

## **Part 2        The Works**

# **Section 5: TECHNICAL CONSTRUCTION SPECIFICATIONS**

For

**THE AVANSE IRRIGATION INFRASTRUCTURE PROGRAM**

And

## **THE DUBRE IRRIGATION SYSTEM REHABILITATION AND IMPROVEMENTS PROJECT**

May 2017

*(rev. 01 – 28 June 2017)*

**Development Alternatives, Inc. / Appui a la Valorisation du Potential  
Agricole Nord Pour la Securite Economique et Environnementale  
(DAI/AVANSE)**

Funded by the United States Agency for International Development / Haiti (USAID/H)

Contract # AID 521-C-13-00006

# Contents

<b>I. Section 1: Technical Construction Specifications .....</b>	<b>4</b>
<b>A. General .....</b>	<b>4</b>
1. Reference to Other Sections .....	4
2. Standards and Regulations to be Followed by the Contractor.....	4
3. Contractor's General Facilities and Work Practices .....	4
a. Mobilization.....	4
b. General Site Facilities and Operations.....	4
c. The Site .....	5
d. Site Office .....	5
e. Existing Utilities and Services .....	5
f. Local Weather and Farming .....	5
g. Tree Cutting / Removal .....	6
h. Survey Monuments, Benchmarks, Levels, References and Staking .....	6
i. Storage of Materials / Equipment .....	7
j. Standby Equipment .....	7
k. Bill Posting and Advertisement.....	7
l. Emergency Arrangements.....	7
m. Management Meetings.....	7
n. Site Diary .....	8
o. Progress Reports.....	8
p. Construction Photographs .....	8
4. Quality Control (QC) Plan, Quality Operations.....	8
a. Standards, Testing and Other Documents.....	9
b. Samples.....	10
c. Unsuitable Materials .....	10
d. Submittals.....	10
5. Health & Safety (H&S) Plan and Site and Operational Security .....	10
<b>B. EARTHWORK.....</b>	<b>11</b>
1. Cleared Materials .....	11
2. Excavation .....	11
3. Shoring .....	11
4. Protection of Adjacent Structures.....	12
5. Water on Site / Dewatering / River Diversions .....	12
a. Planning for Dewatering .....	12
b. Dewatering .....	12
c. Temporary River / Stream Diversion (Diversion Structures and Walls: .....	14
6. Structural Earthwork, Preparation / Grading / Filling .....	17
<b>C. CONCRETE WORK AND FORMWORK .....</b>	<b>Error! Bookmark not defined.</b>
<b>D. MASONRY .....</b>	<b>Error! Bookmark not defined.</b>
<b>E. GABIONS.....</b>	<b>Error! Bookmark not defined.</b>
1. Materials .....	<b>Error! Bookmark not defined.</b>
2. Rock Requirements.....	<b>Error! Bookmark not defined.</b>
3. Foundation Preparation .....	<b>Error! Bookmark not defined.</b>
4. Assembly and Placement .....	<b>Error! Bookmark not defined.</b>

5.	Filling and Backfilling Operation .....	<b>Error! Bookmark not defined.</b>
<b>B.</b>	<b>METAL FABRICATION.....</b>	<b>Error! Bookmark not defined.</b>
1.	Submittals .....	<b>Error! Bookmark not defined.</b>
2.	Delivery, Storage, And Handling .....	<b>Error! Bookmark not defined.</b>
3.	Materials .....	<b>Error! Bookmark not defined.</b>
4.	Fabrication .....	<b>Error! Bookmark not defined.</b>
5.	Welding.....	<b>Error! Bookmark not defined.</b>
6.	Finish .....	<b>Error! Bookmark not defined.</b>
7.	Installation .....	<b>Error! Bookmark not defined.</b>

# **I. Section 1: Technical Construction Specifications**

## **A. General**

### **1. Reference to Other Sections**

Throughout these Specifications, references are occasionally made to other Contract Sections and Contract Documents. All such references are intended solely for the convenience of those using the Documents, and the absence of a reference in no manner excludes the application of every other Section in the Specifications and/or the other Contract Documents that may have any bearing upon the topic, point, issue and/or matter in question. The intention being that the Contract Documents shall be read and applied as a whole.

### **2. Standards and Regulations to be Followed by the Contractor**

It is the responsibility of the Contractor to ensure that construction and non-construction activities carried out to implement this project comply with applicable Haitian Government and any other regional government laws and regulations governing construction activities. This includes engineering design standards, environmental protection, procurement, taxes and levies, public health and safety standards regarding the safeguarding of the public, the Contractor's own workers and site health and safety. Stated United State Government (USG) and United States Agency for International Development (USAID) rules and regulations referenced in this contract also apply to the Work and to the Contractor's operations and activities.

All applicable standards and equipment manufacturer's instruction sheets, orders and circulars apply to the Work and Contractor operations.

Haitian Construction Permits, Building Codes and Structural Regulations: It is the Contractor's responsibility to ensure that all work and all activities comply with local permitting requirements. To this end, the Contractor is responsible to obtain at his cost any such permits.

Construction methods and construction materials codes and standards noted in these specifications and the drawings also apply and must be closely followed and applied by the Contractor during the prosecution of the Work.

### **3. Contractor's General Facilities and Work Practices**

#### **a. Mobilization**

Five days prior to mobilization, the Contractor shall with the engineer, meet with and schedule mobilization with the local Water User's Association. This includes informing them of arrival and work dates, seeking their permission for access, seeking their permission for Material and Equipment Lay-Down yards, permission for use local water and electricity resources, agreed upon payments for housing space, security staff (guards), etc.

#### **b. General Site Facilities and Operations**

The Contractor is required to provide adequate toilet and washroom facilities for all staff. These facilities shall be kept clean and serviceable at all times. They may be temporary facilities or facilities arranged by the contractor with the WUA. The Contractor shall also maintain such facilities in a neat manner and prevent them from becoming a health hazard.

The Contractor is required to provide a formal project Health and Safety Plan to the engineer within 15 days of Contract execution for review and approval. Part of this Plan will be the inclusion of adequate first aid equipment on-site at all times along with at least one formally trained and certified Haiti Red Cross/Crescent Advanced First Aid Trainee. Failure of the Contractor to ensure the availability of first aid equipment and at least one trained staff person on-site at all times will result in an immediate "Stop Work" order being issued. All costs and time delays resulting from any such "Stop Work" order are entirely the Contractor's responsibility.

The Contractor is to maintain a safe, healthy and tidy site office and worksite at all times and all work activities are to be performed with protective and safety equipment appropriate for the task. The Contractor is entirely responsible for workplace safety and unsafe work practices will be identified and recommendations made for revised work methods as appropriate.

**c. The Site**

The Site shall include the following areas:

- a. All routes, roads, paths for any temporary access roads;
- b. The Contractor's temporary working and material storage areas;
- c. The Contractor team's accommodation areas.
- d. The entire existing Dubre 1 (Rehabilitation Construction) Irrigation System Command Area and the existing diversion structure and area within 200 meters of this structure; and
- e. The entire existing Dubre 2 (New Construction) Irrigation System Command Area and the existing diversion structure and area within 200 meters of this structure;

**d. Site Office**

A Site Office will be established by the Contractor at the work site. The location of the site office will be identified by the Contractor for Engineer approval. This can be a temporary trailer or some appropriate existing space in the area. The office will have a complete set of the contract documents. Contractor shall provide a desk, chair, electricity and water/wastewater utilities for the DAI/AVANSE Engineer's Representative. The Site Office will have a parking area, proper signage, electricity, have proper water wastewater facilities for Contractor management staff and project guests. It shall be kept clean and neat at all times.

