. – End Pier Cap treatment

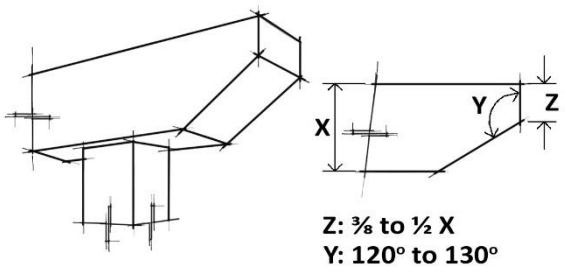


Figure 60. – Beveled pier cap end guidelines opt. 1

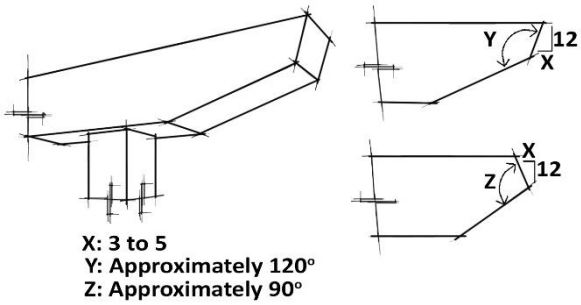


Figure 61. – Beveled pier cap end opt. 2

Tall Pier

Consideration for tall piers should include the following:

- Accentuate the vertical aspects of the pier
- Consider tapering exceedingly tall shafts
- Simplify and consolidate line segments
- Integrate the pier cap to the shaft or to the superstructure
- Use simple vertical shapes, emphasizing the vertical members and de-emphasizing the horizontal members

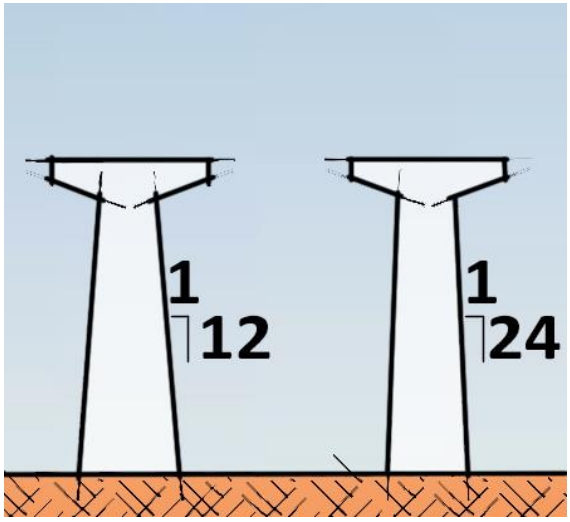


Figure 62. – Tapering tall pier

Pier Shapes

Hammerhead Pier or T- pier

Considerations for Hammerhead piers should include the following:

- Hammerhead piers in a series should be consistent in appearance, e.g., same size, shape, proportions, details.
- Hammerhead pier shafts should not be shorter than the cap beam depth plus 2 meters. When this height is not available, the designer should consider transition to a wall pier.
- Short hammerhead piers may use either vertical or battered sides, depending on the desired aesthetic effect.
- Tall hammerhead pier designs should attempt to use a common batter for all piers.

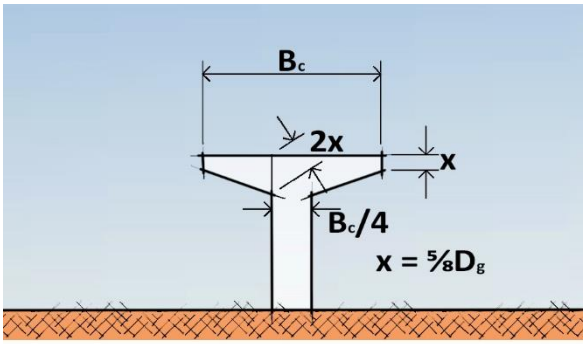


Figure 63. – Hammerhead pier proportion guidelines

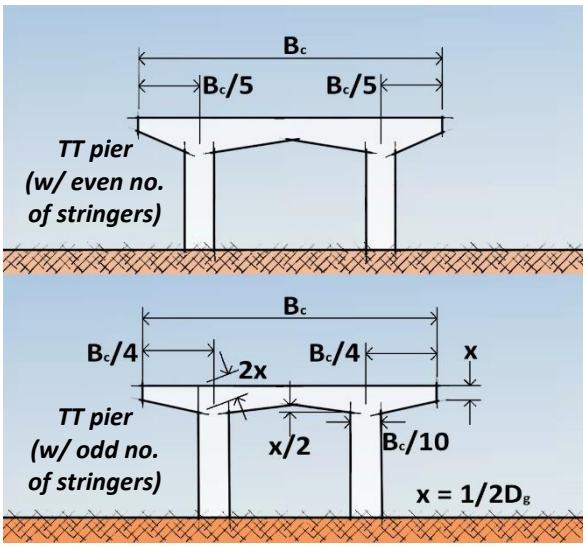


Figure 64. – Double hammerhead pier proportion guidelines

V-shaped Piers

A wall that is narrower at the base than at the top. Considerations for V-shaped piers should include the following:

- Emphasize visual stability.
- Make base lengths at least 2/3 the pier length.

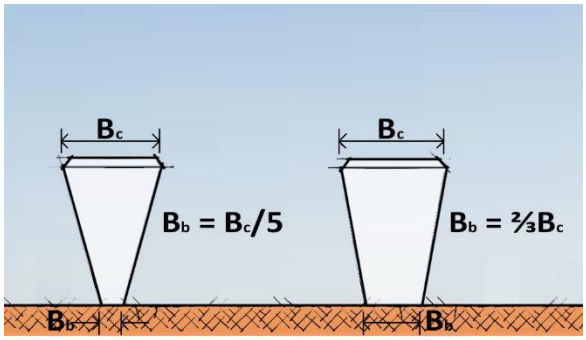


Figure 65. – Base length vs Pier length

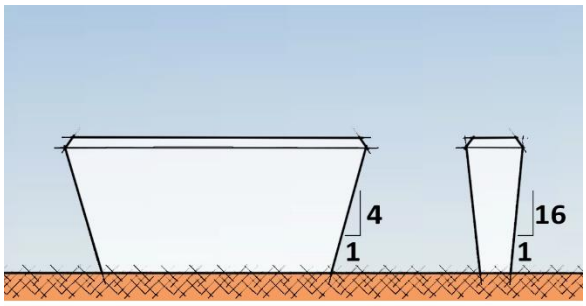


Figure 66. - Suggested batter of V-shaped piers

Tapered Piers

Considerations for Tapered piers should include the following:

- Well-proportioned tapered pier
- Opening in the center
- Quality construction techniques

Other major parameters which can have a large influence on pier aesthetics:

- Taller piers are typically slenderer and result in a more transparent substructure. Shorter piers may require more columns to lessen the cap beam depth. Depending on the structure orientation, light may penetrate the interior of bridges with taller piers far more than for bridges with shorter piers.
- Narrower piers may use a single "hammerhead" cap with a single column, which increases their transparency. Wider piers may require two or more columns, which reduces their transparency, especially when viewed from an oblique angle.
- Highly skewed piers may be unavoidable and often result in a pier layout with multiple columns as is required on wider bridges. The overall visual effect may be more of a colonnade than a span.

