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

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NBCDO MEMORANDUM
CIRCULAR No. 01)
Series of 2015 03.IV.15)
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SUBJECT: GUIDELINES AND IMPLEMENTING RULES ON EARTHQUAKE RECORDING INSTRUMENTATION FOR BUILDINGS

TO : All Building Officials
City / Municipal Engineers and Others Concerned

In the interest of the service and to ensure compliance of all concerned to the provisions of **"Section 105.2 – Earthquake Recording Instrumentation of the National Structural Code of the Philippines (NSCP) and Section 102 of the National Building Code of the Philippines, otherwise known as P.D. 1096",** it is hereby directed that the **GUIDELINES AND IMPLEMENTING RULES ON EARTHQUAKE RECORDING INSTRUMENTATION FOR BUILDINGS** approved by DPWH as part of the IRR of the National Building Code, shall be adopted immediately. The memorandum dated July 15, 2013 issued by then NBCDO Acting Executive Director Emmanuel P. Cuntapay, is hereby superseded.

All Building Officials must submit to the undersigned a quarterly report, Attention: The National Building Code Development Office, for monitoring of compliance to the said Guidelines and Implementing Rules.

For strict and immediate compliance of all concerned.

ROGELIO L. SINGSON
Secretary

Department of Public Works and Highways
Office of the Secretary
WIN5V14952

Encl.: (1) Section 105.2 of NSCP, 2010, 6th Edition
(2) Section 102 of the National Building Code of the Philippines
(3) Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings
(4) Memorandum dated July 15, 2013

7.5.1 JVD/GRV

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GUIDELINES AND IMPLEMENTING RULES ON EARTHQUAKE RECORDING INSTRUMENTATION FOR BUILDINGS

I. INTRODUCTION

Technology on building instrumentation for seismic monitoring has improved tremendously in the past decade. The purpose of the Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings is to provide information on the specifications and uses of earthquake recording instruments for buildings as provided in Section 105.2 of the National Structural Code of the Philippines 2010 Volume 1, 6th Edition (NSCP 2010).

Further, the Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings provide earthquake instrumentation schemes for certain buildings to record building response during major seismic events for subsequent analysis and provide immediate alarm annunciation to ensure that the building occupants can be moved to safety as per the Building Emergency Evacuation Plan (BEEP) of the National Disaster Risk Reduction Management Council (NDRRMC), which is the basis for the guidelines of earthquake drills in the Philippines.

Installation of earthquake recording instruments was first required in the National Structural Code of the Philippines 1992, 4th Edition, wherein structural engineers were only interested in the strength design capacity on the buildings based on seismic parameters provided in the Uniform Building Code (UBC) of the United States, referral code of the NSCP. Structural code developers started to recognize the importance of not only strength but serviceability and performance as well. The experiences from the 1994 Northridge Earthquake in the US and the 1995 Kobe Earthquake in Japan gave credence to these considerations. DPWH therefore deemed it necessary to improve our understanding of the building response based on real seismic event from local earthquake generators by enforcing placement of earthquake recording instrumentation for buildings as the NSCP provision was reiterated in 2001, 5th Edition, as well as in the latest 2010, 6th Edition.

The NSCP 2010 states that *"Unless waived by the building official, every building in Seismic Zone 4 over fifty (50) meters in height shall be provided with not less than three (3) approved recording accelerographs. The accelerographs shall be interconnected for common start and common timing."*

The Philippines needs to have its own earthquake baseline data for validating the seismic design parameters used during and future structural design of buildings, in order to support earthquake disaster mitigation efforts. Hence, the waiver stated in the NSCP 2010 is temporarily suspended until such time that considerable sets of adequate earthquake records have been obtained for various specified types of buildings and relevant provisions in the NSCP have been amended. However, for the purposes of the Earthquake Recording Instrumentation for Buildings, the Department of Public Works and Highways has identified buildings in Table 1 to be necessarily installed by the said seismic monitoring system.

II. **OBJECTIVES**

Section 102 of the National Building Code of the Philippines, otherwise known as PD 1096, states that: "It is hereby declared to be the policy of the State to safeguard life, health, property, and public welfare, consistent with the principles of sound environmental management and control; and to this end, make it the purpose of this Code to provide for all buildings and structures, a frame work of minimum standards and requirements to regulate and control their location, site, design, quality of materials, construction, use, occupancy, and maintenance".

