



**Sindh High Court Annexe Building
Proposed Expansion of 5th & 6th Floor**

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1. PLAIN AND REINFORCED CONCRETE

1.1 SCOPE

The work covered by this section of Specifications consists of furnishing all plant, labor, equipment, appliances and materials, and in performing all operation in connection with the supply and installation of plain and reinforced concrete work, complete in strict accordance with this section of the Specifications and the applicable drawings, subject to the conditions of the CONTRACT.

1.2 GENERAL

- a. Full co-operation shall be given to other trades to install embedded items.
- b. Suitable templates or instructions, or both will be provided for setting items not placed in the forms. Embedded items shall have been inspected, and tests for concrete and other material or for mechanical operations shall have been completed and approved, before concrete is placed.
- c. For special concrete finishes and for special methods of construction (e.g. slip forms), formwork shop drawings shall be designed and prepared by the CONTRACTOR at his own cost. Approval of shop drawings as well as that of actual samples of finished concrete shall be obtained before WORK is commenced.
- d. CONTRACTOR shall also prepare BAR BENDING SCHEDULE, and get the same approved by the ENGINEER, prior to commencement of work.
- e. Approximate equivalent conversion of F.P.S. and S.I. units are indicated in the text. Engineer's decision on any specific conversion shall be final and binding on all parties.

1.3 RELATED SPECIFICATIONS

Latest editions of the following British, ASTM and ACI Standards are relevant to these Specifications where indicated: - (Equivalent Pakistan Standards are also applicable.)

A. British Standards

B.S. 12-78	Portland Cement, Ordinary and Rapid Hardening (in lieu of C-150).
B.S. 410	Test Sieves.



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B.S. 693	General Requirements for Oxyacetylene Welding of Mild Steel
B.S. 882-1201	Concrete aggregates from Natural Sources.
B.S. 1141	Cold Worked Steel Bars for the reinforcement of Concert. General Requirements for the Metal-Arc Welding of Mild Steel
B.S. 1881	Methods of Testing Concrete.
B.S. 3148	Tests for Water for Making Concrete.
B.S. 4027	Sulfate-Resisting Portland Cement.
B.S. 4449	Carbon Steel Bars for the Reinforcement of Concrete.
B.S. 4461	Cold Worked Steel Bars for the Reinforcement of Concrete.

B. Latest ASTM Standards:

A 615-94	Deformed Billet-Steel Bars for Concrete Reinforcement
C 33-93	Standard Specification for Concrete Aggregates
C 39-93a	Compressive Strength of Cylindrical concrete Specimens
C 42-90	Standard Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C 94-94	Standard Specification for Ready Mixed Concrete
C 138-92	Standard test method for unit weight, Yield, and Air Content (Gravimetric) of Concrete
C143-90a	Standard Method of Test for Slump of Hydraulic Cement
C 150-94	Standard Specification for Portland cement
C 171-92 Concrete	Standard Specification for Sheet Materials for Curing
C 172-90	Standard Method of Sampling fresh Concrete
C 173-94	Standard Method of Test for Air Content of freshly Mixed Concrete by the Volumetric Method
C 208	Standard Specification for Insulating Board (Cellulosic Fiber) Structural and Decorative



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C 231-91b	Standard Method Test for Air Content of Freshly Mixed Concrete by the Pressure Method
C 260-94 Concrete	Standard Specifications for Air Entraining Admixtures for Concrete
C309-93	Standard Specification for Liquid Membrane-Forming Compounds for curing concrete
C 494-92	Standard Specification for Chemical Admixtures for Concrete
E 329-90	Specification for minimum requirements for agencies engaged in the testing and or inspection of materials used in construction

C. ACI Standards:

- a. ACI 318 Building Code Requirements for Reinforced Concrete
- b. In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other Standards as may be specified by the ENGINEER for special Materials and Construction are also relevant.

2.0 Materials

2.1 Aggregates (Except for light-weight concrete):

- a. The sources of supply of all fine and coarse aggregates shall be subject to the approval of ENGINEER.
- b. All fine and coarse aggregates shall be clean and free from clay, loam, silt, and other deleterious matter. If required, ENGINEER reserves the right to have them washed by the CONTRACTOR at no additional expenses. Coarse and fine aggregates shall be delivered and stored separately at SITE. Aggregates shall not be stored on muddy ground or where they are likely to become dirty or contaminated.
- c. Fine aggregate shall be hard coarse sand, crushed stone or gravel screenings and shall conform to requirements of ASTM C-33.
- d. Coarse aggregate shall be gravel or broken stone or hard, durable material free from laminated structure and conforming to ASTM C-33 graded as follows for use in mass concrete such as in foundations:



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TOTAL PASSING	PERCENT BY WEIGHT
2" B.S Sieve (50.00 mm)	100
1-1/2" Sieve (38.10 mm)	95 - 100
3/4" Sieve (19.00 mm)	35 - 70
3/8" Sieve (9.50 mm)	10 - 30
No. 4 Sieve (4.75 mm)	0 - 5

Coarse aggregate for all cast-in-place concrete other than mass concrete and thick fair faced cast-in-place concrete shall be graded with the following limits:-

TOTAL PASSING	PERCENT BY WEIGHT
1" Sieve (25.00 mm)	100
3/4" Sieve (19.00 mm)	90-100
3/8" Sieve (9.50 mm)	20- 55
No. 4 Sieve (4.75 mm)	0- 10

Coarse aggregate for thin fair faced cast-in-place concrete shall be graded as follows:-

TOTAL PASSING	PERCENT BY WEIGHT
1/2" Sieve (12.50 mm)	100
3/8" Sieve (9.50 mm)	85-100
No. 4 Sieve (4.75 mm)	10- 30

e. The nominal maximum size of aggregate for precast fair faced concrete shall be smallest of the following:

- i One-fifth of the narrowest dimensions between sides of forms.
- ii One-third of the depth of slabs.
- iii. Three-fourth of the minimum clear distance between reinforcing bars or between bars and form.
- iv 1/2" (12.0 mm).

f. The nominal maximum size of the aggregate for normal weight precast concrete shall be smallest of the following:-

- i. One-fifth of narrowest dimension between forms.



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- ii. One-third of depth of slab.
- iii. Three-fourth of clear distance between bars.
- iv. 1"

g. The aggregate shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as SITE and other conditions permit, preferably for at least a day). The grading of the coarse and fine aggregate shall be tested at least once for every 50 tons (or 750 C. ft) supplied to ensure that the grading is uniform and the same as that of the samples used in the preliminary tests.

2.2 Cement:

- a. Cement shall conform to ASTM C - 150.
- b. Only one brand of each type of cement shall be used for concrete in any individual member of the structure.
- c. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed. There shall be sufficient cement at SITE to ensure that each section of WORK is completed without interruption. If the cement is supplied by THE OWNER, the CONTRACTOR shall inform ENGINEER of his requirement much before its use in construction.
- d. Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- e. CONTRACTOR shall provide and erect, at his own cost, in a suitable place, dry, well ventilated, and water proof shed of sufficient capacity to store the cement.
- f. The cement shall be used as soon as possible after delivery, and cement which ENGINEER considers has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise shall be rejected and removed immediately from the SITE at CONTRACTOR's expense. Any cement in containers, damaged so as to allow the contents to spill or access of the atmosphere to the cement prior to opening at the time of concrete mixing shall be rejected and removed immediately from the SITE at CONTRACTOR's expense.
- g. The mixing together of different types of cement shall not be permitted.

2.3 Water:

Clean and clear water which does not have sweet, saline or brackish taste to be used for mixing and curing of concrete. Where doubt exists, the strength of mortar sample made with questionable water is compared with mortar sample produced with



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acceptable water (like distilled water). The questionable water may be accepted if the sample yield concrete strength of at least 90% of the other sample made with acceptable water.

Water contaminants under no circumstance shall be greater than following limits:-

Oil	-----	0.00 ppm.
Chlorides	-----	1000 ppm.
Sulfates	-----	1000 ppm.
Turbidity	-----	2000 ppm.
Acids	-----	10,000 ppm.