**e. Existing Utilities and Services**

Existing electricity and water services in the area may be used as temporary services for the performance of the Contract and for the Site Office as agreed upon with the local Water User's Association and as approved by the Engineer.

The Contractor at its own expense shall arrange for a temporary and permanent potable water supply system for laborers for drinking water and cleaning water. The water provided shall be of good quality and sufficient quantity.

The temporary wastewater disposal system shall be constructed, operated and maintained by the Contractor during the project's construction period. All toilets provisioned for the contractor's workforce shall include the ability to remove wastewater from the site or properly dispose of wastewater at the site.

**f. Local Weather and Farming**

The Contractor shall schedule its work around the farming and irrigation schedules of the local Water User's Association activities. If this negatively affects its schedule along with any rain or other weather

delays, the Contractor should notify the Engineer of such delays in order to seek Engineer agreement that such a delay will be allowed to impact the schedule.

**g. Tree Cutting / Removal**

The Contractor shall not cut and/or remove any trees on the Site until permission has been granted by DAI/AVANSE. All such activities must also comply with the Project EMMP.

The Contractor shall submit to DAI/AVANSE, at least five (5) days before the commencement of construction, a written request with a detailed drawing showing the trees to be felled together with the outlines of the relevant temporary or permanent structures.

Along with the drawing the Contractor shall submit details as to when the trees must be cut to maintain the schedule.

The Contractor shall be responsible for liaising with and obtaining all necessary licenses for tree cutting. If permission to cut trees is not obtained in time the Contractor may claim for a corresponding extension of time but will not receive monetary compensation for the delay.

**h. Survey Monuments, Benchmarks, Levels, References and Staking**

The datum point for project co-ordinates and levels shall be the survey markers and permanent benchmarks as indicated on the Drawings.

Prior to any construction, the Contractor shall satisfy himself that the existing ground levels as indicated on the Drawings are correct. Should the Contractor wish to dispute any levels he shall submit to DAI/AVANSE a schedule of the position of the levels considered to be in error and a set of revised levels. The existing ground relevant to the disputed levels shall not be disturbed before DAI/AVANSE's decision as to the correct levels is given.

The Contractor shall install all level and survey stations required to carry out the Works so that is functions hydraulically as intended. Such stations shall be of robust construction, protected against damage and the influence of movement that may arise from the execution of the Works. The Contractor shall check the condition and resurvey survey stations at intervals during the progress of the Works if necessary. The Contractor shall provide DAI/AVANSE with the location and description of all survey stations, the results of surveys and all calculations. Where required as noted by the Engineer's Representative, it shall give adequate opportunities for DAI/AVANSE to check such stations prior to their use.

The degree of accuracy (tolerances) employed in the survey and setting out shall be such as will allow the alignment, levels and dimensions specified for the Works to be achieved. In no case shall they exceed 10 mm (vertical and horizontal controls – 95% of all measurements, six (6) seconds angle  $\pm 1$ ). The Contractor shall ensure that all surveying equipment used for the Works is of appropriate accuracy, is properly maintained and that the equipment complies with the manufacturer's specification for accuracy. If requested, he/she shall give adequate evidence to DAI/AVANSE that the calibration of the surveying equipment has been confirmed.

The Contractor shall set construction stakes establishing lines and grades in accordance with the Drawings and shall secure the approval of the Engineer before commencing with the work of construction. The Engineer will, if he deems it necessary, revise the line and grade and require the Contractor to adjust the stakes accordingly. The Contractor shall give the Engineer not less than forty-eight hours notice of his intention to stake out or establish levels for any part of the work in order that arrangements may be made for checking. The Contractor shall measure the staking out and the Engineer will check the measurement. The approved measurement will be the basis of payments.

The surveying and staking shall be performed in accordance with these Specifications to obtain close conformance with the lines, grades and details indicated on the drawings or established by the Engineer. The Contractor shall be responsible for the supervision of the surveying and staking personnel. Any errors resulting from the operations of the surveying personnel shall be corrected at the Contractor's expense. The Contractor may be required to furnish to the Engineer a practicable schedule of staking priorities. This schedule shall be in the form of a progress chart, including the dates and sequence of staking requirements. The Contractor will meet and coordinate with WUA members and ensure that all staking and land work is done with their agreement.

**Staking for new canal linings, new walls, new canals, new structures:** Contractor shall set construction stakes at each 20 m that clearly show vertical and horizontal control for each and every structure that ties to the drawing elevations at the diversion structures. For the new system tertiary, secondary, primary and feeder canals, the Contractor shall stake all the canal construction out using the center lines, length and slope data from the tables in the drawings so as to check that the weir water diversion elevation properly serves the entire canal system and that the canal system correctly irrigates all the farm plots to be served in the new system. These construction stakes shall delineate each canal's center-line by reference and excavation invert depth.

**i. Storage of Materials / Equipment**

Project materials, equipment and components to be used in the construction shall be stored in such a manner as to preserve their quality and condition as directed by manufacturers, suppliers and as is understood to be best industry practices and also as presented in other sections of the Contract. The quantity of materials and components stored on the Site shall be consistent with that necessary for efficient working. Contractor shall keep a neat and tidy lay down area and keep good records of what is stored on site and in the lay down areas.

**j. Standby Equipment**

The Contractor shall provide sufficient spares and standby equipment, in particular with respect to concrete mixing and transportation plant and dewatering plant to ensure completion of crucial operations such as continuous pouring of concrete in case of breakdown of duty equipment.

**k. Bill Posting and Advertisement**

The Contractor shall not undertake or allow billposting or advertising of any kind in the Working area without the written consent of DAI/AVANSE.

The Contractor shall erect a project sign in accordance to USAID branding rules and regulations as directed by DAI/AVANSE.

**l. Emergency Arrangements**

The Contractor shall maintain arrangements whereby he can quickly call out labor outside normal working hours to carry out any work needed for an emergency associated with the Works. DAI/AVANSE shall be provided at all times with a list of addresses and telephone numbers of the Contractor's staff who are currently responsible for organizing emergency work.

**m. Management Meetings**

Site meetings shall normally be held weekly but shall be called for whenever the progress of the works so requires, or when required by DAI/AVANSE. The Contractor shall be represented at all meetings by the Contractor's Representative who shall have the powers to commit the Contractor in all matters concerning the Contract and/or the Work.

Other management meetings will be held as required.

**n. Site Diary**

The Contractor must maintain legible set of drawings and specifications at site at all times. The Contractor must maintain a set of drawings and specifications including daily markups, notes, actual dimensions, changes that can be used in developing end of project "as built drawings" The Engineer's Representative shall have access to this "as built" set of mark ups at all time to ensure they are being kept up every day.

The Contractor shall keep a Site diary provided by DAI/AVANSE wherein full details of all work carried out each day shall be recorded. The diary shall be available for inspection by DAI/AVANSE or DAI/AVANSE any time during normal office hours. At least the following details shall be included:

- i. Location of the various works undertaken;
- ii. Type and quality of work achieved;
- iii. Equipment and plant that arrive on site;
- iv. Number of employees and plant working;
- v. Tests carried out and results;
- vi. Weather conditions;
- vii. Accidents;
- viii. Visitors to the site; and
- ix. Interaction with local people.

**o. Progress Reports**

The Contractor shall submit weekly progress reports to DAI/AVANSE, on the first day of the week following the week concerned, containing at a minimum the following information:

- i. Location of the various works undertaken;
- ii. Actual progress versus planned progress;
- iii. Any work delays;
- iv. Anticipated problems;
- v. Tests carried out including results;
- vi. Prepared materials;
- vii. Supplied materials;
- viii. Two week look-ahead schedule;
- ix. Accidents, injuries and near misses; and
- x. Once every 4 weeks the Contractor shall submit a revised master schedule.