In conformance with the said Section 102 and as provided in the NSCP 2010, these Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings were developed to primarily safeguard lives, and for clear understanding of the actual dynamic behavior of buildings/structures under earthquake loading and confirm the structural design parameters used or to be adopted in compliance to the specific provisions of the NSCP. The recorded data will be used to improve the safety provisions of local structural code there by reducing loss of lives and limbs as well as properties during future damaging earthquakes, and to improve our understanding of the behavior and potential damage of building under the dynamic load of earthquakes. This will be achieved through the development of an integrated network that measures the earthquake source, transmitted ground motions structural response. These measurements will be correlated with observations of structural response to evaluate the current design and construction practices in order to minimize damage to buildings during future earthquakes. The response data from several buildings in a particular area or several areas will also be used as the basis for the government's earthquake disaster mitigation/remedial and rehabilitation strategies including its emergency response and relief operations programs.

The seismic recording and instrumentation machine must be used to set off alarms at specified intensity levels triggering real-time alarm information and may also trigger automatic switch off for utilities such as gas lines, electric power lines and elevators as may be prudent in case of such high intensity earthquake. The recorded

data are also important parameters for buildings' safety re-evaluation and resumption of occupancy including post-earthquake evaluation of buildings. These safety alarm systems have been proven worldwide that they have mitigated secondary consequences of earthquake disasters and have saved countless of lives, or at least minimize the loss of lives.

III. DEFINITION OF TEMS AND ACRONYMS

ACCELERATION. The rate at which the velocity of a particle with time as recorded by seismic accelerograph (expressed in Gal or cm/sec squared).

ACCELEROMETER. A sensing equipment that measures seismic acceleration and pass the information to the accelerograph for further processing and conversion to the intensity, velocity and displacement.

ACTIONS (GROUND MOTION). A general term including all aspects of ground motion, namely acceleration velocity and displacement from an earthquake or other energy source.

BANDWIDTH. The frequency range that the accelerometer operates, measured in Hertz (Hz).

CERTIFIED CIVIL/STRUCTURAL ENGINEER. A civil engineer with special qualifications to practice structural engineering with appropriate training in seismic instrumentation to be conducted by ASEP in coordination with DPWH.

CHANNEL. A path along which information (as data or voice) in the form of electrical signal, passes; a band of frequencies of sufficient width for a single radio or television communication.

CLUSTERED BUILDINGS. A group of buildings (enumerated in Table 1) built close together having similar design, construction, occupancy and function on a sizable tract of land. Each building should be treated separately.

DAMPING. The energy dissipation properties of a material or system under cyclic stress.

DISPLACEMENT. The measured distance traveled by a particle from an initial position.

ENVIRONMENT. The aggregate of surrounding things, conditions, or influences that may affect the operability of an instrumentation device such as accelerograph, velocitimeter, etc.

ERI. Earthquake Recording Instrumentations

FTP. File Transfer Protocol

GB. Giga Byte

GALS. A unit of ground acceleration with conversion as follows: 1 gal = 1 cm/square s, 981.5 gals = 1g where 1 g = 9.815 m/square s (NSCP Sec. 208.2)

g. Acceleration due to gravity equals to 9.81 m/sec^2 or 32.2 ft/sec^2.

INTENSITY. A descriptive scale (such as Philippine Intensity Scale, Modified Mercalli Intensity Scale and Shindo Scale) that indicates the local effects and potential damage produced by an earthquake on the Earth's surface as it affects humans, animals, structures and natural objects such as bodies of water.

IP 67. The Ingress Protection rating system is a classification system showing the degrees of protection of the instrumentation device from solid objects and liquids. The first number refers to the solid objects, normally dust. If the first number is 0, there is no protection provided. A number 5 refers to limited protection against dust. The number 6 is for total protection against dust. The second number of the IP rating system refers to protection against immersion between 15 cm to 1m for 30 minutes.

IP. Internet Protocol

MICROTREMORS. A low amplitude ambient vibration of the ground caused by man-made or atmospheric disturbances.

NATURAL FREQUENCY. The number of wave cycles per second which a system tend to oscillate in the absence of any driving or damping force.

NTP. Network Time Protocol.

PEAK GROUND ACCELERATION (PGA). The maximum ground acceleration at a specific location for time interval.

PERIOD. The time interval required for one full cycle of wave.

REFUGE AREA. An area inside a building, where people evacuate or assemble during a disaster or emergency i. e, fire, which is appropriate for other events but not for earthquake.

RESPONSE SPECTRUM. A plot of the peak or amplitude of steady-state response (displacement, velocity and acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock.

RMS. Root Mean Square

SEISMIC ACCELEROGRAPH. Accelerograph that records the acceleration of particles on the surface of the earth as a function of time, which is called an accelerogram. The accelerograph generally records three (3) mutually perpendicular components of motion in the vertical and two (2) orthogonal horizontal directions.