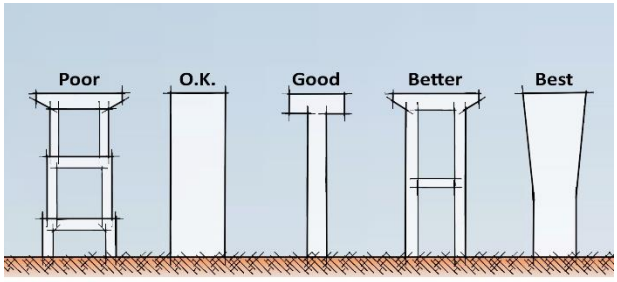


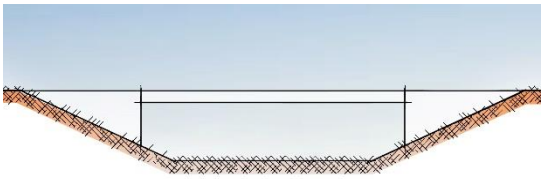
Figure 67. - The emphasis for tall piers; simplification

Abutment

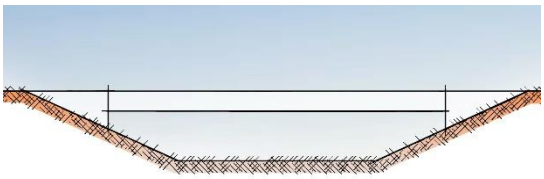
Considerations for abutment placement should include the following:

- The deck and parapet should extend beyond the abutment wall.
- Consideration should be given to extending the wall up and around the girder to remove the notch.
- A slight angle can make the wall appear less dominating especially if next to a footpath.
- Abutments may have an important symbolic function, as these are the points where travelers begin and end their passage over the bridge.

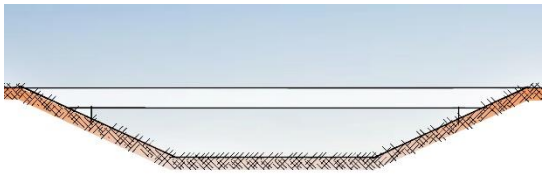
Walled abutments can reduce the slender appearance of the bridge, block the flow of the landscape and confine views.



Reducing the abutments can create a more refined and better looking bridge. It does however increase the span and therefore depth of beam.



Continuing the superstructure or the parapet above the abutment allows the shadow line to reduce the dominance of the abutment, and makes the bridge appear longer and



Angling the abutments provides a more open sleek look and helps visually anchor the span.

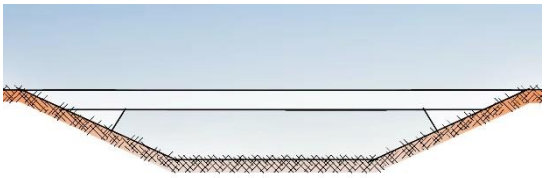


Figure 68. – Abutment's arrangement and their characteristics

General guidelines and proportioning for abutment are the following:

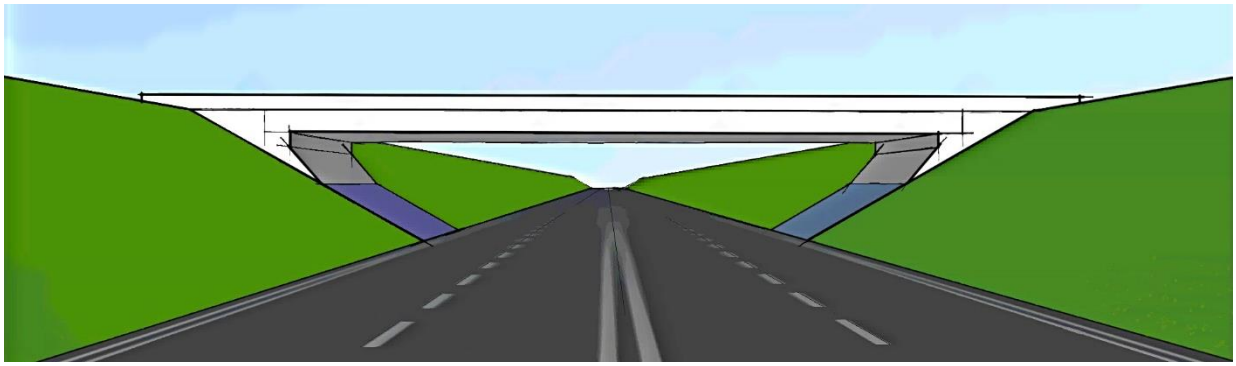


Figure 69. – Predominant abutment lines contrast horizontal flow

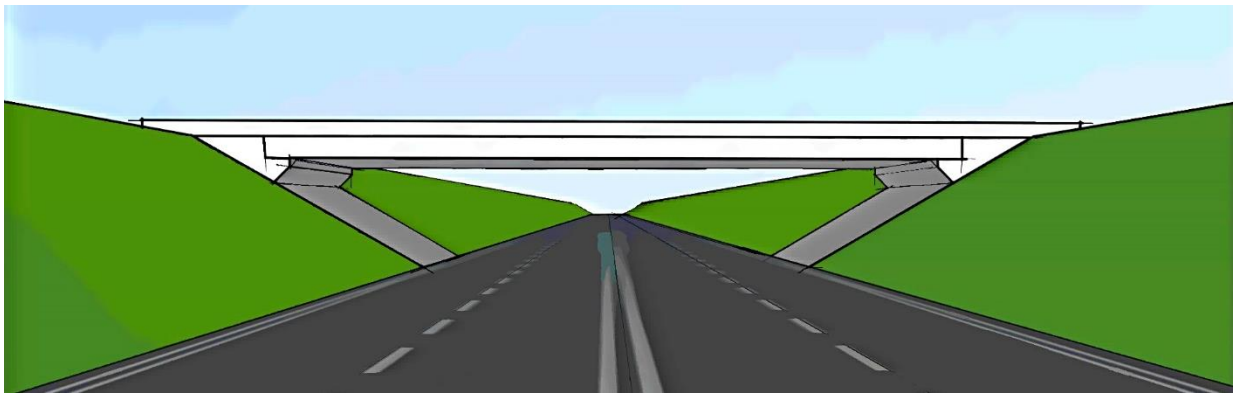


Figure 70. – Predominant abutment lines complement horizontal flow

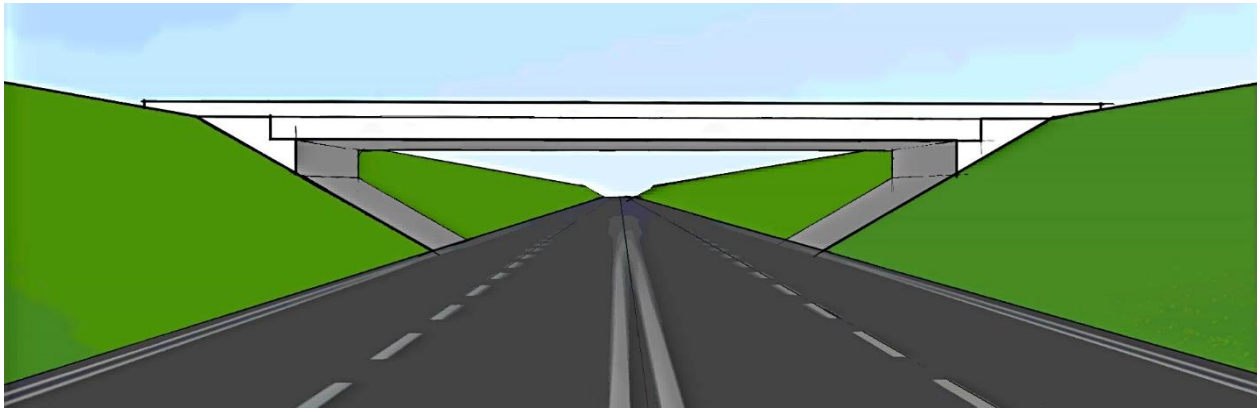


Figure 71. – Vertical abutment face presents a static visual image horizontal flow

