Roof	-	plywood
All other work (including roads)	-	steel panels, plywood or surfaced lumber

Plywood shall be manufactured especially for concrete formwork and shall be oiled with an approved form oil and edge sealed.

3.0 CONSTRUCTION REQUIREMENTS

3.1 Design

a. All forms shall be true in every respect to the required shape and size, shall conform with the established alignment and grade, and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, or offsets, or similar surface defects in the finished concrete. Plywood, 16.0 mm (5/8 in.) and greater in thickness, may be fastened directly to studding if the studs are close enough to prevent visible deflection marks in concrete. The forms shall be tight so as to prevent the loss of water, cement, and fines during placing and vibrating of the concrete. Adequate clean-out holes shall be provided at the bottom of each lift of forms. The size, number and location of such cleanouts shall be subject to the approval of the Engineer.

b. Concrete construction joints will not be permitted on locations other than those shown or specified, except as may be approved by the Engineer. When a second lift is placed on hardened concrete, special precaution shall be taken in the way of the number, location and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. Pipe stubs and anchor bolts shall be set in the form where required.

c. Unless otherwise shown, exterior corners in concrete members shall be provided with 19.0, (3/4 in.) chamfers. Re-entrant corners in concrete members shall not have fillets unless otherwise shown.

d. Reservoir forms and falsework supporting the roof slab shall be designed for a minimum additional live load or 0.96 KPa (20 psf).

e. Column forms shall be checked for plumbness before concrete is deposited. Hand holes shall be provided in column forms at lowest points of pour lifts to render this space accessible for cleaning.

f. All girder, beam, and slab centerlines shall be crowned at least 6.3 mm in all direction for every 4.57 m (15 ft.) span. However, cambers from all cantilevers shall be as indicated on the plans or obtained from the Engineer by the Contractor.

g. The following are the tolerance limits for formwork:

aa. Variation from plumb:

In lines and surfaces of columns, piers, walls and risers:

In	3.05 m (10 ft.)	6.3 mm (1/4 in.)

6.10 m (20 ft.) max	9.5 mm (3/8 in.)
12.20 m (40 ft.), or more	19.0 mm (3/4 in.)

For exposed corner columns and/or piers control joint grooves and other conspicuous lines:

In any bay 6.10 m (20 ft.) max.	6.3 mm (1/4 in.)
In 12.20 m (40 ft.), or more	13.0 mm (1/2 in.)

bb. Variation in cross-sectional dimensions of columns and piers, beams, and thickness of walls and slabs:

Minus	6.3 mm (1/4 in.)
Plus	13.0 mm (1/2 in.)

cc. Footings:

Variations in dimensions on drawings (applied to concrete only and not reinforcing bars or dowels):

Minus	13.0 mm (1/2 in.)
Plus	50.0 mm (2 in.)

Misplacement of eccentricity, two percent (2%) of the footings width in the direction of misplacement but not to exceed 50.0 mm (2 in.).

Reduction in thickness: Five percent (5%) at specified thickness.

3.2 Form Ties

Form ties with integral waterstops shall be provided with cork or other suitable means for forming a conical hole to insure that the form tie may be broken off back the face of the concrete. The maximum diameter or removable cones for rod ties, or of other removable form tie fasteners having a circular cross-section, shall not exceed 38 mm (1-1/2 in.) and all such fasteners shall be such as to leave holes of regular shape for reaming. Holes left by the removal of fasteners from the ends of snap-ties or form-ties shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough before being filled with dry packed mortar. Wire ties for holding forms will not be permitted. No form tying device or part thereof, other than metal, shall be left embedded in the concrete, nor shall any tie be removed in such manner as to leave a hole extending through the interior of the concrete member. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 25 mm (1 in.) back from the formed face or faces of the concrete. Form ties or metal roads left embedded in concrete of water retaining tanks shall be equipped with an integral metal waterstop of not less than 38 mm (1-1/2 in.) in diameter.

3.3 Vertical Surfaces

All vertical surfaces of concrete members shall be formed, except where placement of the concrete against the ground is called for on the Drawings or explicitly authorized by the Engineer. Not less than 25 mm (1 in.) of concrete shall be added to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for

members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.

3.4 Maintenance of Forms

Forms shall be maintained at all times in good condition, particularly as to size, shape, strength, rigidity, tightness, and smoothness of surface. Forms when in place, shall conform to the established alignment and grades. Before concrete is placed, the forms shall be thoroughly cleaned. The form's surfaces shall be treated with a non-staining mineral oil or other lubricant approved by the Engineer. Any excess lubricant shall be satisfactorily removed before placing the concrete. In addition, all forms shall be given a preliminary oil treatment by the manufacturer or shall be oiled by the Contractor at least two (2) weeks in advance of their use. Care shall be exercised to keep oil off the surfaces of steel reinforcement and other metal items to be embodied in concrete. Forms may be reused if in good condition and if approved by the Engineer. Light sanding between uses will be required wherever necessary in the opinion of the Engineer to obtain uniform surface texture on all exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces which are permanently exposed to view. In the case of forms for the inside wall surfaces of hydraulic structures, unused tie rod holes shall be covered with metal caps or shall be filled by other methods approved by the Engineer.