SEISMOGRAPH. A generic term used to describe a recording device that detects ground motion due to earthquake. Typically, this will comprise a recorder and a seismometer, which is a sensor that detects the velocity of the ground. Usually very sensitive than accelerograph and will easily detect a blast at a range of 100 km.

SFTP. Secure FileTransfer Protocol

SIR. Seismic Instrumentation Room

STRONG M0TION. Ground motion of sufficient amplitude to be of interest in evaluating the damage caused by earthquakes or nuclear explosions.

TCP. Transmission Control Protocol

TIME HISTORY. The sequence of values of any time-varying quantity (such as a ground motion measurement) at a set of equal time intervals.

TRI-AXIAL. The characteristics of an accelerometer to provide ground shaking sensing in three (3) dimensions commonly known as x, y, z (i.e., transverse, longitudinal, and vertical).

VELOCITIMETER. An instrument used to measure velocity of a particle.

VELOCITY. A measure of the rate of motion of a particle expressed as the rate of change of its position in a particular direction with time.

IV. EARTHQUAKE RECORDING INSTRUMENTATION REQUIREMENTS

1. Application

The requirements of Earthquake Recording Instrumentation (ERI) shall apply to all existing buildings listed in Table 1, located in Seismic Zone 4 (entire Philippines except, Palawan and Tawi-Tawi located in Zone 2), prior to issuance of Certificate of Occupancy. Building Permits shall only be issued on buildings required for seismic instrumentation when site or location of Seismic Instrumentation Room (SIR) has been indicated or incorporated in the plan.

Table 1 shows the types of buildings required to be installed with earthquake recording instrumentation located in cities and municipalities within 200-km radius from a Type A faults as specified in the NSCP 2010 and as indicated from the active fault maps issued by the Philippine Institute of Volcanology and Seismology (PHIVOLCS). For buildings located in cities and municipalities outside of the 200-km radius, only the installation of a single accelerograph may be placed at the ground floor/lowest-basement level.

For clustered buildings with completely similar design and construction, it should follow the same requirement for a single building.

2. Instrumentation of Selected Building

All owners of existing buildings listed in Table 1 shall provide accessible seismic instrumentation room for the installation of appropriate earthquake recording instruments. Location of said instruments shall be determined by a Civil/Structural Engineer.

For proposed buildings, the Civil/Structural Engineer shall include the layout, installation requirements, and location of the instrument in the structural plan submitted for building permit purposes.

The actual installation of the instruments shall be under the supervision of the Certified Civil/Structural Engineer verified and confirmed by the Building Official.

For existing buildings, the installation and operation of these instruments shall form part of the requirements of the Annual Certificate of Inspection issued by the Building Official.

Owners of existing buildings with already installed Earthquake Recording Instrumentation (ERI) shall be notified by the Building Official to comply with these guidelines accordingly, in case the specifications of the ERI installed do not conform as prescribed in these guidelines. However, the jurisdiction of the annual inspection shall be limited only on reporting the existence of the seismic instruments in a building, detailed installation number, latest certification of the local building official and a narrative physical condition as it was found by the Building Official.

For newly constructed buildings, the installation of these instruments shall form part of the requirements for Certificate of Occupancy issued by the Building Official, indicating there on Earthquake Instrument Notification Procedures in Compliance to these guidelines and rules.

TABLE 1. SEISMIC INSTRUMENTATION REQUIREMENTS

TYPE/HEIGHT OF BUILDING	LOCATION	REQUIREMENTS
GOVERNMENT BUILDINGS A. Hospitals, schools and other buildings above fifty (50) meters in height	At least 3 accelerographs located at: 1. Ground Floor/lowest Basement; 2. Middle Floor, and 3. Floor below Roof	ERI in compliance with this IRR
B. Hospitals with fifty (50)-bed capacity or more and schools with twenty(20) classrooms or more but not than three(3) storeys	One Accelerograph installed at Ground Floor/Lowest Basement	ERI in compliance with this IRR
C. Provincial/City/Municipal Halls and Buildings	One Accelerograph installed at Ground Floor/Lowest Basement	ERI in compliance with this IRR

TYPE/HEIGHT OF BUILDING	LOCATION	REQUIREMENTS
PRIVATE BUILDINGS A. Buildings above fifty (50) meters in height	At least 3 accelerographs located at: 1. Ground Floor / Lowest Basement 2. Middle Floor, and 3. Floor Below Roof	ERI in compliance with this IRR
B. Hospitals with fifty (50)-bed capacity or more and schools with twenty (20) classrooms or more but not less than 3 storeys	One accelerographs installed at the Ground Floor / Lowest Basement	ERI in compliance with this IRR
C. Commercial buildings with occupancy of at least 1,000 persons or gross floor area of at least 10,000 square meters.	One accelerographs installed at the Ground Floor / Lowest Basement	ERI in compliance with this IRR
D. Industrial buildings with occupancy of at least 1,000 persons and gross floor area of at least 10,000 square meters	One accelerographs installed at the Ground Floor / Lowest Basement	ERI in compliance with this IRR

