During the construction of the roadway, the roadbed shall be maintained in such condition that it will be well drained at all times. Side ditches or gutters emptying from cuts to embankments or otherwise shall be so constructed as to avoid damage to embankments by erosion.

1.1.2.5 Protection of Structures

If embankment can be deposited on one side only of abutments, wing walls, piers or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of, or excessive pressure against the structure. When noted on the Plans, the fill adjacent to the end bent until the superstructure is in place. When embankment is to be placed on both sides of a concrete wall or box type structure, operations shall be so conducted that the embankment is always at approximately the same elevation on both sides of the structure.

1.1.2.6 Rounding and Warping Slopes

Rounding – Except in solid rock, the tops and bottoms of all slopes, including the lopes of drainage ditches, shall be rounded as indicated on the Plans. A layer of earth overlaying rock shall be rounded above the rock as done in earth slopes.

Warping - Adjustments in slopes shall be made to avoid injury in standing trees or marring of weathered rock, or to harmonize with existing landscape features, and the transition to such adjusted slopes shall be gradual. At intersections of cuts and fills, slopes shall be adjusted and warped to flow into each other or into the natural ground surfaces without noticeable break.

1.1.2.7 Finishing Roadbed and Slopes

After the roadbed has been substantially completed, the full width shall be conditioned by removing any soft or other unsuitable material that will not compact properly or serve the intended purpose. The resulting areas and all other low sections, holes or depression shall be brought to grade with suitable selected material. Scarifying, blading, dragging, rolling or other methods of work shall be performed or used as necessary to provide a thoroughly compacted roadbed shaped to the grades and cross-sections shown on the plans or as staked by the Engineer.

All earth slopes shall be left with roughened surfaces but shall be reasonably uniform, without any noticeable break, and in reasonably close conformity with the Plans or other surfaces indicated on the Plans, or as staked by the Engineer, with no variations therefrom readily discernible as viewed form the road.

1.1.2.8 Serrated Slopes

Cut slopes in reparable material (soft rock) having slope ratios between 0.75:1 and 2:1 shall be constructed so that the final slope line shall consist of a series of small horizontal steps. The step rise and tread dimensions shall be shown on the plans. No scaling shall be performed on the stepped slopes except for removal of large rocks which will obviously be a safety hazard if they fall into the ditchline or roadway.

1.1.2.9 Earth Berms

When called for in the Contract, permanent earth berms shall be constructed of well graded materials with no rocks having a diameter greater than 0.25 the height of the berm. When local material is not acceptable, acceptable material shall be imported, as directed by the Engineer.

Compacted Berms

Compacted berm construction shall consist of moistening or drying and placing material as necessary in locations shown on the drawings or as established by the engineer. Material shall contain no frozen material, roots, sod, or other deleterious materials. Contractor shall take precautions to prevent material for escaping over the embankment slope. Shoulder surface beneath berm will be roughened to provide a bond between the berm and shoulder when completed. The Contractor shall compact the material placed until at least 90 mass percent of the maximum density is obtained as determined by AASHTO T 99, Method C. The cross-section of the finished compacted berm shall reasonably conform to the typical cross-section as shown on the Plans.

Uncompacted Berms

Uncompacted berm construction shall consist of drying, if necessary, and placing material in locations shown on the Plans or as established by the Engineer. Material shall contain no frozen material, roots, sod or other deleterious materials. Contractor shall take precautions to prevent material form escaping over the embankment slope.

2.8 Structural Fill

2.8.1 Scope of Work

Structural fills shall include but not be limited to all fills designed to support buildings, hydraulic structures, and channels. In addition, structural fills may be required to support pipelines in certain areas as shown on the drawings, or as directed by the Engineer. Structural fills shall be furnished as specified where existing materials encountered at bearing elevations are found to be unsuitable then the Contractor is directed to replace them, or where the drawings show foundation elevations set above the grade of soils with satisfactory bearing capacity, or as directed by the Engineer. Structural fill shall be used below structures having underdrains where shown on the Drawings.