3.5 Removal of Forms

Direction of the Engineer concerning the removal of forms shall be strictly followed, and this work shall be done with care so as to avoid injury to the concrete. No heavy loading on lean concrete will be permitted. In the case of roof slabs and above-ground floor slabs, forms shall remain in place until test cylinders for the roof concrete attain a minimum comprehensive strength of 15.52 MPa (2,250 psi) provided that no forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained a strength of 15.52 MPa (2,250 psi) and has been in place for a minimum of seven (7) days. The time required to establish said strength will be determined by the Engineer who will make several test cylinders for this purpose from concrete used in the first group of roof panels placed. If the time so determined is more than seven-day minimum, then it shall be used as the minimum length of time. Forms for all vertical walls and columns shall
remain in place at least three (3) days after the concrete has been placed. Forms for all parts of the work not specifically mentioned herein shall remain in place for periods of time as ordered by the Engineer.

3.6 Formworks for Concrete Pavement

3.6.1 Forms

Forms shall be of steel or of wood, of an approved section, and of a depth-equal to the thickness of the pavement at the edge. The base of the forms shall be of sufficient width to provided necessary stability in all directions. The flange braces must extend outward on the base to not less than 2/3 the height of the form.

All forms shall be rigidly supported on a bed of thoroughly compacted material during the entire operation of placing and finishing the concrete. Forms shall be provided with adequate devices for secure setting so that when in place, they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing or paving equipment.

3.6.2 Preparation of Grade (Side Form Construction)

After the sub grade or base has been placed and compacted to the required density, the areas which will support the paving machine and the grade on which the pavement is to be constructed shall be trimmed

to the proper elevation by means of a properly designed machine extending the work at least 60 cm beyond each edge of the proposed concrete pavement. If loss of density results from the trimming operation, it shall be restored by additional compaction before concrete is placed. If any traffic is allowed to use the prepared sub grade or base, the surface shall be checked and corrected immediately before the placing of concrete. The sub grade or base shall be uniformly moist when the concrete is placed.

3.6.3 Setting Forms

a. Base Support

The foundation under the forms shall be hard and true to grade so that the form when set will be firmly in contact for its length and at the specified grade. Any roadbed, which at the form line is found below established grade, shall be filled with approved granular materials to grade in lifts of three (3) cm. or less, thoroughly rerolled or tampered. Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

b. Form Setting

Forms shall be set at least 150 m in advance of the point where concrete is being placed. After the forms have been set to correct grade, the base shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. The forms shall not deviate from true line by more than one (1) cm at any point.

c. Grade Alignment

The alignment and grade elevations of the forms shall be checked and corrections shall be made by the Contractor immediately before placing the concrete. Testing as to crown and elevation, prior to placing of concrete can be made by means of holding an approved Template in a vertical position and moved backward and forward on the forms.

When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

***** End of Section *****

SECTION 03200
CONCRETE REINFORCEMENT

1.0 GENERAL

1.1 Scope

This item shall consist of furnishing, bending, fabricating and placing of steel reinforcement of the type, size, shape, and grade required in accordance with this specifications and in conformity with the requirements shown on the Plans or as directed by the Engineer.

1.2 Submittals

Contractor shall submit for the approval of the Engineer detailed reinforcement drawings. These drawings will include bar-placing , bar bending, bar list, and any other reinforcement drawings as may be required to facilitate placement and checking of reinforcing bars. The reinforcement drawings submitted shall show the name of the structure location by stationing where the reinforcement drawing is intended and all the

necessary information required by the Engineer. It shall likewise bear the tamp or seal of Contractor as evidence that the drawings have been checked by the Contractor.

2.0 MATERIAL REQUIREMENTS

All reinforcing steel bars to be furnished shall be Grade 40 for 20 mm and smaller and Grade 60 for 25 mm and larger or PNS 49, deformed type and conforming to the requirements of ASTM A-615. The nominal dimensions and unit weights of bar designation shall be in accordance with the following table:

Bar Diameter	Designation Weight Number kg/m	Nominal Cross Section Area (sq. mm)	Dimensions Perimeter (mm)
6 mm	0.222	28.30	18.85
8 mm	0.395	50.27	25.13
10 mm	0.616	78.54	31.42
12 mm	0.888	113.10	37.70
16 mm	1.579	201.10	50.27
20 mm	2.466	314.16	62.83
25 mm	3.854	490.90	78.54
28 mm	4.833	615.75	87.96
32 mm	6.313	804.25	100.53
36 mm	7.991	1,017.90	113.10

Bar numbers are based on the number of weights of an inch included in the nominal diameter of bars. The nominal diameter of a deformed bar is equivalent to the diameter of a plain bar having the same weight per foot of the deformed bar.

3.0 CONSTRUCTION REQUIREMENTS

Workmanship shall be at the highest grade and shall be in accordance with the latest standard practice of the industry.

3.1 Cutting and Bending

Cutting and bending of reinforcing bars may be done in shop or at the job site. All bending works shall be in accordance with the latest standard practice and by approved machine methods. Radii for bends and hooks will be specified on the approved detailed reinforcement drawings in accordance with sound design procedure. Unless otherwise specified, hooks and bends shall not be required for concrete with thickness less than 150mm.

3.2 Placing

Reinforcement shall be laid, anchored and embedded in the concrete as shown on the drawings or as directed by the Engineer. Unless otherwise directed, the spacing of reinforcement bars shall be measured along the center line of the bars. Reinforcement shall be inspected for compliance with

This item covers all the materials as cement, aggregates, water, admixtures, reinforcement, and the proportioning, mixing, transporting, placing, finishing, curing and protecting of concrete, including supplies, equipment, tools and all other incidentals necessary for concrete works.

1.2 Reference Standards

Concrete materials, methods and procedures shall conform to the applicable standards of the American Society for Testing and Materials (ASTM), the Philippine National Standards (PNS), and the American Concrete Institute (ACI).