**p. Construction Photographs**

An initial set of photographs shall be taken by the contractor at the designated locations before the commencement of the works. Photographs shall be taken each week at the designated locations and submitted with the Contractor's monthly report. A final and complete set of photographs shall be taken after completion of the works. All photographs shall be taken with color digital cameras that will automatically record the date-month-year the photographs were taken.

#### **4. Quality Control (QC) Plan, Quality Operations**

The Contractor shall have an Engineer approved written quality control plan and procedures in place prior to mobilizing to the site. The Quality Assurance Plan will include:

- A Document Control Plan
- A Communications Plan

- A Material and Method Testing Plan
- A Reporting Plan
- Forms that shall be used every day and month for reporting QC to the Engineer for showing that Contract required documents and periodic actions are being carried out as directed.

The Contractor shall also name an on-site person as the Quality Control Manager/Officer whose responsibility it is to manage the QC Plan.

The Contractor's quality assurance program shall be submitted in writing to DAI/AVANSE for review and approval in sufficient detail to delineate those items to be inspected and the manner in which they are to be inspected, and shall adequately describe all construction quality control activities contemplated, including provision for adequate documentation of Contractor's performance of such quality control and inspection.

**a. Standards, Testing and Other Documents**

Materials shall always be transported stored, tested and installed by the Contractor according to international trade technical rules and best professional practice. Supporting documents and certificates shall attest to the origin and quality of materials. Brand names, or proven equivalent, shall be submitted by the Contractor prior to delivery, attesting to the quality of materials for desired properties including strength, bulkiness, shape, appearance and overall quality of the material. All materials used in the Works shall generally comply with American Society for Testing and Materials (ASTM) or equivalent standards unless otherwise specified by DAI/AVANSE. Where proprietary products are specified, similar products from other manufacturers will be permitted only with the approval of the DAI/AVANSE Engineer. Tests to be carried out during construction

#	Type of Work	Test	Instruction
1	All Civil Works	Sample field tests of water, sand, aggregates and stone	Contractor shall supply test reports before delivery of material to the site
2	Backfilling and Compaction	Density of compacted material	Manual test in presence of the Engineer's Representative as requested.
3	Concrete Work	Quality of cement	Cement shall comply with ASTM C 150 (AASHTO M 85).
4	Concrete Work	Concrete Slump test	For each batch prepared, slump test shall comply with ASTM C 143. Two test standards and shall be within +25 mm or + one third of the required value whichever is less
5	Concrete Work	Compressive Strength Testing	Tests shall comply with ASTM. Two sample cubes shall be tested at 7 days at two 28 days for mixes and pours on the job site.

#	Type of Work	Test	Instruction
6	Masonry Work	Block/Stone	Stone masonry works shall include materials
7	Foundations for Civil Work	Soil density test	California Bearing Ration testing may be required by the Engineer

**b. Samples**

Where required, the Contractor shall submit for DAI/AVANSE's approval samples and test reports of proposed materials and manufactured articles, and such samples shall be kept by DAI/AVANSE for reference.

**c. Unsuitable Materials**

If any materials or articles brought onto the Site are found to be of inferior quality or in any way unsuitable, such materials or manufactured articles shall forthwith be removed from the Site at the Contractor's expense and as directed by the Engineer.

**d. Submittals**

1. Project Signs (2);
2. Permanent Project Markers;
3. Mechanical Gate Fabrication Plan (dimension schedule (5), materials, welding specification, painting specification, plan to allow Engineer inspection in Port au Prince of completed gates prior to shipping);
4. Slide Gate Fabrication Plan (dimension schedule (57), material specification, shop drawings (2-one for a mechanical gate and one for slide gate) welding specification, painting specification, schedule-plan to allow Engineer inspection and approval of all completed gates in Port au Prince prior to shipping to Cap Haitien);
5. Cement;
6. Reinforcing Steel; and
7. Gabion Rock.

All submittals shall be made using a standard cover sheet provided by the Engineer to the Contractor. Submittals shall include as required:

- a. Manufacturer's Product Information (Make, Model #, Date of Manufacture, Use recommendations, transport and storage instructions, installation instructions, etc.) Contractor shall demonstrate to the Engineer's satisfaction that such materials and/or equipment meet stated specification requirement;
- b. Non-material Deliverables: Must meet the definition as defined in these specifications or other Contract Documents; and
- c. Any work carried out with unapproved materials or under unapproved method statements or operational plans may be unacceptable and may require replacement at the expense of the Contractor;

## **5. Health & Safety (H&S) Plan and Site and Operational Security**

The Contractor shall have an Engineer approved written Health & Safety Plan with procedures in place prior to mobilizing to the site. The H&S Plan will include:

- a. A Health and Safety Policy
- b. A list of each individual project construction activity, a Risk Assessment for each and Contractor Plan to mitigate each risk;
- c. A H&S Training Plan for all staff;
- d. Personal Protective Equipment (PPE) List for each staff person
- e. A H&S Reporting Plan
- f. Forms that shall be used every day and month for reporting H&S activities to the Engineer for showing that Contract required documents and periodic actions are being carried out as directed.

The Contractor shall also name an on-site person as the Health & Safety Program Manager/Officer whose responsibility it is to manage the H&S Plan. The Contractor shall provide PPE for every staff person at his/her expense. The Contractor is responsible and liable to ensure that all Contractor staff and all site visitors are trained in H&S operations and are using proper PPE.

The Contractor shall be responsible for the protection and the security of the Site, and all work, materials, equipment, and all existing or completed facilities thereon, against vandals and other unauthorized persons. The Contractor is also responsible to ensure the safety and security of all people who may visit the site.

## **B. EARTHWORK**

### **1. Cleared Materials**

The Contractor shall remove or otherwise dispose of all trees, stumps, roots, topsoil, vegetable matter and other objectionable material from the areas shown on the Drawings or as directed by DAI/AVANSE.

All cleared and excavated material shall be disposed of in spoil tip areas as directed by DAI/AVANSE. Depending on its nature and quality the material shall either be: stockpiled for re-use, disposed of by burning, disposed of by earthfilling. Material intended for re-use in the Permanent Works shall be stockpiled separately from all other materials. The Contractor shall dispose of all shrubs, bushes and other vegetable and combustible material by stockpiling followed by controlled burning as approved by the Engineer.

The Contractor shall be responsible for the disposal of surplus excavated material off site but no excavated material suitable for re-use in the Works shall be removed from the site except on the direction, or with the permission of the Engineer.

### **2. Excavation**

Excavation shall be carried out to the lines, levels, slopes and dimensions as shown on the Drawings or as directed by DAI/AVANSE. Any excavation in excess of such dimensions or instructions shall be made good with suitable, well-compacted material or concrete as directed by DAI/AVANSE. Excavated material from trenches and/or structure locations shall be piled in places as directed by the Engineer. Any remaining material left over from backfilling operations shall be stockpiled and saved as directed by the Engineer for possible use in other earthwork operations on the project.

Excavated material from the drains shall be placed far enough away from the drains that the material cannot erode back into the drain over time.

### **3. Shoring**

The Contractor shall provide wooden or some other form of shoring in excavated areas exceeding 1.2 meters as directed by the Engineer. Shoring works also shall be approved by the Engineering

#### **4. Protection of Adjacent Structures**

In the event that excavation is within two meters or less from an existing structure, the Contractor shall provide measures to protect the existing structure from foundation and/or other damage caused by reduction in bearing capacity during construction.