2.8.2 Technical Requirements

a. Structural fills shall be carried down to undisturbed earth having adequate bearing capacity as determined by the Engineer. Compacted structural fill shall be constructed beneath foundations laterally outward to the limits defined by a 1:1 sloped outward and downward from a point located at least one (1.0) meter to the exterior of the bottom edge of all foundations and carried downward at that slope to suitable undisturbed earth.

b. Structural fill shall be well graded and non-plastic materials. Before any structural fill is paved over the existing ground surface, the ground shall be cleared and grubbed and the topsoil shall be stripped in accordance with these specifications. Structural fill particles shall be sound and not more than five percent (5%) shall pass the No. 200 sieve, nor more than fifty percent (50%) the No. 40 sieve. The material shall be free from organic matter, clay lumps, or other deleterious materials. The maximum particle size shall not exceed seventy-five percent (75%) of the lift thickness.

c. A sieve analysis of the proposed structural fill material shall be submitted for review and approval by the Engineer at least 30 days before the first use of the material. In addition, samples of structural fill shall be submitted to the Engineer for sieve analysis for each 2,500 cubic meter of structural fill placed, or whenever the source or quality of fill material is varied. The Engineer shall have the right to reject structural fill material at any time.

d. As specified in the paragraph for Area Excavation-Common, the bearing surface in areas of structural excavations shall be scarified to a depth of 150mm below the drainrock base, and recompacted to at least ninety-five percent (95%) of Modified Proctor maximum density, after the soil is brought to near the optimum moisture content. If in-place densities are not adequate, the Engineer will require additional rolling and/or modification of soil moisture content until satisfactory results are obtained. Rolling shall be by pneumatic tire rollers or smooth drum vibratory rollers of capacities per instructions from the Engineer.

e. Structural fill layers shall be placed in lifts of 200mm in depth after compaction. Fill material shall be approved by the Engineer and hauled to the fill and tipped directly on the fill lift being placed. No material shall be dozed from any bench or layer to a lower bench or layer. Material shall be spread on each layer by graders or dozers.

f. Each lift shall be brought to near optimum moisture-content prior to compaction. No compaction of completely dry material shall be permitted. Each lift shall be compacted to ninety-five percent (95%) of Modified Proctor optimum density using pneumatic tire rollers or smooth drum vibratory rollers of capacities approved in advance by the Engineer. Should any test reveal inadequate compaction of a structural fill layer, then the entire layer shall receive at least one additional complete pass of the roller. A complete pass shall include a single coverage of the entire layer including twenty percent (20%) overlap of drum width. If after a reasonable amount of recompaction is completed, and satisfactory results have not been obtained, then the Contractor shall remove the lift and replace it with satisfactory material. Care shall be taken to avoid contamination of structural fill with other materials.

The Contractor shall be required to replace any such contaminated structural fill layers at his own expense.

g. The minimum number of passes per lift is two, after which the Engineer may conduct whatever test work it deems necessary to determine the degree of compaction obtained. Additional passes of the roller shall be required until adequate results are obtained. Retesting of compaction shall be at the Contractor's expense.

h. In areas inaccessible to large rollers, hand-held tampers may be used to obtain adequate compaction, but use of hand-held equipment must be approved in advance by the Engineer.

i. Structural fill shall be brought up to the required grade in lifts of equal compacted depth. Each lift shall meet the requirements of this Section.

2.9 Pipe Bedding and Trench Backfill

2.9.1 Scope of Work

As specified, buried pipe may be laid directly on the prepared trench bottom as shown on the drawings. Alternatively, the Engineer at its option may require that the trench be over-excavated by 150mm and replaced with gravel bedding material. Payment shall be made for over-excavation and replacement bedding when such over-excavation and replacement bedding is directed by the Engineer and carried out to the depths and lengths as required.