1.3 Submittals

1.3.1 Concrete Mix Design

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Furnish a complete list of materials including type, brand, source and amount of cement, and admixtures; applicable reference specifications; and copies of test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the job conditions. Obtain approval before concrete placement. Submit additional data regarding concrete aggregates if the source of aggregate changes.

1.3.2 Certificates of Compliance

a. Aggregates
b. Admixtures
c. Cement

2.0 MATERIALS REQUIREMENTS

2.1 Cement

2.1.1 General

The cement shall conform to the requirements of the standard specification of Portland Cement, ASTM C-150 Type 1 or PNS 07. Special cement may be used subject to the approval of the Engineer provided it meets the requirements of Portland Cement with regards to strength, soundness and setting time.

2.1.2 Storage

Contractor shall, immediately upon delivery of cement to the jobsite, store the same in a dry, weathertight and properly ventilated structure with adequate provisions for the prevention of absorption of moisture. All storage facilities shall be subject to the approval of the Engineer and shall be such as to permit easy access for the inspection and identification. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement of the same type, which has been stored at the site for 60 days or more before using cement of lesser storage age. Any cement stored at the project site over four months shall not be used unless retest proves it to be satisfactory. Sacked cement shall not be stocked higher than 14 sacks for storage for a period of no longer than 30 days and not higher than seven sacks for longer period.

2.2 Fine Aggregates

2.2.1 General

The term "Fine Aggregates" is used to designate aggregates in which the maximum size of particles is 5 millimeters. Fine aggregates for concrete, mortar and grout shall be provided by the Contractor and shall consist of natural sand, manufactured sand, or a combination of both. The different components shall be batched separately, subject to the written approval of the Engineer, or blended prior to the delivery to the batching plant.

As a means of providing moisture control, the Contractor may be required to stockpile fine aggregates over porous drain to remove excessive water and to stabilize the moisture content.

2.2.2 Quality

Fine aggregates shall conform to the requirements of ASTM C33 or PNS 18 and shall consist of hard, tough durable, uncoated rock particles. The Contractor shall exercise every possible precaution in transporting, washing and screening operations to prevent contamination of sand particles. Fine aggregates shall conform to the following requirements:

a. Grading

It is assumed that the sand available in natural deposits will require processing to provide a suitable gradation. Regardless of the source, the fine aggregates shall be well graded from fine to coarse and the gradation as delivered to the mixers shall conform to the following requirements unless otherwise approved:

Sieve Designation US Standard Square Mesh	Percent by Weight Passing Individual Sizes
3/8"(9.50mm)	100
No. 4 (4.75mm)	95 - 100
No. 8 (2.36mm)	85 - 95
No. 16 (1.18mm)	60 - 85
No. 30 (0.600mm)	25 - 60
No. 50 (0.300mm)	10 - 30
No. 100 (0.150mm)	2 - 10

In addition to the grading limits shown above, the fine aggregates as delivered to the mixer shall have the fineness modulus of not less than 2.30 or more than 3.00. The grading of the fine aggregates also shall be controlled so that the fineness modulus of at least 9 to 10 samples of the fine aggregates as delivered to the mixer shall not vary more than 0.10 from the average fineness modulus of all samples previously taken. The fineness modulus shall be determined by dividing by 100, the sum of the cumulative percentages retained on the US standard sieve No. 4, 8, 16, 30, 50 and 100. At the option of the Contractor, fine aggregates may be separated into more sizes or classifications, but the resulting sand when combined before entering the concrete mixer shall be of uniform grading within the limits specified above.

b. Particle Shape

The shape of the particles shall be generally spherical or cubical and reasonably free from flat or elongated particles. A flat or elongated particle is defined as a particle having a maximum dimension in

excess of five times the minimum dimension. Rocks which break down into such shape, regardless of the type of processing equipment used, will not be approved for use in the production of fine aggregates.

c. Deleterious Substances

The maximum percentages of deleterious substances in the fine aggregates as delivered to the mixer shall not exceed the following values:

	Percent by Weight
Materials passing No. 200	3
Screen Designation 16	1
Shale (Designation 17)	1
Clay (Designation 13)	1
Total of other deleterious substances (such as alkali, mica, soft, flaky particles and loam)	2

The designation in parenthesis refers to methods of testing described in the seventh (7th) edition of the US Bureau of Reclamation Concrete Manual and ASTM.

The sum of the percentages of all deleterious substances shall not exceed 5% by weight. Fine aggregates producing a color darker than the standard in the colorimatic test for organic impurity (USBR Designation 14 or ASTM C-40) may be rejected. Fine aggregate having specific gravity (USBR Designation 9 or ASTM C-128, saturated surface dry basis) of less than 2.60 may be rejected. The fine aggregate may be rejected if the portion retained on No. 50 (0.300mm) screen, when subjected to five cycles of sodium sulphate test for soundness (USBR Designation 19 or ASTM C-88) shows an average loss of more than 10% by weight. fine aggregates delivered to the batching plant may be rejected if it contains more than 0.15% soluble sulphate for any one sample or more than 0.10% for an average of at least 9 out of 10 consecutive test samples of finished sand, when samples are taken hourly. The percent soluble sulphate in fine aggregates shall be determined in accordance with the method of test prescribed in subparagraph (d) below. The use of beach sand is prohibited without the written consent of the Owner.

d. Sampling

Sampling of fine and coarse aggregates shall be done in accordance with the appropriate requirements of Section 12 of ASTM C-33. The source from which fine and coarse aggregates is to be obtained shall be selected well in advance of the time when the materials will be required in the work. Unless otherwise specified, all test samples should be taken under the supervision of the Engineer in sufficient time as approved to permit adequate testing and examination of the results sufficiently in advance of the time for use in concrete. Routine control test and analysis of the fine and coarse aggregate s at various stages in the processing operation shall be made. The approval of a source shall not be construed as containing approval of all materials from the source, and the Contractor will be held responsible for the specified quality of all such materials used in the work.