#### **5. Water on Site / Dewatering / River Diversions**

The Contractor shall not allow water to lie in any part of the Works unless required to do so under the Contract. Water arising from or draining into the Works shall be drained or pumped to an approved disposal point. Any drainage sumps or silt traps required shall, where practicable, be sited outside the area excavated for the Permanent Works.

The Contractor shall provide, install, maintain and operate all necessary diversion and/or pumping and other equipment for dewatering the various parts of the Works in order to keep the excavations, foundations and other parts of the Works free from water as required for constructing each part of the Works.

The Contractor shall take all necessary precautions to prevent any adjacent ground from being adversely affected by any dewatering process.

The Contractor shall be responsible for and shall repair at his own expense any damage to the foundations or any other part of the Works caused by failure or inadequacy of dewatering operations.

##### **a. Planning for Dewatering**

The Contractor shall meet with the Engineer and develop a dewatering plan for all excavation and structural placement activities in the canal system and in or near to the River. The Contractor shall provide a plan and include equipment to be used for the Engineer's approval. The Contractor also may need to develop a plan that includes partially damming the river to as to divert water away for construction activities. This will also be part of the dewatering plan.

##### **b. Dewatering**

The Contractor shall provide all equipment, material, labour, and do all dewatering as required to construct the dam, drains and canals in the dry. The procedures and plan for dewatering shall be prepared by the Contractor and submitted to the Engineer for review, comments and possible acceptance prior to the commencement of any earthwork operations. All water removed by dewatering operations shall be disposed of in a manner to cause minimum or no damage to adjacent properties and the environment. The Contractor shall be solely responsible for proper design, installation, related equipment, proper operation, maintenance, removal correcting any failure and repair of all components of the system.

Prior to preparing the dewatering plan the Contractor shall visit the site and thoroughly familiarize himself with the terrain, topography, surface and subsurface characteristics of the site and adjacent areas. He shall collect or obtain data on existing structures, seasonal and maximum river flows, rainfall, soil permeability, backfill material and all other factors that might affect or contribute to the success of his plan. The Contractor shall perform all tests, borings, sampling he considers necessary to prepare his dewatering plan. The Contractor shall photographs and or video parts of or all of the site and where necessary include as part of his plan.

The dewatering system shall be of sufficient size and capacity required to prevent seepage or surface water and rainwater runoff from entering the excavated areas; lower and control

groundwater to permit excavation, concrete and backfill placement, subgrade and foundation preparation and compaction; embankment construction and reconstruction, all to be performed in a dry condition. The system shall include but not limited to, a sump system with pumps, pipes, generators and other equipment, appurtenances and other related earthwork necessary for the required control and disposal of water. The Contractor shall drawdown groundwater to at least 80 cm below the bottom of excavations at all times in order to maintain a dry and undisturbed condition.

The dewatering system shall be designed and installed so that if the operation of any one part is disrupted or malfunction, the remaining part plus activated redundant or standby components are capable of maintaining the dewatering system at the required levels. The Contractor shall also provide:

- A standby dewatering system that meets the following minimum requirements;
- Additional or replacement pumps, pipes in cases of malfunction or breakdown;
- Standby generators to ensure uninterrupted power; and
- A Minimum of three days (72 hours) fuel.

The Contractor shall control, by acceptable means, all water regardless of source. Water shall be controlled and disposed at each berm, structure, canal, drain etc. when necessary. The entire periphery of the excavated areas shall be ditched and diked to prevent water from entering the excavation where applicable. The Contractor shall be fully responsible for disposal of the water and shall provide all necessary means at no additional expense to the Owner.

The Contractor shall be responsible for and shall compensate, repair without cost to the Owner, any damage to adjacent field, crops, cultivation, canals, drains, structures, work in place, excavation, damage to the bottom due to heave and damage resulting from removing or excavating material and pumping out in the excavated area. The Contractor shall be responsible for damages to any other area or structure caused by his failure to maintain and operate the dewatering system proposed and installed.

The dewatering plan shall show the methods, details and location of dewatering and discharge components including a sufficient number of detailed sections to clearly illustrate the capacities and scope of work. Other details shall include relationship of the dewatering system, number, depth and location of observation wells, size of collection and discharge line, location and size of sumps, details of embankments, disposal of water. Observation wells shall be minimum 40 mm diameter.

The systems shall be designed and laid out in such a way that portions of the system may be isolated for routine maintenance or repair in cases of malfunction or accidental damage without affecting the normal operation of the system. The plan shall include emergency measures to be put into operation during partial and complete failure of the dewatering system

Prior to commencing excavation the Contractor shall demonstrate the effectiveness of the system by running the system and measuring the water level in all the observation wells. All systems and equipment directly or in directly related to the stand-by system shall be tested in the presence of the Engineer.

Operate the dewatering system continuously twenty-four (24) hours per day, seven (7) days per week until all structures have been satisfactorily constructed, including placement of fill materials, and the site longer require dewatering as determined by or agreed with the Engineer

The Contractor shall record the water level in the observation wells first and last thing at the start and end of the each working day and during the weekend or holidays. Results shall be promptly submitted to the Engineer. The Contractor shall test and demonstrate the proper working condition of the standby system every two (2) weeks

The work listed in Bill-of-Quantities for dewatering will be paid for at the contract lump sum price. Such payment will constitute full compensation for preparing, furnishing, installing, operating, maintaining and removal of the necessary, channels, drains, sumps, pumps and piping, operation, maintenance and for all labor, equipment, tools, materials, fuel and all other items necessary and incidental to the execution and satisfactory completion of the work.

The contract lump sum shall be disbursed uniformly over the Contract Period. Should the Engineer agree that the dewatering is not needed prior to the expiration of the Contract Period the unpaid balance will be paid to the Contractor

**c. Temporary River / Stream Diversion (Diversion Structures and Walls:**

The Contractor shall furnish all materials, equipment, fuel and labor necessary temporarily divert the stream flow through or around the construction area, to isolate construction activities from contact with stream flow, prevent impacts on the water quality from the construction work, to protect streams, to protect and maintain the environment and water quality while providing a dry work area during work within the channel.

The Contractor is fully responsible for and work shall include designing, installing, operating, maintaining, removing, and disposing of the temporary stream diversion, stormwater runoff, unseasonal river flows, environmental compliance and other Work directly or indirectly related to temporarily diverting the stream

**Detailed Instructions**

The diversion shall consist of but not limited to new flow channels, pipes, bypass pumps, flow barriers (dams), temporary erosion and sediment controls, and removing all such temporary works after they have served their purposes.

1. Prior to preparing the Temporary Diversion Plan the Contractor shall visit the site and thoroughly familiarize himself with the terrain, topography, surface and subsurface characteristics of the site and adjacent areas. He shall collect or obtain data on existing structures, seasonal and maximum river flows, rainfall, soil permeability, availability of fill material and all other factors that might affect or contribute to the success of his plan. The Contractor shall perform all tests, borings, sampling he considers necessary to prepare his diversion plan. The Contractor shall photograph and or video parts of or all of the site and where necessary include as part of his plan.
2. The procedures and plan for diverting the stream shall be prepared by the Contractor and submitted to the Engineer for review, comments and possible acceptance at least ten (10) prior to the commencement of any earthwork operations. Plan shall consist of written description, photographs, video and drawings detailing all temporary stream diversion requirements. The Diversion plan shall include by not limited to the following information:
  - Identify the name of the water body where the temporary stream diversion will be placed. Provide drawings showing the location of the temporary stream diversion channel, including proposed access routes and equipment to be used to construct and maintain the diversion;