Potassium and NaOH 0.5 to 1.0% by weight of cement.

Sea water shall not be used for any reinforced concrete works or where concrete is later required to be plastered, painted or otherwise decorated.

3. Reinforcement:

a. Reinforcement for concrete shall conform to the respective British, ASTM or other standards as specified in the Drawings and CONTRACT Documents or as may be specified by ENGINEER.

b. Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of B.S. 4449 for plain mild steel bars and shall have a minimum yield stress of 36 ksi, (248 N/mm sq).

c. Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of B.S. 4461 for deformed cold worked steel bars and shall have minimum yield strength of 60ksi, (460 N/mm sq). with a minimum elongation of 12%.

d. Reinforcement shall be obtained only from the manufacturer approved by the ENGINEER. If and when required CONTRACTOR shall provide all necessary facilities to ENGINEER for the selection of test pieces and shall cause these to be prepared and submitted where directed for tests at CONTRACTOR's cost.

e. If the reinforcement is to be supplied by the OWNER, the CONTRACTOR shall inform ENGINEER of his requirements much before its use in construction.

f. CONTRACTOR shall report immediately on receipt of any consignment, having any deviation in the standard weights of the reinforcing



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bars beyond those allowed in respective standards mentioned in clause (4.4.b) and (4.4.c) herein before.

4. CONCRETE MIX PROPORTIONS

4.1 General:

a. The proportions of ingredients shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement by the methods of placing and consolidation employed on the WORK, but without permitting the materials to segregate or excessive free water to collect on the surface. Specific approval of the ENGINEER is required to waive limitations on mixture proportions.

b. The proportions of ingredients shall be selected in accordance with Section 5.6 to produce the proper place ability, durability, strength and other required properties.

4.2 Strength:

The Specified compressive strength of the concrete cylinder, shall be 3000 psi, (21 N/mm sq) except where otherwise noted on Drawings. The equivalent cube strength shall be at least 25% higher than the specified cylinder strength. Strength requirements shall be based on the sampling and testing methods of ASTM C 39-72 (and BS 1881 for cube).

4.3 Durability:

Maximum permissible water-cement ratios for concrete in severe exposures to be as follows, unless lower water-cement ratio is required to meet specified strength limits:

Type of Structure	Structure Continuously wet or frequently freezing and thawing ¹	Structure exposed to sea or sulfates
i. Thin sections & sections with less than 1" cover over steel	0.45	0.40 ²
ii. All other Structures	0.50	0.45 ²

¹Concrete should also be air-entrained.

²If S. R. Cement is used, permissible water-cement ratio may be increased by 0.05.



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4.4 Slump:

Unless otherwise permitted or specified, the concrete shall be proportioned and produced to have a slump of 4" (100 mm) or less. A tolerance of upto 1" (25 mm) above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated. The slump shall be determined by the "Test for Slump for Portland Cement Concrete" (ASTM C-143).

4.5 Admixtures:

If required or permitted, admixtures used shall be in accordance with the manufacturer's instructions except as otherwise specified herein.

4.6 Methods of Obtaining Mix Design:

For concrete of normal weight, mix proportions to provide the desired characteristics shall be developed using the methods/procedure covered by the latest edition of Recommended Practice for Selecting Proportions for Normal Weight Concrete ACI 211.1.

Trial mixtures having proportions and consistencies suitable for the WORK shall be made based on ACI 211.1, using at least three different water-cement ratios which will produce a range of strengths encompassing those required for the WORK. Trial mixes shall be designed to produce the specified slump. The temperature of concrete used in trial batches shall be reported.

For each water-cement ratio, compression test of cylinder/cube shall be made, cured, and tested in accordance with "ASTM C - 39 or BS 1881". From the results of these tests a curve shall be plotted showing the relationship between the water-cement ratio and compressive strength. From this curve, the water-cement ratio to be used in the concrete shall be selected to produce the required/specified design strength. The cement content and mix proportions to be used shall be such that this water-cement ratio is not exceeded when slump is the maximum permitted. Control in the field shall be based upon maintenance of proper cement content and slump.

5. PLANT AND WORKMANSHIP

5.1 Formwork:

- a. Forms shall be used, wherever necessary, to confine the concrete and shape it to the required dimensions. Forms shall have sufficient



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strength to with-stand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.

Structurally adequate, form work shall also conform to the requirements of the special architectural finishes of the in-situ Plain and Reinforced Concrete specified/or shown on the Drawings. Shop drawings of such form shall be subject to the approval of the ENGINEER prior to its use. ENGINEER shall refuse concreting of any part which in his opinion may not yield specified finishes.

b. Earth cuts shall not be used as forms for vertical surface or reinforced concrete work unless required or permitted.

c. Mud centering shall not be permitted without the prior approval of the ENGINEER.

d. Formwork shall be made of either timber, steel, plywood, proprietary building boards and such special material, as may be shown on the drawings or approved by the ENGINEER which gives the required finish to the surface of concrete. Wooden frame work shall be free from loose knots and shall be well seasoned. For the external concrete finishes 1/16" (1.5 mm) thick mild steel sheet forms shall be used. CONTRACTOR shall furnish shop drawings of such formwork prepared on the basis of architectural concept for the approval of the ENGINEER.

e. Formwork shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of concrete, and shall be sufficiently tight to prevent loss of cement slurry. The design and Engineering of the formwork, as well as its construction, shall be the responsibility of CONTRACTOR. Where necessary to maintain the specified tolerances, the formwork shall be **cambered** to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads.

CONTRACTOR shall establish and maintain in an undisturbed conditions, and until final completion and acceptance of the WORK, sufficient control points and bench marks to be used for reference purpose to check tolerances.

f. Requirements for facing materials are given in clause 8 "Finishing of formed Concrete". The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.



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g. Where natural plywood form finish, grout cleaned finish, smooth rubbed finish, scrubbed finish, or sand floated finish is required, forms shall be smooth (faced with plywood, liner sheets, or prefabricated panels) and true to line, in order that the surfaces produced with required little dressing to arrive at true surfaces. Where any as-cast finish is required, no dressing shall be permitted in the finishing operation.

h. Where as-cast surfaces, including natural plywood form finish, are specified, the panels of materials against which concrete is cast shall be arranged orderly with joints between panels planned in approved relations to opening, building corners, and other architectural features.

i. Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall provide for locating form ties within the, joints so that patches of tie holes will not fall within the panel areas.

j. Forms shall not be re-used if there is any evidence of surface wear and tear or defect which would impair the quality of the surface. Forms shall be thoroughly cleaned and properly coated before re-use.

k. The formwork may be designed so that soffits of slabs and sides of beams, columns, and wall may be removed first leaving the forms to the soffits of beams and their supports in position.

l. Positive means, wedges or jacks of accurate adjustment and proper removal of shores and struts shall be provided and all settlement shall be taken up during placing of concrete. Forms shall also be securely braced against lateral deflections.

m. Where concreting of narrow members is required to be carried out within formwork of considerable depth, temporary openings in the sides of the formwork shall be provided where necessary to facilitate the placing and consolidation of the concrete. Small temporary openings shall be provided at the bottom of the formwork to columns, walls and deep beams to permit the cleaning out of debris and observations immediately before concrete is deposited.

n. Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. After the ends or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than twice the diameter or twice the minimum dimension of the tie from the formed faces of concrete to be permanently exposed to view except that in no case shall



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this distance be less than 3/4" (19 mm) when the formed face of the concrete is not to be permanently exposed to view, form tie may be cut off flush with the formed surfaces. Through bolts shall be permitted provided that they are greased to allow for easy withdrawal and the holes subsequently made good. Through bolts are not to be used on water-retaining structures.

o. At construction joints, contact surface of the form sheathing for flush surfaces exposed to view shall overlap the hardened concrete in the previous placement by not more than 1" (25 mm). The forms shall be held against the hardened concrete to prevent offsets or loss of mortar at the construction joint and to maintain a true surface.

p. Runways or planks for moving labor and equipment shall be provided with struts or legs and shall be supported directly on the formwork or structural member without resting on the reinforcing steel.

q. All surfaces of the embedded items shall be cleaned and any accumulated mortar or grout from previous concreting and of all other foreign material is removed before concrete is placed in them.

r. Board forms having joints opened by shrinkage of the wood shall be swelled until closed by wetting before concrete is placed. Plywood and other wood surface not subject to shrinkage shall be sealed against absorption of moisture from the concrete either by (1) a field applied, approved form oil or sealer, or (2) a factory applied non- absorptive liner. When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Care shall be taken that such approved coating is kept out of contact with the reinforcement. Where "as-cast" finishes are required, materials, which may impart a stain to the concrete shall not be applied to the form surfaces. Where the finished surface is required to be painted, the material applied to form surface shall be compatible with the type of paint to be used.

s. In normal circumstances generally where temperatures are above 68°F (20°C) where ordinary cement is used, forms may be struck after expiry of the following periods.