2.2.3 Storage

Fine aggregates shall be stored in such a manner as to avoid the inclusion of any foreign materials in the concrete. The storage of stockpile shall be constructed so as to prevent segregation. Depositing of

materials in storage and its removal there from shall be done in such a manner as to result in increasing the uniformity of the grading insofar as this is practicable. All fine aggregates shall remain in free drainage storage for at least seventy-two (72) hours prior to use. Sufficient live storage shall be maintained at all times to permit continuous placement of concrete.

2.3 Coarse Aggregates

2.3.1 General

The term "Coarse Aggregate" is used to designate aggregates of such sizes as to fall within the range of 0.5 cm, to 7.5 cm or any size or range of sizes within such limits. The coarse aggregates shall be reasonably well graded within the nominal size ranges hereinafter specified. Coarse aggregate for concrete shall be furnished by the Contractor and shall consists of crushed rock of mixture of natural gravel and crushed rock. Coarse aggregate, as delivered to the batching plant shall have a uniform and stable moisture content. Any rewashing found necessary to provide clean aggregates shall be done prior to finish screening. Rewashing shall not be performed in finish screen.

2.3.2 Quality

Coarse aggregates shall conform to the requirement of ASTM C-33 or PNS 78 and shall consist of hard, dense, uncoated durable rock fragments.

a. Grading

The coarse aggregates shall be well graded from fine to coarse. It shall be separated into the following specific size groups. The grading of the aggregates within the separated size groups as delivered to the mixer shall be as follows:

Coarse aggregates shall contain not more than 1.5 percent of materials passing the No. 200 sieve meshing, nor more than 5% of soft fragments.

It shall have an abrasion loss of not more than 40 percent at 500 revolutions. Sodium sulphate soundness shall not be more than 12% loss.

Unless otherwise directed, the maximum sizes of aggregates to be used in concrete for the various parts of the work shall be in accordance with the following:

General Use	Max. Aggregate Dia
Lean Concrete to control water Intrusion and other miscellaneous uses	37.5 mm
Concrete for Footings, Walls	37.5 mm
Slabs Beams, 0.22 to 0.75 meter thick	
Concrete for thin walls, slabs beams less than 0.22 meters thick	19 mm
Concrete for reinforced concrete pipes	12.5 mm

In all cases, the diameter of the aggregate shall not exceed 1/2 the distance between the reinforcing steel bars of the members being placed.

b. Particle Shape

The particle shape of the crushed coarse aggregate shall be generally spherical or cubical and reasonably free from flat or elongated particles. A flat or elongated particle is defined as a particle having a maximum dimension in excess of five times the minimum dimensions. Rocks which breaks down into such shape will not be approved for the production of aggregate.

c. Deleterious Substances

The deleterious substances in any size of coarse aggregate, as delivered to the mixer, shall not exceed the following values:

	Percent by Weight
Material Passing No. 200 (Screen Designation 16)*	1/2
Shale (Designation 18)	1
Clay Lumps (Designation 13)	1/2
Other Deleterious Substances	1

The designations in parenthesis refers to methods of Testing described in the seventh edition of the U.S. Bureau of Reclamation Concrete Manual and ASTM.

The sum of the percentages of all deleterious substances in any size, as delivered to the mixer, shall not exceed 3% by weight. Coarse aggregate may be rejected if it fails to meet the following requirements:

1. Petrographic Examination

If more than 10% of poor aggregate particles can be identified in physical quality test and in case 20% of the particles would be classified with respect to the chemical quality (USBR Desig. 7 or ASTM C-295).

2. Sodium-Sulfate Test for Soundness (USBR Desig. 9 or ASTM C-88)

If the weighted average loss, after cycles is more than 12% by weight.

3. Specific Gravity (USBR Desig. 10 or ASTM C-127)

If the specific gravity (saturated surface-dry basis) is less than 2.60.

4. Sampling

All sampling of coarse aggregates shall be in accordance with Subsection 2.2.2(d), Section 03300.

2.3.3 Storage

Coarse aggregate storage or stockpiles shall be built in such a manner as to avoid the inclusion of any foreign materials in the concrete and to prevent segregation and excessive breakage. Water sprayers shall be installed to keep that portion of the coarse aggregate stockpiles saturated which is intended for immediate use in concrete. Sufficient live storage shall be maintained at all times to permit continuous placement of concrete.

2.4 Aggregates Sampling and Testing

Sampling of aggregate materials approved for use in the work, shall be done in accordance with ASTM Sampling Method at 10 days in advance of the time when the placing of concrete is expected to begin.

The samples of aggregates shall be obtained and tested in accordance with the following ASTM standard methods:

Sampling Aggregate	C 75
Sieve Analysis	C 136
Amount of material finer than 200 sieve	C 117
Organic impurities	C 40
Mortar Strength	C 87
Soundness	C 88
Soft particles	C 235
Abrasion Loss	C 131
Clay lumps	C 142

No aggregate shall be used until official advice had been received that it has satisfactorily passed all tests. Material from source which has been previously tested and shown satisfactory compliance with all the requirements given herein may be used without further testing. Test reports for previous tests must be available before approval can be given.

