

TECHNICAL SPECIFICATIONS

STRUCTURAL

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SECTION 02100 PREPARATION OF SITE

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Work includes furnishing all labor, materials, tools and equipment required for the preparation of the Site prior to construction.

1.2 SUBMITTALS

A. Detailed working drawings.

1.3 PROTECTION

The Contractor shall exercise the greatest care in protecting existing structures and piping while proceeding with work under this Section. All repairs required because of damage from the Contractor's operations shall be at the expense of the Contractor and no claims for additional payment will be accepted.

PART 2 – PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 CLEARING, GRUBBING AND STRIPPING

- A. Except as otherwise directed, cut, grub, remove and dispose of all trees, stumps, brush, shrubs, roots, paving and any other objectionable material within the construction limits shown on the Drawings. All stumps, brush and roots shall be grubbed, removed from the site and disposed properly and legally.
- B. Protect the area beyond the limits of grading shown on the Drawings and any trees designated by the Engineer from damage by any construction operation by erecting suitable barriers or other approved means.
- C. Strip topsoil from all areas to be occupied by buildings, trenches, roadways, the sludge lagoons, and all other areas to be excavated or filled. Avoid mixing topsoil with subsoil and stockpile it in areas on the site as approved by the Engineer. Topsoil shall be stockpiled free from brush, trash, large stones and other extraneous material. Any topsoil remaining, after all work is in place, shall be disposed of by the Contractor as directed by the Engineer.

**** END OF SECTION ****

SECTION 02200

EXCAVATION, BACKFILL, FILL, GRADING AND SLOPE PROTECTION

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Work includes furnishing all labor, materials, equipment and incidentals necessary to perform all excavation, backfilling, filling, grading, and slope protection as shown on the Drawings.

1.2 RELATED SECTIONS

Other Sections of the Specifications shall also apply to the extent required for proper performance of this Work.

Section 33001	Site Preparation
Section 33003	Yard Piping
Section 33004	Roadways and Paving
Section 33006	Loaming and Seeding
Section 33007	Waste Water Disposal System

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM D698	Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D1556	Density of Soil in Place by the Sand Cone Method
ASTM D1557	Laboratory Compaction Characteristics of Soil Using Modified Proctor Test
ASTM D2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)

1.4 SUBMITTALS

- A. Proposed methods of construction including dewatering, excavation, sheeting, bracing, filling, compaction and backfilling for the various portions of the project.
- B. Samples as required by the applicable Reference Standards and under Part 2 – PRODUCTS of this Specification.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that materials conform to the specifications, and to be paid for by the Contractor.

1.6 PROTECTION

A. Sheet piling and Bracing – General

1. The Contractor shall furnish, put in place and maintain such sheet piling and bracing as may be required to support the sides of excavations, to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction, and to protect adjacent structures from undermining or other damage. If, in the opinion of the Engineer, sufficient or proper supports have not been provided, additional supports shall be put in at the expense of the Contractor. The Contractor is responsible for the sufficiency of such supports. Care shall be taken to prevent voids outside of the sheet piling, but if voids are formed, they shall be immediately filled with compacted granular fill and rammed.
2. The Contractor shall leave in place all sheet piling and bracing which the Engineer may direct him in writing to leave in place at any time during the progress of the Work for the purpose of preventing injury to structures, utilities or property, whether public or private.
3. All sheet piling and bracing not to be left in place shall be carefully removed in such a manner as not to endanger the construction of other structures, utilities or property. All voids left or caused by withdrawal of sheet piling shall be immediately refilled with compacted granular material by ramming with tools especially adapted to that purpose, or by other means as approved.
4. The right of the Engineer to order sheet piling and bracing left in place shall not be construed as creating any obligation on his part to issue such orders, and his failure to exercise his right to do so shall not relieve the Contractor from liability to damages to persons or property occurring from or upon the work occasioned by negligence or otherwise, growing out of a failure on the part of the Contractor to leave in place sufficient sheet piling and bracing to prevent any caving or moving of the ground.
5. No wood sheet piling shall be withdrawn if driven below mid-diameter of any pipe, and under no circumstances shall any wood sheet piling be cut off at a level lower than one foot above top of any pipe.

B. Pumping and Drainage

1. The Contractor shall at all times during construction, provide and maintain proper equipment and facilities to remove all water entering excavations. Excavations shall be kept dry so as to obtain a satisfactory undisturbed sub-grade foundation until the fills or structures to be built thereon have been completed to such extent that they will not be floated or damaged by allowing water levels to return to natural levels.

2. Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the sub-grade soils at proposed bottom of excavation.
3. The Contractor shall maintain the water level below the bottom of excavation in the various work areas continuously. The Contractor's proposed method of dewatering, if required, shall be approved by the Engineer.
4. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.
5. The Contractor shall take all additional precautions to prevent uplift of any structure during construction. All such arrangements shall be subject to the approval of the Engineer.
6. Drainage shall be disposed of in an approved area only so that flow or seepage back into the excavated area will be prevented.
7. Floatation shall be prevented by the Contractor by maintaining a positive and continuous removal of water. The Contractor shall be fully responsible and liable for all damages that may result from failure to adequately keep excavations dewatered.
8. Removal of dewatering equipment, if required, shall be accomplished after the system is no longer required; the material and equipment constituting the system shall be removed by the Contractor.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General

1. Excess materials which have been excavated and stockpiled in selected areas on the site which meet the Specifications shall be used as much as possible for fills.
2. For both materials obtained on site and for materials obtained off-site, the Contractor shall notify the Engineer of the source of the material and shall furnish the Engineer for approval, a representative sample weighing approximately 25 kilograms, at least ten calendar days prior to the date of anticipated use of such material. Samples shall be resubmitted as required until approval is obtained.

B. Fill

1. Common Fill

Common fill may be obtained from on-site excavated material if approved by the Engineer or from off-site sources. Common fill shall consist of mineral soil,

substantially free of clay, organic material, silt, loam, wood, trash, and other objectionable material which can not be compacted properly.

Common fill shall not contain broken concrete, masonry, rubble, asphalt pavement, or other similar materials. It shall have physical properties such that it can be readily spread and compacted during filling.

Common fill shall not contain stones larger than 250mm in any dimension, nor stones larger than 150mm in the upper 0.50 meter of fill. Not more than 30% shall pass a No. 200 sieve. The liquid limit of the fraction passing a No. 40 sieve shall not exceed 50%.

2. Structural Fill

Structural fill shall be furnished and placed as required to replace materials encountered and found unsuitable below foundation elevation of structures; or when foundation elevation is set above existing grade as shown on the plans or directed by the Engineer in writing. Structural fill shall be used below all structures that have under drains as shown on the Drawings.

Structural fill shall consist of suitably graded clean sands or gravel-sand mixtures belonging to Group Symbol SW or GW of the Unified Soil Classification, ASTM D2487. Particles shall be sound and not more than 15% shall pass the No. 200 sieve, nor more than 50%, the No. 40 sieve.

The composite material shall be non-plastic and free from organic matter, clay lumps, or other deleterious materials.

3. Granular Fill

Granular fill material shall consist of hard, durable, free draining sand and gravel or hard stone; shall be free from organic matter or other deleterious substances and shall be reasonably well-graded within the following limits:

Size	Per Cent by Weight Passing
75mm (3 in.)	100
0.60mm (No. 30)	0-20
0.15mm (No. 100)	0-5

4. Screened Gravel

Screened gravel shall consist of hard, durable, rounded or sub-angular particles of proper size and gradation, and shall be free from sand, loam, clay, excess fines, and deleterious materials. Screened gravel shall be graded within the following limits:

Sieve Size	Per Cent by Weight Passing
16mm (5/8 in.)	100

13mm (1/2 in.)	40-100
10mm (3/8 in.)	15-45
2.0mm (No. 10)	0-5

PART 3 - EXECUTION

3.1 STRIPPING AND GRUBBING

Before any fills are placed or any paving or construction started, the area of all such work shall be stripped and grubbed of all top organic materials to a minimum depth of 150mm. Any weak, loose, soft, spongy, or otherwise unsuitable materials shall be removed from the site, and may be deposited in a spoil area, as directed by the Engineer, but shall not be used in any on-site fills.

3.2 EXCAVATION

Excavation shall include, without classification, the removal of all materials of whatever nature encountered, including all obstructions of any nature that would interfere with the proper execution and completion of the Work. The removal of said materials shall conform to the lines and grades shown on the Drawings.

The Contractor shall furnish, place, and maintain all supports and shoring that may be required for the sides of the excavations, and all pumping, ditching, or other approved measures for the removal or exclusion of water, including taking care of storm water reaching the site of the Work from any source so as to prevent damage to the Work or adjoining property.

Excavations shall be sloped or otherwise supported in a safe manner in accordance with the latest applicable safety requirements of the Department of Public Works and Highways and as approved by the Engineer.

A. Excavation Below Grade

1. If the bottom of any excavation is taken out below the limits specified on the Drawings, or directed by the Engineer, it shall be refilled at the

Contractor's expense with concrete, compacted structural fill, or other material satisfactory to the Engineer.