Blueprint of the as-built plans of the buildings;

3. Additional Requisite Information of Buildings to be Instrumented

It is necessary to establish a baseline data to make effective use of the records to be collected from the accelerograph installed in the building. The following information are required:

a. Blueprint of the as-built plans of the buildings;
b. Structural design calculations/computations;
c. Dynamic analysis (mode shapes and frequencies), as used in the design calculations, if available, forced vibration test results, and ambient vibration test results; and,
d. Comprehensive sub-surface soil exploration and investigation report.

V. STANDARD SPECIFICATIONS

1. The following are the minimum specifications for Earthquake Recording Instruments (ERI) to be used for buildings listed in Table 1:

a. Accelerogaph

- Seismic qualified as tested by recognized international testing laboratory
- Stores seismic activity information as gathered by the attached accelerometer
- Equipped with fault detection
- Provides real-time alarm information (either audio, visual or both) during an earthquake event.
- Equipped with internal battery back-up power to ensure continuous operation during a power fluctuation.
- Where applicable, it may include:
  - Minimum design life: 10 years and should be demonstrated and certified to have a 40,000-hour (minimum) mean time between failures
  - Minimum of three components (vertical, longitudinal and transverse)
  - Natural Frequency: Above 50 Hz
  - Damping: Approximately 60-70 percent critical
  - Sensitivity: 2g
  - Bandwidth: DC to 100 Hz
  - Environment: IP 67

b. Recording

- Sampling Frequency : Minimum of 100 samples per second
- Time: From at least 20 seconds before the ground shaking begins until 30 seconds after the last triggering level motion
- RMS Noise: System noise shall be less than 40 µg measured over 0-30 Hz.
- Media : Memory Card
- Continuous Recording : capable of continuous recording
- AD Converter : 16 bits

c. Timing

- Interval: Half a second or less
- Accuracy: Plus or minus 0.2 second per 100 seconds
- Type : GPS or NTP Server

d. Triggering (As applicable)

- Method: Pendulum or other device using earthquake motion as an exciting force
- Level: Accelerograph: 0.5 to 100 gals nominal velocitimeter: 5 µm/s to 1 mm/s
- Time: Full operation of accelerograph/velocity in not over 0.1 second after activitation.

e. Power

- Battery maintained by charger

f. Communication

- Ethernet: 10 base –T or 100 base-TX
- Protocol: TCP/IP FTP/SFTP

2. Records. To maintain continuous recording of data, a media for recording must be used at all times.

3. Battery Inspection. The accelerograph shall be tested with any charge device disconnected from an electric power source.

VI. LOCATION AND INSTALLATION OF THE INSTRUMENTS

1. General

The instrument shall be located so that access by qualified technical personnel is maintained at all times and is unobstructed by room contents. A sign stating "MAINTAIN CLEAR ACCESS TO THIS INSTRUMENT" shall be posted in a conspicuous location. *No instrument shall be located in refuge area.*

The preferred locations of the instruments are in small, seldom used rooms or closets near a column (in a vertically-aligned stack), with adequate space to securely mount the instrument and an approved protective enclosure attached securely to the floor. The location shall be marked on the submitted structural and architectural floor plans and properly approved.

2. Buildings with Three (3) or More Accelerographs

For buildings with 3 or more accelerographs, the instruments shall be located in the ground floor/lowest basement, middle floor, and floor below the roof. The locations of the instruments are selected to provide the maximum information of the building response from a major earthquake. Such information would form part of the valuable data in understanding the building's behavior during major seismic event.

3. Orientation of Instruments

All instruments shall be installed with the same orientation relative to the building, with the orientation chosen such that the reference or long dimension of the instrument is aligned with a major axis of the building. The orientation of the instruments shall be clearly marked on the submitted structural and architectural plans. The owner/supplier shall certify that the instruments are oriented as per plan and confirmed by the concerned Building Official.

VII. DATA RETRIEVAL AND INTERPRETATION

Immediately after the occurrence of magnitude 6 earthquake or greater, the Building Official shall require the owner to retrieve the data and to have the data interpreted by a Certified Civil/Structural Engineer. The data and interpretation shall be submitted by the Owner to DPWH for storage, post-earthquake safety evaluation of the buildings and emergency response demands through the concerned Building Official.