-	Walls, columns and vertical sides of beams	48 hours or as directed by the ENGINEER.
-	Slabs (Shores or props left under, removal and refixing of props not permitted).	10 days
-	Beams soffits(Shores or	14 days



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- props left under, removal and refixing of props not permitted).
- Removal of shores or props to slabs:
 1. Spanning upto 14 ft. (4 meters) 14 days
 2. Spanning over 14 ft. (4 meters) 21 days

 - Removal of shores or props of beams:
 1. Spanning upto 20 ft. (6 meters) 21 days
 2. Spanning over 20 ft. (6 meters) 28 days

For rapid hardening cement 1/2 of the above period will be sufficient in all cases except vertical sides of slabs, beams and columns which should be retained for a minimum of 24 hours.

t. Proper allowance shall be made for the decrease in rate of hardening of concrete in cold weather and the minimum periods must be increased when the mean daily temperature is below 68°F, (20°C).

u. When repair of surface defects or finishing is required at an early age, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.

v. Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or the treatment required on such sloping surfaces shall be performed at once and followed by the specified curing.

w. All formwork shall be removed without such shock or vibration as would damage the reinforced concrete.

x. When re-shoring or re-propping is permitted or required, the operations shall be planned in advance and shall be subject to approval. While re-shoring is underway no live load shall be permitted on the new construction. In no case during re-shoring shall concrete in beams, slab, columns or any other structural member be subject to combined dead and



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construction loads in excess of the load permitted by ENGINEER for the developed concrete strength at the time of re-shoring. Re-shores shall be placed simultaneously with stripping operations are but in no case later than the end of working day on which stripping occurs.

Re-shores shall be tightened to carry their required loads without over stressing the concrete. Re-shores shall remain in place at least until representative tests of the concrete being supported have reached the strength/time specified in 6.1.s.

y. Floors supporting props or shores under newly placed concrete shall have their original supporting props or shores left in place or shall be re-shored. The re-shoring system shall have a capacity sufficient to resist the anticipated loads and in all cases have a capacity equal to at least one half of capacity of the shoring system above. The re-shores shall be located directly under a shore position above unless other locations are permitted.

The re-shoring or re-propping shall extend over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads in such a manner that the design superimposed load of the floors supporting shores or props are not exceeded.

No loads, other than those permitted by the ENGINEER in connection with the actual work in hand, shall be allowed on suspended floors until 28 days after concreting where ordinary Portland cement is used and 14 days when rapid hardening Portland cement is used.

z. It is required to give forms for reinforced concrete an upward camber to ensure that the beams or slabs including cantilever slabs do not have a sag when they have taken up their deflection. Camber, unless indicated otherwise on drawings, should be about 1/240 for supported beams and slabs and 1/180 for cantilevers.

5.2 Reinforcement:

a. All metal for reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.

b. Reinforcement is to be accurately placed as shown in the Drawings, and secured against displacement by using 18-20 gauge black annealed wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern.



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Where concrete blocks are used for ensuring the cover they shall be made of mortar not leaner than 1 part of cement to 2 parts of sand. Where the concrete surface will be exposed to the weather in the finished structure the portions of all accessories in contact with the formwork shall be galvanized or shall be made of plastic.

- c. Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the Bending Schedule .
- d. The cutting tolerance for all bars shall be $\pm 1"$ (± 25 mm).
- e. Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as in Table 1.

TABLE 1--BENDING TOLERANCES

DIMENSIONS OF BENT BARS				TOLERANCE			
Over		Upto and Including		Plus/Minus			
Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
--	--	36	900	1/8	3	1/4	6.0
36	900	72	1800	1/4	6.0	1/2	12.0
72	1800	--	--	1/2	12.0	125.0	

- f. Bars shall be placed to the following tolerances:
 - i. Concrete cover to formed surface: $\pm 1/4"$ (6.0 mm)
 - ii. Minimum spacing between bars: $\pm 1/4"$ (6.0 mm)
 - iii. Top bars in slabs and beams:
 - * Members 8" (200 mm) deep or less: $\pm 1/4"$ (6.0 mm)
 - * Members more than 8" (200 mm) but not over 24" (600 mm) deep: $\pm 1/2"$ (12.0 mm)
 - * Members more than 24" (600 mm) deep: $\pm 1"$ (25 mm)



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- iv. Crosswise of member: spaced evenly within 1" (25 mm)
- v. Lengthwise of members: +/- 2" (50 mm)
- g. Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed the above tolerances, resulting arrangement of bars shall be subject to approval of the ENGINEER.
- h. Vertical bars in column shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all columns dowels.
- i. Reinforcement shall not be bent or straightened in a manner that will injure the material. No bars shall be bent twice in the same place, nor shall they be straightened after bending.

Unless permitted by the ENGINEER, reinforcement shall not be bent after being partially embedded in hardened concrete. Bars which depend for their strength on cold working shall not be heated for any reason (except for welding) Reinforcement larger than 1-1/2" (38.0 mm) in dia may be bent by the use of heat at (not exceeding 1550 °F). Bars bent shall not be cooled by quenching.
- j. No splice of reinforcement shall be made except as shown on the working Drawings.
- k. Welding shall be permitted for bars only under suitable conditions and with suitable safeguards in accordance with B.S 693. 1856, or AWS D 12.1, provided the type of reinforcement bars have the required welding properties. Tack welding may be used to fix in position bars that cross each other, only with prior approval of the ENGINEER.
- l. Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete exposed part to be built into later concrete.
- m. No concreting is to be carried out until the reinforcement has been checked and approved by the ENGINEER.



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5.3 **Batching:**

- a. All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement, unless marked otherwise, may be taken as 112 lbs (50 kg) or as directed by the ENGINEER
- b. Aggregate shall be batched by weight, due allowance being made for water content. Aggregate may be batched by volume only with the prior permission of ENGINEER. The apparatus for weight batching may be an integral part of the mixer or a separate unit of a type approved by ENGINEER.. It shall be accurate within 2% and shall be checked for accuracy at least once a week.
- c. Where the batching plant is of the type in which cement and aggregate are weighed in the same compartment, the cement shall be introduced into the compartment between two sizes of aggregate.
- d. Where volumetric batching of aggregate is permitted gauge boxes shall be provided for measuring the coarse and the fine aggregate. These shall be **deep and narrow rather than shallow and wide**. Tests for the bulking of sand shall be made at intervals and the necessary quantity of sand added.
- e. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time.

5.4 **Mixing:**

- a. The concrete shall be mixed in an approved batch mixer conforming to the requirement of B.S 1305. It shall be fitted with the manufacturer's plate stating the rated capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device.
- b. Mixing shall continue for the period recommended by the mixer manufacturer or until apparently the mix is uniform in color, whichever period is longer. If it is desired to use a mixing period less than 1-1/2 minute ENGINEER's approval shall be obtained in writing.
- c. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added.



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- d. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixing blades shall be replaced when they have lost 10% of their original height.
- e. Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be re-tempered, but shall be discarded.

5.5 Transport:

- a. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent segregation or loss or addition to ingredients. It shall be deposited as nearly as practicable in its final position so as to avoid re-handling or flowing. All skips vehicles, or containers used for transporting the concrete shall be thoroughly cleaned.
- b. During hot or cold weather, concrete shall be transported in deep containers to minimize the loss of water/heat.