2. Compacted structural fill, when used for refill, shall be placed in not greater than 150mm layers.

B. Structure Excavation

1. Excavation for structures to be founded on base slabs and footings are intended to be carried to undisturbed natural soil of suitable approved bearing capacity. If, upon uncovering and in the opinion of the Engineer, the material at or below the normal grade of excavation as indicated on the Drawings, is unsuitable for the support of structures, such material shall be over excavated

and replaced with compacted structural fill. The Contractor will be paid based on unit price established in the Schedule of Bid Prices.

2. Excavation, including removal of rock and boulders, shall be made to such lines and grades as will give suitable room for buildings and structures, for bracing and supporting, pumping and draining, and to the limits indicated on the Drawings. The bottom of the excavations shall be rendered firm and dry and in all respects acceptable to the Engineer.
3. Excavation and dewatering shall be accomplished by methods which preserve the undisturbed state of subgrade soils. Subgrade soils which become soft, loose, "quick", or otherwise unsatisfactory for support of structures as a result of inadequate excavation, dewatering or other construction methods, shall be removed and replaced by compacted structural fill at the Contractor's expense.
4. Dewatering shall be such as to prevent boiling or detrimental under seepage at the base of the excavation. The Contractor shall install such means as required to preserve the stability of the base of the excavation.
5. Excavating equipment shall be satisfactory for carrying out the work in accordance with the Specifications.
6. When excavation for foundations has reached prescribed depths, the Engineer shall be notified and he will inspect conditions. If materials and conditions are not satisfactory to the Engineer, the Engineer will issue instructions as to the procedures, and if additional costs are involved, adjustments of the Contract will be made on the basis of unit prices agreed upon by the Engineer and the Contractor in accordance with the provisions of the Contract Documents.

C. Miscellaneous Excavation

The Contractor shall perform all the remaining miscellaneous excavation. He shall make all excavations necessary to permit the placing of loam and plants, for constructing roadways, and any other miscellaneous earth excavation.

3.3 FILL AND COMPACTION

A. General

1. Fills shall be placed as shown on the Drawings or as directed by the Engineer. Where embankments are to be placed and compacted on hillsides, or to be placed against existing embankment, or to be built one half at a time, the slopes of original hillsides, existing embankments, or new fill shall be cut into or benched in order to accommodate each layer of new work a horizontal distance of not less than 1.5 meters. Materials thus removed shall be spread and compacted with the new materials.
2. Compaction shall be performed as specified hereinafter for the particular materials and operations:
 - a) A pass shall be one complete coverage of the area to be compacted by the rear wheel tire treads or tractor treads in contact with the flat earth surface.

- b) Areas adjacent to structures and other areas inaccessible to a roller or truck shall be compacted with approved mechanical compaction equipment. Compaction of the fill by such means shall be to the same degree of compaction as obtained by other approved equipment. The Engineer may make the necessary tests to determine the amount of compactive effort necessary to obtain equal compaction. The fill compacted by mechanical compactors shall be placed in 150mm layers and thoroughly tamped over the entire surface. Compaction equipment is subject to approval by the Engineer.
- 3. The surface of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated, and no soft spots or un compacted areas will be allowed in the Work.
- 4. Temporary bracing shall be provided as required during filling and backfilling of all structures to protect partially completed structures against all construction equipment loads, hydraulic pressures, and earth pressures.

B. Placing Structural Fill

- 1. After all unsuitable materials have been stripped and removed, the area to be filled shall be compacted by rolling using pneumatic tire rollers or tandem rollers of capacity approved by the Engineer. Moisture content of the material in situ should be dry to the optimum. The Engineer shall conduct density test on the compacted base. At least 95% of modified proctor maximum density (ASTM D1557, Method C) must be attained.
- 2. Fill shall be spread by graders or bulldozers and compacted in layers not thicker than 150mm.
- 3. Compacted structural fill shall be placed and compacted as specified laterally to the limits defined by a 1 on 1 line sloped outward and downward from a point at least 0.7 meters outside the bottom edge of all footings.
- 4. Water shall be added by means of sprinklers to each layer in amounts that will bring the fill material to its optimum density. Compaction will not be permitted on completely dry materials.
- 5. A minimum of two coverage is required for each layer. The Engineer may, during the progress of the work, conduct tests as to the degree of compaction of the fill and may require additional passes when density of the fill has not reached 95% of modified proctor dry density (ASTM D1557, Method C).
- 6. In areas inaccessible to the large rollers, hand-held tampers shall be used in which case, maximum layer heights shall be 0.15 meter when compacted or as required to achieve 95% of modified proctor dry density.

C. Backfilling – Common Fill

- 1. Common fill may be used as backfill against the exterior walls of structures or in other areas as designated by the Engineer. Common fill materials shall be placed in layers having maximum thickness of 300mm measured before compaction. Moisture content of the material at the start of compaction shall be at or near optimum.

2. Common fill shall be compacted to at least ninety per cent of maximum density as determined by ASTM D698.
3. Materials placed in fill areas shall be deposited to the lines and grades shown on the Drawings, making due allowance for settlement of the material and for the placing of loam thereon.
4. The surfaces of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the grading plan. No soft spots or uncompacted areas will be allowed in the Work.
5. No compaction shall be done when the material is too wet either from rain or from excess application of water.

3.4 GRADING

- A. Grading in preparation for placing of loam, planting areas, paved walks and roadways, and appurtenances shall be performed at all places that are indicated, to the lines, grades, and elevations shown on the Drawings or as directed by the Engineer. All material encountered of whatever nature within the limits indicated, shall be removed and disposed of. During the process of grading, the sub-grade shall be maintained in such condition that it will be well drained at all times. When directed, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the condition of the Work.
- B. If at the time of grading, it is not possible to place any material in its proper section of the permanent structure, it shall be stockpiled in approved areas for later use. No extra payment will be made for the stockpiling or double handling of excavated material.
- C. The right is reserved to make minor adjustments or revisions in lines or grades, if found necessary as the work progresses, due to discrepancies on the Drawings or in order to obtain satisfactory construction.
- D. Stones or rock fragments larger than 100mm in their greatest dimensions will not be permitted in the top 150mm of the finished sub-grade of all fills or embankments.
- E. In cuts, all loose or protruding rocks on the back slopes shall be barred loose or otherwise removed to line or finished grade of slope. All cut and fill slopes shall be uniformly dressed to the slope, cross section, and alignment shown on the Drawings, or as directed by the Engineer.

3.5 DISPOSAL OF UNSUITABLE/SURPLUS MATERIALS AND ROCKS

- A. Unsuitable excavated materials shall be removed from the immediate site of work and disposed of by the Contractor on the Owner's land as directed by the Engineer.
- B. Suitable excavated material may be used for fill or backfill, if it meets the specifications for common fill. Excavated material so approved may be neatly stockpiled at the site where designated by the Engineer provided there is an area available that will not inconvenience traffic or adjoining property owners. If space limitations do not permit stockpiling on the site, the Contractor will be required to make arrangements for off-site stockpiling. Transport of such material from and to the immediate site, including any stockpiling agreements, shall be entirely at the Contractor's expense and shall not constitute grounds for additional payment.

- C. Surplus excavated material shall be used to fill depressions or other purposes as the Engineer may direct.
- D. The Contractor shall remove and dispose of all pieces of rock which are not suitable for use in other parts of the Work. Rock disposed of by hauling away to spoil areas is to be replaced by approved surplus excavation obtained elsewhere on the Work, insofar as it is available. Any deficiency in the backfill material shall be made up with acceptable material approved by the Engineer.
- E. Fragments of ledge and boulders smaller than 25kgs.weight may be used in backfilling trenches and other deep fills. If, in the opinion of the Engineer, the quantity is excessive, he may order the removal and disposal of some of this rock. The small pieces of rock used as backfill shall not be placed in trenches until the pipe has at least 0.7 meters of earth over it. The Contractor shall place these pieces of stone in thin layers, alternating them with earth to be sure that all voids between the stones are completely filled with earth to prevent the occurrence of voids and settlement which will result there from.
- F. Rock may be used for fill only with the approval of the Engineer.

3.6 COMPACTION/FIELD DENSITY TESTS

Field density tests shall be performed in accordance with the test procedure specified in ASTM D1556.

The location and frequency of field tests shall be at the discretion of the Engineer. Necessary tests shall be performed by the Engineer for acceptance of a compacted layer before attempting to place new fill material. Any layer or portion thereof that does not meet minimum compaction requirements shall be reworked and re-compacted until it meets the specified density requirements as determined by the Engineer.

**** END OF SECTION ****

SECTION 03150 CONSTRUCTION JOINTS

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Work includes furnishing all materials, labor, equipment and incidentals required to make all concrete joints tight as detailed on the Drawings.

1.2 RELATED SECTIONS

Other Sections of the Specifications shall also apply to the extent required for proper performance of this Work.

Section 33009	Concrete Reinforcement
Section 33010	Concrete Finishes

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM D412	Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D746	Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2240	Rubber Property – Durometer Hardness

1.4 SUBMITTALS

- A. Detailed working drawings.
- B. Samples/test reports/certificates as required by the applicable Reference Standards.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and to be paid for by the Contractor. The Contractor shall furnish the owner certified copies of records showing that each material has been pre-tested, and

complied with all applicable requirements of this Standard. The Contractor shall, at his own expense, replace all rejected materials for failure to comply with this Specification.