During construction, aggregate will be sampled or delivered to the mixer to determine compliance with Specification provision. Test shall be made in accordance with applicable ASTM standards.

2.5 Admixtures

In order to reduce the cement content and/or the amount of mixing water, and to improve the concrete workability, the Contractor may be allowed to use Admixtures and as such he shall submit to the Engineer for approval such Admixture he proposes to use. However, no additional payment will be made to the Contractor in view of this as the cost thereof is considered included in the contract unit price for the different classes of concrete.

The following types of admixtures will be given consideration provided that they conform to the provisions of this paragraph:

a. Air entraining agent
b. Water reducing admixtures
c. Water reducing and retarding admixtures
d. Water reducing and accelerating admixtures

Admixtures shall be furnished in a powder or liquid form. If furnished in a solution it shall contain at 50% solids and a mold inhibitor. The admixtures effect on the properties of Portland Cement concrete mixtures shall meet the requirements of ASTM C 494.

Admixtures will be accepted on manufacturers certification of conformance with the specifications but permission to clip on certification shall be in no way relieve the Contractor of responsibility for furnishing an admixture not meeting specification requirements. Where the Engineer has reason to believe that

testing is necessary to prove compliance with the requirements of these specifications, it may order these admixtures to be sampled and tested anytime. The Contractor shall provide facilities satisfactory to the Engineer for readily procuring samples for test.

Air Entraining Agent - concrete produced with water reducing agents shall contain four to six percent of entrained air by volume. The air entraining agent shall conform to the requirements of ASTM C 260, and shall be tested in accordance with ASTM C 233. The total calculated air content of the concrete is discharged from the mixer shall be as follows:

Coarse Aggregate Maximum Size	Total Air - Percent by Volume of Concrete
2 cm	5 ± 1
3.8 cm	4 ± 1

The agent in solution shall be maintained at uniform strength and shall be added to the batch in a portion of the mixing water. This solution shall be batched by means of a mechanical batcher capable of accurate measurement. When a retarder dispersing agent is used in the concrete, the portion of the mixing water containing the air-entraining agent shall be introduced separately into the mixer.

Water Reducing Agent or Water Reducing and Set Retarding Agent - the Contractor may be allowed to use an approved water reducing agent, or water-reducing and set retarding agent in concrete. The ASTM designations for these admixtures are Type A and Type D, respectively. The agent used shall be either suitable calcium, sodium or ammonium salts of lignosulfonic acids or of the nonlignin, hydroxylated carboxylic and acid groups. The agent shall be of uniform consistency and quality within each container and from shipment to shipment.

The amount of water reducing, or water reducing and set retarding agent to be used in each concrete mix shall in general be within the following limits:

Lignosulfonic Acid Type 0.27 to 0.37 percent of solid crystalline lignin, by weight, of cement.

Hydroxylated Carboxylic

Acid Type 0.25 to 0.50 percent of liquid, by weight.
Water Reducing and Accelerating Admixture - the ASTM designation for this admixture is Type E. Water reducing and accelerating admixture may be used by the Contractor for speeding up precasting and post-tensioning operations for precast and prestressed beams, girders, slabs and bearing pads, if approved.

2.6 Water

The water used in concrete, mortar and grout shall be free from objectionable quantities of silt, organic matter, alkali, salts and other impurities. The recommendation of the seventh edition of the U.S. Bureau of Reclamation Concrete Manual for mixing water shall be followed,

3.0 CONSTRUCTION REQUIREMENTS

3.1 Classification and Proportioning of Concrete Mixtures

a. Classification and Design Mixtures

The mixture for all classes of concrete shall be designed by the Contractor to obtain the compressive strength at the age of 28 days as specified below.

Size of Compressive Class of Aggregates	Minimum Comp. Strength	Designated Maximum Dia. Aggregate
Y 12.5 mm	3,000 psi	12.5 mm to 4.75 mm
AA 19 mm	3.000 psi	19.0 mm to 4.75 mm
A 37.5 mm	3,000 psi	37.5 mm to 4.75 mm
B 50 mm	2,500 psi	50.0 mm to 4.75 mm
C 75 mm	2,500 psi	75.0 mm to 4.75 mm
Z 75 mm	(1,500-2,000 psi)	5.0 mm to 4.75 mm

Unless otherwise specified, the Contractor shall prepare a design mix for concrete pavement that will produce a compressive strength of 3,500 psi when tested at fourteen (14) days.

b. Aggregate Content

Concrete mixtures shall be designed to use the largest size and the maximum amount of coarse aggregate as practicable for the intended use of the concrete.

c. Consistency

The amount of water to be used in the concrete shall be regulated as required to secure concrete of the proper consistency and to adjust for any variation in the moisture content or grading of the aggregates as they enter the mixer.

It shall be such consistency that it will flow around reinforcing steel bar but individual particles if the coarse aggregate when isolated shall have coating of mortar containing its proportionate amount of sand. The consistency shall be gauged by the ability of the equipment to properly place it and not by the difficulty in mixing or transporting. Addition of water to compensate for stiffening of the concrete before placing will not be permitted. Uniformity in concrete consistency from batch will be required.

The slump of the concrete at the time of placing shall not exceed 5 centimeters in heavy concrete sections and at top of walls, piers and parapets, 10 centimeters for pumped or air placed concrete, 7.5 centimeters for concrete elsewhere.

The Engineer reserves the right to require a lesser slump whenever concrete of lesser slump can be consolidated readily into place by means of the vibration specified in Subsection 3.8(e), Section 03300.