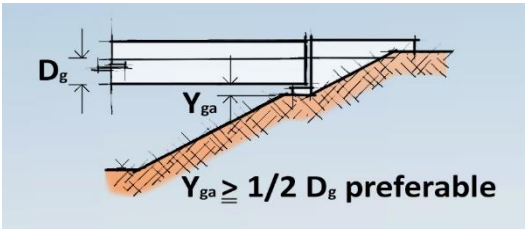


Figure 72. – Stub Abutment

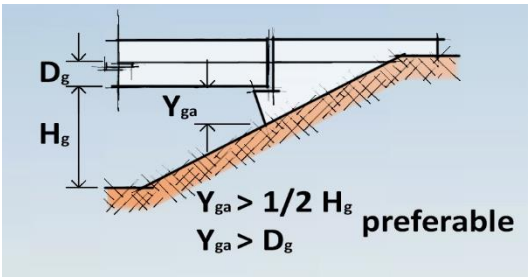


Figure 73. – Semi deep Abutment

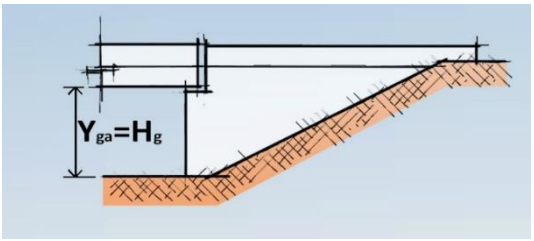


Figure 74. – Deep Abutment

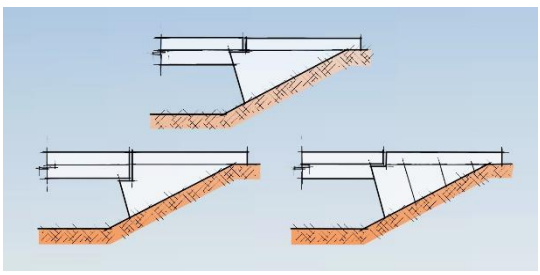


Figure 75. – Methods of reducing the apparent height of an abutment

The Bridge Curtilage

The space around the bridge

- There should be continuity between the existing landscape and the space around the bridge.
- The space should be designed so that it complements the adjacent landscape character.

The space under the bridge

- This is often perceived as dirty, derelict, dark and unsafe, but they actually present an opportunity for designers.

Guidelines to consider are the following:

- The surface treatment of the space.
- Most shade and water tolerant plants should be used.
- Function of the space.
- Design of the soffit.
- Good lighting.
- Security, maintenance, and recreation trail.

Traditional Park

This includes tree planting, gardens, seating areas, and walking paths

Nou Pont de Fusta Bridge proposal, Puentes, Valencia

Seart – Sylvia Park, Auckland, New Zealand

Mirage: Underpass park, Toronto, Canda

Space under the bridge - HNTB's Proposal for the 6th Street Viaduct Replacement

Auburn Avenue underpass, Atlanta Downtown, USA

Cumbernauld underpass, Scotland

Both underpasses uses wall murals and good lighting to enhance and offer security to the area.

Figure 76. – Bridge Curtilages Approach

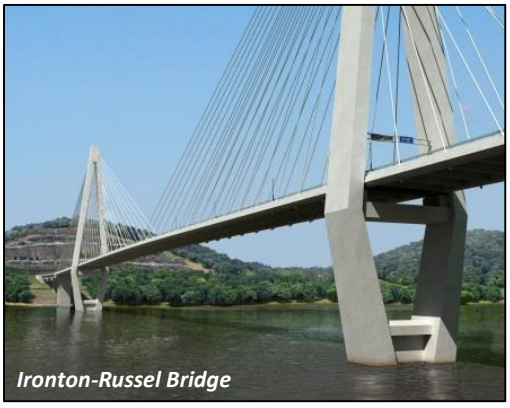
CHAPTER 4. BRIDGE APPURTENANCES

This chapter discusses the surface treatment and accessories of the bridge. Consideration of these features is crucial since it is often said that "the devil is in the detail"; It is the small things that can make or break a design, and this is especially important to bridges where the details are highly visible.

4.1 SURFACE TREATMENT

4.1.1 Colors

The application of special color or texture treatments **is not necessary** for the creation of a good-looking bridge.



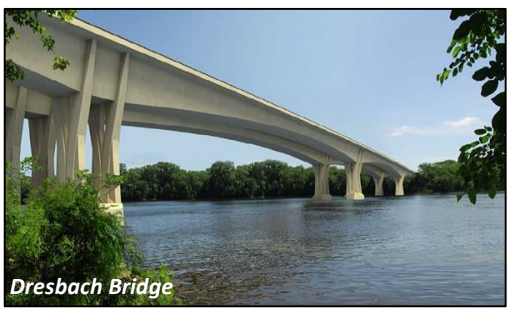


Figure 77. – Colors Treatment

Structural materials have their own characteristic color and surface finish. Appropriately shaped materials in their natural state can create an aesthetic bridge without the use of additional treatments. Color and texture are sources of enrichment and interest which can enhance a good structural design. The designer must decide whether to leave each structural material as is or to add some additional color, texture, or other surface treatments.

The purpose of color and texture in the design of a structure is to further enhance the aesthetic impression of the structure's overall form and the shape of its major components.

The two major goals of color, texture and other surfacing materials used for the enhancement of a bridge's aesthetics are:

- To create a positive response from the viewer.
- • To differentiate the various parts of the structure's lines so that the structural form and shape is clarified and enhanced.

The selection of surface treatments should be influenced by surrounding environmental features, historical context and community traditions.

The **orientation** of the bridge should also be considered. Features depending on the creation of shadows for their effect will work better on surfaces facing south, east, and west. Colors will appear brighter on south facing surfaces, and, for half the day, on east and west facing surfaces. They will also fade faster on these surfaces.

The degree of **maintenance** is another major consideration in the coloring of structural components. The designer can count on steel being repainted periodically, though perhaps not in an exotic color or pattern. It is unlikely that concrete will be recoated. Textured or colored concrete in locations subject to vehicular impact is a particular problem, as it is almost impossible to repair it to match the original.

Differences in Materials - Concrete vs. Steel
Steel

Steel bridges give an opportunity to use colors in many ways, dramatic or conservative. A wide variety of colors are available in paint but steels are limited to surface coatings only. Quality control is relatively easy to achieve, and the need for periodic repainting for maintenance reasons means that the color will be periodically renewed.

Approaches to coloring concrete:

Integral coloring (coloring of the cement paste)- Integrally colored concrete is the most durable, but the colors available tend to be limited, and generally members of the earth-tone family such as light gray, tans, and browns, but may include light shades of red, green, and blue. Quality control for integral coloring is crucial to maintaining a uniform color from batch to batch.

Staining – available in either transparent or opaque liquids that can be applied to the cured surface of concrete. The stain penetrates the surface to provide insoluble, abrasion-resistant color deposits in the pores of the concrete. Stains will not hide surface defects and may not hide discolorations in the concrete. Concrete stains are available in a full range of colors. This technique is really only useful when the mottled effect is desirable.

External / Surface coatings - typically consist of an acrylic-latex base and can be used to provide a slight surface texture, as well as color. These coatings are excellent for hiding minor imperfections in the concrete. They require little quality control, and provide a durable, low-cost finish. Surface coatings also provide a simple means to cover graffiti.

Both the integral coloring and staining techniques create color and texture matching problems if later maintenance patching becomes necessary.

Basically, avoid coloring concrete; if color is strongly desired, consider a coating in an earth tone.

Color Characteristics:

- Light colors, grays and white, retain their initial color and are not sensitive to ultraviolet rays.
- A neutral palette of black, grays and white tend to give a clear definition of the bridge as an object in the landscape
- Reds, blues, and earth tones may change over time depending on their exposure to sunlight.
- Reddish colors fade quicker.
- Earth tones and blues tend to last longer.
- Full-hued colors (forest green, royal blue) tend to attract attention to the bridge, they are not harmonious with the naturally occurring environment.
- Bright pastels and reflective metallic colors attract attention in almost any circumstance. Avoid colors like Dayglo orange which go with nothing in the environment and will attract too much attention to the bridge.
- Browns tend to blend in to most backgrounds except sky.
- Lighter colors tend to attract less attention but still have some vitality. Light colors result in stronger shadows, making any design which depends on contrasting shadows more effective. Dark colors "swallow" shadows.
- Very light colors may be hard to distinguish especially in direct sunlight.
- Darker colors will fade over time and any flaking will be more noticeable.
- Hot colors such as reds, oranges, yellows, and intense colors attract attention. Use these colors with discretion.
- Light blue and green colors are less bold and tend to diminish the visual importance.
- Reversing the intensity of color can reverse the effect.