5.6 Placing:

- a. Before placing of concrete, formwork shall have been completed, water shall have been removed, reinforcement shall have been secured in place, expansion joint material, anchors, and other embedded items shall have been kept in position, and the entire preparation shall have been approved.
- b. No concrete is to be placed into the foundation trenches until the ground to receive the same has been examined and approved by ENGINEER for this purpose.
- c. The actual sequence of construction proposed by CONTRACTOR shall be subject to ENGINEER's approval before construction starts on any part of the structure, and this sequence shall not be varied without ENGINEER's prior approval.
- d. The concrete shall be placed after it has been mixed as soon as is practicable. Once the concrete has left the mixer no more water shall be added, although the concrete may be mixed or agitated to help maintain workability. The concrete shall not be used if, through any cause, the workability of the mix at the time of placing is too low for it to be compacted fully and to an acceptable finish by whatever means are available.

The time between mixing and placing should be reduced if the mix is richer or the initial workability of the mix is lower than normal, if a rapid hardening cement or an accelerator is used, or if the work is carried out at a high temperature or exposed to a drying atmosphere. CONTRACTOR



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shall ensure that the delay between mixing and placing does not exceed 30 minutes under any circumstances. Any concrete which does not satisfy this requirement shall not be used.

e. The concrete shall be deposited as nearly as possible in its final position to avoid re-handling. In no circumstances may concrete be made to flow along the forms by the use of vibrators. Concreting shall be carried out on as a continuous operation using methods which shall prevent separation or loss of ingredients.

f. The free fall of concrete shall not be allowed to exceed eight feet and where it is necessary for the concrete to be lowered more than this amount, it is not to be dropped into its final position, but it is to be placed through pipe, the lower end of which shall be kept in, or close to the freshly deposited concrete. The dia. of the pipe shall be not less than 4 times the maximum size of aggregate.

g. For mass concrete, concrete shall be placed in layers approximately 18" (450 mm) thick. Vibrator heads shall extend into the previously placed layer.

h. The workmen carrying concrete to the SITE, and all other workmen moving about before the concrete is placed shall move only along runways or planks placed over the forms.

i. Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by ENGINEER, the surface will be brought to a true, hard smooth, level using a cement sand mortar in the ratio of 1 volume of cement to 3 volumes of sand. Two layers of building paper weighing 1.3 oz/sq. ft (400 g/m) will then be laid flat to separate the concrete from the surface on which it is to be laid.

5.7 Construction Joints:

a. Concreting shall be carried out continuously upto construction joints, the position and arrangement of which shall be pre-determined with the approval of the ENGINEER.

b. Joints not shown on the Drawings shall be so made and located as to least impair the strength of the structure and shall need prior approval of ENGINEER. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset to a distance equal to twice the width of the secondary beam. Joints in walls and columns shall be at the underside of floors slab or beams, and at the top of footings.



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Beams, brackets, columns, capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

c. All reinforcing steel shall be continued across joints. Key and inclined dowels shall be provided as directed by ENGINEER. Longitudinal keys at least 1- 1/2" (40 mm.) deep shall be provided in all joints in walls and between walls and slab or footings.

d. When the work is to be resumed on a surface which has hardened, such surface shall be roughened in an approved manner which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.

e. The hardened concrete of construction joints and of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in un-exposed walls and all others not mentioned below shall be dampened (but not saturated) immediately prior to placing of fresh concrete.

f. The hardened concrete of joints in exposed work, joints in the middle of beams, and slabs and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout of similar proportions to the mortar in the concrete. The grout shall be as thick as possible on vertical surface and at least 1/2" (12.0 mm) thick on horizontal surface. The fresh concrete shall be placed before the grout has attained its initial set.

g. Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brush. Care being taken to avoid dislodging of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 6" (150 mm) in thickness, and shall be well rammed against old work, particular attention being paid to corners and close spots.

h. Stop ends for movement joints or construction joints shall be made by splitting them along the lines of reinforcement or the concrete. Stop ends made of expanded metal or similar material may only be left permanently in the concrete with prior written approval of ENGINEER. Where such stop ends are used, no metal may be left permanently in the concrete closer to the surface of the concrete than the specified cover to the reinforcement. Wood strips inserted for architectural treatment shall be kerfed to permit swelling without pressure on the concrete.

5.8 Embedded Items:

a. The material, design and location of water stops in joints shall be as indicated in the Drawings. Each piece of pre-molded water stop shall be of



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maximum practicable length in order that the number of end joints will be held to a minimum.

Joints at intersections and at end of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective watertightness fully equal to that of the continuous water-stop material, and shall permanently develop not less than 50% of the mechanical strength of the parent section, and shall permanently retain their flexibility.

b. Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than four percent of the area of the cross section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location so as not to impair unduly the strength of the construction. Such sleeves, conduits in compression in the displaced concrete, provided that they are not exposed to rusting or other deterioration, are of uncoated or galvanized iron or steel not thinner than standard steel pipe, have a nominal inside diameter not over 2" (50 mm) and are spaced at centers not less than thrice their diameter. Except when plans of conduits and pipes are approved by ENGINEER embedded pipes or conduits other than those merely passing through, shall not be larger in outside diameter than one-third the thickness of the slab, walls, or beam in which they are embedded nor shall be spaced closer than three diameters on center, nor so located as to impair unduly the strength of the construction. Sleeve pipes, or conduits with-in the limitations of this section may be embedded in concrete with the approval of ENGINEER, provided they are not considered to replace the displaced concrete.

c. All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.

All Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

d. Expansion joint material, waterstops and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

5.9

Consolidation:

a. All concrete shall be consolidated by vibration, so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of form, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a



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minimum frequency of 800 vibrations per minute and sufficient amplitude to consolidate the concrete effectively.

Vibrators shall be inserted and withdrawn at points approximately 18" apart (450 mm). At each insertions, the duration shall be sufficient to cause consolidation, generally from 5 to 15 sec. A spare vibrator shall be kept on the SITE during all concreting operations. Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process supplemented if necessary by spading to work the coarse aggregate back from the formed surface.

b. If there is any tendency for the mix to segregate during consolidation, particularly if this produces excessive laitance, the mix proportions shall be modified to affect an improvement in the quality of the concrete to the satisfaction of ENGINEER and in conformity with the provisions of Clause 5.

c. Vibrators shall not be allowed to contact the formwork for exposed concrete surface.

d. Mechanical vibrators shall be of a type suited in the opinion of ENGINEER to the particular conditions.

e. Over-vibration or vibration of very wet mix is harmful and should be avoided.

5.10

Curing and Protection:

a. Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures, and mechanical injury, and shall be maintained with minimal moisture loss at a relative constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval of ENGINEER.

b. For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion and finishing:

- Ponding or continuous sprinkling.
- Application of absorptive mats or fabric kept continuously wet.
- Application of water proof sheet materials approved by ENGINEER.



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- Application of other moisture retaining covering as approved.

- Application of curing compound conforming to ASTM C 309. The compound shall be applied in accordance with the recommendations of the manufacturer immediately after any sheen which develops after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other materials to be bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from area to receive bonded applications.

c. Moisture loss from surface placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping forms wet until they can be safely removed. After form removal, the concrete shall be cured until the end of the limit prescribed in Clause 6.10.d by one of the methods of Clause 6.10.b.

d. Curing in accordance with clause 6.10.a & 6.10.b shall be continued for at least 14 days in the case of all concrete except concrete with Rapid hardening Portland cement for which the period shall be at least 7 days.

Alternatively if tests are made of cylinders/cubes kept adjacent to the structure and cured by the same methods, moisture retention measures, unless stated otherwise on drawings, may be terminated when the average compressive strength has reached 70 percent of the minimum specified works strength. If one of the first four curing procedures of clause 6.10.b is used initially, it may be replaced by one of the other procedures of that Clause any time provided the concrete is not permitted to become surface dry during the transition.

e. When the mean daily outdoor temperature is less than 41 degree F (5 C) then temperature of the concrete shall be maintained between 50-68°F (10°C-20°C) for the required curing period of Clause 6.10.d. When necessary arrangements for heating, covering, insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury to concentration of heat. Combustion heaters shall not be used during the first 24 hours unless approved precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.

f. When necessary, provision for windbreak, shading for spraying, sprinkling, ponding or wet covering with a light colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as concrete hardening and finishing operations will allow.