- Detail all elements of the temporary stream diversion including but not limited to, pipes, pumps, dikes, berms, sand bags, new channels, geofabrics, and all equipment;
  - Calculations demonstrating the capability of the diversion system to convey the peak flows and runoffs established by the Contractor;
  - Methods for anchoring temporary stream diversion pipe, pumps, generators and associated hardware;
  - Specifications for all materials and equipment to be used as part of the diversion including pumps, diversion capacities and pipe sizes; and
  - Provide the method(s), including locations and details for blocking both the upstream and downstream ends of the diversion. Include provisions for scour protection at the temporary stream diversion outfalls.
3. The contractor is encouraged to schedule work in the stream during periods of low rainfall and low flow.
  4. Temporary new diversion channel or channels may be constructed within the areas shown on the drawings. The Contractor is responsible for compensation to the owners for using the property and damages incurred. The temporary new channel shall be sized using Manning's formula to convey the maximum flow estimated by the Contractor. Channel shall be lined with non-erodible material or otherwise protected from erosion. Scour protection shall be provided at the outfall of the temporary stream diversion stream.
  5. The flow barrier shall be of non-erodible material, able to withstand the anticipated flows, and shall not pollute the stream or surrounding areas. The flow barrier may be constructed of, or any combination of aggregate, riprap, sand bags, concrete barriers, sheet piling, or other appropriate materials.
  6. Bags used for sand bagging shall be made from materials, which are resistant to ultra-violet radiation, tearing and puncture, and woven tightly enough to prevent leakage of fill material. The material filling the bags shall consist of sand, gravel, river gravel, coarse aggregate. Material shall be void of soil, clay, silt, organic material.
  7. Aggregate diversion consist of clean aggregate placed in the stream with the base and upstream side lined with a medium weight-nonwoven filter fabric. The fabric shall be firmly secured to resist the anticipated flow. Sandbags may be added along the base to anchor the fabric and stop the flow of water under the berm.
  8. The upstream flow barrier shall be installed first followed by the downstream flow barrier.
  9. The Contractor shall excavate, stabilize, maintain, and operate the temporary stream diversion channel constructed as part of his diversion plan. Prior to commencing excavation of the diversion channel the Contractor shall install watertight plugs at both ends of the diversion channel to avoid stream flow from entering the diversion channel prematurely. The plugs may be constructed of a combination of rip-rap, sandbags, sheet piling, or the existing undisturbed soil. The temporary stream diversion channel shall be properly stabilized before removing the plugs.
  10. The excavation and stabilization of the temporary stream diversion channel shall be a continuous process with the stabilization occurring immediately after the excavation of an area.

11. When fabric is used for or as part of the lining of the temporary stream diversion channel, the fabric shall be wide enough to span from bank to bank so that any seams will be perpendicular to the diversion channel flow. When seams parallel to the flow direction are necessary, they shall be pre-sewn or field sewn following manufacture's specifications. Sections of fabric shall be joined with the upstream sections of fabric overlapping the downstream sections of fabric a minimum of 1 meter. The fabric shall be secured per the manufacturer's specifications. The fabric shall lay flat on the channel and be in direct contact with the soil without any void spaces. Sharp objects shall be removed to avoid puncturing the fabric. Prior to diverting stream flow, the Contractor shall ensure the fabric is properly secured at the upstream end of the temporary channel, as well as all along the channel.

Once the temporary stream diversion channel has been completely excavated and stabilized and ready to receive stream flow, the downstream plug shall be removed first, followed by removal of the upstream plug.

12. When a piping system is used for the temporary stream diversion, the upstream and downstream diversion points shall be properly stabilized first to avoid erosion. Then the pipe shall be installed and the flow barriers built, starting with the upstream flow barrier. The pipe shall be located to minimize potential erosion. Select the pipe size to accommodate the design flow projected by the contractor using no more than 80 percent of the pipe full flow capacity. Select a Manning's n value based on the type of pipe material that will be used.
13. For a pumped diversion system select the size and number of pump (or pumps) with capacity equal to or greater than the projected flow rate. The number shall include back-up pumps and all back-up pumps should be on site and in good working order at all times. Designate a method for filtering of sediment-laden water created because of the construction activities. Non-sediment laden bypass water does not require filtering, however, it still must discharge onto a non-erodible, energy-dissipating surface prior to joining the stream flow.
14. Cover the intake of pump with a screen to prevent fish entering the pump. The opening of the screen shall be approved by the Engineer. Inlet velocity through the fish screen shall not exceed 0.15 meters/sc. Alternatively, the Contractor may install a fish blocker upstream and downstream of the diversion dams prior to construction of the diversion dams. Collect and return fish trapped between the fish blockers to the downstream channel. Stabilize the pump outlet location to prevent scour and erosion.
15. Once a pumped diversion begins, the pump must run continuously until it is no longer necessary to bypass flows. The Contractor shall have back-up pumps and generator and three (3) days fuel on site at all times and shall provide twenty-four (24) hour monitoring of the pumping operation each day.
16. All aspects of the diversion system must be inspected and maintained frequently to remain in effective operating condition. At a minimum inspect the temporary stream diversions at the end of each day, to ensure that the structure is maintained and not damaged, the streambed and stream banks are stable and not eroding, and that sediment is not entering the stream or blocking fish passage or migration. Inspect flow barriers at the start and end of each workday and at any time that excess water is noted in dry work areas. For diversion channels, inspect the diversion channel itself

for signs of erosion, and repair or replace the lining if there are signs of failure. Remove all significant sediment accumulations to maintain the designed carrying capacity.

17. All temporary stream diversions shall be removed within two (2) days after the system is no longer needed. Remove the diversion from the downstream to upstream. After diversion of the stream back to the natural streambed, backfill and stabilize the temporary diversion channel to its original condition.
18. The work listed in Bill-of-Quantities for temporary stream diversion will be paid for at the contract lump sum price. Such payment will constitute full compensation for preparing, furnishing, installing, operating, maintaining and removal of the necessary, channels, drains, sumps, pumps and piping, operation, maintenance and for all labor, equipment, tools, materials, fuel and all other items necessary and incidental to the execution and satisfactory completion of the work.
19. Twenty five percent (25%) of the contract lump sum shall be paid to the Contractor at the start of the diversion work. The remainder (75%) shall be disbursed uniformly over the Contract Period. Should the Engineer agree that all work included is satisfactorily complete, the diversion is not needed and the area is fully restored the unpaid balance will be paid to the Contractor.

## **6. Structural Earthwork, Preparation / Grading / Filling**

Prior to placing any permanent material, the formation must be thoroughly dewatered, cleaned and prepared as approved by the Engineer. No work which may be required above subgrade formation level shall be executed until the prepared subgrade formation has been approved by the Engineer.

All unsuitable material shall be removed from proposed X-section formation. Such materials shall include but not be limited to all topsoil, sod, loam and rock fragments with a dimension in excess of 75 mm except in the area of river training works where rock fragments with a dimension not exceeding 150 mm shall be accepted.

The formation surface shall be levelled and well compacted to ensure the dry density of the subgrade formation material is maintained to original earth. All soft spots shall be excavated to a firm base and the voids backfilled with suitable granular material placed in thin layers and compacted to prevent erosion of loss of formation shape.

Where the slope of the existing ground is greater than 1 (vertical) to 3 (horizontal) or where directed by the Engineer, horizontal terraces in steps not greater than 0.5 m in height and 1 (vertical) to 1.5 side slopes shall be cut into the existing ground before placing fill material.

Any blinding layer or prepared surface which is damaged before being covered shall be repaired at the expense of the Contractor and to the satisfaction of the Engineer.

If required for construction operations, fill material shall be comprised of material that is similar in character and type to the native soils in and around the construction activity. It will have the ability to be compacted to form a stable layer as directed by the Engineer. The material shall be sufficiently mixed to produce a homogeneous fill. The material shall not have an organic content of more than 5% by weight and all unsuitable foreign material shall be excluded from the fill. No piece of fill material with a dimension exceeding 100 mm will be permitted within 300 mm of the formation level and no piece exceeding 75 mm will be permitted within 150 mm of the formation level.