General Color Selection Guidelines:

- Integrate the bridge into the surrounding landscape.
- Provide for a strong bridge identity by visually contrasting the bridge with its surroundings. This may be particularly appropriate in the case of sites with little vegetation where the bridge can be viewed from a distance.
- Identify the bridge with a geographic region or culture through the use of colors that will form this association.
- Consider whether there is a reason to color the concrete or give special attention to the color of the steel.
- The color combination of signs, lights, and railings should be considered in the color selection.

For Painting requirements refer to DPWH Standard Specification for Highways, Bridges & Airports – Item 411 p. 318 -326

4.1.2 Textures & Ornaments

Texture & ornamentation are elements that can add visual interest and emphasis. Structural elements, such as stiffeners and bearings, can serve this function. Indeed, traditional systems of architectural ornament started from a desire to visually emphasize points where force is transferred, such as from beam to column through an ornamental capital. Patterns of grooves or insets and similar details are other examples.

Textures

Formliners and other types of surface texturing can be used to create patterns, add visual interest and introduce subtle surface variations and shading, which in turn soften or reduce the scale or mass of abutments, piers and walls.

There are a variety of formliners available. Some mimic other materials, while others have more abstract or geometric designs. Consider the following when specifying formliners:

Figure 78. – Texture Treatment

- When simulating another material, such as stone or brick, formliners should be made as realistic as possible. Use color in addition to texture to assist in the simulation.

- When using formliners to simulate another material, avoid suggesting a material that would not be utilized in that application. For example, stone texturing on a cantilevered pier cap surface creates disharmony since a stone cantilever would not be stable if constructed.

- When a geometric pattern or texture is used, consider its relationship to the overall bridge composition. The parts must relate to the whole.

- Care should be exercised in the use of formliners for girder fascia or parapet exterior faces. Inappropriate use may disrupt the superstructure lines.

Texturing can also be achieved through rustication grooves, form strips, varying surface profiles, veneers, bush-hammering, mechanical stamping or acid washing.
A few guidelines for execution of texturing include the following:

• The use of textures needs to be closely monitored, since poor detailing or construction can severely affect the appearance.

• Depth of recess should be greater when viewed from a distance with consideration of how sunlight/shading will affect the appearance.

- The use of horizontal lines in patterns may require special attention to avoid conflict with the roadway and bridge profile, which are rarely level.

- Consider the observer's perspective. When texture is viewed up close the relief will appear deeper and the pattern may appear more complicated.

- Consider the speed and position of the observer. Finely textured surfaces on a rural freeway bridge may not be perceptible.

- Keep it simple.

Ornamentation

While attitudes regarding the appropriateness of ornamentation in bridge design have varied over time, some best practices have evolved.

- Avoid using false structure as ornament. Aside from requiring additional costs to construct and maintain, adding false structure will rarely improve a design and is often viewed as extraneous clutter.

- Don't use ornament as "make up" to disguise an inappropriate design. The form and composition of an inappropriately designed bridge can rarely be improved by applying ornament.

- If ornament is appropriate, use it sparingly. Less is generally better than more.

Concrete Quality

Bridge aesthetics can be affected by the quality of the concrete finish. A poor finish with staining or voids can mar an otherwise fine structure. This is particularly important if the bridge structure is visible and accessible. It is preferable to use steel shuttering and pre-cast factory made elements for highly visible bridge parts such as piers, girders and parapets to ensure a controlled, high quality finish. Retardants and sealants should be tested to ensure that they do not result in staining when the shuttering is removed. Concrete surfaces close to traffic and accessible to the public should have a class one finish. If the bridge is only visible from a distance then in aesthetic terms the finish is not so critical, although it should be noted that variation in concrete coloration due to staining can be noticed from a wide area. *For Concrete Surface Finishing refer to DPWH Standard Specifications for Highways, Bridges & Airports – Item 407.3.6 p. 283-286*

Even using high quality concrete and steel shuttering, concrete quality can be affected by admixtures from oil and curing compounds, as in this example of staining on the girder

Figure 79. – Concrete Quality

Feature Lighting

Bridge lighting must be sensitive to motorists, pedestrians, boaters and other users. It should be selected and located to enhance and highlight the structure, yet minimize glare and unnecessary distraction. The lighting must respond appropriately to the context, both in terms of surrounding structures and environmental conditions. Considerations of wildlife and light pollution in the night sky concerns should be weighed together with those of aesthetics.

There is an opportunity to light the bridge as a whole depending on context, cost, safety and environment constraints. Where appropriate feature lighting of bridges can extend the aesthetic benefits of a bridge throughout a day and make them a positive presence in the night. Lighting can also enhance the safety and passive surveillance around a bridge.

Lighting should be energy efficient, avoid light spill and be easy to maintain. It should also respect the structural qualities of the bridge – accentuating the materials and main structural elements such as piers, arches and girders. That is not to say the feature lighting should not be dynamic and creative. LED lighting systems can be designed to provide both subdued and imaginative effects at different times of the day or calendar.

Bridges showing the dramatic effects of its elements

The structure is a variable depth segment bridge built in balanced cantilever. The pier-up lighting illuminates the piers and the underside of the superstructure. The designers chose to light the piers on either side of the navigation channel and only the ends of the side piers.

Figure 80. – Feature lighting example

4.1.3 The Details

There are four important aesthetic considerations in the detailing of a bridge:

- The aesthetics of the bridge details must be considered as part of the whole bridge design.
- The design of the details should minimize the potential for staining.
- The bridge detail should not impair the view from the bridge.
- Good access for inspections and maintenance should be considered early in the design phase.

Joint and Connections

The joints in bridge structures at the ends of the span or along the superstructure are an opportunity to enhance the bridge design and provide another level of detailed aesthetic interest. Differentiate between bearings and other connections and recognize these in the design.

There is a neat, simple and tight joint between two girders. The potential for staining is minimised and the bearings can be clearly seen for inspection. The relationship with the parapets has also been considered and the girder joint neatly lines up with the joint between the precast parapets.

Figure 81. – Connections of structural components

The design of the bridge abutment should incorporate, in a sensitive attractive manner, access provision for bridge inspections.

Figure 82. – Design of bridge abutment

Bridge Barriers

The design of the bridge barrier can influence views from the bridge, influence the apparent depth of the superstructure and reduce the slenderness ratio. If views and slenderness are to be maximized the bridge barrier should be as transparent as possible which means using bridge rail rather than a full height parapet.

A two rail barrier is better than a single rail barrier in this respect:

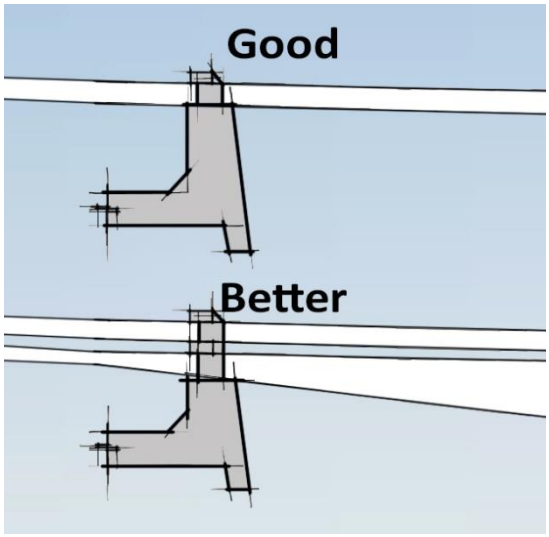


Figure 83. – Design of bridge barrier

Consideration should be given to the transition between the bridge barrier and the road safety barrier. A neat simple connection should be designed.

The post for bridge barriers should generally be perpendicular to the bridge, however on a greater than 4 percent gradient it generally looks better if the posts are vertical.