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g. Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 5°F (3°C) in any one hour or 50°F (28°C) in any 24 hour period.

h. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibration. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods by application of curing procedures, and by rain or running water, self-supporting structures shall not be loaded in such a way as to over stress the concrete.

5.11

Works in Extreme Weather:

a. Unless adequate protection is provided and approval is obtained concrete shall not be placed during rain. Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

b. When the temperature of the surrounding air is expected to be below 40 degrees F (4.4 C) during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed shall be no lower than 55 degrees F (13 - C) for sections less than 12" (300 mm) in any dimension nor 50°F (10°C) for any other sections.

When necessary, concrete materials should be heated before mixing and carefully protected after placing; in general, heating of mixing water alone to about 140°F (60°C) may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials, containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 5.5 gallons (25 liters) per bag of cement. If water or aggregate is heated above 100°F (38°C) the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 100°F (38°C).

c. During hot weather, the temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or cold joints and should not exceed 90°F (32.°C). For massive concrete this temperature should not exceed 70°F (21.°C). When the temperature of the concrete exceeds 90°F (32°C),precautionary measures approved by ENGINEER shall be put into effect. When the temperature of the steel is



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greater than 122°F (50°C) steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or flake ice or well-crushed ice of a size that will melt completely during mixing may be substituted for all or part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.

Other precautions recommended by ACI standard 305R-91 shall also be adopted.

6. TEST FOR CONCRETE QUALITY

6.1 General:

CONTRACTOR shall provide samples of concrete for testing at ENGINEER's direction. Proper facilities shall be provided for making and curing the test specimens in accordance with the specifications. A competent person shall be employed by CONTRACTOR whose first duty shall be to supervise all stages in the preparation and placing of the concrete. All test specimens shall be made and SITE tests carried out under his direct supervision and at CONTRACTOR's cost.

6.2 Samples:

Conduct strength tests on at least one test sample per 50 cubic yards of concrete (38 cu meters) with a minimum of 3 samples per concrete pour. Each test sample shall consist of no less than 9 concrete test cylinders made from a single sample of concrete from a randomly selected batch of concrete, taken at point of discharge from mixer or truck, cured under standard conditions. 3 cylinders from each sample shall be tested at age 7 days, 3 at age 14 days and 3 at age 28 days unless otherwise directed by the ENGINEER.

6.3 Adequacy of Mix:

In case of Concrete mix, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the specimen is below the specified strength or if the average strength of the three specimens is not less than the specified strength and the difference between the greatest and least strengths is not more than 20% of that average.

When the results of tests show that the strength of any concrete is below the minimum specified, ENGINEER may give instructions for the whole or part of the work concerned to be removed and be replaced at the expense of CONTRACTOR. CONTRACTOR shall bear the cost of any other part of his, or any other CONTRACTOR's work, which has to be removed and replaced as a result of the defective concrete. If any concrete is held to have failed, ENGINEER may order the proportions of that class of concrete to be changed in order to provide the specified strength.



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7. FINISHING OF FORMED CONCRETE

7.1 General:

a. After removal of forms the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Drawing or as specified in Clause 8.5.

b. When finishing is required to match a small sample furnished to CONTRACTOR, the sample finish shall be reproduced on an area at least 100 square feet in an inconspicuous location designated by ENGINEER before proceeding with the finish in the specified location.

7.2 As-Cast Finishes:

a. Rough Form Finish:

No selected form facing materials shall be specified for rough form finish surfaces. Tie holes and defects shall be patched, Unless if required to be retained if so directed by ENGINEER. Fins exceeding 1/4" (6 mm) in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

b. Smooth Form Finish:

The form facing material shall produce a smooth hard uniform texture on the concrete. It may be plywood, tempered concrete-form grade hardboard, metal, plastic paper, or other approved material capable of producing the desired finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched. All fins shall be completely removed.

7.3 Architectural Finishes:

a. Textured Finishes:

Textured form liners may be of formed plastic sheet, wood, sheet metal, or other material designated in Drawings. Liner panels shall be secured in forms by cementing or stapling, but not by methods which will permit impressions of nail heads, screw heads washers, or the like to be imparted to the surface of the concrete, unless shown otherwise on the



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Drawings. Edges of textured panels shall be sealed to each other or to dividing strips, if specified or shown, to prevent bleeding of grout. The sealant used shall be non-staining to the surface.

b. **Applied Finishes:**

When finishes of plaster or similar trowelled materials are to be applied, the surface of the concrete shall be prepared to ensure permanent adhesion of the finish. If the concrete is less than 24 hours old, it can be roughened with a heavy wire brush or scouring tool. If the concrete is older the surface may be roughened mechanically or by etching with dilute hydrochloric acid. After roughening, the surface shall be washed free of all dust, acid, chemical retarder, and other foreign material before the final finish is applied.

7.4 Rubbed Finishes:

The following finishes shall be produced on concrete with a smooth form finish. Where smooth rubbed finish is to be applied, the forms shall have been removed and necessary patching completed as soon after the placement of the concrete as possible without compromising any structural requirements.

a. **Smooth Rubbed Finish:**

Smooth rubbed finish shall be produced on newly hardened concrete not later than a day following form removal.

Surfaces shall be wetted and rubbed with carborundum brick or other abrasive until uniform color and texture are produced. No cement grout shall be used other than the cement paste drawn from the concrete itself by the rubbing process.

b. **Grout Cleaned Finish:**

No cleaning operations shall be undertaken until all contiguous surfaces to be cleaned are completed and accessible. Cleaning as the work progresses shall not be permitted.

Mix 1 part Portland cement and 1-1/2 part fine sand with sufficient water to produce a grout having the consistency of thick paint. White Portland Cement shall be substituted for a part of the grey Portland cement in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch. Wet the surface of the concrete sufficiently to prevent absorption of water from the grout and apply the grout uniformly with a brush or a spray gun. Immediately after applying the grout, scrub surface vigorously with a cork float or stone and fill all air bubbles and



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holes. While the grout is still plastic, remove all excess grout by working the surface with a rubber float, sack or other means. After the surface whitens from drying (about thirty minutes at normal temperature) rub vigorously with clean burlap. The finish shall be kept damp for at least 36 hours after final rubbing.

c. **Cork Floated Finish:**

1. Remove forms at an early stage, within 2 to 3 days of placement where possible.
2. Remove ties, and all burrs and fins.
3. Mix 1 part Portland cement and 1 part fine sand with sufficient water to produce a stiff mortar.
4. Dampen surface.
5. Apply mortar with firm rubber float or with trowel, filling all surface voids.
6. Apply a small amount of water with a fog spray to prevent too rapid drying of compressed mortar.
7. Apply a small amount of water with a fog sprayer.
8. Produce the final texture with a cork float using a swirling motion.

7.5 Unspecified Finishes:

If the finish is not designated in the Drawings, the following finishes shall be used as applicable:

a. **Rough Form Finish:**

For all concrete surface not exposed to public view and / or are specified to have subsequent finishing.

b. **Smooth Form Finish:**

For all concrete surfaces exposed to public view and or are not required to have subsequent finishing.

7.6 Related Unformed Surfaces:

Tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be floated to a texture reasonably consistent with that of the formed surfaces. Final treatment on form surfaces shall continue uniformly across the unformed surfaces.



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8. REPAIR OF SURFACE DEFECTS:

8.1 General:

- a. Any concrete failing to meet the specified strength or not formed as shown on Drawings, concrete with surface beyond tolerances or with defective surfaces which cannot be properly repaired or patched in the opinion of ENGINEER shall be removed and replaced at CONTRACTORS's expenses. ENGINEER may reject any defective concrete and order it to be cut out in part or in whole and replaced at the CONTRACTOR's expense. Only in case of minor surface defects, ENGINEER may approve a surface treatment in accordance with the Clause. 9.2
- b. All ties and bolt holes and all repairable defective areas shall be patched immediately after the removal of forms.