The fill material shall be placed in layers parallel to the formation level and shall be built up evenly over the whole area of the work. Sufficient slope shall be maintained at all times to ensure adequate drainage.

Fill material shall be compacted in such a manner as to ensure maximum density of the material. The material shall be placed in layers of compacted thickness not exceeding 150 mm unless otherwise directed by the DAI/AVANSE Engineer. Unless otherwise specified, the layers of fill material shall be compacted throughout to achieve a dry density of at least 95% of the maximum dry density.

Backfill behind retaining walls shall, if shown to include filter material shall be uncompacted crusher run or river gravel with 85% of material 20 mm or larger.

All fill material left over at the end of the work shall be either removed or stockpiled as directed by the Engineer. All stock piled material shall be shaped and placed in a neat manner so as to be easily accessible by the WUA members and to not pose an erosion issue that would result in sediments running into the river, canals, and/or drains.

## **C. CONCRETE WORK, FORMWORK, STEEL, MASONRY**

### **1. Description & General Requirements**

The work specified in this section consists of the construction of all concrete and masonry structures and requirements for concrete mixes and testing of concrete mixes. This work shall include, but not be limited to the construction of footings, floor slabs, columns, hydraulic structures, and walls. Concrete structures shall be constructed in accordance with this Specification section and in conformity with the lines, grades, dimensions, and notes shown on the Drawings.

#### **a. Submittals**

Contractor shall submit the following:

**Tests:** Each delivery of cement to site shall be accompanied by a manufacturer's certificate showing that the cement has been tested and analyzed by an Independent Testing Laboratory, and the date of such tests and analyses. Cement shall conform to the requirements of ASTM C 150 (AASHTO M 85). The Engineer shall approve all cement delivered to the site.

**For reinforced concrete (RCC):** Carry out test mixes and pours and submit test results of a concrete compression machine which must have a minimum compressive strength test result of 21 Mpa (3,000 pounds per square inch) after 28 days.

#### **b. Delivery, Storage and Handling**

Materials shall be inspected upon delivery for damage.

**Storage:** Cement shall be stored in a watertight and well-ventilated building with a raised platform not less than 150 mm off the ground. Each consignment of cement shall be identified with a serial number and date of delivery and stored separately.

Contractors shall not store cement higher than eight bags high. Cement shall not be stored in the direct sunlight. It shall be stored in a shaded place.

#### **c. Materials**

**Cement:** Type: Utilize Portland Cement, Type I. Cement shall conform to the requirements of ASTM C 150 (AASHTO M 85).

**Aggregates:** Aggregates shall be clean crushed rock and natural sand. The combination of these shall be approved by the Engineer. Rock for crushing shall consist of fragments or particles of approved

naturally occurring stone which are sound, hard, durable, clean and free from clay or other adherent coatings and which shall show no evidence of disintegration or decomposition. On no account shall naturally occurring boulder, shattered rock or weathered rock be used. Rock which form flat or flaky particles when crushed or which contains excessive quantities of mica or laminated materials shall not be used. The rock shall be free from all chemical substances likely to react in a harmful manner with other constituents of the concrete.

- i. Rock shall be crushed, screened to sizes and, if so required, thoroughly washed using efficient plant methods as approved by the Engineer.
- ii. Sand shall be washed to remove traces of salt or other impurities and shall be formed of sound, clean and durable particles, free from hollow shells, discoloration, clay, silt, organic impurities or other deleterious substances.
- iii. The chloride content expressed as a percentage of chloride by mass of combined aggregates shall not exceed .06% for 95% of test results with no result greater than .08%.

The maximum size of course aggregates shall be 2.5 centimeters.

**Formwork:** Plywood or metal panel formwork sufficient for straight, perpendicular structural and visual requirements. Planking may be used with the approval of and after inspection by the Engineer. Do not use weak formwork that causes bulges, gaps or holes in the poured concrete.

**Reinforcing Steel:** Reinforcing Steel Bars shall be deformed bars and shall be tested for a minimum yield strength of 60,000 pounds per square inch (420 Mpa).

**Water Stops:** All concrete poured/placed for hydraulic structure shall have plastic water stops placed at every joint as approved by the Engineer.

**Stone Masonry:** All rocks and stones to be used for project stone masonry works shall be approved by the engineer with actual samples transmitted as Submittals. Rocks shall not be metamorphic or sedimentary. They shall be hard, sound and free from decay, weathering and fissures. Stones with round surface shall not be used. All stones placed into any structure shall be hammered and shaped to remove and unstable surfaces or parts.

#### d. **Construction Requirements and Procedures**

**Concrete Mixing:** General mixing will be with a machine mixer. All concrete shall be power machine mixed and machine vibrated. The approved type of mixer shall have a drum rotating about a horizontal or inclined axis and must be kept in good condition at all times. The drum shall rotate at the appropriate speed as approved by the Engineer.

About 10 percent of the water required for the batch shall enter the drum in advance of the cement and aggregates, and the remainder of the water shall be added gradually while the drum is in action so that all the water is in the drum by the end of the first quarter of the mixing time. The concrete shall be mixed until a mixture of uniform color and consistency is obtained. For a mixer with a capacity of 750 litres or less, mixing shall continue for at least one and one half minutes after all the water has been added. For each additional 500-litre capacity or fraction thereof, the minimum mixing time shall be increased by 15 seconds.

The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer. The whole of the batch shall be removed before materials for a fresh batch enter the drum. On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean water. Any deposits of old concrete in the drum shall be cleaned out by rotating clean aggregate and water in the drum before any fresh concrete is mixed. Concrete mixed as specified shall

not be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

The Contractor shall carry out the design of concrete mixes under the supervision of the Engineer. The data of mix proportions shall be prepared and proposed by the Contractor to obtain the concrete having appropriate water-cement ratio, suitable workability, durability, low shrinkage and required design strength with the minimum cement content and amount of fine aggregate. Considering the results obtained from the trial mixes above, the Engineer will notify the Contractor of the mix proportions for the concrete to be used in the various portions of the works.

The Contractor shall furnish samples of cement used for the works in sufficient quantity required for such design of concrete mixes, cost of which shall be deemed to be included in the lump sum price. The exact proportions in which concrete materials are to be mixed will be verified by the Engineer from time to time during the performance of the work. The Contractor shall not be entitled to compensation due to changes that the Engineer may make in the mix proportions. All concrete materials shall be measured in set volume boxes at all times. Such boxes shall be repaired as required by the Engineer.

The determination of the mix proportions by the Engineer shall not relieve the Contractor of his responsibilities for producing and placing concrete conforming to the specified requirement. Compliance with concrete compressive strength requirement shall be based on compressive strength tests carried out in accordance with the appropriate standard being used. Cement contents for various mix proportions of concrete shall be determined from the design mixes approved or directed by the Engineer.

**Concrete Placing:** Immediately after mixing, the concrete shall be transported to the place of final deposit by methods which will prevent the separation, loss or contamination of any of the ingredients. Any method involving the use of pipes or chutes for transporting concrete will not be permitted, except with the written approval of the Engineer. Transport of concrete from the mixers shall be as rapid as possible and the Contractor shall always be responsible for the concrete being placed within such a time from the addition of the water to the mixer that the previous lift of concrete has not commenced setting.