2.9.2 Technical Requirements

a. Bedding material shall consist of sand or selected sandy soil, and shall be free of loam, clay, and deleterious materials.

b. Bedding shall be brought to optimum moisture content and shall be compacted using hand-held tampers to ninety-five percent (95%) of Standard Proctor density.

c. Trench backfill to a depth of 300mm over the top of the pipe shall use clean sand/sandy gravel as specified for structural fill. Trench backfill shall be subject to material and compaction testing and acceptance or rejection by the Engineer.

d. Trench backfill shall be placed in 100mm layers uniformly on each side of the pipe, and then compacted by hand-held tampers to ninety-five percent (95%) of Standard Proctor maximum density. Extreme care shall be used to avoid damaging the pipe during compaction. Such layered compaction shall continue to a depth of 300mm over the top of the pipe. This is defined as the pipe zone. If the pipe is located under or within the zone of influence of a structure or under roadways, then the backfill above the pipe zone shall be the same material used in the pipe zone and shall be compacted to ninety-five percent (95%) of Modified Proctor maximum density in 200mm lifts until the backfill reaches the foundation, roadway base or leaves the zone of influence of the structure. The zone of influence is defined as starting at a horizontal distance of 1.0 meter outside of the foundation's bottom outside edge, and extending outward laterally in a downward direction at a 1:1 slope.

e. In areas away from structures and/or roadways or their zone of influence as defined in this section, backfill above the pipe zone shall be common fill compacted to ninety-five percent (95%) of Standard Proctor maximum density in 200mm lifts.

f. Water settling by flooding and jetting of pipe trench backfill material shall not be permitted, unless otherwise approved by the Engineer.

g. In no case shall backfill material be end-tipped directly from a truck into a pipe trench. All backfill material shall be tipped at the trench edge and then transferred to the trench by hand or with small capacity frontment loaders. All due care shall be taken to insure that displacement of the pipe or damage thereto does not occur. If damaged or displaced, repair shall be made promptly as directed by the Engineer and at the Contractor's expense.

h. Backfilling of pipes shall begin as soon as practical after the pipe has been laid, jointed and inspected, except that backfilling must be coordinated with testing as specified.

i. Clean sand shall be used for bedding and backfill in the pipe zone for any pipe not concrete encased and having a coal-tar enamel coating for corrosion protection.

j. Concrete encased pipe shall be covered with moist earth for curing within 24 hours after concrete placement, but only after the concrete has developed sufficient strength to resist any deformation. The curing time for the concrete encasement shall be a minimum of 28 days. No earth load shall be placed on the encasement until the 28 day period has elapsed.

k. Where specifically shown on the Drawings or as directed by the Engineer, the pipe shall be backfilled with sand cement in the pipe zone as defined in this section. Sand cement for pipe backfill shall consist of a mixture of graded fine aggregate and Portland Cement, Type I or II as specified in Division 03, Concrete. The minimum cement content shall be 100 kg/cu.m. The sand cement and water shall be proportioned so as to yield a minimum compressive strength of 7 MPa after seven (7) days as determined on two comparison cylinders taken twice during each shift. Material poured into test cylinders shall not be tamped or vibrated. Forty-eight hours after being made, cylinders shall be totally immersed in water, and shall be removed from water twenty-four (24) hours before testing and allowed to drain and air dry. The average diameter of

the cylinders used for calculating the cross-sectional area shall be determined before the cylinders are immersed in water. Cylinders shall otherwise be tested in accordance with ASTM C39. Sand cement shall be thoroughly mixed using the minimum quantity of water required to yield a fluid, readily pumpable, mixture. Sand cement shall be placed in uniform lifts not exceeding a depth of 150mm on each side of the pipe in such a manner that any movement of floating of the pipe is precluded and no voids are formed. The presence of dirt clumps, or other extraneous matter will not be allowed. Light poling or vibration will be permitted. Within one hour of placement, sand cement shall be covered with a 150mm layer of damp earth, but trench backfill may not be completed until 24 hours after placement of the sand cement grout.

2.10 Common Fill and Site Grading

2.10.1 Scope of Work

Common fill shall include all other fill not classified as structural fill, trench backfill or landscaping loam. Common fill shall be used for rough grading site, backfill on some portions of structures, and other miscellaneous applications.