PART 2 - EXECUTION

2.1 INSTALLATION

- Construction joints shall be provided as indicated on the Drawings. Unless otherwise indicated on the Drawings, bonding will be required at all horizontal joints in walls. Surfaces shall be prepared in accordance with Section 33010.
- Construction joints will be permitted at locations other than those indicated on the Drawings, provided a written permission from the Engineer is obtained.
- The surfaces of the groove for the rubber sealant shall not be coated with curing compound.
- Where indicated on the Drawings, joint sealant shall be placed in all joints to the depth shown. Cleaning of the grooves, priming, handling and application of the materials, including bond breaker, shall be as recommended by the manufacturer.
- Waterstops for all joints shall be continuous around the corners and intersections, either in horizontal or vertical direction, as indicated on the Drawings. Field splices and joints shall be made in accordance with the waterstop manufacturer's instructions, using a thermostatically controlled heating iron.
- Holes for steel tying wires shall be drilled in the water stops as recommended by the manufacturer.
- Steel tying wire shall be as specified in Section 33009, Concrete Reinforcement.
- A sufficient number of wire ties shall be installed to ensure that the waterstops remain in their original position during the placement of concrete.

**** END OF SECTION ****

SECTION 03200 CONCRETE REINFORCEMENT

PART 1 – GENERAL

1.1 SCOPE OF WORK

The WORK includes fabrication and installation of all steel bars and steel tie wire, clips, supports, chairs, and spacers required for the reinforcement of concrete as shown on the Drawings.

1.2 RELATED SECTIONS

Not Used

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM A82	Steel Wire, Plain, for Concrete Reinforcement
ASTM A615/A615M ASTM A706/A706M	Deformed and Plain Billet – Steel Bars for Concrete Reinforcement
PNS 49	Philippine National Standard – Steel Bars for Concrete Reinforcement

1.4 SUBMITTALS

- A. Detailed working drawings and bending schedules of all reinforcement.
- B. Samples and test certificates as required by the applicable Reference Standards.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and shall be paid for by the Contractor. The Contractor shall furnish the owner certified copies of records showing that each material has been pre-tested, and complied with all applicable requirements of this Standard. The Contractor shall, at his own expense, replace all rejected materials for failure to comply with this Specification.

PART 2 – PRODUCTS

2.1 MATERIALS

Reinforcement steel shall be deformed, new billet steel bars conforming to ASTM A615, Grade 60 and 40, substantially free from mill scale, rust dirt, grease or other foreign matter.

Chemical Composition: The percentages of carbon, manganese, phosphorus, sulfur and silicon on finished bars shall conform to the specified values in PNS 49 as shown in Table 2.

Rail –steel bars will not be permitted in the Work.

Table 2 – Chemical Requirements

Element	Chemical Composition, Per Cent Maximum	
	Hot-Rolled Non-Weldable Deformed Steel Bar	Hot-Rolled Weldable Deformed or Plain Steel Bar
Carbon	-	0.38
Manganese	-	1.26
Phosphorus	0.0625	0.058
Sulfur	0.0625	0.058
Silicon	-	-

Reinforcement steel shall bear a mill identification symbol, shall be tagged with the size and mark number so that different types may be identified, and shall be stored off the ground to protect the steel from moisture and dirt until placed in final position.

Steel wire for tying reinforcing bars and waterstops shall conform to ASTM A82.

The following reinforcing steel bar sizes shall be used for all reinforced concrete design under this Contract.

Bar Designation	Approximate Cross Sectional Area (mm ²)	Approximate Unit Weight (kg/m)
#10	78	0.616
#12	113	0.888
#16	201	1.579
#20	314	2.466
#25	492	3.854
#28	615	4.833
#32	804	6.313
#36	1018	7.991

Should the Contractor wish to use reinforcing steel bars having areas different from those shown (with consequent different designations), the following requirements shall apply:

- If the proposed substitute bar has an area from 97% to 105% of the designated bar, a direct substitution may be made without changes to bar spacing.
- If the proposed substitute bar has an area less than 97% of the designated bar, substitution may be allowed provided bar spacing is reduced to not more than the minimum clear distance between bars.
- If the proposed substitute bar has an area more than 105% of the designated bar, changes in spacing is limited to a maximum spacing of 300mm. All proposed changes shall be submitted to the Engineer for approval.
- Changes shall be implemented upon approval by the Engineer of the reinforcing arrangement Drawings, required as shop drawings, which shall be finalized upon issuance by the Engineer of the guidelines on related criteria, as maximum and minimum spacing and bond strength.
- Approval by the Engineer of bar size substitutions does not relieve the Contractor of other specified requirements, including steel grade and bar deformations.

PART 3 - EXECUTION

3.1 FABRICATION OF REINFORCEMENT

Reinforcement steel shall be accurately fabricated to the dimensions shown on the shop drawings and bar schedules.

All reinforcing bars shall be bent cold around a pin with a free revolving collar having a diameter of the bar of not less than the following:

- Four times for stirrups
- Six times for bars up to and including 25mm diameter
- Eight times for bars over 25mm diameter
- Ten times for bars 43mm and 57mm diameter

Reinforcement steel shall not be straightened nor rebent. Bars with kinks or bends not shown on the Drawings will not be accepted.

3.2 INSTALLATION OF REINFORCEMENT

All reinforcing bars shall be accurately placed as shown on the Drawings, and in accordance with the shop drawings and bar schedules. The reinforcing bars shall be secured against displacement with annealed iron wire ties of minimum GA#16 GI Wire (i.e. 1.39mm diameter) or suitable clips at the intersections.

Except as otherwise indicated on the Drawings reinforcement steel shall be installed with a clearance for concrete cover as follows:

▪ Concrete placed directly on earth	75 mm
▪ Formed surfaces in contact with the soil, water or exposed to the weather	75 mm
▪ Concrete cover of main reinforcement steel for columns and beams	40 mm
▪ Walls not in contact with the soil, water or exposed to the weather	40 mm
▪ Top of slabs exposed to weather for Ø16 and smaller	
▪ Underside of slabs over water surface, but not in contact with the water	50 mm
▪ Top of slabs exposed to weather for Ø20mm and above	
▪ All other slab surfaces	20 mm

No reinforcing bars shall be welded.

All reinforcing bars in slabs shall be supported on concrete cubes or chairs of the correct height, containing soft steel wires embedded therein for fastening to the reinforcement steel. Such spacers or chairs shall have a minimum compressive strength of 24 MPa.

Reinforcing bars for vertical surfaces in beams, columns and walls shall be properly and firmly positioned from the forms by means of stainless steel (tipped) bolsters or other equal methods approved by the Engineer.

Reinforcement steel projecting from structures that are to be concreted or where concrete has already been poured shall not be bent out of its correct position.

**** END OF SECTION ****

SECTION 03300 CONCRETE

PART 1 – GENERAL

1.1 SCOPE OF WORK

The WORK includes furnishing all labor, materials, equipment and incidentals necessary for the construction of all concrete work.

1.2 RELATED SECTIONS

Other Sections of the Specifications shall also apply to the extent required for proper performance of this Work.

Section 33009	Concrete Reinforcement
Section 33010	Concrete Finishes
Section 33011	Construction Joints

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C33	Concrete Aggregates
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C42	Obtaining and Testing Drilled Cores and Sawed Beams
ASTM C94	Ready-mixed Concrete
ASTM C143	Slump of Hydraulic-Cement Concrete
ASTM C150	Portland Cement
ASTM C347	Recommended Practice for Concrete Formwork, US Corps of Engineers CRD C-572
ASTM C494	Chemical Admixtures for Concrete
ASTM C805	Rebound Number of Hardened Concrete

1.4 SUBMITTALS

- A. Samples as required by the applicable Reference Standards and in accordance with Part 3 – EXECUTION of this Specification.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and shall be paid for by the Contractor. The Contractor shall furnish the owner certified copies of records showing that each material has been pre-tested, and complied with all applicable requirements of this Standard. The Contractor shall, at his own expense, replace all rejected materials for failure to comply with this Specification.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Cement: Cement shall be Portland Cement conforming to ASTM C150, Type II, as follows:

Table 1- Physical Requirements of Cement

Test	Requirement
Compressive Strength for ages indicated, min. 3 days 7 days	12.0 MPa 19.0 MPa
Time Setting by Vicat Method Initial Set, minimum Final Set, maximum	45 minutes 375 minutes
Fineness, by turbidimeter test, minimum	160 m ² /kg

- B. Aggregates

1. Fine Aggregate: Fine aggregate shall be washed inert natural sand conforming to ASTM C33, and shall range in size from coarse to fine within the following limits of US Standard sieve sizes:

Table 2- Grading Requirements for Fine Aggregates

Sieve Designation	Per Cent (%) Passing
9.5 mm (3/8)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	80-100

1.18 mm (No. 16)	50-85
0.60 mm (No. 30)	25-60
0.300 mm (No. 50)	5-30
0.150 mm (No. 100)	0-10
0.075 mm (No. 200)	0-3

2. Coarse Aggregate: Coarse aggregate shall be well graded crushed stone or washed gravel conforming to ASTM C33, size No. 67 as follows:

Table 3 – Grading Requirements for Coarse Aggregates

Sieve Designation	Weight Per Cent Passing
25 mm (1")	100
19.0 mm (3/4)	90-100
9.5 mm (3/8)	20-55
4.75 mm (No. 4)	0-10
2.36 mm (No. 8)	0-5
0.075 mm (No. 200)	0-1

3. Water: Water used in mixing, curing or other designated application shall be reasonably clean and free of oil, salt, acid, alkali, grass or other substances injurious to the finished product.