Notwithstanding the approval of the design mixtures and the above specified minimum cement content for different classes or gradation of aggregates, the Contractor shall be responsible that all concrete meet the desired strength.

3.2 Mixing Concrete

a. General

Concrete shall be machine-mixed. Hand mixing shall be allowed only in cases of emergency when there is machine breakdown or malfunction, and in the construction of small structures where the total volume of

concrete is less than two cubic meters. A written consent of the Engineer must be secured by the Contractor in both cases.

No concrete shall be mixed, placed or finished when natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

b. Mixing at Site

Concrete shall be thoroughly mixed in a batch mixer of an approved capacity and type which ensure a uniform and homogenous mixing of the concrete materials. The minimum mixing time for each batch, after all materials and water are introduced into the mixer, shall be as follows:

Capacity of Mixer	Mixing Time
0.40 cu.m. or smaller	1-1/2 minutes
0.60 to 1.20 cu.m.	1-1/2 minutes
1.50 to 2.30 cu.m.	2 minutes
3 cu.m.	2-1/2 minutes

Overmixing, requiring the introduction of additional water to preserve the required consistency, will not be permitted. Overmixed concrete shall be wasted.

c. Truck Mixing

Truck mixing shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured at the proportioning plant before being charged into the drum. Except as subsequently provided, the truck mixer shall be equipped with the tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can readily be verified. The mixing water maybe added directly to the batch in which case a tank shall not be required. Truck mixer must be provided with a device by which the mixing time can be readily verified by the Engineer.

When cement is fed into the mixer drum containing water or on surface with wet aggregates and when the temperature is above 32□C, or when high early strength Portland Cement is used, the mixing limit shall be reduced to 1.5 minutes. The limitation in time between the introduction of the cement to the aggregates and the beginning of the mixing may be waived, when the aggregates are sufficiently free from moisture, since in this case there is no harmful effect on the cement.

3.3 Re-Tempering

Concrete, mortar and grout mixers which have developed initial set shall not be used. Concrete, mortar and grout which have partially hardened shall not be retempered or remixed.

3.4 Sampling and Testing of Concrete

The Contractor shall provide required samples of concrete. Sampling will, in all cases be performed by or under the direct supervision of the Engineer and Contractor shall provide without cost to the Owner all available tools and labor as may be required. Concrete sampling shall be carried on during concrete operations at the rate of one standard sample for each 75 cubic meters of concrete or fraction thereof placed during each continuous placing operations but in no case shall there be less than one (1) sample

for each class of concrete for each day concreting. Each standard sample shall consist of three standard cylinders (6 inches diameter by 12 inches high). Testing of the cylinders shall be one (1) sample at 7 days and two (2) samples at 28 days.

Sampling shall conform to ASTM Designations C-172, preparations, storage and curing to ASTM Designation C-31 and testing to ASTM Designation C-39. The sample shall be tested by an approved testing laboratory at the expense of the Contractor.

3.5 Time of Hauling and Placing Mixed Concrete

Concrete shall be placed in its final position in the forms within 45 minutes after the introduction of the mixing water to the cement and aggregates, or the cement to the aggregates.

3.6 Delivery

The rate of the delivery of the concrete during concreting operation shall be such as to provide for the proper handling and placing of the concrete. The rate shall be such that the interval between batches shall not exceed 40 minutes. The method of delivering and handling the concrete shall be such as to facilitate proper placing with the minimum of rehandling and without damage to the concrete structure.

3.7 Conveying and Placing Concrete

a. General

Approval of the Engineer shall be obtained before starting any concrete pour. Concrete placement will not be permitted when,in the opinion of the Engineer, conditions prevent proper placement and consolidation. Before concrete is placed, all saw dust, chips, and other construction debris and extraneous matters will be removed from the interior of forms, struts, stays, and braces, serving temporarily to hold the forms in correct shape and alignments, pending the placing of concrete at their location, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary as may be. These temporary members shall be entirely removed from the forms and not be buried in concrete. Surfaces of existing concrete left after the partial demolition against which new concrete is to be placed, shall be cleared thoroughly of all loose concrete coatings or concrete dust by brushing or other effective means followed by thorough washing or jetting. Such surfaces shall be kept moist at least 24 hours before pouring the new concrete.

Concrete shall be placed only in the presence of the Engineer or his duly authorized representatives.

Any and all concrete placed in the absence of the Engineer or his duly authorized representative will not be considered for measurement and payment, and shall be removed at the direction of the Engineer with the Contractor assuming all losses.

Concrete shall be conveyed from the mixer to forms, as rapidly as practicable, by methods which will prevent segregation, or loss of ingredients. There shall be no vertical drop greater than 1.5 meters except where specifically authorized by the Engineer. Belt conveyors, clutes similar continuously exposed flow, will not be permitted.

b. Concrete on Earth Foundation

All concrete shall be placed upon clean and damp surfaces free from standing or running water. Prior to placing concrete, the earth foundation shall be satisfactorily compacted in accordance with these specifications.

c. Concrete on Rock and Other Concrete

Rock surfaces or hardened concrete upon or against which concrete is to be placed shall be clean, free from oil, standing or running water, mud, drummy rock objectionable coatings, debris, loose and semi detached or unsound fragments. Fault, fissures and seams in rock shall be cleaned to satisfactory depth and to firm rock on the sides. Immediately before concrete is placed, all surfaces shall be cleaned thoroughly by the use of high velocity, air water jets, wet sand blasting or other satisfactory means. When required by the Engineer, roughing by grooving with pneumatic tool, of existing concrete surfaces against which concrete is to be placed may be required. All surfaces against shall be wetted before placing concrete and approximately horizontal surface shall be covered immediately before the concrete is placed, with a layer of mortar not to exceed 15mm in thickness and of the same cement-sand ratio as used in the concrete.