8.2 Repair of Defective Areas:

- a. All honeycombed and other defective concrete shall be removed down to sound concrete. The area to be patched and area at least 6" (150 mm) wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine sand or an approved bonding agent shall then be well brushed/ applied into the surface.
- b. The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2-1/2 parts sand by damp loose volume. White Portland cement shall be substituted for a part of the grey Portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch.
- c. The quantity of mixing water shall be not more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.
- d. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to loose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface to permit initial shrinkage; it shall be left undisturbed for at least one hour before being finally finished. The patched area shall be covered by approved curing compound, except as specified in Clause 9.2 g. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.



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e. Where as-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast concrete surfaces shall not exceed 2 square ft. in each 1000 square feet (2 sq. m in each 1000 sq.m) of as-cast surface. This is in addition to form tie patches, if the project design permits to fall within as-cast areas.

f. Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good color match with the concrete when both patch and concrete are cured and dry. After initial set, surface of patches shall be dressed manually to obtain the same texture as surrounding surfaces.

g Patches in architectural concrete surfaces shall be cured for 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

8.3 Tie and Bolt Holes:

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar.

8.4 Proprietary Materials:

If permitted or required by ENGINEER proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendation with prior approval of ENGINEER.

9. CONCRETE CONSTRUCTION TOLERANCE

Where tolerances are not stated in the Specifications or Drawing for any individual structure or feature, maximum permissible deviations from established lines, grades and dimensions shall conform to the following. The CONTRACTOR is expected to set and maintain concrete forms so as to ensure completed work within the tolerance limits. These allowable tolerances shall not relieve CONTRACTOR of his responsibility for correct fitting of indicated materials. These tolerances are not cumulative.

9.1 Variation from the plumb (or as specified for sloped walls).

- | | | |
|----|--|--------------|
| a. | In the lines and surfaces of columns, piers and walls. | |
| | * In any 10 ft (3 m) of length or height: | 1/4" (6 mm) |
| | * In any storey or 20 feet (6 meters) Max: | 3/8" (10 mm) |



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Minus:	1/4" (6 mm)
Plus:	1/2" (12.0 mm)

9.6 Footings:

- a. Variations in dimensions in plan.

*	Minus :	1/2"(12.0 mm)
*	Plus (plus variation applied to concrete only, not to bars dowels):	2" (50 mm)
- b. Misplacement or eccentricity of concrete.

*	2 percent of the footing width in the direction of misplacement but not more than 2"(50 mm)
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- c. Reduction in thickness

*	Minus 5 percent of specified thickness.
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9.7 Variation in Steps

- a. Rise: 1/8" (3 mm)
- Tread: 1/4" (6 mm)
- b. In consecutive steps
- Rise: 1/16" (1.0 mm)
- Tread: 1/ 8" (3 mm)

9.8 Tolerance for Precast Concrete:

Forms must be true to size and dimensions of concrete members shown on the plans and be so constructed that the dimensions of the finished product will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on ENGINEER's Drawings.

- a. Overall dimensions of members per 10 ft (3 mm)

+/- 1/16" (1.0 mm)



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- | | | |
|----|---|--|
| b. | Cross-sectional dimensions Section less than 3"(75 mm) | +/- 1/16" (1.0 mm) |
| c. | Section over 3" (75 mm) less than 18" (450 mm) | +/- 1/ 8" (3 mm) |
| d. | Section over 18" (450 mm) | +/- 1/ 4" (6 mm) |
| e. | Deviations from straight lines in long sections. | Not more than 1/8 inch per10 ft. (3mm / 3 m) |
| f. | Deviation from specified camber | +/- 1/16" (1.5 mm) per 10 ft (3m) of span |
| g. | Maximum differential between adjacent units in erected position | 1/4 inch (6 mm) |

9.9 Tolerance for Pavements:

a. Ramps

- | | |
|--|---|
| Departure from established alignment | +/- 1/2 inch (12.0 mm). |
| Departure from established longitudinal | +/- 1/4" (6 mm) grade on any line. |
| Departure from transverse template contour except at transverse joints | +/- 1/8 inch (+/- 3 mm). |
| Departure from transverse template control at transverse joints | +/- 1/4" (+/-6 mm) in width of one traffic lane |

9.10 Pavements for Parking Areas:

Twice values listed for ramp pavements.

10. ACCEPTANCE OF STRUCTURE

10.1 General:

- a. Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the CONTRACT Documents.
- b. Completed concrete work which fails to meet one or more requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the CONTRACT Documents.



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c. Completed concrete work which fails to meet one or more requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the CONTRACT Documents. In this event, modifications complies with the requirements.

10.2 Dimensional Tolerances:

a. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of Section 10 considered potentially deficient in strength and subject to the provisions of Section 11.4.

b. Formed surfaces resulting in concrete outlines larger than permitted by the tolerances of Section 10 may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to be removed in accordance with this Section.

10.3 Appearance:

a. Architectural concrete with surface defects exceeding the specified limitations shall be removed in accordance with this Section.

b. Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or misplaced items interfere with other construction.

c. Inaccurately formed concrete surfaces exceeding the limits of Section 6 & of Section 10 and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

d. Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods.

e. Concrete not exposed to view, but of defective appearance, may be accepted at the discretion of the ENGINEER.

10.4 Strength of Structure:

a. The strength of structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions:



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- Concrete strength requirements not considered to be satisfied in accordance with Section 7.
 - Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements of Section 4.4 & 6.2 of the CONTRACT Documents.
 - Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.
 - Curing less than that specified.
 - Inadequate protection of concrete from extreme temperature during the early stages of hardening and strength development.
 - Mechanical injury, construction fires, accidents or premature removal of formwork likely to result in deficient strength.
 - Poor workmanship likely to result insufficient strength.
- b. Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- c. Core tests may be required when the strength of the structure is considered potentially deficient.
- d. If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their results evaluated in accordance with ACI Standard 318.
- e. Concrete work judged inadequate by structural analysis or by results of a load test shall be reinforced with additional construction, if so directed by ENGINEER or shall be replaced, at the CONTRACTOR's expense.
- f. The CONTRACTOR shall pay all costs incurred in providing the additional testing and/or analysis required by this Section.
- g. THE OWNER will pay all costs of additional testing and/or analysis which is made at his request and which is not required by specifications, or the CONTRACT Documents.



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11. METHODS OF MEASUREMENT OF CONCRETE WORKS

11.1 General:

a. Unless otherwise specifically stated in the Bill of Quantities, or herein, all items shall be deemed to be inclusive of, but not limited to, the following:

- i. Labor/plant and all costs in connection therewith.
- ii. Materials, goods and all costs in connection therewith, e.g. conveyance, delivery, unloading, storing, returning, packing, handling, hoisting, lowering.
- iii. All fixtures and all costs in connection therewith for precast works.
- iv. Fitting and fixing materials and goods in position.
- v. Waste of materials, and Square cutting.
- vi. Mixing, transporting, hoisting, placing in from at any level, compacting through vibration & curing etc. complete including the cost of formwork& its removal(but excluding cost of reinforcement).
- vii. Establishment charges, overhead charges and profit.
- viii. All other expenses, charges and taxes specified in Conditions of CONTRACT.

b. Works shall be measured net as fixed in position as per drawings and instructions of ENGINEER. Each measurement shall be taken to the nearest 1/2" (12.0 mm). This rule shall not apply to any dimensions stated in the descriptions.