4. Admixtures

- Admixtures conforming to ASTM C494 may be used upon approval of the Engineer in writing, to control the time setting, to effect water reduction and to increase workability. Proportioning and mixing shall be as recommended by the manufacturer.
- The admixture may be a hydroxylated carboxylic acid type or a hydroxylated polymer type, but shall contain no calcium chloride. The use of an admixture shall not change the required quantities of cement specified under Table 4 of this Section.
- The total air entrained measured at the discharge from the truck shall be 3.0 per cent maximum for finished slabs and 3.5 to 5.0 per cent for all other concrete.

2.2 QUALITY OF CONCRETE

- A. Before placing any concrete, the Contractor shall discuss with the Engineer the source of materials and concrete he proposes to use. Samples of aggregate and cement shall be furnished to the Engineer for testing.

- B. The Contractor shall submit to the Engineer, his proposed design mix for evaluation.
- C. Compressive strength, water-cement ratio and cement factor specified in Table 4 shall apply for regular and pumped concrete:

Table 4 – Concrete Quality Requirements

Test	Requirements	
	Concrete Fill	All Structural Concrete
Minimum Compressive Strength at 28 days (Mpa)	17.0	21.0 – 42.0
Maximum Net Water Content (liters/100kg cement)	62.0	53.0
Minimum Cement Content (kg/m ³)	260	330
Total Air Content (%)	3.5 – 5.0	3.5 – 5.0
Concrete Temp., Max. (°C)	32	32

- D. Consistency of the concrete as measured in accordance with ASTM C143 shall be as shown in Table 5.

No excessively wet concrete will be permitted. Concrete delivered to the site having a slump more than that specified herein will be rejected.

Table 5 – Concrete Consistency

Type of Structure	Slump (mm)	
	Recommended	Range
Pavement and Slabs on Ground	50	25-75
Plain footings, gravity walls, slabs and beams	50-75	25-100
Heavy reinforced foundation walls and footings	75-100	50-125
Thin reinforced walls and columns	100	75-125

2.3 FORMS

- A. Forms shall be made of either steel or new lumber approved by the Engineer and shall be free from roughness and imperfections, substantially watertight, adequately braced and tied to prevent movement and displacement when concrete is placed and vibrated. No wooden spreaders will be allowed in the concrete. Forms shall be thoroughly cleaned before using and shall be treated with approved non-staining oil or other approved material and allowed to dry before placement of the reinforcing steel.
- B. Form ties in concrete exposed to view shall be the cone-washer type. Throughbolts or common wire shall not be used for form ties.
- C. Molding or bevels shall be built into the forms to produce a 20-mm chamfer on all exposed projecting corners.
- D. Forms for walls shall have removable panels at the bottom for cleaning, inspection and scrubbing-in of bonding paste.

PART 3 - EXECUTION

3.1 MIXING CONCRETE

- A. Ready-mixed or transit-mixed concrete shall conform to ASTM C94. The concrete supplier shall furnish to the Engineer for his approval, the dry proportions to be used, with evidence that these will produce concrete of the quality specified.
- B. Ready-mixed or transit-mixed concrete shall be transported to the site in watertight agitator or mixer trucks. Discharge at the site shall be within one (1) hour after the cement was first introduced into the mix. Retempering (i.e. mixing with or without additional cement, aggregate or water) of the concrete which has partially hardened, will not be permitted.

3.2 PLACING OF CONCRETE

- A. All debris, dirt and water shall be removed from the forms. Forms, reinforcement steel, pipes, conduits, sleeves, anchors and other embedded items shall be inspected and approved by the Engineer before placing any concrete. The Contractor shall advise the Engineer of his readiness to proceed at least 12 hours before each placement of concrete.
- B. The surfaces of previously placed concrete, such as vertical or horizontal construction joints, shall be roughened, cleaned of foreign matter and laitance, and saturated with water.

Immediately before the new concrete is placed, all hardened surfaces shall receive a thorough coating of neat cement grout at least 5 mm thick which shall be well scrubbed in by means of stiff bristle brushes. The new concrete then shall be placed before the grout sets up.

Concrete shall be uniformly placed during the process of depositing until the completion of the layer to maintain an approximately horizontal plastic surface. The rate of placing concrete in forms shall not exceed 0.60 meter of vertical rise

per hour. The spreading of mounds of concrete with vibrator or by shoveling will not be permitted.

- C. Concrete shall not be placed in water or stay submerged within 24 hours after placing, except for curing nor shall running water be permitted to flow over concrete surfaces within four days after the placing of concrete.
- D. Chutes for conveying concrete shall be of U-shaped metal and provided with a baffle plate at the end. Chutes shall be placed at an angle of not less than 25 degrees, nor more than 45 degrees from horizontal and shall be kept clean and free from hardened concrete. Maximum length of chute to be traveled by plastic concrete shall not be more than 1.50 meters.
- E. In thin walls or columns of considerable height, the concrete shall be placed in such a manner as to prevent segregation and accumulation of hardened concrete on the forms or the reinforcement steel located above the concrete mass. Free fall of concrete shall not be permitted to exceed 1.50 meters below the ends of hoppers, chutes, ducts, tremies, or "windows" in wall forms, without approval of the Engineer.
- F. Where waterstop type construction joints are provided, the concrete shall be properly worked by rodding and vibrating around the waterstops to produce watertight joints, before any concrete is poured on the upper surfaces, particularly in the case of horizontal waterstops in slabs.

Waterstops shall be accurately positioned and securely held in place, and shall be protected at all times to prevent damage or displacement. Any damage to, or displacement of waterstops shall be corrected by the Contractor to the satisfaction of the Engineer.

3.3 TAMPING AND VIBRATING

- A. During and immediately after placing the concrete, compaction shall be carried out by experienced operators using high-speed internal mechanical vibrators. Care shall be taken to ensure that vibration is continued long enough to produce optimum consolidation without segregation of the aggregates or migration of air.
- B. At least one vibrator shall be used for every eight cubic meters of concrete placed per hour. One spare vibrator in operating condition shall be available on the site.
- C. Vibrators shall be supplemented with proper wooden spade, puddling adjacent to forms and rodding around embedded fixtures, to remove trapped air bubbles and to prevent honeycombing.

3.4 CURING AND PROTECTION

- A. All concrete work shall be properly cured. Details of the Contractor's curing procedures and curing compounds intended to be used shall be subject to the approval of the Engineer.
- B. All exposed surfaces including finished surfaces shall be treated immediately after concrete has been poured, to provide continuous moist curing for at least 7 days. Walls and vertical surfaces may be covered with continuously saturated burlap or kept moist by other approved means. Horizontal surfaces, slabs, etc. shall be

ponded to a depth of 15mm or kept continuously wet by means of sprinklers or other approved methods.

- C. Formed surfaces shall be thoroughly soaked with water at least twice each day until the forms are removed. Curing shall continue as specified above.
- D. Where finishing of concrete surfaces is performed before the end of the curing period, the concrete shall not be permitted to dry out and shall be kept continuously damp by means of a fog of water from the time the concrete has been placed until the end of the curing period.
- E. The Contractor shall protect all concrete work against injury from the elements and defacements of any nature during construction operations.

3.5 REMOVAL OF FORMS

- A. The Contractor shall not remove any forms for at least 48 hours or until the concrete has attained a strength of at least 30 per cent of the ultimate 28-day strength. This is equivalent to approximately 50-day-degrees of moist curing. Day degree represents the total number of days times the average daily air temperature in °C at the surface of the concrete, e.g. 2 days at an average temperature of 25°C equals 50 day-degrees.
- B. Forms for beams and slabs shall not be stripped for at least 150-day degrees and supports shall not be removed until the concrete has attained at least 60% of the specified 28-day strength and is capable of safely supporting its own weight. Construction live loads shall not be placed upon it until the concrete has attained its specified 28-day strength.
- C. Removal of forms shall be in accordance with ACI – 347. Forms shall be stripped such that they will not damage the concrete. No forms shall be removed until the concrete has gained sufficient strength to support itself. The Contractor is responsible for the safety of all structures.

3.6 REPAIR OF DEFECTIVE CONCRETE

- A. Defective or honeycombed areas, as determined by the Engineer, shall be chipped down to at least 25mm deep into sound concrete by means of chisels or chipping hammers. If honeycombs exist around reinforcement steel a clear space, at least 10mm wide shall be chipped all around the steel.
- B. For areas less than 40mm deep, the patch may be made as in filling form-tie holes.
- C. Thicker repairs will require build-up in successive 40mm deep layers on successive days, and each layer shall be applied with neat cement pastes.
- D. For very deep patches, a non-shrink aggregate, with or without the addition of pea gravel, may be the used subject to the approval of the Engineer.
- E. The materials shall be mixed as recommended by the manufacturer of the non-shrink aggregate or as directed by the Engineer.