2.10.2 Technical Requirements

a. Common fill may be obtained from on-site excavated material if tested and approved or from off-site sources, which shall also be tested and approved by the Engineer. Common fill shall consist of mineral soil, substantially free of clay lumps, organic materials, loam, wood, trash, and other objectionable material that may be compressible or which cannot be compacted adequately. Common fill shall not contain stones larger than 100mm in any dimension, nor stones larger than 60mm in the top half meter of fill. Common fill shall not contain broken concrete, masonry, rubble, pavement, or other debris. It shall be easily spread and compacted, and the percent passing a No. 200 sieve shall not exceed twenty percent (20%). the liquid limit of the portion passing the No. 40 sieve shall not exceed fifty percent (50%).

b. The Contractor shall provide temporary surface drainage facilities as required to intercept or divert runoff water that otherwise might interfere with grading work in progress or damage grading work already in place. Permanent storm drainage facilities may be used for a portion of the temporary drainage requirement, but shall be flushed and cleaned before final acceptance of the work. All slopes shall be protected from damage resulting from surface water flow during construction prior to implementing final slope protection requirements.

c. Common fill shall be placed in layers having a maximum thickness of 250mm after compaction, unless the Contractor can demonstrate to the Engineer that thicker layers can be adequately compacted. Common fill shall be compacted to at least ninety-five percent (95%) of Standard Proctor maximum density. Moisture content of the material shall be at or near optimum when compaction begins. All common fill shall receive a minimum of two (2) passes of the compaction roller. The Engineer shall review and approve the compaction equipment used, including type of unit, weight and loading transmitted to the fill fifteen (15) days before final placement begins.

d. Backfill shall not be dropped directly upon any structure or pipe. Material placed within 600mm of any structure or pipe shall be free of rocks, or consolidated masses of soil materials having maximum dimensions greater than 60mm. Backfill shall not be placed on or around any structure until the concrete has cured for a minimum period of twenty-eight (28) days.

e. Backfill around water-retaining structures shall not be placed until the structures have been

tested for water-tightness, and the structures shall be full of water while backfill is being placed. Backfill around structure shall be placed in uniform depth son all sides of the structure. Backfill within two (2) meter of structures shall be compacted using hand-held tampers. Construction equipment, trucks or other vehicles weighing in excess of 4,500 kg shall not be permitted closer to the walls than a horizontal distance equal to the depth of the fill at that time.

f. Placement of common fill shall include all material and labor associated with rough site grading preparatory to final landscape grading. Grading in preparation for placing of loam and topsoil in planting areas, and construction of finishing facilities such as sidewalks, parking areas, roads, signs, etc. shall be performed at all locations indicated, to the lines, grades and elevations shown in the drawings. Such work shall be performed at all times in such a manner that the technical requirements for final slopes, lines and grades can be met. The Contractor shall notify the Engineer immediately of any incongruities encountered in final grading, including contouring problems, slope stability difficulties or aesthetic considerations.

g. All conflicting or excess materials encountered within the site grading limits shown, of whatever nature, shall be removed from the site and disposed of as directed. The intent of this section is that the Contractor shall perform all work necessary to render the site ready for final landscaping.

h. The Contractor shall provide at his own expense any temporary stockpiling, processing and rehandling of fill materials required for grading the site in a logical construction sequence, and to meet the requirements of this section or the direction of the Engineer.

i. The Engineer shall have the right to make minor adjustments or revisions to lines or grades, during the course of construction, to meet the project objectives, and the Contractor shall only be reimbursed for such modifications on the basis of changes in quantities. No changes in Unit Prices shall be permitted.

j. Stones or rock fragments larger than 60mm in their greatest dimension will not be permitted within the top 150mm of the finished subgrade of all fills and embankments.

k. In cut slopes, all loose or protruding rocks or consolidated soil masses shall be barred loose or otherwise removed to line or finished grade. All cut and fill slopes shall be uniformly trimmed to the slope, cross section, and alignment shown on the drawings. All cut slopes shall be trimmed to a stable grade and cross section.

2.11 Subsurface Drainage (Only Where Applicable)

2.11.1 Scope of Work

Subsurface drainage includes provisions for foundation drains, slope and embankment drains, roadway subdrains and related facilities as shown on the drawings or as directed by the Engineer.