d. Lift on Concrete

The permissible depth of concrete placed in one lift will be as shown in the detailed Drawings or as directed for each structure by the Engineer. Unless otherwise authorized or shown, lifts or mass concrete shall not exceed 1.5 meters in height, and a minimum of 72 hours shall elapse between the placing of each successive lifts. Lifts of three meters will be permitted in piers and walls. Height of lift specified herein will not apply where the use of slip form has been approved. All concrete, when placed and vibrated shall be approximately horizontal layers not to exceed 500mm in thickness unless otherwise specifically authorized. The placement of concrete surfaces shall not have reached their initial set before additional concrete is placed thereon. Slabs shall generally be placed in one lift unless the depth is so great that this procedure will proclude objectionable results.

e. Consolidation of Concrete

Consolidation of concrete shall be by the use of mechanical vibration equipment. The vibrating equipment shall be on the internal type and shall at all times be adequate in number of units and power of each units shall be capable to properly consolidate all concrete. The frequency of vibration shall not be less than 6,000 revolutions per minute. Form or surface vibrators shall not be used, unless otherwise specified in other Section of this Technical Specification. The duration of vibration shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. In consolidating each layer of concrete the vibrating head shall be allowed to penetrate under the action of its own weight and revibrate the concrete in the upper portion of the underlying layer.

At least one (1) standby unit of vibrating equipment in good running condition shall be at the pouring site at any one time.

f Finishing of Concrete Lift Surface

The manipulation of the concrete adjacent to the surface of the lift in connection with completing lift placement shall be the minimum necessary to produce not only the degree of consolidation desired in the surface layer of concrete but also a surface with the desired degree of roughness for bond with the next lift. Surface vibration or excessive surface working will not be permitted. All unfinished top surface not covered by forms and which are not to be covered by additional concrete or backfill, shall be carried slightly above grade, as directed, and struck off by board finish.

g. Placing Concrete Through Reinforcement

In placing concrete through reinforcement, care shall be taken so that no segregation of the coarse aggregate occurs. On the bottom of beams and slabs, where the congestion of steel near the forms makes placing difficult, a layer of mortar of the same cement-sand ratio is used in the concrete shall be first deposited to cover the surface.

h. Depositing Concrete in Water

When specifically authorized, concrete may be deposited in water. The methods and equipment used shall be subject to approval of the Engineer.

3.8 Repair of Concrete

No repair of work or plaster finish on formed concrete structures will be permitted, unless otherwise provided in these Specifications or directed by the Engineer. All defective concrete shall be removed and replaced with the Contractor assuming all expenses and losses. If directed, the Contractor shall notify the Engineer of the start of the repair work at least 24 hours in advance thereof and shall repair concrete only in the presence of the Engineer or its authorized representative, unless inspection of such repair work is waived.

Workmanship methods, preparation of concrete for repair, materials and curing shall be as directed. Only workmen skilled in the repair of concrete shall perform such work. Repairs of defective concrete shall be within 48 hours after the removal of forms.

Surfaces to which concrete is to be bonded shall be clean and dry when coated with epoxy.

Surfaces of concrete to be repaired with sealing compound method shall be cured by the water curing method for one day before application of the sealing compound. All repair shall be sound and free from shrinkage, cracks and drummy areas after they have been cured and have dried 30 days.

Surfaces of repairs which will be exposed to view shall blend inconspicuously with surrounding concrete surfaces.

3.9 Construction Joints

Construction or contraction joints shall be provided where shown or specified in the Drawings.

The Waterstop: The waterstop shall conform to ASTM D412 and shall have a minimum tensile strength of 9.65 MPa (1400 psi) and ultimate elongation of 280%.

Expansion Joint Filler: The expansion joint filler shall be pre-formed, non-extruding type of filler constructed of cellular neoprene sponge rubber or polyurethane of firm texture conforming to ASTM D 1752, Type I.

Sealant for joints shall be polyurethane polymer designed for bonding to concrete.

***** End of Section *****

SECTION 04100

UNIT MASONRY

1.0 GENERAL

1.1 Scope of Work

The work includes furnishing labour, equipment and materials, and performing all operations required to complete concrete masonry work as shown and specified on the drawings and specifications.

1.2 Applicable Documents

The following specifications and standards shall form part of this specification to the extent required by the references thereto.

ASTM	American Society for Testing and Materials
C144-87	Standard Specification for Aggregate for Masonry Mortar
PSA	Product Standards Agency Pub. (Phil.)
PNS 16-84	Concrete Hollow Blocks, Specs for

1.3 Requirements

Concrete masonry work of the type indicated shall be provided and shall be properly coordinated with the work of other trades.

2.0 MATERIALS

2.1 Concrete Hollow Blocks

Concrete hollow block shall be a standard product of a recognized manufacturer conforming to PNS 16, as indicated on the drawings.

2.2 Cement, Reinforcing Steel, and Water

Cement, reinforcing steel and water shall be as specified in Division 3.0, Concrete.

2.3 Lime

Lime may be either finely pulverized quick lime, slake or hydrated lime (92% hydrated) and shall be a standard product of a recognized manufacturer.