Where a metallic non-shrink aggregate is utilized, the final 15mm of the patch shall be composed of 1 to 1-1/2 cement / sand mortar without the non-shrink aggregate

to prevent rust staining of the surface. After hardening, the patch shall be rubbed as for filling form-tie voids, in accordance with Section 33010, Rubbed Finish.

- F. All exposed concrete surfaces and adjoining work stained by spilling or leakage of concrete shall be cleaned to the satisfaction of the Engineer.

3.7 INSPECTION

Installation of reinforcing steel, pipes, sleeves, anchors and other embedded items, batching, mixing, transportation, placing, curing and finishing of concrete shall at all times be subject to the inspection of the Engineer. No concrete shall be placed without the prior approval of the Engineer.

3.8 FIELD CONTROL

- A. Sets of six (6) cylinder specimens shall be taken at random by the Contractor in the presence of the Engineer in accordance with ASTM C31. One (1) set per 50 cubic meters of concrete, or fraction thereof, poured during the day shall be made for the compressive strength test. At least one set of samples for strength test shall be made for each class of concrete.
- B. Two (2) cylinders shall be tested after 7 days and two cylinders after 28 days. Should the average strength of the 28-day test specimens be less than the specified value, a verification test shall be conducted on the remaining two (2) cylinder samples, after 28 to 45 days. Compressive tests shall be in accordance with ASTM C39 and shall be performed by a laboratory engaged by the Owner. Testing fees shall be paid by the Contractor.
- C. The Contractor shall assist, cooperate and provide the concrete for the test cylinders and such auxiliary personnel and equipment needed to take the test specimens.
- D. Ready-mixed concrete shall be sampled and tested in accordance with the following methods.

Table 9 – Sampling and Test Methods for Ready-Mixed Concrete

Sampling/Test Method	Applicable ASTM Standard
Compressive Test Specimens	C31
Compression Tests	C39
Yield, Unit Weight	C138
Air Content	C138/C173/C231
Slump	C143
Sampling Fresh Concrete	C172
Temperature	C1064

3.9 FIELD TESTING

- A. Should the average strength of the verification test specimens be less than the specified value, the Engineer may take further core samples from the portion of the structure which was determined by the Engineer to represent the deficient 28-day/verification test specimens.
- B. If the strength of any core samples is less than the minimum requirements shown in Table 4, the Contractor shall strengthen or replace the portions of the structure concerned at no additional cost and to the satisfaction of the Engineer.
- C. The Contractor shall also deduct from payments otherwise due to him, the actual cost to the Owner for taking all core samples extracted from that portion of the Work.
- D. Slump tests, temperature and entrained air measurements shall be made when specimens for strength tests are taken and during placement of concrete, as often as necessary for control checks. If measured slump or air content falls outside the specified limits, a check test shall be made immediately on another portion of the same composite sample. In the event of a second failure, the concrete shall be considered to have failed the requirements of the specification and the whole batch shall be rejected.

3.10 BASIS OF ACCEPTANCE / REJECTION

Final acceptance of all concrete will be based on satisfactory results of compressive strength tests.

Strength tests representing each class of concrete must meet the following two requirements:

- The average of any three consecutive strength tests shall be equal to, or greater than the specified strength.
- No individual strength test shall be more than 15% below the specified strength.

Except as provided below, acceptance criteria will be as outlined in ASTM C94 and ACI 318. Concrete which achieves the required compressive strength will be accepted as satisfactory for payment provided placement, finish and tolerance meet the specified requirements.

Concrete with average strength deficient by not more than fifteen per cent (15%) of the required strength may be accepted, subject to cost reduction given in the following schedule:

Per Cent (%) Deficiency In Average Strength	Per Cent (%) of Unit Price Reduction
Less than 3	0
0 to less than 5	15
5 to less than 10	30

10 to 15	40
more than 15	100

Concrete represented by test results wherein the average strength indicated a deficiency of not more than fifteen percent (15%) but with an individual test deficient by more than fifteen percent (15%) will not be eligible for payment but may be accepted or ordered replaced at the discretion of the Engineer.

Concrete represented by compressive strength tests that fail to achieve the required strength as specified, shall be liable to rejection and subsequent removal and replacement.

However, if any strength tests falls below the specified value by more than 15%, or an individual test is deficient by more than 15%, and load carrying capacity has been significantly reduced, tests of cores drilled from the area in question may be required in accordance with ASTM C42, wherein L/D ratio is not less than 1.25 prior to capping. In such cases, three (3) cores shall be taken for each strength test more than 15% below the required value.

If concrete in the structure will be dry under service conditions, cores shall be air dried for 7 days before test and shall be tested dry. If concrete in the structure will be more than superficially wet under service conditions, cores shall be immersed in water for at least 40 hours and be tested wet.

Concrete in an area represented by core tests shall be considered structurally adequate if the average of three (3) cores is equal to at least 85% of the specified strength, and if no single core is less than 75% of the minimum requirement. Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted.

Acceptance and subsequent payment of concrete in question shall be based on the results of such tests, provided the complete operation has been supervised by the Engineer.

Rebound hammer test (ASTM C805) may be carried out by the Contractor prior to drilling core samples from structure in question, but the results of such rebound tests shall not be used as basis for acceptance or rejection of the concrete.

**** END OF SECTION ****

SECTION 03730 CONCRETE REPAIR USING EPOXY RESIN CONCRETE GROUTS AND MORTARS

PART 1 – GENERAL

1.1 APPLICABLE PUBLICATIONS

The publications listed below form part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1.1 Military Specification

MIL-L-51149 Liquid Polymer, Polysulfide

1.1.2 American Society for Testing of Materials (ASTM) Publications

C 33-81 Concrete Aggregates

C 117-80 Materials Finer than No. 200 Sieve in Mineral
Aggregates by Washing

C 136-81 Sieve Analysis of Fine and Coarse Aggregates

C 144-81 Aggregate for Masonry Works

C 881-78 Epoxy-Resin-Base Bonding System for Concrete

D 1652-73 Epoxy Content of Epoxy Resins (R1980)

D 1824-66 Apparent Viscosity of Plastics and Organosols at
Low Shear Rates by Brookfield Viscometer

D 1963-74 Specific Gravity of Drying Oils, Varnishes Resins,
and Related Materials at 25/25 Degrees C.

D 2419-74 Sand Equivalent Value of Soils and Fine
Aggregates (R1982)

E 70-77 PH of Aqueous Solutions with the Glass Electrode

1.2 SUBMITTALS

1.2.1 Certified Test Reports

- a. Aggregates: Sieve analysis test in accordance with ASTM C136 and ASTM C117.

- b. Epoxy Resin Binder: Conforming to ASTM C881 and covering the following:
 - 1. Viscosity
 - 2. Consistency
 - 3. Gel Time
 - 4. Absorption
 - 5. Shrinkage
 - 6. Thermal Compatibility
- c. Epoxy Resin Binder: Conforming to the two component epoxy resin binder type 1 specified hereinafter and covering the following.
 - 1. Epoxy Number
 - 2. Epoxy Viscosity
 - 3. Epoxy Specific Gravity
 - 4. Polysulfide Viscosity
 - 5. Polysulfide Specific Gravity
 - 6. Polysulfide pH
 - 7. Polysulfide Water Content
 - 8. Polysulfide Sulfur Content

1.2.2 Job Mix Formula: Submit for approval at least 15 days before work commences a job-mix formula for each use of epoxy resin. Test reports shall accompany the mix design. The formula shall identify the proposed source of the materials and state the proportions of aggregates and epoxy resin. Samples of materials to be used on the job shall be used to determine the job mix.

1.2.3 Samples: Submit the following samples for approval:

- a. Not less than two sample epoxy concrete and epoxy mortar specimens for each mix design, 6-inches, $\frac{3}{4}$ inch thick.
- b. Aggregates, 1-lb sample size, fine and coarse aggregates combined.
- c. Epoxy resin components, 1 pint each

1.2.4 Equipment: Submit descriptive information on the mixing and application equipment.

1.3 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the Owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and shall be paid for by the Contractor. The Contractor shall furnish the Owner certified copies of records showing that each material has been pre-tested, and complied with all applicable requirements of this Standard.

PART 2 – PRODUCTS

2.1 MATERIALS

2.1.1 Epoxy Concrete and Epoxy Mortar:

2.1.1.1 Epoxy Resin Binder

2.1.1.1.1 ASTM C 881, Type III, Grade 2, Class C, with a bond strength of 1,400 psi.

2.1.1.1.2 A two-component epoxy resin-base binder of the epoxy resin-polysulfide polymer type with a suitable curing agent. The ratio of epoxy resin to polysulfide polymer shall be approximately 2:1 (by weight). The epoxy binder shall be a 100 percent solids system and no diluents, wetting agents, or volatile solvents shall be incorporated. The epoxy resin binder shall be Type I and shall conform to the following requirements:

2.1.1.1.2.1 2 Base Polymer: The base polymer shall be thermosetting resin of the epoxy type and shall be a translucent liquid having properties as specified herein. The epoxy resin shall be composed of 100 percent reactive constituents, which are condensation products of the reaction of epichlorohydrin with bisphenol A. This product shall be essentially pure liquid dislycidly either of bisphenol A and maybe allowed to contain only trace amounts of hydrolyzable chlorine, but no reactive diluents. The epoxy resin or base polymer shall conform to the requirements specified in the Table I.