Before any RCC concrete is placed, the formwork and the rebar shall be thoroughly cleaned of all dirt, shavings, loose stones, and other debris. Forms shall be treated with a non-staining material or shall be saturated with water immediately before the concrete is placed. For all exposed surfaces, the forms shall be treated with a non-staining material, as approved by the Engineer, to prevent the adherence to the concrete. The forms shall be free from any material that shall adhere to or discolor the concrete.

The concrete shall be placed gently in position and shall normally not have a free fall of more than one meter, thus, pour bottom half of column then pour top half of column after wall is in place. To convey the concrete as near as possible to its final position, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections. The concrete shall be placed so as to prevent water from collecting at the ends, corners or along the faces of the forms, and water shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form. All concrete shall be placed and compacted in even layers with each batch adjoining the previous one.

The thickness of the layers shall be between 15 and 30 cm for reinforced concrete and up to 45 cm for un-reinforced concrete, the thickness depending on the width of forms, amount of reinforcement and the necessity of placing each layer before the previous one commences to set, all as instructed by the Engineer. The concrete shall be carefully and continually placed and worked around the reinforcement steel and into the corners of the formwork so that the concrete shall be in close contact with the reinforcement steel and free from honeycombing.

All vibration, compaction and finishing operations shall be completed immediately after the placing of concrete in its final position. Workers shall not be permitted to walk over freshly placed concrete until it has hardened sufficiently to carry their weight without distortion and great care shall be taken to ensure

that reinforcement projecting from concrete recently placed is not shaken or disturbed so as to destroy or damage the initial set of the concrete in contact with it.

Concreting in any one part or section of the work shall be carried out in one continuous operation and no interruption of concerning work will be allowed without the approval of the Engineer. Where beams and slabs together form an integral part of the structure, they shall be poured in one operation. After a beam, wall or column has been cast, an interval of one hour shall be allowed before casting the continuous slab. The same applies for all abrupt changes in sections.

Freshly placed concrete shall be adequately protected from rain, dust storms, chemical attack and the harmful effects of sun, heat, wind, flowing water, vibrations and shocks. It shall also be fenced off or otherwise protected to prevent persons from walking thereon or articles being placed or thrown thereon. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors. The Engineer will determine when the protection is no longer required, but in any case this shall not be less than 24 hours after the time of placing.

The Contractor shall install construction joints, expansion joints for all RCC and PCC work as directed by the Engineer. For all work below the water table or the water line, the Contractor shall propose and install water stops as approved by the Engineer.

**Weather Precautions:** During hot weather, steps shall be taken to reduce the concrete temperature and rate of water evaporation by proper attention to the cooling of the mixing water before use, production methods and the handling and curing. The concrete mixing shall be screened and covered as a protection from wind, rain and sun, and adequate similar precautions taken throughout the transit, placing and curing of the concrete whenever conditions require them.

When the shade air temperature is 35 degrees C and rising, special precautions shall be taken during all concrete operations so that the temperature of the concrete when placed does not exceed 32 degrees C. Shading of aggregates and plant, the cooling of mixing water and other steps taken shall be to the approval of the Engineer. Fresh concrete placed at these temperatures shall be shaded from the direct rays of the sun to the satisfaction of the Engineer.

**Continuity of Concrete Work:** The Contractor shall carry out the work in such a manner that the placing of the concrete in any particular section of the structure shall be executed without any interruption whatsoever from the beginning to the end of the operation. When interruptions are permitted by the Engineer, no fresh concrete shall be deposited on or against the concrete placed before the interruption until the latter is sufficiently set to resist injury. Particular care shall be taken to ensure that partially set concrete shall not be damaged by shock or any other cause whatsoever.

Casting of concrete shall not commence until a sufficient quantity of approved material is at hand to ensure continuity of operation, nor shall work commence until there is sufficient equipment in reserve in case of breakdown.

**Concrete Curing and Protection:** Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, rain or running water. The protection shall be applied as soon as practicable after completion or placing by covering concrete with a layer of sacking, canvass, hessian, straw mat or similar absorbent material, or a layer of sand kept constantly wet for seven (7) days.

**Concrete Finishing:** All concrete shall be given an ordinary clean surface finish. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, and after having been kept saturated with water for a period of not less than three hours, shall be carefully pointed and trued with a mortar of cement and fine. Mortar used in pointing shall

not be more than one hour old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges. The resulting surfaces shall be smooth, true and uniform in shape and uniform in color.

**Concrete Finishes for Monolithic Slabs:** Scratch finish for surfaces to receive concrete floor topping or mortar setting bed. Trowel finish for surfaces to be exposed to view or covered with resilient flooring, carpet, tile, or other thin finish system.

- i. Trowel and fine broom finish for surfaces to receive thin set ceramic or quarry tile;
- ii. Nonslip broom finish for exterior concrete platforms, steps, and ramps; and
- iii. Nonslip aggregate finish for concrete stair treads, platforms, ramps, and sloped walks.

**Concrete Mortar Plaster Finish (Applies to Stone Masonry Canals):** The Contractor shall apply concrete mortar finishes on locations indicated on the drawings, according to specified thickness, or as directed by the Engineer. Unless otherwise directed by the Engineer, mortar shall be composed of 1 part Portland cement and 3 parts fine aggregate by volume, to which hydrated lime may be added in an amount equal to 10 percent of cement by weight. The finish concrete mortar finish shall have a compressive strength of at least 50 kg/square centimeter.

## 2. Reinforcing Steel

This Subsection contains a description and the specification for the furnishing, bending, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with the Drawings, as specified herein and as directed by the Engineer.

**Materials:** All reinforcing steel bars shall be deformed billet steel and shall meet the requirements of Grade 420 Mpa. Testing shall be performed to verify tensile yield. Submit test results of reinforcement steel which shall have a minimum yield strength of 60,000 pounds per square inch (420Mpa).

**Handling and Placing Reinforcement:** All reinforcement steel shall be protected as far as practicable from mechanical injury or surface deterioration, from rusting or other causes from the time of shipment until it is placed. Reinforcement steel stored at the site shall be laid on wood floors or sills suitably spaced so that no reinforcement steel shall be laid upon or come in contact with the ground. When the weather is dry and the time for storage before installation is limited, housing may be omitted, but if rainy or exceptionally humid weather occurs or is anticipated, bars shall be stored under cover.

**Steel Quality and Supply:** Representative samples of all reinforcement steel that the Contractor proposes to use in the Works must be submitted, before work is commenced, to the Engineer for his approval, together with manufacturer's certificates stating clearly for each sample the place of manufacture, expected date and size of deliveries to the Site, and all relevant details of composition, manufacture, strengths and other qualities of the steel.

In the event a reinforcement steel sample under testing fails to meet the specification requirements at any time, or the Engineer considers that samples which were presented to him for test were not truly representative, or if it becomes apparent that reinforcement steel which has not been approved has been used on the Works, the Engineer may instruct the Contractor to break out and remove completely all such sections of the work already constructed using such suspect reinforcement steel. Such work that must be replaced shall be done so at the Contractor's expense.

Reinforcement steel shall be protected at all times from damage by storing on blocking, racks, or platforms. Prior to placing concrete, reinforcing steel which is to be embedded shall be free from heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance.

**Bending and Anchorage:** Each reinforcement steel bar shall be cut and bent to the dimensions specified on the Drawings. For bending of reinforcement steel bars, the recommendations of the manufacturer shall be adhered to in each case. All bars shall be bent cold. Qualified men shall be employed for cutting and bending, and proper appliances shall be provided for such work. Splicing, except where indicated on the Contract Drawings will not be permitted. Lap lengths shall be as indicated on the Drawings.