2.11.2 Technical Requirements

a. All subsurface drainage pipes shall be either Schedule 40 PVC pipe, or non-reinforced concrete drain pipe of the types and classes required. All pipes in drainage trenches shall be perforated and surrounded by drainrocks to the dimensions shown on the drawings. In addition, where shown on the drawings, the free draining backfill shall be wrapped in non-woven polypropylene drainage fabric. Upon leaving the drainage trench location, the pipe shall be non-perforated and

shall discharge as shown on the drawings, or as directed by the Engineer. The pipe dimensions shall be as shown on the drawings.

b. Perforated pipe holes shall be located on the bottom of the pipe 13mmØ @ 150mm o. c. staggered.

c. The minimum allowable slope shall be 0.005 while the minimum pipe diameter shall be 100mm. where the drainrock in the trench or bed is enclosed within drainage fabric, the drainrock shall be open-graded material as shown on the drawings.

d. All drainrock shall be graded crush rock or granular material, free of organic material, loam, wood, trash, and other objectionable material. Rock shall be sound, durable material, angular or sub-angular in shape, of suitable quality to insure permanence in its intended use. Round stones, flat thin stones, or soft material such as sandstones shall not be permitted. Drainrock shall be lightly compacted with hand tampers after placement.

e. Filter cloth shall be used where shown on the drawings to provide a positive separation between drainrock and soil layers being drained. Filter fabric shall be made of polypropylene, melted and extruded into continuous filaments, formed into non-woven layered sheets and then needle-punched to form an inseparably bonded fabric. All filter fabric used shall have a minimum thickness of 2.28mm as measured by ASTM D1777. The minimum grab strength shall be 100 kg, while the maximum elongation shall be 140 percent; both as measured by ASTM D1682. Trapezoidal tear strength shall be a minimum of 25 kg as determined per ASTM D2263 procedures. Burst strength shall be 2.4 MPa as measured in accordance with ASTM D751. The water permeability of the fabric shall have an equivalent sieve size of 0.200mm to 0.149mm. the fabric shall be no-biodegradable, and resistant to a full range of pH values from 1 to 13. Material specifications and samples shall be submitted for review by the Engineer prior to first use.

2.12 Slope and Bank Protection (Only Where Applicable)

2.12.1 Scope of Work

Slope and bank protection shall consist of furnishing and placing two classes of material:

- riprap (grouted in place or loose)
- vegetative cover

Slope and bank protection include all material and labor necessary to apply protective covers or vegetation to embankments, channels, streambanks, etc. to protect these works from erosion due to rainfall, stormwater runoff or streamflow.

2.12.2 Technical Requirements

a. Riprap (Handplaced, Grouted or Loose)

aa. Unless otherwise authorized by the Owner, the Contractor shall promptly place riprap or other bank protection measures in conjunction with the construction of the slopes or embankments being constructed, with time delays allowed only for proper completion of the affected embankments, or to prevent admixture of riprap and bank material. Riprap shall be either loose or grouted as directed on the drawings or by the Engineer and shall be placed by hand at the locations and in close conformity with the lines and grades shown on the drawings.

bb. Riprap shall be placed on foundation slopes of compacted gravel excavated below anticipated scour to the elevations shown on the drawings. A trench shall be excavated at the base of the slope to start the placement of riprap. The gravel drainage blanket shall be graded to a depth of 150mm to yield a continuous, uninterrupted bed of the required thickness. It shall be compacted at a minimum by one pass of a crawler-type tractor of total gross weight equal to 14,000 kgs. Additional grading shall be done, or additional gravel furnished and placed, to repair any damage done to the gravel bed by water action prior to placement of riprap.

cc. Riprap shall be hand-placed on the prepared gravel bed, starting at the trench excavated at the slope base which shall receive a course of the largest stones meeting the specifications. Riprap shall be placed in progressive courses upwards from this base, with each stone placed in contact with surrounding stones, but with its weight carried by the underlying material and not by the adjacent stones. Stones shall be laid so that the minimum dimension is perpendicular to the prepared bed.

Spaces between stones shall be filled with spalls of suitable size to construct a solid, stable slope free from large voids and defects. The exposed face of the hand-placed riprap shall be made as smooth as the shape and size of the stones will permit, but shall not vary more than 200mm from a plane surface on the required slope. Where shown on the drawings, hand-placed riprap shall then be grouted or mortared in place.

dd. The riprap shall be sound, durable rock which is roughly rectangular in shape and of sufficient quality to insure permanence in the conditions under which it is to be used. Rounded stones, boulders, sandstones, or similar soft stone or flat rocks shall not be used. The material supplied shall ba free of fines, overburden, spoil, shale, and organic materials, and shall be subject to approval by the Engineer.

ee. For grouted riprap, at least fifty percent (50%) of the stones shall weigh in excess of seventy (70) kgs each. The smallest dimension of each stone shall not be less than 300mm.