Table I. Requirements for the Epoxy Resin or Base Polymer

Property	Test Method	Requirements	
		Min.	Max.
Epoxy Number	ASTM D 1652	175	210
Viscosity, Poises at 23 C	ASTM D 1824	100	180
Specific Gravity at 25/25 C	ASTM D 1963	1.15	1.18

2.1.1.1.2.2 2 Polysulfide Polymer. The polysulfide polymer flexibilizer shall be a dichloroethylformal polysulfide in the 1000-molecular weight range conforming to the requirements specified in Table II.

Table II. Requirements for Polysulfide Polymer

Property	Test Method	Requirements	
		Min.	Max.
Viscosity at 23C centipoises	ASTM D 1824	700	1200
Specific Gravity at 25/25 C	ASTM D 1963	1.24	1.30
pH	ASTM E 70	6.0	8.0
Water content, percent	MIL-L-51149	-	0.1
Sulfur content, percent	ASTM D 129	36	40

2.1.1.1.2.2. 2 Curing Agent: The curing agent shall be furnished combined with the polysulfide polymer flexibilizer as the polysulfide-curing agent component. The curing agent used shall be a tertiary amine type. When incorporated in the binder system, the curing agent shall be unaffected by moisture present on the surfaces to which the epoxy resin binder is applied or that moisture present in unhardened Portland cement concrete at the time of placement on the surface of the binder. These agents shall be a combination of 2-, 4-, 6-trimethylaminomethyl phenol and dimethylaminomethyl phenol. The 2-, 4-, 6-trimethylaminomethyl phenol may be used alone when application condition warrant.

2.1.2.2 Aggregate: Aggregate shall conform to the quality requirements of ASTM C 33 for epoxy concrete and shall have a minimum sand equivalent of 75 percent when tested in accordance with ASTM D 2419. ASTM C 144 for epoxy mortar. The material passing the No. 200 sieve shall be non-plastic and it shall be composed of a minimum of 75 percent limestone dust, talc or silica inert filler.

2.1.2.2.1 For Epoxy Concrete: Maximum size 3/8-inch. Shall conform to the following requirements:

Sieve Designation	Percent Passing by Weight
3/8 in	100
No.4	70-80
No.8	50-65
No. 16	37-53
No. 30	20-37
No. 50	10-20
No. 100	5-10
No. 200	3-5

2.1.2.2.2 For Epoxy Mortar: Maximum size: No 8 sieve

2.1.2 Pressure Grouting Epoxy:

2.1.2.1 For Pumping Into Cracks: ASTM 881, Type I, Grade I, Class C.

2.1.3 Bond Breakers : Use the type and consistency recommended by the sealant manufacturer for the particular application.

2.2 EQUIPMENT: The equipment for blending the epoxy resin binder and mixing the binder and aggregates shall be approved by the Engineers. A suitable capacity metal or polyethylene container recommended by the epoxy manufacturer shall be used as the mixing vessel for blending the epoxy resin. Mixing shall be accomplished using a power drive (air or spark-proof) propeller type blade except that hand mixing may be used for small batches. Equipment for field mixing of aggregates and epoxy resin shall be as specified by the epoxy manufacturer.

PART 3 – EXECUTION

3.1 CONSTRUCTION PROCEDURES

3.1.1 General: Mix the epoxy materials with or without fillers in strict accordance with the manufacturer's instruction. All application of the mixed materials shall be performed within the working life or pot life of the epoxy resin system. Unused mixed materials which have reached the end of the working or pot life, shall be removed from the jobsite. Field mixing and size of batch shall be determined by the Contractor. Epoxy concrete, epoxy mortar, non-pressure epoxy grout, and pressure grouting of cracks shall be provided as indicated and required by this specification.

3.1.2 Epoxy Concrete:

3.1.2.1 Preparation of Patch Area: Remove loose concrete from the spalled areas indicated. Inspect the cavity of any remaining defective concrete by tapping with a hammer or steel rod throughout the areas and listening for dull or hollow sounds. In areas where tapping does not produce a solid tone, remove additional concrete until tapping produces a solid tone. Use a high frequency chipping hammer or concrete saw to deepen cavity. Make saw cuts a minimum of ½ inch deep at a minimum distance of one inch outside the farthest edge of the spall. Roughen saw cut surface by sand blasting. Remove residual fines from all surfaces with a high pressure water jet. Remove any free water with an oil free air jet.

3.1.2.2 Spalls at Joint: Spalls to be repaired that are adjacent to all joints and working cracks shall have performed joint filler of proper dimensions inserted to the bottom of the chipped spall cavities and shall be expanded a minimum of one inch beyond (horizontally) the entire working faces of the spall. The filler strip shall be secured in place prior to and during placement of epoxy concrete. A bituminous

cement bond breaker shall be applied to all working faces at keyed joints. Care shall be exercised to keep bituminous cement bond breaker off of concrete surface to be bonded. After the epoxy concrete has completely cured, the top inch of the preformed joint filler shall be sawed out and liquid joint sealer installed.

3.1.2.3 Mixing materials: Make batches small enough to assure placement before binder sets.

3.1.2.4 Prime coat: prime all surfaces of the cavity with the epoxy resin binder. Scrub prime coat into the surface with the stiff bristle brush. Make coating approximately 20 mils thick.

3.1.2.5 Epoxy Concrete Preparation: Mix epoxy resin binder and aggregates in accordance with manufacturer's recommendations.

3.1.2.6 Placement of Epoxy Concrete: Place epoxy in layers not exceeding 2 inches thick. Use vibratory floats, plates, or hand tampers to consolidate the concrete. Level each layer and screed the final surface to match the adjoining surfaces. Remove excess epoxy concrete on adjacent surfaces before concrete hardens. After the finishing operations and while the epoxy resin concrete is still tacky, uniformly spread a thin coating of Portland cement on the surface of the repaired area and lightly brush the cement into the surface. Upon completion of finishing operations, cure epoxy concrete in accordance with the manufacturer's recommendations.

3.1.3 Epoxy Mortar for cracks and saw Kerfs:

3.1.3.1 Preparation of Area: Concrete to which epoxy mortar is to be applied shall be newly exposed concrete free of loose and unsound materials: Prepare surfaces by sandblasting, scarifying or water blasting. Surfaces shall be dry before application of epoxy mortar.

3.1.3.2 Mixing Materials: Make batches small enough to assure placement before binder sets.

3.1.3.3 Prime Coat: Prime all surfaces with the epoxy resin binder. Scrub prime coat into the surface with a stiff bristle brush. Make coating approximately 20 mils thick.

3.1.3.4 Epoxy Mortar preparation: Mix epoxy resin binder and aggregates in accordance with manufacturer's recommendations.

3.1.3.5 Placement of Epoxy mortar: Apply epoxy mortar to concrete surface by trowel, roller or squeegee at a thickness not less than, nor more than, that recommended by the manufacturer. Work mortar into place and consolidate thoroughly so that all contact surfaces are wet by the feather edge epoxy mortar into adjacent surfaces.

3.1.4 Non-Pressure epoxy Grout: Prepare grout accordance with the manufacturer's instructions.

3.1.4.1 Cement Dowels: Immediately prior to placing dowel clean the hole of dust and other deleterious materials. Fill the hole with grout to a level that leaves enough space for the dowel without overflowing. Insert the dowel in the hole and tap down. If necessary add more grout.

3.1.4.2 Grout Cracks

3.1.4.2.1 Preparation of Area: Concrete to which epoxy grout in to be applied shall be newly exposed concrete free of loose and unsound materials. Prepare surfaces by sandblasting, scarifying or water blasting. Surfaces shall be dry before application of epoxy grout.

3.1.4.2.2 Apply epoxy grout to concrete surface by trowel, roller or squeegee at a thickness not more than 2-inches or as recommended by the manufacturer. Work grout into place and consolidate thoroughly so that all contact surfaces are wet by the grout. Finish surface of grout to the required texture. Do not feather edge epoxy grout into adjacent surfaces.

3.1.5 Pressure Grouting of Cracks: Fill cracks in concrete slabs, beams an by pumping a low viscosity epoxy resin system under pressure into the cracks. Install valves into position along the cracks by bonding in concrete with high viscosity, non-sagging epoxy resin paste mixture. Cracks shall be filled by pumping the low viscosity epoxy system through the valves.

3.1.5.1 Rout out cracks along its entire length to a depth of ¼ inch and a width of 3/8 inch. Vacuum or jet-blow off all dust and particles an the area of the groove.

3.1.5.2 At maximum intervals equivalent to the thickness of the member being repaired or 12 inches and at the juncture of two cracks the bottom of the groove shall be sawed flat and a valve inserted at each interval.

3.1.5.3 The groove between valves shall be filled flush with the concrete surface with the high viscosity epoxy mixture.

3.1.5.4 After the resin mixture has hardened and cured, a tube from a pressure pot containing the low viscosity resin mixture shall be attached t the first valve and the resin mixture pumped into the crack. Use a maximum pressure of 60 psi or less to protect the existing concrete.