Tapering the barrier and parapet is a neat way of ending the bridge barrier

Figure 84. – Tapered Barrier

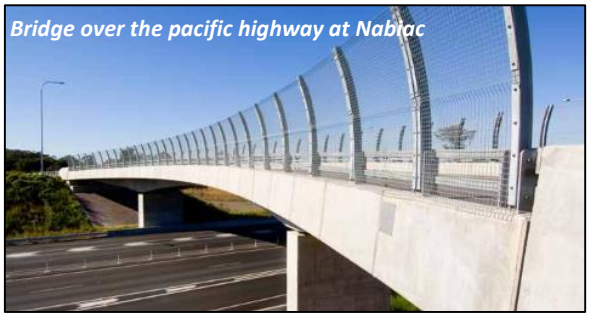
Safety Screens

The safety screen is designed to prevent objects being thrown from the bridge and damaging vehicles or injuring people below. These screens should be an integral part of the bridge design.

There are several aesthetic considerations:

- The bridge screen being a peripheral element to the true function of the bridge should avoid obscuring the superstructure.
- Screen posts should align with the safety barrier posts and be perpendicular to the bridge, not vertical (below 4 percent gradient).
- The screens should extend to the ends of the bridge span.

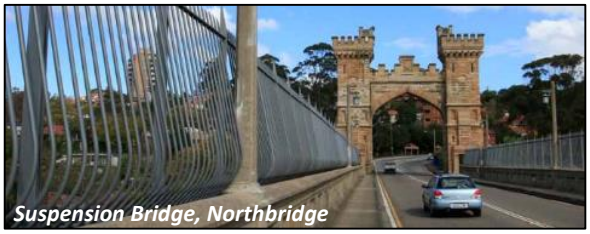
- There should be a neat, elegant transition to the bridge barrier `safety screens; a simple taper or stepped drop in height can help with this, but is not always necessary.



The bridge barrier piers and safety screen posts are aligned and integrated. The bridge parapet is expressed and not obscured. The shaped form of the barrier is considered as part of the whole structural design of the bridge to create a beautiful aesthetic outcome.
Figure 85. – Integrated Safety Screen

Protective fencing

Occasionally, special fencing is needed to protect pedestrians, secure the bridge and make it difficult for people to jump from the bridge. This can be a complex matter, requiring detailed consideration on a new bridge and consideration where and how it is retrofitted on an existing bridge. It is a detail like any other and needs to be approached by designers so that the aesthetics of the existing bridge are not affected and the fence is integrated with the whole design.



A new protective fence on suspension Bridge, Northbridge proved to be a challenging new addition to the historic structure. The style and shape of the fence was carefully considered so that it fitted with the bridge aesthetic and also prevented access over the parapets. A picket type fence proved to be most appropriate with a curved form to both add interest and make it difficult to stand on the parapet.

Figure 86. – Protective Fencing

Signage and Advertising

With the exception of name plates and navigation signs, signage should be kept off bridges if at all possible. They add clutter and complexity and detract from the structure. They also obstruct views from the bridge.

An outdoor advertising site, then the advertising structure needs to be designed as an integrated bridge element with consideration of its visual effect. As a minimum, the soffit of the bridge should not be obscured and the sign should not block views of the key structural elements such as cables, arches and bearings or views from the bridge.

As a minimum, the soffit of the bridge should not be obscured and the sign should not block views of the key structural elements such as cables, arches and bearings or views from the bridge. Signs on bridges should ideally be simplified and related to the bridge design

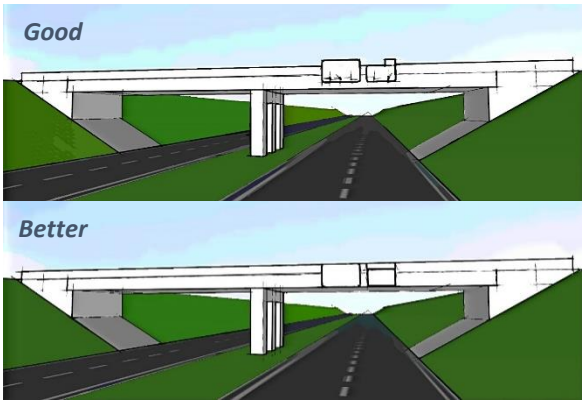


Figure 87. – Integrated Signage on bridge

Lighting Fixtures

Where possible lighting on bridges should be minimized or avoided. Where necessary it should be designed as part of the bridge with supports elegantly designed and well detailed.

The light columns should relate to the other bridge elements in position and form.

Lighting has been used to provide a design feature as well as provide lighting for the road. A closer spaced light fixture is used which introduces a regular rhythm. Its height can be lower and therefore relates to the bridge better than a taller fixture. A special detail was included in the parapet as a structural and decorative element

Figure 88. – Incorporated Lighting Fixtures on bridge

LED lighting in the handrail combined with overhead lighting on the road crossing creates an interesting low maintenance effect.

Figure 89. – Lighting in the handrail

A closer spaced lower height lighting column has been used to emphasise the curve of the bridge and provide a more rational, neater effect at night.

Figure 90. – Closer space lower height lighting

Dranage

Generally, bridge drainage is dealt with on or within the bridge structure and is more of a water quality issue than an aesthetic one. However, where the drainage system is exposed, aesthetics must be considered and the design of the drainage feature must be considered as part of the whole.

When they cannot be hidden, pipes should be neatly aligned to follow the form and lines of girders and piers.

Conveyance of bridge drainage is a design consideration that often has a major visual impact on bridge appearance. If it is ignored, the consequences of having downspouts and other exposed bridge plumbing can seriously damage the appearance of a bridge.

- Work with the roadway engineers to identify potential drainage issues before the project geometry is set. If the bridge length is relatively short, investigate conveying drainage off of the bridge without downspouts.

- If downspouts will be required, investigate their visual impact at the time the deck cross section is developed. Avoid embedded piping as this very often becomes a maintenance issue.

Noise Walls

Where possible avoid the need for noise walls on bridges.

If necessary, noise walls must be considered at the outset of the bridge design process and become an integrated part of the whole bridge design.

In general, transparent panels should be used so that the apparent slenderness of the superstructure is not affected and views or solar.

Ornaments

While attitudes regarding the appropriateness of ornamentation in bridge design have varied over time, some best practices have evolved.

- Avoid using false structure as ornament. Aside from requiring additional costs to construct and maintain, adding false structure will rarely improve a design and is often viewed as extraneous clutter.

- Don't use ornament as "**make up**" to disguise an inappropriate design. The form and composition of an inappropriately designed bridge can rarely be improved by applying ornament. The bridge type should be appropriate to its scale

- If ornament is appropriate, use it sparingly. Less is generally better than more.

Bridge over Thornton Colorado Highway 25

Bridge ends on this crossing over US 36 in Broomfield, Colorado

CHAPTER 5. PARTICULAR CONDITIONS

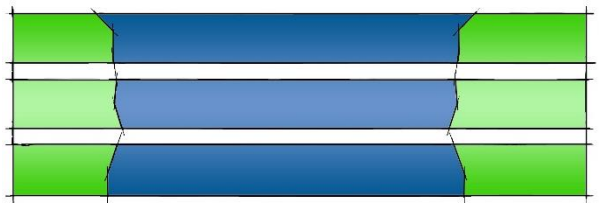
5.1 NEW BRIDGES NEXT TO EXISTING BRIDGES

"The relationship between two bridges, almost side by side spanning the same stretch of water, is like the relationship between two musical instruments playing a duet. The music sounds better if the two instruments are in harmony with each other and keep to the same rhythm and tempo. The two instruments should produce sounds that contrast, in order to create a melody that is more interesting and colorful."
FOSTER AND PARTNERS, IN THE ARCHITECTURE OF BRIDGE DESIGN, 1997

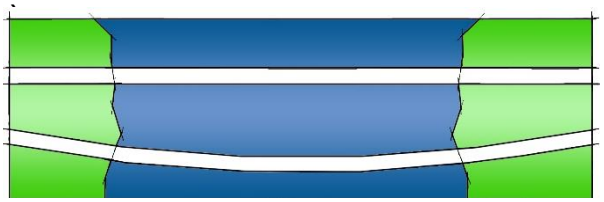
Designing a new bridge next to an existing bridge can be a significant challenge. Competition between structural forms can create clutter and neither bridge can be presented well, irrespective of individual aesthetic value. Alternatively, where structural forms are complementary a memorable landmark can be created where the experience of crossing a bridge is enhanced by the view of an adjacent bridge.