VIII. DATA STORAGE AND ARCHIVING

Data storage and archiving shall be at DPWH Central Office or other data centers designated by the DPWH. The ASEP, upon written request to the DPWH, shall be provided by the said data.

IX. CERTIFICATE OF INSTALLATION OF EARTHQUAKE RECORDING INSTRUMENTATION

Upon compliance of the building owners to these guidelines and implementing rules on earthquake recording instrumentation, the Building Official shall issue a Certificate of Installation of Earthquake Recording Instrumentation. The Certificate must be posted in a conspicuous place, properly protected/secured in the ground floor lobby of the building as well as at the site of each instrument.

X. PROHIBITION

The mixing/combination of the seismic equipment's peripherals and parts with other brands or maker must not be done because these systems and parts are not inter-operable(or if they are, it diminishes its accuracy) and will definitely contribute to the dysfunctionality of the machine in time.

XI. TESTING, INSPECTION AND COMMISSIONING

Each component of seismic monitoring system shall be tested individually and as a complete system for proper functioning of all operational features. Only test equipment from company with international testing certification shall be allowed to make the testing. Only calibrated results shall be subjected to commissioning and acceptance, and shall qualify towards the issuance of the necessary permits by the Office of the Building Official. Test results must be signed by the respective suppliers and shall be submitted to the Building Official, as a requirement for the certification of the Building Official who will commission the instrument.

The owner of the building shall be responsible for the protection and maintenance of the site of the ERI as prescribed in this IRR.

Building Owner, Building Official, and Supplier shall inspect, test, and commission the seismic monitoring system together to ensure that the systems are in proper operational condition and comply with the requirements of these guidelines.

XII. SUPPORT AND MAINTENANCE

The seismic monitoring system shall have a maintenance clearance as per the requirement of the National Structural Code of the Philippines under Section 105.2. "Maintenance and service shall be provided by the owner of the building."

The supplier shall provide guarantee that the system shall have a maintenance period for at least 10 years.

For the service period, the maximum service interval is one year. The three Recording accelerographs shall be integrated together to function in unison that a failure in one unit shall not hinder the progress of the entire building seismic monitoring system. The accelerograph shall be equipped with fault detection and alarm that in the event of a fault, the building owners shall call the supplier, and report the fault to Building Official. Calibration testing shall be made in a per year basis to ensure that the integrated systems are in its proper operational efficiency.

The equipment obsolescence shall not hinder the proper continuous operation of the equipment throughout the 10yearsduration. When the equipment's supplier finds that the instrument must be removed from the building for repair, there must be a service unit as a temporary replacement to continue the collection of data, if and when there is an occurrence of an earthquake during the duration of the repair.

XIII. SEPARABILITY CLAUSE

If any provision of these Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings or the application thereof to any person or circumstance is declared unconstitutional or invalid by any competent court, the other sections and provisions hereof which are not affected thereby shall continue to be in full force and effect.

XIV. REPEALING AND AMENDING CLAUSE

All Department Orders, Rules and Regulations, Memoranda, Circulars and other issuances in consistent here with or contrary to the provisions of these Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings are hereby superseded or modified accordingly.

XV. EFFECTIVITY

These Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings shall take effect fifteen days after its publication once a week for three (3) consecutive weeks in a newspaper of general circulation.

XVI. REFERENCES

1. D. Skoinik et. Al. A Quantitative Basis for Building Instrumentation Specifications, NSF CMMI Researchand Innovation Conference 2009 (Hawaii)
2. M. Celebi. Seismic Instrumentation of Buildings: Special GSA/USGS Project (2002).
3. Guideline for ANSS Seismic Monitoring of Engineered Civil Systems- Version 1.0
4. National Building Code of the Philippines (PD 1096)
5. National Structural Code of the Philippines (NSCP) 2010 5th Edition
6. Industry Code and Standards
   a. National Fire Protection Association

- NFPA 70 National Electrical Code
- NFPA 72 National Fire Alarm Code

b. Factory Manual Engineering and Research Corporation

Pursuant to the General Powers given to the Secretary of Public Works and Highways vested in him by Sections 102 and 203 of Presidential Decree (PD) No. 1096, otherwise known as the National Building Code (NBC) of the Philippines, these Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings with the purpose to provide clear information on earthquake recording instruments in buildings/structures are hereby approved and adopted as part of the IRR of the NBC.

APPROVED in the City of Manila, Philippines, this 12th day of JAN 2015.

ROGELIO L. SINGSON
Secretary

Department of Public Works and Highways
Office of the Secretary

WIN5I02546

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