3.1.5.5 As the resin mixture appears in the second valve, pinch closed the first valve, and attached the tube from the pressure pot to the second valve and commence pumping. Avoid delays in the pumping operations.

3.1.5.6 After the epoxy mixture has been pumped through all of the valves and the mixture has hardened, removed the valves by grinding off the valves flush with the concrete. Coat the areas of the valves with the high viscosity resin mixture and allow to cure.

3.2 FIELD TESTING AND INSPECTION:

3.2.1 Sampling: As soon as the epoxy resin and aggregate materials are available for sampling, obtain by random selection a sample of each batch in the presence of the Engineer. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by designated name, specification number, batch number, project contact number, intended use and quantity involved.

3.2.2 Testing: At the discretion of the Engineer, samples provided maybe tested for verification.

3.2.3 Inspection: Examine material at the jobsite to determine that it is material referenced in the report o test result or certificate of compliance.

3.2.3.1 Surface preparations and application procedures will be examined by the Engineer to determine conformance with the requirements specified. Approve each separate operation prior to initiation of subsequent operations.

**** END OF SECTION ****

SECTION 04200 MASONRY

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Work includes furnishing all labor, materials, equipment and incidentals required to construct all concrete masonry unit walls including the following:

- Concrete hollow block walls.
- Masonry reinforcing bars for concrete blocks.
- Grouting.
- Connecting wall anchors, ties, bolts and related embedded items.
- Installation of frames for doors, windows, louvers, steel lintels, and recessed fixtures.

1.2 RELATED SECTIONS

Other Sections of the Specifications shall also apply to the extent required for proper performance of this Work.

Section 33030	Cement Plastering
Section 33019	Caulking and Dampproofing
Sections 33020 to 33028	Doors, Windows and Glass

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM C33	Concrete Aggregates
ASTM C90	Loadbearing Concrete Masonry Units
ASTM C144	Aggregate for Masonry Mortar
ASTM C150	Portland Cement

1.4 SUBMITTALS

- A. Detailed working drawings.
- B. Samples as required by the applicable Reference Standards.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and shall be paid for by the Contractor. The Contractor shall furnish the owner certified copies of records showing that each material has been pre-tested, and complied with all applicable requirements of this Standard. The Contractor shall, at his own expense, replace all rejected materials for failure to comply with this Specification.

1.6 PROTECTION OF MATERIALS

All perishable materials for the Work of this Section shall be delivered, stored and handled to preclude damage of any nature. Manufactured materials, such as cement, shall be delivered and stored in their original containers, plainly marked with identification of material and maker. Materials in broken containers, or in packages showing watermarks or other evidence of damage, shall not be used and shall be removed from the site.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Cement

Portland cement shall conform to ASTM C150, Type I. Masonry cements shall not be used. One color of cement shall be used throughout the Work.

Cement shall be used for the application intended and in accordance with the approved recommendation of the manufacturer.

B. Sand for Mortar

Sand shall be clean, durable particles, free from injurious amounts of organic matter and shall conform to the requirements of ASTM C144, Aggregate for Masonry Mortar.

Sand for grout shall conform to ASTM C144 or C33 as required.

C. Water

Water shall be free from injurious amounts of oils, acids, alkalis, organic matter, and shall be clean and fresh.

D. Concrete Hollow Blocks

1. Classification

Concrete block shall conform to ASTM C90, Type I, Normal Weight.

2. Manufacturing Requirements

Concrete hollow blocks shall be manufactured from Portland cement conforming to ASTM C150.

Aggregates for concrete blocks shall consist of sand and evenly graded pea gravel conforming to ASTM C33.

All concrete hollow blocks shall be even textured with straight and true edges, wet steam cured for at least 18 hours and then air cured in covered storage for not less than 28 days before delivery to the job site and shall conform to the requirements of Table 1.

Table 1 – Quality Requirements

Compressive Strength (Minimum, MPa)		Water Absorption (Maximum, kg/m ³)	Moisture Content (Maximum, % of Total Absorption)
Average of Five (3) Samples	Individual Sample	Average of Five (3) Samples	Average of Five (3) Samples
7.1	6.9	208	40

The moisture content of hollow blocks when laid shall not exceed 35 per cent.

3. Dimensions

The actual dimensions of the concrete hollow blocks shall be as shown in Table 2.

Table 2 - Dimensions

Nominal Dimension (mm)			*Actual Dimension (mm)		
Width	Height	Length	Width	Height	Length
100	200	400	92	194	397
150	200	400	143	194	397
200	200	400	194	194	397

No average dimension shall differ from the specified actual dimensions by more than 3 mm.

4. Minimum Face Shell and Web Thickness

The following dimensions shown in Table 3 shall apply for minimum face and web thickness.

Table 3 - Minimum Thickness of Face Shells and Webs

Nominal Width mm (in.)	Face Shell Thickness (Minimum, mm)	Web Thickness (Minimum, mm)
102 (4")	19	19
152 (6")	25	25
203 (8")	32	25

2.2 MORTAR MIXES

Masonry mortar for setting blocks shall be in the proportion of 1 part cement to 3 parts sand or as otherwise approved by the Engineer. Mortar shall be mixed with water in an amount compatible with workability. Ingredients shall be accurately measured by volume.

Mixing shall be done immediately before usage. The Contractor shall use the dry-mix method, wherein the materials for each batch shall be well turned together until the cementitious materials has been thoroughly distributed throughout the mass, after which the water shall be gradually added until a thoroughly mixed mortar of the required plasticity is obtained.

Mortar boxes shall be cleaned out at the end of each day's work and all tools shall be kept clean. Mortar that has begun to set shall not be used.

The mixing of mortar by hand will be permitted only when the quality of hand mixing is comparable to mechanical mixing. The Engineer reserves the right to reject hand mixing and require all mixing by mechanical means. Mortar shall not be retained for more than 1-1/2 hours and shall be constantly mixed until used.

Pointing mortar shall be prehydrated mortar mixed dry, and water added while mixing to obtain a damp, or workable mix. After one or two hours, sufficient water shall be added to bring it to proper consistency, which shall be somewhat drier than masonry mortar.

The color of mortars shall be uniform throughout for adjoining areas, and shall be satisfactory to the Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

All masonry shall be laid plumb and true to lines. Masonry shall be carried up in a uniform manner. No portion shall be raised more than one meter above adjacent portions, except with the approval of the Engineer.

B. Concrete Hollow Block

- Concrete blocks shall be laid in running bond, unless otherwise indicated. Joints shall not exceed 10 mm, shall be uniform throughout, and finished slightly concave and smooth.

Pointing shall be performed with the proper tools to a dense and neat finish. Finger pointing will not be allowed.

All blocks shall be laid in a full bed of mortar applied to shells. Apply mortar to the vertical joint of blocks that have already set in the wall, and to all contact faces of the unit. Each unit shall be placed and shoved against the previously laid block to produce a well-compacted vertical mortar joint for the full shell thickness.

Intersecting bearing walls shall be tied together with metal ties at 0.80-meter vertical spacing. Bends of tie and reinforcing bars shall be embedded in cells filled with mortar.

Concrete blocks shall be reinforced with gage 10mm diameter at 0.60 meter on centers in vertical and horizontal direction.

- All necessary block cutting shall be neatly done by a masonry saw or cutting shall be done by hammering at any times with an approved hand tool.
- Unless otherwise shown on the Drawings, door, window and louver frames shall be installed using screws and expansion shields. All frames shall be set tightly against the masonry wall.
- Control joints shall be installed as detailed on the Drawings. The joints shall be raked out to a depth of 20 mm for the full height of the wall and caulked. The maximum length between joints shall be 10 meters, if not shown on the Drawings, or as directed by the Engineer.

Joints made at the intersection of block walls with structural concrete, and where indicated, shall be filled with mortar grout and pointed.

C. Concrete Hollow Block to be Plastered

Concrete block walls, which are to be plastered, shall be laid in running bond. Joints are to be left rough to assist in the bonding of plaster. Otherwise, concrete block masonry shall conform to paragraph B, Concrete Hollow Block. Control joints in plastered block walls shall be carried through the plaster, but the joints shall not be plastered.

3.2 LINTELS, TIES AND MICELLANEOUS ITEMS

The Contractor shall build in all miscellaneous items specified in other sections to be set in masonry including frames, lintels, reinforcing steel, electrical boxes and fixtures, sleeves, grilles, anchors and other miscellaneous items. All anchorage, attachments, and bonding devices shall be set so as to prevent slippage and shall be completely covered with mortar.

SECTION 05101A

STRUCTURAL STEEL RETROFITTING

PART 1 – GENERAL

1.1 SCOPE OF WORK

The Work includes providing all labor, materials, equipment and incidentals necessary to furnish and install all additional structural steel items including cover plates and side plates required for the retrofitting of the structural elements as shown on the Drawings.

1.2 RELATED SECTIONS

Other sections of the Specifications shall also apply to the extent required for proper performance of this Work.