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

SECTION 02600
STORM DRAINAGE SYSTEM

1.0 GENERAL

1.1 References

Material requirements, methods, procedures, testing requirements and other related items called for in this Section shall conform to the applicable standards of the American Association of State Highway and Transportation Officials (AASHTO), American Concrete Pipe Association (ACPA), American National Standards Institute, (ANSI) and American Society for Testing and Materials (ASTM).

1.2 Submittals

Submit the following in accordance with Section 01100, Submittals. Submit within 90 days after the contract award date and prior to commencing work on the system.

1.2.1 Manufacturer's Catalog Data

a. Pipes and Fittings

b. Joints and couplings

the cylinders used for calculating the cross-sectional area shall be determined before the cylinders are immersed in water. Cylinders shall otherwise be tested in accordance with ASTM C39. Sand cement shall be thoroughly mixed using the minimum quantity of water required to yield a fluid, readily pumpable, mixture. Sand cement shall be placed in uniform lifts not exceeding a depth of 150mm on each side of the pipe in such a manner that any movement of floating of the pipe is precluded and no voids are formed. The presence of dirt clumps, or other extraneous matter will not be allowed. Light poling or vibration will be permitted. Within one hour of placement, sand cement shall be covered with a 150mm layer of damp earth, but trench backfill may not be completed until 24 hours after placement of the sand cement grout.

2.10 Common Fill and Site Grading

2.10.1 Scope of Work

Common fill shall include all other fill not classified as structural fill, trench backfill or landscaping loam. Common fill shall be used for rough grading site, backfill on some portions of structures, and other miscellaneous applications.

2.10.2 Technical Requirements

a. Common fill may be obtained from on-site excavated material if tested and approved or from off-site sources, which shall also be tested and approved by the Engineer. Common fill shall consist of mineral soil, substantially free of clay lumps, organic materials, loam, wood, trash, and other objectionable material that may be compressible or which cannot be compacted adequately. Common fill shall not contain stones larger than 100mm in any dimension, nor stones larger than 60mm in the top half meter of fill. Common fill shall not contain broken concrete, masonry, rubble, pavement, or other debris. It shall be easily spread and compacted, and the percent passing a No. 200 sieve shall not exceed twenty percent (20%). the liquid limit of the portion passing the No. 40 sieve shall not exceed fifty percent (50%).

b. The Contractor shall provide temporary surface drainage facilities as required to intercept or divert runoff water that otherwise might interfere with grading work in progress or damage grading work already in place. Permanent storm drainage facilities may be used for a portion of the temporary drainage requirement, but shall be flushed and cleaned before final acceptance of the work. All slopes shall be protected from damage resulting from surface water flow during construction prior to implementing final slope protection requirements.

c. Common fill shall be placed in layers having a maximum thickness of 250mm after compaction, unless the Contractor can demonstrate to the Engineer that thicker layers can be adequately compacted. Common fill shall be compacted to at least ninety-five percent (95%) of Standard Proctor maximum density. Moisture content of the material shall be at or near optimum when compaction begins. All common fill shall receive a minimum of two (2) passes of the compaction roller. The Engineer shall review and approve the compaction equipment used, including type of unit, weight and loading transmitted to the fill fifteen (15) days before final placement begins.

d. Backfill shall not be dropped directly upon any structure or pipe. Material placed within 600mm of any structure or pipe shall be free of rocks, or consolidated masses of soil materials having maximum dimensions greater than 60mm. Backfill shall not be placed on or around any structure until the concrete has cured for a minimum period of twenty-eight (28) days.

e. Backfill around water-retaining structures shall not be placed until the structures have been

tested for water-tightness, and the structures shall be full of water while backfill is being placed. Backfill around structure shall be placed in uniform depth son all sides of the structure. Backfill within two (2) meter of structures shall be compacted using hand-held tampers. Construction equipment, trucks or other vehicles weighing in excess of 4,500 kg shall not be permitted closer to the walls than a horizontal distance equal to the depth of the fill at that time.