If possible, the new bridge should be located so that the two bridges are seen as separate elements in the landscape and can be designed as separate entities, for example, the different bridges over Sydney Harbour.

This can only be achieved through an appropriate horizontal separation.



Appropriate horizontal separation



Horizontal separation by varying the alignment

Figure 91. – New & Existing Separation

A closer spacing can be achieved by varying the alignment of the new bridge but still at an appropriate distance.

However, in most cases adequate separation cannot be achieved and the new bridge and the existing bridge must be considered as related in aesthetic terms. The following two strategies should then be considered:

- A new design.
- Duplication of the existing design.

5.1.1 A new design

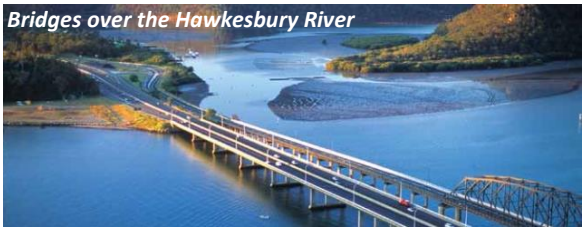
If accurate duplication is not possible an entirely different bridge design should be produced but very importantly, the designs should not compete but be complementary.

- The bridges should either be parallel in vertical and horizontal alignment or curved in symmetry with the existing bridge (The New Iron Cove Bridge in Sydney works well precisely because its alignment is different).

- Consideration should be given to matching the following elements: bridge height, pier spacing and pier alignment.

Where the existing bridge is a distinctive or iconic local or regional asset it is appropriate that the new bridge be as respectful as possible. Whilst the new bridge should be simple and respectful it should be at least as confident and representative of its era as the old bridge.

The Iron Cove Bridge duplication is respectful of the old bridge in its simple appearance and its spans and piers aligning, but also confident and bold in its own right. Its separation from the existing bridge has significantly helped to achieve a good outcome.



The proximity of the bridges over the Hawkesbury River at Brooklyn results in an interplay between the designs. The two bridges are not separate but seen as one visual entity. The old bridge could not be replicated but the new bridge is respectful in terms of matching

Figure 92. – Complementary design of bridges

5.1.2 Duplication of the existing design

This approach tends to be more applicable to modern bridges than older bridges, where technology and safety standards have changed and old design and construction skills lost or expensive to re-learn. The approach is basically to replicate the existing bridge design. It does not need to be exact but at least the following should be addressed:

- Where possible the bridges should be parallel in vertical and horizontal alignment.
- Spans and pier alignments should match.
- Key aspects of the existing bridge such as pier dimensions, girder shapes, abutment locations, and lighting fixtures should be replicated.
- In some cases, details can be copied but this is not essential.

If there are any concerns that the bridge cannot be closely duplicated, then the new design approach should be considered.

The duplication of the Hume highway Sheahans Bridge at Gundagai (left) adopted the existing haunch shape and pier spacing. The materials and details are however different styles but there is a design unity.

On the Alfords Point Bridge, the duplication (right) adopted the bridge form in its entirety.

Figure 93. – Duplication of the Existing design

5.2 MODIFICATIONS AND ADDITIONS TO HERITAGE BRIDGES AND BRIDGES OF CULTURAL VALUE

"It's not good because it's old – it's old because it's good." ANON

Bridges of historic value come under several categories: listed heritage bridges, bridges that may become listed and bridges that have heritage or cultural value irrespective of listing. The principles following apply to all.

There are three objectives to be adopted:

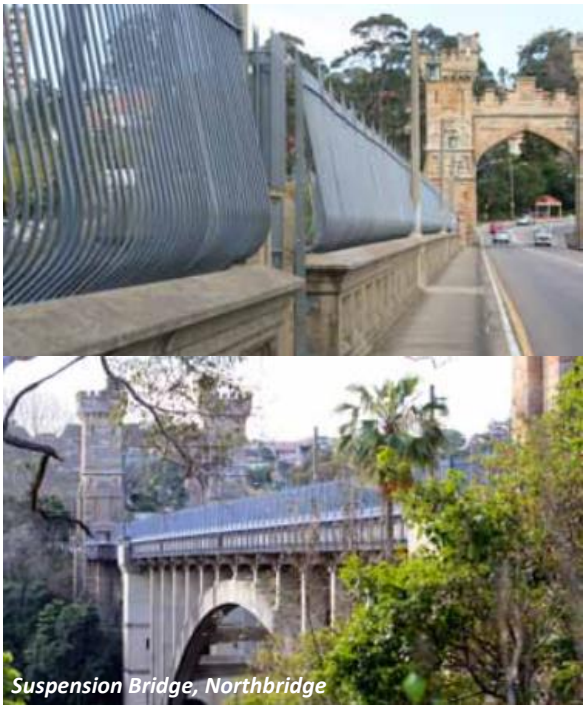
- Distinguish new work from old.
- Respect the setting.
- Respect the character of the heritage or culturally important bridge.

5.2.1 Distinguish new work from old

New work must be distinguishable from the old bridge. There are several means to achieve this:

- By date stamping the new work so that it is identifiable, particularly where materials and form are carefully duplicated, such as new timber trusses.

- By using new modern materials and forms to fit in sensitively, but differentiate from the old elements and forms of the existing bridge.



Suspension Bridge, Northbridge: inside and outside views of the retrofitted safety screen. This is a new expressive form which complements the character of the old bridge.

Figure 94. – Complementing the character of the old bridge

- By keeping a clear physical distance and sense of separation with the old bridge when building a bridge duplication.

- By avoiding pastiche (false imitation or mixture of styles) when designing a bridge duplication or connection to an old bridge: any new elements or bridge duplication should be true to the materials and technology of the time of modification and minimal in extent.

In this adaptive re-use of an old bridge, the wrought iron lattice truss bridge at Redbourneberry was duplicated and incorporated into an adjacent cycleway. The angle span at the far end was built as part of the duplication. Its design however is pastiche since it attempts to imitate the existing truss. Not only is this false and confusing but it jars with the new bypass.

Figure 95. – Adaptive re-use of an old bridge

- It is essential that the principle of distinguishing new from old is not abused by making the new work visually obtrusive and at odds with the character of the old.

- By providing signage an interpretation where appropriate.

5.2.2 Respect the setting

Heritage is part of place. Bridges of heritage significance often define and sometimes are an icon within the community. They are often an important visible element. Preservation of, modifications to, and duplication of, such bridges should respect their setting by:

- Preserving the curtilage, in this instance, the envelope around, below and above the bridge necessary to protect its heritage or cultural value. The bridge and its curtilage form a spatial and aesthetic entity, and may also be part of a listed heritage precinct. Therefore, keep the curtilage as intact as possible and ensure that design changes of the bridge are sensitive to the character of that curtilage. Consider that the curtilage is also part of a wider setting.

Stonequarry Creek Bridge at Picton, which spans a 'gorge' near the town, dramatizes the setting.
Figure 96. – Preserving the curtilage

5.2.3 Respect the character of the heritage or culturally important bridge

The character of the old bridge should always be respected – whether duplicating, retrofitting or modifying a bridge of heritage significance. This can be achieved in different ways, depending on the scale of work to be carried out:

Duplicating a bridge of heritage significance

- Respect the old bridge through adequate physical separation.
- Where possible, keep a sense of the scale of the old bridge, through protection of the major elements in its curtilage and the view points to the bridge.
- Where possible match the profile of the old bridge and keep the rhythm of the piers and uprights.
- Use form, materials and colour that complement, but do not visually overpower.

Signage and interpretation signboards, in the agreed common style suitable for heritage bridges.

Signage can also be used to explain changes to other culturally important bridges.