Not applicable

1.3 SPECIFICATIONS AND STANDARDS

Except as otherwise indicated, the current editions of the following Standards apply to the WORK of this Section:

ASTM A36	Carbon Structural Steel
ASTM A325	Structural Bolts, Steel, Heat Treated, 120/105 Ksi Minimum Tensile Strength
ISO 261	ISO General Purpose Metric Screw Threads - General Plan
AWS A5.1	Mild Steel Covered Arc-Welding Electrodes
AWS D1.4	Structural Welding Code – Reinforcing Steel

1.4 SUBMITTALS

A. Detailed shop drawings of all structural steel elements to be retrofitted.

1.5 QUALITY ASSURANCE

The Contractor is responsible for the performance of all tests and inspection required by this Standard Specification. However, the owner reserves the right to perform any or all prescribed tests and inspection where such is deemed necessary to ensure that delivered materials conform to the specifications, and shall be paid for by the Contractor. The Contractor shall furnish the owner certified copies of records showing that each material has been pre-tested, and complied with all applicable requirements of this Standard. The Contractor shall, at his own expense, replace all rejected materials for failure to comply with this Specification.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Structural shapes, plates and bars unless otherwise noted shall conform to the requirements of ASTM A36.
- B. Welding rods shall conform to AWS A5.1. All welding rods shall be E70XX grade.
- C. High strength steel bolts shall conform to ASTM A325.
- D. Hexagonal Nuts
- E. Standard Washers

PART 3 - EXECUTION

3.1 WELD SURFACE PREPARATION

Prior to commencement of welding works, the Contractor shall thoroughly prepare and clean the structural steel surfaces of all dirt, grease, rust or other foreign matter.

3.2 COVER PLATE INSTALLATION

- A. Temporary support in the form of shoring shall be installed prior to execution of retrofitting works, where applicable.
- B. Materials for welding shall be the best available as recommended by the manufacturer of the materials to be welded, and in accordance with AWS Standard.
- C. Welding of parts shall be in accordance with the Structural Welding Code D1.1 of the AWS and shall only be done by welders certified as to their ability to perform welding in accordance with the locally accepted requirements.
- D. Weld sizes shall be as per the issued structural drawings.
- E. Welding inspection shall be done as per AWS Standard.

3.3 PAINTING

- A. After installation, the Contractor shall thoroughly prepare and clean the structural steel surfaces of all dirt, grease, rust or other foreign matter.
- B. Paint shall be applied by qualified painters. Paint color is to match the existing.

**** END OF SECTION ****

Table 1 – Carbon Fiber Properties or approved equivalent

Dry Fiber Density (g/cc)	1.81
Dry Fiber Thickness (mm)	0.331
Dry Fiber Tensile strength (N/mm ²)	4 900
Tensile modulus (N/mm ²)	242 000
Dry Fiber Elongation at Break (%)	1.70
Laminate Nominal Thickness (mm)	0.331
Laminate Nominal Cross Section (mm ² per m width)	331
Laminate Tensile Strength (N/mm ²)	2 866
Laminate Modulus of Elasticity in Tension (kN/mm ²)	241
Laminate Elongation at Break in Tension (%)	1.33

2. Epoxy Resin or approved equivalent

Table 2 – Primer

Density (kg/l), Component A+B mixed at +23°C	1.30 ± 0.1
Viscosity (mPas)	
+ 10°C	~10 000
+ 23°C	~6 000
+ 35°C	~5 000
Modulus of Elasticity in Flexure, 7 days at +23°C (N/ mm ²)	~3 800
Tensile Strength, 7 days at +23°C (N/ mm ²)	~30
Modulus of Elasticity in Tension, 7 days at +23°C (N/ mm ²)	~4 500
Elongation at Break, 7 days at +23°C (%)	0.9
Tensile Adhesion Strength, Concrete fracture (N/mm ²) On Sandblasted substrate	>4
Coefficient of Thermal Expansion (°C) Temperature range - 10°C - +40°C	4.5 x 10 ⁻⁵
Glass Transition Temperature, 30 days curing time (°C)	
+ 30°C	+58
Heat Deflection Temperature (°C)	

Technical Specifications

+ 10°C, 7 days curing time	+36
+ 23°C, 7 days curing time	+47
+ 35°C, 7 days curing time	+53
Service Temperature (°C)	- 40 to 45

Table 3 – Main Impregnating Resin

Density (kg/l), Component A+B mixed at +23°C	1.16
Viscosity (mPas)	
+ 15°C	~2 000
+ 23°C	~700
+ 40°C	~200
Modulus of Elasticity in Flexure, 7 days at +23°C (N/ mm ²)	~2 800
Tensile Strength, 7 days at +23°C (N/ mm ²)	~45
Modulus of Elasticity in Tension, 7 days at +23°C (N/ mm ²)	~3 500
Elongation at Break, 7 days at +23°C (%)	1.5
Tensile Adhesion Strength, Concrete fracture (N/mm ²) On Sandblasted substrate	>4
Coefficient of Thermal Expansion (°C) Temperature range - 20°C - +40°C	6.0 x 10 ⁻⁵
Glass Transition Temperature (°C)	
+ 30°C, 30 days curing time	+53
Heat Deflection Temperature (°C)	
+ 15°C, 7 days curing time	+43
+ 23°C, 7 days curing time	+49
+ 40°C, 3 days curing time	+60
+ 40°C, 7 days curing time	+66
Service Temperature (°C)	- 40 to 45

PART 3 - EXECUTION

3.1 SAFETY

- A. Safety policy issued shall be posted at a noticeable place in the site.
- B. All personal protective equipment required for safe completion of the job shall be worn properly.

3.2 PRE – PROJECT PREPARATION

- A. Obtain all equipment and materials as per checklist and any special project requirements.

3.3 SURFACE PREPARATION

- A. Surfaces where the Carbon Fiber is to be applied must be sound.
- B. Rust scales, oil or grease, old paint coating, and other contaminants must be removed by any applicable method approved by the Engineer.
- C. Inject cracks. Cracks greater than 0.25mm (0.010 in.) must be stabilized using epoxy injection methods.
- D. Honeycombs and bug holes shall be filled up.
- E. Remove form lines, sharp edges and protrusions by grinding or filling with putty. Ridges greater than 5mm may need to be ground down as per engineer's inspection.
- F. Sharp edges, fins, and protrusions that can cause voids between the wrap and the steel girder surface or those that are injurious to the fibers shall be removed by grinding or any approved method approved by the Engineer. Ridges greater than 5mm may need to be ground down as per engineer's inspection.
- G. Smoothen any surface undulations greater than 15mm over 1m as per the inspection of the engineer.
- H. Radius corners perpendicular to the fiber orientation by grinding as per the project specifications.
- I. Ensure and open pore structure of the substrate by either sandblasting, high-pressure water blasting or wire brushing.
- J. Surfaces must be cleaned of dust and debris by blowing with air or broom cleaning.
- K. The substrate should be dry before the application of the Composite Strengthening System.
- L. All other method of surface preparation equal to the above standard maybe permitted subject for approval by the Engineer.

3.4 PREPARATION WORK FOR PROJECT

- A. Review project specifications in detail.
- B. Pre-cut fabric with off-site labor where possible.
- C. Check surface-prep of substrate to make sure all patchwork is complete and cured.

substrate pores and to become "tacky".

- C. Apply the saturated Carbon Fabric to the element to be strengthened as indicated on the drawings.
- D. For maximum adhesion of vertical or overhead applications, apply the layers of Carbon Fabric individually, waiting approximately 1 hour in between layers. Columns may be continuously wrapped.
- E. Apply Carbon Fabric with uniform and smooth pressure either with a stiff spatula or a surface roller removing and air bubbles caught beneath the fabric surface. More resin may be added to the applied Carbon Fabric with a wetted roller if necessary.
- F. For Columns:
 - Wrap the column with the specified number of wraps as calculated and indicated on the specification. Wrap TOP first; BOTTOM second or as per project specifications. Sequence to be advised on daily work sheet for each column. Follow the approved drawings.
 - While continuously wrapping, apply Carbon Fabric with uniform and smooth pressure either with a stiff spatula or a surface roller, securing and smoothing each layer.
- G. For Beams (including shear strengthening):
 - Wrap the beam with the specified number of wraps as calculated and indicated on the specification. Sequence to be advised on daily work sheet for each beam. Follow the approved drawings.
 - Apply shear strengthening layers on top of the flexural strengthening layers or as per engineering drawings. This method helps to secure the ends of the flexural strengthening.
 - Install FibrAnchors as per specifications if required.
- H. For Walls (including URM walls):
 - Apply specified number of layers as calculated and indicated on the specification. Application sequence to be advised on daily work sheet. Follow the approved drawings.
 - Install FibrAnchors as per specifications if required.
- I. For Slabs
 - Apply specified number of layers as calculated and indicated on the specification. Application sequence to be advised on daily work sheet. Follow the approved drawings.
 - Additional set time may be necessary to properly adhere large sheets of Carbon Fabric in overhead applications.
 - Install FibrAnchors as per specifications if required.
- J. At Wall / Slab Connections:
 - Install specified radius bedding of Epoxy Putty at joint of wall and slab, insuring that radius extends equally between the wall and slab as per drawings. Allow the Epoxy Putty to cure overnight to a tacky, firm state.