f. Placement of common fill shall include all material and labor associated with rough site grading preparatory to final landscape grading. Grading in preparation for placing of loam and topsoil in planting areas, and construction of finishing facilities such as sidewalks, parking areas, roads, signs, etc. shall be performed at all locations indicated, to the lines, grades and elevations shown in the drawings. Such work shall be performed at all times in such a manner that the technical requirements for final slopes, lines and grades can be met. The Contractor shall notify the Engineer immediately of any incongruities encountered in final grading, including contouring problems, slope stability difficulties or aesthetic considerations.

g. All conflicting or excess materials encountered within the site grading limits shown, of whatever nature, shall be removed from the site and disposed of as directed. The intent of this section is that the Contractor shall perform all work necessary to render the site ready for final landscaping.

h. The Contractor shall provide at his own expense any temporary stockpiling, processing and rehandling of fill materials required for grading the site in a logical construction sequence, and to meet the requirements of this section or the direction of the Engineer.

i. The Engineer shall have the right to make minor adjustments or revisions to lines or grades, during the course of construction, to meet the project objectives, and the Contractor shall only be reimbursed for such modifications on the basis of changes in quantities. No changes in Unit Prices shall be permitted.

j. Stones or rock fragments larger than 60mm in their greatest dimension will not be permitted within the top 150mm of the finished subgrade of all fills and embankments.

k. In cut slopes, all loose or protruding rocks or consolidated soil masses shall be barred loose or otherwise removed to line or finished grade. All cut and fill slopes shall be uniformly trimmed to the slope, cross section, and alignment shown on the drawings. All cut slopes shall be trimmed to a stable grade and cross section.

2.11 Subsurface Drainage (Only Where Applicable)

2.11.1 Scope of Work

Subsurface drainage includes provisions for foundation drains, slope and embankment drains, roadway subdrains and related facilities as shown on the drawings or as directed by the Engineer.

2.11.2 Technical Requirements

a. All subsurface drainage pipes shall be either Schedule 40 PVC pipe, or non-reinforced concrete drain pipe of the types and classes required. All pipes in drainage trenches shall be perforated and surrounded by drainrocks to the dimensions shown on the drawings. In addition, where shown on the drawings, the free draining backfill shall be wrapped in non-woven polypropylene drainage fabric. Upon leaving the drainage trench location, the pipe shall be non-perforated and

shall discharge as shown on the drawings, or as directed by the Engineer. The pipe dimensions shall be as shown on the drawings.

b. Perforated pipe holes shall be located on the bottom of the pipe 13mmØ @ 150mm o. c. staggered.

c. The minimum allowable slope shall be 0.005 while the minimum pipe diameter shall be 100mm. where the drainrock in the trench or bed is enclosed within drainage fabric, the drainrock shall be open-graded material as shown on the drawings.

d. All drainrock shall be graded crush rock or granular material, free of organic material, loam, wood, trash, and other objectionable material. Rock shall be sound, durable material, angular or sub-angular in shape, of suitable quality to insure permanence in its intended use. Round stones, flat thin stones, or soft material such as sandstones shall not be permitted. Drainrock shall be lightly compacted with hand tampers after placement.

e. Filter cloth shall be used where shown on the drawings to provide a positive separation between drainrock and soil layers being drained. Filter fabric shall be made of polypropylene, melted and extruded into continuous filaments, formed into non-woven layered sheets and then needle-punched to form an inseparably bonded fabric. All filter fabric used shall have a minimum thickness of 2.28mm as measured by ASTM D1777. The minimum grab strength shall be 100 kg, while the maximum elongation shall be 140 percent; both as measured by ASTM D1682. Trapezoidal tear strength shall be a minimum of 25 kg as determined per ASTM D2263 procedures. Burst strength shall be 2.4 MPa as measured in accordance with ASTM D751. The water permeability of the fabric shall have an equivalent sieve size of 0.200mm to 0.149mm. the fabric shall be no-biodegradable, and resistant to a full range of pH values from 1 to 13. Material specifications and samples shall be submitted for review by the Engineer prior to first use.