Figure 97. – Good example of signage

Adding major new elements such as pedestrian walkways

- If external to the structure, it may be best to add new elements on the opposite side of the most historic and locally valued vistas to the bridge.

- Respect and match, where possible, spacing, rhythms and proportions of the old bridge.
- Use similar materials or materials that complement the old.

Minor modifications

- Consider the relationship of modifications to the scale and character of the bridge, other elements and materials, the rhythm of existing uprights, and colour.

- Carry out a visual analysis to ensure that the bridge modification fits into its built, natural and community context and provides a well-designed solution which minimises adverse visual impacts from all critical viewpoints.

Repainting

- Keep painting up to date to prevent prolonged attack on the raw material, protect the bridge and its elements in the long term and maintain the aesthetic quality of the bridge.

- Truss bridges are best repainted in white which was the original color used. This gives them visual identity as a type and consistency as a family of bridges across the state. Such a strategy would be cost effective.

5.3 PEDESTRIAN BRIDGES

5.3.1 Opportunities and constraints

There are a number of important differences between pedestrian and vehicular bridges that influence design:

Design flexibility

Pedestrian bridges carry lighter loads than vehicular bridges: this allows the designer to exploit greater flexibility in the shape and proportion of the bridge, within a reasonable budget, which can lead to great variety and character.

Views

Pedestrians and cyclists spend more time on a pedestrian and shared path bridge than a traffic bridge: therefore the view from the bridge takes on added significance and detail and materials are more closely appreciated.

Ramps

Pedestrian bridges have ramps. Ramp design can be innovative but should not dominate views or detract from the expression of the essential element of the bridge – its span. This is especially the case when ramps are folded or coiled at the ends of the structure.

Safety screens

Pedestrian bridges invariably require safety screens. In the design of these it is important to avoid a caged feeling when bridges are narrow.

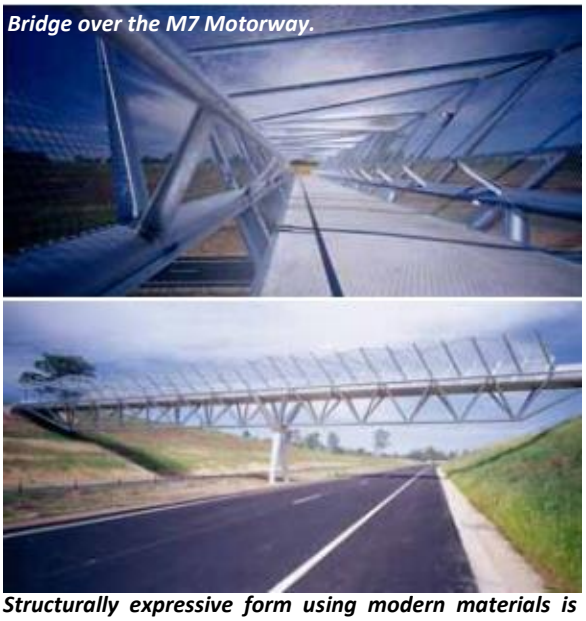
Lifts and stairs

Where the site is very constricted, or ramps would be excessively long, lifts could be provided. It is important to locate lifts carefully and design them as part of the whole structure. The same applies to the use of stairs to access a pedestrian bridge.

Design flexibility

- Consider how a bridge can reflect local character, provide a milestone on a journey, forma gateway to an area, create a focal point or celebrate something.

- Depending on context, the rules normally applicable to road bridges may be stretched when using cable stay, truss, arch and suspension which are suitable for light loads.



Structurally expressive form using modern materials is evident in this space-frame.

Figure 98. – Modern design of pedestrian bridge

- Consider the use of lighting to both emphasize the form of the bridge and distinguish it by night – within the constraints of cost, surrounding properties and adjacent light fixtures.

5.3.2 Views

- Provide adequate space on the bridge to allow stopping and viewing without significantly interrupting pedestrian and cycle movement.
- Avoid hidden or secluded spaces which, if present, will make it more difficult to monitor personal safety.
- Advertising and signage on or near a bridge is not desirable but, where it is considered appropriate it should not obscure the form of the bridge, the surveillance of pedestrians or views from the bridge
- On girder bridges with lift shafts consider an open end to the bridge rather than terminating it at the lift shaft. This will allow views out from the bridge and reduce the sense of enclosure
- Consider the use of lift shafts with at least one glass wall to add a feeling of surveillance and provide views as the bridge is ascended.

5.3.3 Ramps

If ramps are needed, now or in the future, for access and connection to surroundings the following guidelines should be considered:

- Attempt to locate the bridge where the ramp can be its shortest possible length.

- Minimize the extent of the ramp by using natural or new landform, for example, crossing a road in cutting avoids ramps entirely.

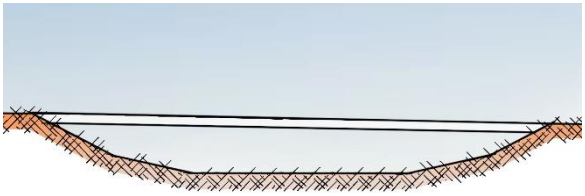


Figure 99. – Adopting the natural landform as a base of ramp

- Where a road is at a grade the approach ramps on the uphill side can be relatively short.

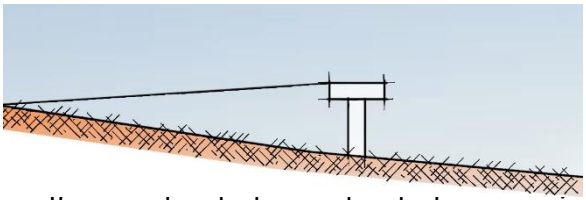


Figure 100. – Consideration of site gradient

- It an elevated constructed ramp is required the design must be carefully considered due to its visual prominence. The design of ramp and bridge should be integrated and unified in appearance.

- Use planting to integrate ramps with their surroundings and reduce their visual impacts.

- Connections between ramp and superstructure must be as simple and seamless as possible.

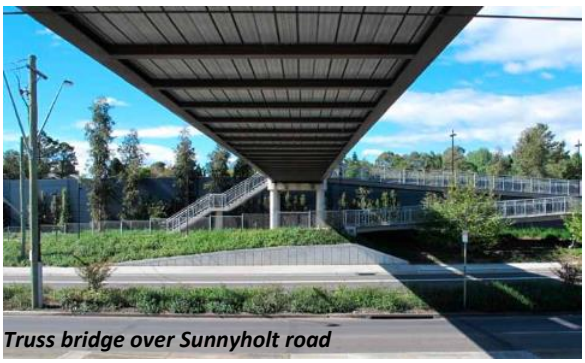
- Ramp design and geometry should be simple and thoughtfully done, for example, compact spirals are sometimes preferable to long switchbacks.

- Consider the aesthetic impact of standards relating to ramp slope and frequency of landings (required for disabled and cyclist use) which may increase ramp length and interrupt the desired smooth lines of the structure. It may be necessary to obscure the landings by a higher than necessary parapet wall.

- Where possible and earth works allow, consider visually separating the ramp and span, by integrating the ramp into the adjacent land form.

Earthworks have been utilised to cost effectively create the landscaped ramp to the Faulcon bridge over the Great Western Highway.

Figure 101. – United of Ramp and site gradient



The ramps on this truss bridge over Sunnyholt road have been designed to match the materials and form of the truss. Planting has been used to help fit the ramps into the landscape (compare pictures taken three years apart) and a neat two post pier with cantilevered brackets simplifies the structure. The access to the bridge passes through a non-structural extension to the truss form which provides a neat, substantial, connection between truss and ramp/ stairs. The use of closed hollow sections would have been better than open steel sections from a maintenance point of view as open sections collect debris and dirt leading to premature breakdown of protective coating systems.

Figure 102. – Harmonization of ramp, superstructure and its setting

5.3.4 Safety Screens

In terms of comfort in using the bridge the following should be considered:

- When required it is preferable to have safety screens as simple fences rather than a cage.