2.4 Delivery, Storage and Protection of Materials

Delivery, storage and protection of materials shall be as specified in Division 3.0, Concrete, and as specified herein.

a. Lime shall be delivered in original sealed containers plainly marked with name and brand of manufacturer, and kept dry until used. Defective lime or lime showing partial set or caking shall not be used.

b. Concrete masonry units shall immediately upon delivery to the job site be stacked under covered area or otherwise protected from exposure to the weather and contact with soil. Care shall be exercised in handling the blocks to avoid breakage.

3.0 WORKMANSHIP

Masonry walls shall be placed level and plumb all around. One section of the walls shall not be placed in advance of the others, unless specifically approved. Unfinished work shall be stepped back for joining with new work; toothing shall not be permitted. Heights of masonry shall be checked with an instrument at sills and heads of openings to maintain the level of the walls. Door and window frames, louvered openings, anchors, pipes, and conduits shall be installed in carefully and neatly as the masonry work progresses. Spaces around metal door frames shall be filled solidly with mortar. Drilling, cutting, fitting and patching, to accommodate the work of others, shall be performed by skilled workers. Bolts, anchors, inserts, plugs, ties, and miscellaneous metal work specified elsewhere shall be placed in position as the work progresses. Chases of approved dimensions for pipes and other purposes shall be provided, where indicated necessary. Tops of exposed walls and waterproof membrane, well secured in place. Walls and partitions shall be structurally bonded or anchored to each other and to concrete walls, beams, and columns.

3.1 Mortar Mixing

Mortar materials shall be measured in approved containers, which shall insure that the specified proportions of materials can be controlled and accurately maintained during the progress of the work. Unless specified otherwise, mortar shall be mixed in proportions by volume. The aggregates shall be introduced and mixed in such a manner that materials will be distributed uniformly throughout the mass. A sufficient amount of water shall be added gradually and the mass further mixed, not less than 3 minutes, until a mortar of the plasticity necessary for the purpose intended shall be obtained. The mortar shall be mixed in a manner such that the quantity of water can be controlled accurately and uniformly. Mortar boxes, pans, or mixer drums shall be kept clean and free of debris or dried mortar. The mortar shall be used before the initial setting of the cement has taken place. Retempering of mortar in which cement has started to set shall not be permitted.

3.2 Proportion

Mortar shall be mixed in the volumetric proportions of one part Portland cement, 1/4 part hydrated lime and 3 parts sand.

3.3 Mortar Joints

Mortar joint shall be uniform in thickness, and the average thickness of any three consecutive joints shall be 9.50 mm. "Gage rods" shall be made and approved prior to starting the work and shall be used throughout the work. Changes in coursing or bonding after the work has started shall not be permitted. Joints in masonry which will not be exposed shall be struck flush. Joints shall be brushed to remove all loose and excess mortar.

3.4 Concrete Masonry Unit Work

The first course of concrete masonry unit shall be laid in full bed of mortar, for the full width of the unit; the succeeding courses shall be laid with broken joints. Concrete masonry units with the cells vertical shall have bed-joints formed by applying the mortar to the entire tops surfaces of the inner and outer face shells, and the head joints formed by applying the mortar for a width of about 25mm to the ends of the adjoining units laid previously. The mortar for joints shall be smooth, not furrowed, and shall be of such thickness that it will be forced out of joints as the units are being placed in position. Where anchors, bolts, ties and reinforcing bars occur within the cells of the units, such cells shall be solidly filled with mortar or grout as the work progresses. Horizontal tie reinforcement shall be provided where indicated. Reinforcement shall be continuous and provided in the longest available lengths. Reinforcement above and below opening shall extend and be embedded into the columns, unless otherwise shown on the drawings. Splices shall overlap not less than 150 mm. Reinforcement shall be embedded in the mortar joints in such manner that all parts shall be protected by mortar. The two top courses of filler block walls shall have their cores filled with grout when placed in position.

Unless otherwise shown on the drawings, the blocks compressive strength, the size and spacing of vertical bars shall be as follows:

For 150 mm (6") CBH	- 12mm (1/2") dia. at 600 mm (24") on centres' - Minimum compressive strength of 350 psi for non-load bearing. - Minimum compressive strength of 1,400 psi for load bearing.
For 100 mm (4") CHB	- 10mm (3/8") dia. at 600 mm (24") on centers - Minimum compressive strength of 1,400 psi for load bearing. - Minimum compressive strength of 350 psi for non-load bearing.
For horizontal bars:	- 12mm (1/2") dia. at 600 mm (24") on centers (every third course) for 150 mm (6") and 100 mm (4") CBHs.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Samples of Materials

Samples of cement, sand, lime, reinforcing bars and concrete hollow blocks shall be submitted for inspection and approval before delivery of these materials to the site.

4.2 Tests and Test Reports

The testing requirements stated herein or incorporated in referenced contract documents may be waived provided certified copies of report of tests from approved laboratories performed on previously manufactured materials are submitted and approved. Test reports shall be accompanied by notarized copies from the manufacturer certifying that the previously tested material is of the same type, quality, manufacture, and make as those proposed for this project.

ACCELELOGRAPH SPECIFICATIONS

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 framework 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, velocimeter, 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 File Transfer 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	One Accelerograph installed at	ERI in compliance with this

schools with twenty (20) classrooms or more but not than three (3) storeys	Ground Floor/Lowest Basement	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. Accelerograph

- 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

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:

16bits

- c. Timing
- Interval: Half a second or less
- Accuracy: Plus or minus 0.2 second per 100 seconds
- Type: GPS or NTP Ser ver

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 sha ll 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

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. Skink et. Al. A Quantitative Basis for Building Instrumentation Specifications, NSF CMMI Research and 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