2.12 Slope and Bank Protection (Only Where Applicable)

2.12.1 Scope of Work

Slope and bank protection shall consist of furnishing and placing two classes of material:

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- vegetative cover

Slope and bank protection include all material and labor necessary to apply protective covers or vegetation to embankments, channels, streambanks, etc. to protect these works from erosion due to rainfall, stormwater runoff or streamflow.

2.12.2 Technical Requirements

a. Riprap (Handplaced, Grouted or Loose)

aa. Unless otherwise authorized by the Owner, the Contractor shall promptly place riprap or other bank protection measures in conjunction with the construction of the slopes or embankments being constructed, with time delays allowed only for proper completion of the affected embankments, or to prevent admixture of riprap and bank material. Riprap shall be either loose or grouted as directed on the drawings or by the Engineer and shall be placed by hand at the locations and in close conformity with the lines and grades shown on the drawings.

bb. Riprap shall be placed on foundation slopes of compacted gravel excavated below anticipated scour to the elevations shown on the drawings. A trench shall be excavated at the base of the slope to start the placement of riprap. The gravel drainage blanket shall be graded to a depth of 150mm to yield a continuous, uninterrupted bed of the required thickness. It shall be compacted at a minimum by one pass of a crawler-type tractor of total gross weight equal to 14,000 kgs. Additional grading shall be done, or additional gravel furnished and placed, to repair any damage done to the gravel bed by water action prior to placement of riprap.

cc. Riprap shall be hand-placed on the prepared gravel bed, starting at the trench excavated at the slope base which shall receive a course of the largest stones meeting the specifications. Riprap shall be placed in progressive courses upwards from this base, with each stone placed in contact with surrounding stones, but with its weight carried by the underlying material and not by the adjacent stones. Stones shall be laid so that the minimum dimension is perpendicular to the prepared bed.

Spaces between stones shall be filled with spalls of suitable size to construct a solid, stable slope free from large voids and defects. The exposed face of the hand-placed riprap shall be made as smooth as the shape and size of the stones will permit, but shall not vary more than 200mm from a plane surface on the required slope. Where shown on the drawings, hand-placed riprap shall then be grouted or mortared in place.

dd. The riprap shall be sound, durable rock which is roughly rectangular in shape and of sufficient quality to insure permanence in the conditions under which it is to be used. Rounded stones, boulders, sandstones, or similar soft stone or flat rocks shall not be used. The material supplied shall ba free of fines, overburden, spoil, shale, and organic materials, and shall be subject to approval by the Engineer.

ee. For grouted riprap, at least fifty percent (50%) of the stones shall weigh in excess of seventy (70) kgs each. The smallest dimension of each stone shall not be less than 300mm.

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

SECTION 02600
STORM DRAINAGE SYSTEM

1.0 GENERAL

1.1 References

Material requirements, methods, procedures, testing requirements and other related items called for in this Section shall conform to the applicable standards of the American Association of State Highway and Transportation Officials (AASHTO), American Concrete Pipe Association (ACPA), American National Standards Institute, (ANSI) and American Society for Testing and Materials (ASTM).

1.2 Submittals

Submit the following in accordance with Section 01100, Submittals. Submit within 90 days after the contract award date and prior to commencing work on the system.

1.2.1 Manufacturer's Catalog Data

a. Pipes and Fittings

b. Joints and couplings

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

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

3.0 CONSTRUCTION REQUIREMENTS

3.1 Design

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

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

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

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

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

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

g. The following are the tolerance limits for formwork:

aa. Variation from plumb:

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

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

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

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

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

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

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

cc. Footings:

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

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

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

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

3.2 Form Ties

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

3.3 Vertical Surfaces

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

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

3.4 Maintenance of Forms

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

3.5 Removal of Forms

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

3.6 Formworks for Concrete Pavement

3.6.1 Forms

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

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

3.6.2 Preparation of Grade (Side Form Construction)

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

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

3.6.3 Setting Forms

a. Base Support

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

b. Form Setting

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

c. Grade Alignment

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

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

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

SECTION 03200
CONCRETE REINFORCEMENT

1.0 GENERAL

1.1 Scope

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

1.2 Submittals

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

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

2.0 MATERIAL REQUIREMENTS

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

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

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

3.0 CONSTRUCTION REQUIREMENTS

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

3.1 Cutting and Bending

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

3.2 Placing

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