- The need for the cage, and a caged effect, should be avoided. It provides a platform for vandal access and creates an oppressive feeling of enclosure.

- If a closed system cannot be avoided then the design and shape of the cage should ensure that the experience of crossing the bridge is not oppressive.

- Feature lighting should be considered to make the crossing attractive and well lit.

The absence of a cage creates a more open welcoming space.

It gives an open feel even through it is caged. It is suited to the bridge and is well designed.

Figure 103. – Good examples of safety screens designed

5.3.5 Lifts and stairs

- Where space is limited or lifts stairs are required their design should be simple and compact and appear as light and slender as possible.

- Lifts should, where possible, be part of the supports of the girder. Combining lift shaft and pier creates a simpler, more refined, structure and can reduce costs but maintenance needs to be considered.

- The use of at least one transparent glass wall should be considered. This reduces the visual bulk of the lift, provides views and gives a feeling of good passive surveillance to and from the surroundings.

The form and fencing, colours and use of the lift shaft as a pier are visually strong but the bulky pier support detracts from this bridge

Transparent lift shafts can be attractive and feel safer due to the passive surveillance they allow.

Figure 104. – Lift and stair

5.4 RAILWAY BRIDGES

There are a number of aesthetic principles applicable to rail bridges:

- A railway bridge should express its purpose and easily recognized as such.

- Railway bridges, in accommodating the heavy weight of trains, should generally appear strong and substantial.

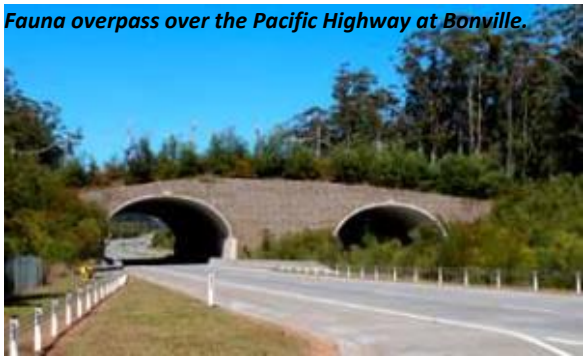
- Railway bridges need to be stiffer than road bridges for stability in terms of deck vibration and shock loading which generally rules out suspended structures.

- Constraints on the vertical and horizontal alignment of the railway, create flatter straighter structures than road bridges.

- Railway bridges necessarily have a heavier appearance in their design with deeper girders, bulkier columns, and shorter spans. Consequently, close attention needs to be given to their proportion and refinement.

5.5 FAUNA OVERPASSES

These are bridges, but have a different aesthetic to vehicular and pedestrian bridges. In general, they have a strong connection to the landscape and need to emphasize this through their materials and earthworks. There is no need for parapet or typical pier forms but the elements need to be carefully considered so that a good aesthetic outcome is achieved.



Arched forms and gabions give an impression of strength and an ecological/landscape purpose.

Figure 105. – Fauna Overpass

5.6 ART AND BRIDGES

Well-designed bridges and the more iconic structures are often seen as sculptural artefacts in the landscape with artistic qualities in their own right.

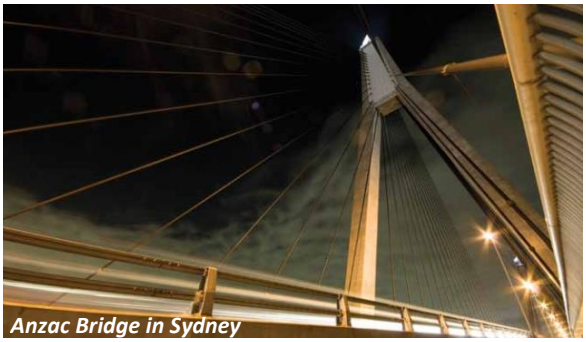
On occasion designers integrate art as an element into the design of bridges.

For example, piers can be designed with a texture or motif embedded into the structure. Painting can be used to provide an artistic image or color a bridge element in a striking way. Safety screens can be designed with motifs and patterns layered into the mesh. Lighting can be used with the bridge to create an artistic effect.

The Aspire sculpture in ultimo brightens up a dark, unattractive under bridge space. Art can improve poor spaces but it would be better if the bridge design and land use planning avoided the need for such spaces in the first place.

It was conceived as a sculptural piece along a corridor. Such an approach should be used circumspecifically and not be the norm.

Occasionally the detailed concrete work on older bridges leaves an opportunity for paintings. These RMS bridge abutments in the rocks in Sydney have been painted in historic photographic images which have received a heritage award from the National trust.



The bridge designer, Robert Maillart, regarded structurally expressive bridges as pieces of art in their own right.

Figure 106. – Example of arts in bridges

ANNEX A

	Department of Public Works and Highways	Issue Date:	23 May 2017
	Bureau of Design	Doc. Code:	DPWH-BOD-BrD-QMSF-14
	BRIDGES DIVISION	Revision No.:	0
	Checklist for Aesthetic Design of Bridges	Page No.:	Page 1 of 4

Project Name : _____

_____

_____

Implementing Office : _____

Consultant/Contractor : _____

Proposed development				**Is there an existing theme in the area?**			
☐	New			☐	Yes, *specify*		
☐	Replacement			☐	None		
☐	Appurtenances improvement						
☐	Structural improvement: ( ) Widening, ( ) Retrofitting *(use DPWH-BOD-BrD-QSMF-11 Field Inspection Form)*			**Is the bridge part of a larger project?**			
Setting				☐	Yes, *specify*		
☐	Urban			☐	No		
☐	Rural			**Are there clearance envelope requirements?**			
Nearby land use				☐	Yes, *specify*		
☐	Residential	☐	Industrial	☐	Minimum span(m)		
☐	Natural landscape	☐	Agricultural	☐	Vertical(m)		
☐	Tourist destination	☐	Others, *specify*	☐	Horizontal(m)		
☐	Commercial			☐	Others, *specify*		
Type of traffic				☐	None		
☐	Pedestrian			**Communities (LGU) attitude towards the bridge**			
☐	Highway			☐	Historic		
☐	Highway & pedestrian			☐	Traditional		
☐	Others, *specify*			☐	Forward-looking		
Crossing condition				☐	Others, *specify*		
☐	Highway, Width(m)			**Studies done**			
☐	River, Width(m)		Depth(m)	☐	Feasibility study	☐	Hydraulic analysis
☐	Open Water, Width (m)		Depth(m)	☐	Envi. assessment	☐	None
☐	Others, *specify*			☐	Envi. impact study	☐	Others, *specify*
The bridge is best viewed at				**Cost limitations**			
☐	Superstructure			☐	Yes, *amount (php)*		*source*
☐	Substructure			☐	None		
☐	All			**Agencies/Parties involved**			
☐	Others, *specify*			☐	Community	☐	Businesses/Individuals
Is the nearby land use historical?				☐	Gov't agencies	☐	Others, *specify*
☐	Yes, *specify*						
☐	No			**Required data**			
Architectural features around the area				☐	Topographic survey		
☐	Building type, *specify*	☐	Ornament	☐	Hydrographical survey		
		☐	Color	☐	Hydrologic and hydraulic analysis		
☐	Form, *specify*	☐	Others, *specify*	☐	Geotechnical/Soil report data		
From which viewpoint the bridge will be seen				☐	Historic review *(For replacement of historical bridge)*		
☐	Street/Road/Highway	☐	Bridge	☐	Other data as may be necessary		
☐	Waterways	☐	Buildings				
☐	Recreational areas/ Open areas	☐	Others, *specify*				

I. FINDINGS/OBSERVATIONS:

II. COMMENTS:

III. RECOMMENDATIONS

PREPARED BY:

NAME OF INSPECTOR
Designation, Bridges Division

NAME OF INSPECTOR
Designation, Bridges Division

NOTED:

NAME
Chief, Bridges Division

IV. SKETCH:

V. **PHOTOGRAPHS:**

Prepared by:	Reviewed by:	Approved by:
NAME Chief, Bridges Division	**NAME** Director III	**NAME** Director IV

LIST OF FIGURES

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