11.2 Concrete:

a. Concrete shall be measured as executed but no deduction shall be made for the following:



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- Volume of any steel embedded in the concrete.
 - Volume occupied by water pipes, conduits etc., not exceeding 4 square inch (2500 sq. mm) each in cross-sectional area.
 - Voids not exceeding 1 square foot in work given in square feet and 0.1 sq M in work given in Sq Meters. If any void exceeds above limit total void shall be deducted.
 - Voids not exceeding 1 cubic foot in work given in cubic feet, 0.03 cubic meter in work given in cubic meter. If any void exceeds above limits, unit total void shall be deducted.
- b. Voids, which are not to be deducted as per Section 12.2.a above, refer only to openings or vents which are wholly within the boundaries of measured areas. Openings or vents which are at the boundaries of measured areas shall always be subject to deduction irrespective of size.
- c. Junctions between straight and curved works shall in all cases be deemed to be included with the work in which they occur.
- d. Concrete work shall be classified and measured separately as follows unless otherwise described elsewhere:-
- Buildings, foundation beams, foundation slabs, footings, bases of columns, machine foundations, mass concrete etc., in cubic feet (Cu Meter).
 - Floor slabs on ground with floor beams in cubic feet (Cubic Meter).
 - Walls in foundations, plinth and superstructure in cubic feet (Cubic Meter) stating thickness.
 - Columns, piers, pilasters, pillars etc., in cubic feet (Cubic meter).
 - Lintels, beams and brackets in cubic feet (Cubic Meter).
 - Suspended floors, roofs and stair landings in square feet (sq. Metre) stating thickness.
 - Stairs (excluding landing) in cubic feet (Cubic Meter).



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- Railings in cubic feet (Cubic Meter), square feet (Sq. Meter), or linear feet (Meter) stating description.
- Parapets, purdees and the like in cubic feet (Cubic Meter) stating thickness.
- Jali, blocks in square feet (Sq. Meter) stating thickness & description.
- Precast concrete items shall each be enumerated except if otherwise shown in the Bill of Quantities, separately stating the description.

e. Measurement of walls shall be taken between attached columns, piers or pilasters. The thickness of attached columns, piers or pilasters shall be taken as the combined thickness of the wall and the columns, piers or pilasters. Attached or isolated columns, piers, pilasters and the like (except where caused by openings) having a length on plan not exceeding four times the thickness shall be classified as columns. Those having a length over four times the thickness and caused by openings in walls shall be classified as walls.

Columns shall be measured from the top of footings/beams or floor surfaces to the under side of beams or slabs as the case may be. Where the width of the beams is less than the width of columns, the extra width at the junction shall be included in the beam.

The depth of the beams shall be measured from bottom of the slab to the bottom of the beams, except in case of inverted beams where it shall be measured from top of slab to the top of beam. The cross section below or above the slab.

11.3

Formwork:

a. Formwork (if separate and extra payment is specifically stated in the Bill of Quantities) shall be measured in square feet (Sq. M) as the actual surface of the finished structure which required to be supported during the deposition of the concrete, including the upper surfaces to the work sloping more than 15 degree from the horizontal. No allowance shall be made for overlaps and passing at angles and no deduction shall be made for the following:-

- Voids not exceeding ten square feet (1 Sq. m).



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- Intersections of main beams with walls or columns.
- Intersections of secondary beams with main beams.
- b. Formwork shall be deemed to be inclusive of, but not limited to items detailed in section 12.1 and the following:-
 - Batten, struts, reversed cut strings, bolting, oiling, wedging, easing, striking, removing and making good exposed faces of concrete after removal of formwork. Also yokes, wales sheathing, jack rods, jacks, working platforms and finishers, scaffolds, etc.
- c. Forming chamfers not exceeding 2" (50mm) wide and forming splayed internal angles not exceeding 1/2" (12.0 mm) wide shall not be paid for extra.
- d. Temporary stop ends for constructed joints shall not be measured and paid for.
- e. Classification of formwork (if separate and extra payment is specifically stated in the Bill of Quantities) shall be as follows:-
 - To horizontal or sloping soffits of suspended slabs, floors, roofs, staircases, landings and the like.
 - To sloping upper surfaces of suspended slabs, floors, roofs and the like where more than 15 degree from horizontal.
 - To vertical or battering sides of foundations, foundation beams and slabs, ground beams, machine foundations and the like.
 - To vertical or battering sides of walls, solid balustrades and the like.
 - To vertical or battering sides.
 - To vertical or battering sides of stanchion casings, columns, piers, plasters and the like.
 - To sides and soffits of openings in walls, recesses in walls, projecting panels on walls and the like.
 - To sides and soffits of horizontal or sloping beam casings, beams, brackets, lintels, staircase, strings and the like.
 - To sloping upper surfaces of beam casings, beams, brackets, lintels, staircase-strings and the like where more than 15 degrees from horizontal.



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- To edges of beds, roads, footpaths, paving and the like.
- To edges of suspended slabs, floors, roofs, landing and the like.
- To risers of steps and staircases.
- To sides of kerbs, up stands and the like.

f. Formwork to throats, grooves, chases, rebates, chamfers over 2" wide (50 mm) splayed internal angles over 1/2" wide (12.5 mm) moldings and the like shall each be measured separately in linear feet stating the size.

11.4

Rate for Reinforcement:

a. The rate tendered for any type of reinforcement by the CONTRACTOR shall also be inclusive of the cost of binding wire wastages, and the cost of concrete, metal or plastic chairs and spacers or hangers, etc.

b. All reinforcement shall be provided in length shown in Drawings and as per Specifications.

Should the CONTRACTOR provide lengths of reinforcement which are greater than shown on the Drawings no payment of extra length shall be made. Overlaps, unless clearly shown in working Drawings, shall not be allowed and measured.

c. The CONTRACTOR shall be paid for reinforcement by weight computed from Table-2 and from linear measurements of reinforcements actually used at SITE as per the Drawings, Specifications and instructions of ENGINEER. No payment shall be made for steel chairs or wastage. CONTRACTOR shall not claim for the difference in the actual weights of bars and their standard weights given in Table -2.

TABLE-2:

Nominal Bar Diameter (Inches) ¹	Bar Number	Weight lbs/ft
1/4"	-	0.167
3/8"	# 3	0.376
1/2"	# 4	0.668
5/8"	# 5	1.043
3/4"	# 6	1.502



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7/8"	# 7	2.044
1"	# 8	2.670
1-1/8"	# 9	3.400
1-1/4"	#10	4.303
1-3/8"	#11	5.313
1-3/4"	#14	7.650
2-1/4"	#18	13.600

(mm)	(kg/m)
8	0.395
10	0.616
12	0.887
16	1.576
20	2.463
22	2.980
25	3.849
28	4.828
32	6.306
36	7.981

¹To the nearest 1/8

12. EXPANSION JOINT COVERS

12.1 – GENERAL

12.1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.



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12.1.2 SUMMARY

- A. Provide all labor, materials, equipment and services, and perform all operations required for complete installation of Expansion Control and related work as indicated on the drawings and specified herein.
- B. Work Included: The work of this section shall include, but not be limited to the following:
 - 1. Floor expansion joint cover assemblies.
 - 2. Wall/ceiling expansion joint cover assemblies.
 - 3. Exterior expansion joint seals.
 - 4. Specialty expansion joint systems.
 - 5. Roof expansion joint assemblies.
 - 6. Fire barrier systems.
- C. Related Work Specified Elsewhere
 - 1. Concrete – Section 03300.
 - 2. Unit Masonry – Section 04200.
 - 3. Miscellaneous Metal – Section 05500.
 - 4. Flashing and Sheet Metal – Section 07620.
 - 5. Sealant and Caulking – Section 07920.
 - 6. Color designs – Section 09050.

12.1.3 QUALITY ASSURANCE

- A. Materials and work shall conform to the latest edition of reference specifications specified herein and to all applicable codes and requirements of local authorities having jurisdiction.
- B. Loading Characteristics:
 - 1. Standard Floor Covers – shall be designed to withstand a minimum point load of 500 lbs. without damage or permanent deformation. Heavy-duty covers should withstand a point load of 2,000 lbs.

12.1.4 SUBMITTALS

- A. Product Data – Submit copies of manufacturer's latest published literature for materials specified herein for approval, and obtain approval before materials are fabricated and delivered to the site. Data to clearly indicate movement capability of cover assemblies and suitability of material used in exterior seal for UV exposure.
- B. Certificates – Material test reports from qualified independent testing laboratory indicating and interpreting test results relative to compliance of expansion joint assemblies with requirements indicated.
- C. Shop Drawings – Submit shop drawings for work specified herein for approval and obtain approval prior to fabrication and shipment of materials to the job site.
 - 1. Shop drawings showing full extent of expansion joint cover assemblies; include large-scale details indicating profiles of each type of expansion joint cover assembly,



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splice joints between sections, joinery with other types, special end conditions, anchorage's, fasteners, and relationship to adjoining work and finishes. Include description of materials and finishes and installation instructions.

- D. Samples – Samples of materials specified herein shall be submitted for approval, and approval obtained before materials are delivered to the site. Samples shall include the following:
1. Samples for each type of metal finish indicated on metal of same thickness and alloy to be used in work. Where normal color and texture variations are to be expected, include two (2) or more units in each set of samples showing limits of such variations.
 2. Samples of each type of flexible seal to be used in work with color samples as above.

12.1.5 DELIVERY, STORAGE AND HANDLING

- A. Exercise proper care in the handling of all work so as not to injure the finished surface, and take proper precautions to protect the work from damage after it is in place.
- B. Deliver materials to the job site ready for use, and fabricated in as large sections and assemblies as practical. Assemblies shall be identical to submitted and reviewed shop drawings, samples and certificates.
- C. Store materials under cover in a dry and clean location off the ground. Remove materials that are damaged or otherwise not suitable for installation from the job site and replace with acceptable materials at no additional cost.

12.1.6 PROJECT CONDITIONS

- A. Where necessary, check actual locations of walls and other construction to which work must fit, by accurate field measurements before fabrication. Show recorded measurements on final shop drawings and coordinate fabrication schedule with construction progress to avoid delay of work.

12.2 – PRODUCTS

12.2.1 MATERIALS

- A. Aluminum – ASTM B221, alloy 6063-T5 for extrusions; ASTM B209, alloy 6061-T6 for sheet and plate.
 1. Protect aluminum surfaces in contact with cementitious materials with heavy metal free high solids primer or chromate conversion coating.
- B. Structural Steel Shapes – ASTM A36.
- C. Steel Plates – ASTM A283 Grade C.
- D. Rolled Steel Floor Plates – ASTM A786



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- E. Bronze – ASTM B455 alloy C38500 for extrusions; alloy C28000 Muntz Metal for plates.
- F. Brass – UNS alloy C26000 for half-hard sheet and coil.
- G. Stainless Steel – ASTM A167, Type 304 with 2B finish, unless indicated otherwise, for plates, sheets and strips.
- H. Extruded Preformed Seals – Single or multi-layered rubber extrusions as classified under ASTM D2000, designed with or without continuous, longitudinal, internal baffles and formed to fit compatible frames, in color indicated or if not indicated, as selected by architect from manufacturer's standard colors.
- I. Exterior Seals – Typically two single layered flexible extrusions, one interior PVC and one exterior Santoprene 8000 series non-hydroscopic, thermoplastic rubber, as classified under ASTM D2000, retained in a set of compatible frames, in color indicated or if not indicated, as selected by architect from manufacturer's standard colors.
- J. Fire Barriers – Designed for indicated or required dynamic structural movement without material degradation or fatigue in accordance with ASTM E1966. Tested in maximum joint width condition as a component of an expansion joint cover in accordance with UL 2079 including hose stream testing of wall assemblies at full-rated period by Underwriters Laboratories Inc.
- K. Accessories – Manufacturer's standard anchors, fasteners, set screws, spacers, flexible vapor seals and filler materials, drain tubes, adhesives, and other accessories compatible with material in contact, as indicated or required for complete installations.

12.2.2 FABRICATION

A. General – Provide expansion joint cover assemblies of design, basic profile, materials, and operation indicated. Select units comparable to those indicated or required to accommodate joint size, variations in adjacent surfaces, and structural movement. Furnish units in longest practicable lengths to minimize number of end joints. Provide hairline mitered corners where joint changes directions or abuts other materials. Include closure materials and transition pieces, tee-joints, corners, curbs, cross-connections and other accessories as required to provide continuous joint cover assemblies.

B. Interior Expansion Joint Covers

- 1. Extruded Aluminum Cover Assemblies – Provide continuous extruded aluminum frame assemblies of suitable profile to receive free floating cover plate of design indicated. Furnish depth and configuration to suit type of construction with no exposed fasteners. All aluminum in contact with concrete to have heavy metal free high solids primer, exposed aluminum to be finished as noted, free of gaskets and filler and be capable of 50% expansion and contraction without loss of cover. Floor covers must withstand minimum 500-lb. point load without damage or permanent deformation unless otherwise indicated. Provide continuous flexible water stops where detailed. All as C/S Allway series manufactured by Construction Specialties, Inc.



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- a) Heavy Duty Floor Cover – Provide continuous heavy duty frame on each side of joint with seating surface to accept serrated cover plates fixed with countersunk fasteners 12" on center. Minimum ¼" thick center plate to be free floating and capable of withstanding 2,000-lb. point load without damage or permanent deformation.

12.3 – EXECUTION

12.3.1 Examination

- A. Make a thorough examination of all surfaces receiving the work of this section and before starting the installation, notify the architect, in writing, of any defect which would affect the satisfactory completion of the work of this section.

12.3.2 Preparation

- A. Examine the contract drawings and specifications in order to insure the completeness of the work required under this section.
- B. Verify all measurements and dimensions at the job site and cooperate in the coordination and scheduling of the work of this section with the work of related trades, with particular attention given to the installation of items embedded in concrete and masonry so as not to delay job progress.
- C. Provide all templates as required to related trade for location of all support and anchorage items.

12.3.3 Installation

- A. In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for all phases of work, including preparation of substrate, applying materials and protection of installed units.
- B. Provide anchorage devices and fasteners where necessary for securing expansion joint cover assemblies to in-place construction, including threaded fasteners with drilled-in fasteners for masonry and concrete where anchoring members are not embedded in concrete. Provide fasteners of metal, type and size to suit type of construction indicated and provide for secure attachment of expansion joint cover assemblies.
- C. Perform all cutting, drilling and fitting required for installation of expansion joint covers. Install joint cover assemblies in true alignment and proper relationship to expansion joints and adjoining finished surfaces measured from established lines and levels.
- D. Allow adequate free movement for thermal expansion and contraction of metal to avoid buckling.
- E. Set floor covers at elevations to be flush with adjacent floor materials. If necessary, shim to level, but ensure base frames have continual support to prevent rocking and vertical deflection.



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- F. Locate wall, ceiling, roof and soffit covers in continuous contact with adjacent surfaces. Securely attach in place with all required accessories.
- G. Locate anchors at interval recommended by manufacturer, but not less than 3" from each end and not more than 24" on center.
- H. Maintain continuity of expansion joint cover assemblies with end joints held to a minimum and metal members aligned mechanically using splice joints. Cut and fit ends to produce joints that will accommodate thermal expansion and contraction of metal to avoid buckling of frames.
- I. Adhere flexible filler materials (if any) to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
 - 1. Installation of extruded preformed seals: install seals to comply with manufacturer's instruction and with minimum number of end joints.
 - 2. For straight sections provide preformed seals in continuous lengths.
 - 3. Vulcanize or heat-seal all field splice joints in preformed seal material to provide watertight joints using manufacturer's recommended procedure.
 - 4. Apply manufacturer's approved adhesive, epoxy or lubricant-adhesive to both frame interfaces prior to installing preformed seal.
 - 5. Seal transitions in accordance with manufacturer's instruction.
- J. Installation of Exterior Seal Joint Assemblies
 - 1. Seal all end joints within continuous runs and joints at transitions in accordance with manufacturer's directions to provide a watertight installation.
 - 2. Install exterior flexible seal in standard lengths.
 - 3. Seal transitions and butt joints in accordance with manufacturer's instruction
 - 4. Install secondary seals in continuous lengths; vulcanize all field splice joints in secondary seal material to provide watertight joints using manufacturer's recommended procedures.

12.3.4 Cleaning and Protection

- A. Do not remove strippable protective material until finish work in adjacent areas is complete. When protective material is removed, clean exposed metal surfaces to comply with manufacturer's instructions.