**Fixing of Reinforcement Steel:** The reinforcement steel shall be assembled to the shapes and dimensions as indicated on the Drawings. The reinforcement steel shall be of the cross-sectional areas indicated and shall be fixed rigidly and accurately in the forms in the positions indicated on the Drawings. The reinforcement steel shall be firmly bound together at intersections of reinforcement steel to ensure that the reinforcement steel framework as a whole shall retain its shape, and the framework shall be so temporarily supported with spacer bars as to retain its correct position in the forms during the process of depositing and consolidating the concrete.

The end of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface. No temporary metal supports to the reinforcement steel will be allowed and metal clips or supports shall not be placed in contact with forms for exposed surfaces.

At the time of concreting, all reinforcement steel shall have been thoroughly cleaned and freed from all loose rust, scale, mud, oil or any other coatings that might destroy or reduce the bond and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete.

The placing of all reinforcement steel bars will be checked by the Engineer and in no case is concrete to be placed around any reinforcement steel that has not been approved by the Engineer.

The insertion of bars into or the removal of bars from concrete already placed will not be permitted. Reinforcement steel temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer. Main reinforcement steel carrying determinate stresses shall be spliced only where indicated on the Drawings or on approved shop drawings.

The minimum spacing center to center of parallel bars shall be 2.5 times the diameter of the bar, but in no case shall the clear distance between the bars be less than 1.5 times the maximum size of the coarse aggregate of 2.5 centimeters. All reinforcement steel shall have a clear coverage as indicated on the Drawings.

### **3. Stone Masonry Work and Walls**

Select stones for their locations and lay them in the stone masonry wall with the minimum of stonecutting. Stones shall be selected based on their size and fit within the structure. Selection shall be done by experienced stone masons. The Contractor shall propose a chief stone mason to be approved by the Engineer. The Chief Stone Mason shall be on the Work Site at all times guiding all stone works when such operations are on-going. For footings, select the largest, flattest and most regular stones for footings, and set them in concrete blinding in accordance with drawings. For caps and copings, select stones of reasonably uniform size and finish the top of the wall to a level line or cap with precast concrete sections.

**Retaining Walls and Canal Walls:** Where dry or mortared stone walls will as retaining walls, construct the stonework to be free draining through the wall. Batter back the wall face 50 – 70 mm for every 300 mm in height. Cap the top of the wall. Backfill progressively, with a layer at least 300 mm thick of porous material, such as coarse aggregate or crushed rock in the size range 20 – 40 mm. Install filter fabric to stop movement of silt into porous material. Install weep holes on all such walls as directed on the drawings. The thickness of gravel filters behind such walls shall have a minimum thickness of 450 mm.

Where stone walls are mortared, batter back the wall face 50 – 70 mm for every 300 mm in height. Cap the top of the wall. Backfill progressively, with a layer at least 300 mm thick of porous material, such as coarse aggregate or crushed rock in the size range 20 – 40 mm. Install filter fabric to stop movement of silt into porous material. Install a slotted pipe drain at the bottom of the wall backfill to ensure all water is drained away from the wall face. The thickness of gravel filters behind such walls shall have a minimum thickness of 450 mm.

**Mortar and Placement:** Cement mortar shall be prepared by mixing cement and sand by volume. Proportion of cement and sand shall be 1:6 (one part of cement and six part of sand) or as specified. The sand being used shall be sieved before use. The mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within initial setting time of cement, after the water is added to the dry mixture. Mortar unused for more than initial setting time or cement shall be rejected and removed from the site of work.

For any stone masonry work on the Project, green work shall be protected from rain, running water of accumulated water from any source, by suitable means. Masonry work, as it progress shall be kept thoroughly wet by sprinkling water at regular intervals, on all faces. Curing shall be done after 24 hours of completion of day's work and shall be done for at least 10 days after completion. Proper watering cans with spray nozzles, rubber or PVC pipes shall be used for this purpose.

All stones shall be wetted before laying to prevent absorption of water from mortar. The stones shall be laid so that the pressure is always perpendicular to the natural bed. The courses (if any) shall be built perpendicular to the pressure which the masonry will bear. In case of battered walls, the base of stone and plan of courses (if any) shall be at right angles to the batter. The walls shall be carried up truly plumb or to the specified batter. Every stone shall be carefully fitted to the adjacent stones, so as to form neat and close joints. Vertical joints shall be staggered as far as possible. The bond shall be obtained by fitting in closely the adjacent stones. Transverse bonds shall be provided by the use of bond stones extended from the front to the back of the wall. At angular junctions the stones at each alternate course shall be well bonded into the respective courses of the adjacent wall.

Jointing: Stones shall be so laid that all joints are fully packed with mortar. Face joint shall be minimum 20mm thick. The joints shall be struck flush and finished at the time of laying; when plastering and pointing is not required. If walls are to be plastered or pointed, joint shall be raked to a minimum depth of 20mm during the progress of work when the mortar is still green. For the faces of the wall which are not to be plastered, stone surface shall be cleared of mortar splashing to give uniform stone appearance.

#### **4. Demolition of Existing Concrete or Masonry**

Any existing concrete or stone masonry that requires to be demolished shall include a plan for the Salvage of the materials for re-use. This includes broken mass concrete and stone masonry. The Contractor shall develop a demolition plan that includes re-use and shall discuss such reuse with the engineer and the Water User's Association.

The demolition plan shall also include:

- a. A schedule for demolition activity, including excavation, removal operations, and disposal operations;
- b. Protection for adjacent structures before commencement of demolition. This can include shorting, sheeting, temporary braces, etc.
- c. Disposal plan for the structure after stripping and removal of roof coverings and other external cladding.

The Demolition Plan shall be submitted to the Engineer for approval seven (7) calendar days prior to execution of the demolition activity. Any damage to and the full cost to replace any other nearby existing structures caused from the demolition shall be the responsibility of the Contractor.

## D. GABIONS

Gabions shall consist of rectangular wire mesh formed containers filled with rock. Gabions will be non-raveling double twisted wire mesh, consisting of two wires twisted together in two 180 degree turns. They shall have uniform square or rectangular pattern and a resistance twist at each intersection. Gabions shall be provided by the Contractor as baskets or mattresses, as shown in the construction drawings. Baskets shall have a height of 300mm or greater. Mattresses shall have a thickness of 300mm or less.

Baskets and mattresses shall be fabricated within a dimension tolerance of plus or minus 5 percent, except that the mattress height shall be within 10 percent.

### 1. Materials

Gabions shall be fabricated, assembled and installed in accordance with the nominal wire sizes and dimensions found in Tables 1 and 2. Wire for fabrication and assembly shall be hot-dipped galvanized. The wire shall have a minimum tensile strength of 60,000 psi. Galvanized steel wire shall conform to ASTM A 641, Class 3, Soft Temper. Alternate fasteners for use with wire mesh gabions, such as ring fasteners, shall be formed from wire meeting the same quality and coating thickness requirements as specified for the gabions. All fasteners shall meet the closing requirements of the gabion manufacturer or be approved by the Engineer.

**Table 1, Gabion Baskets, Height 12, 18, or 36 Inches; Length as Specified**

Type of Wire	Mesh Size Inches	Wire Diameter Inches	Total Diameter Inches	Galvanized Coating Oz./SF
Woven Mesh	3 ¼ x 4 ½	0.118	0.118	0.80
	3 ¼ x 4 ½	0.105	0.145	0.80
Selvage		0.153	0.153	0.80
		0.132	0.172	0.80
Lacing and Internal Connecting Wire		0.086	0.126	0.70
Spiral Binder		0.105	0.145	0.80

**Table 2 Gabion Mattresses, Height 6, 9, or 12 Inches; Length as Specified**

Type of Wire	Mesh Size Inches	Wire Diameter Inches	Total Diameter Inches	Galvanized Coating Oz./SF
Woven Mesh	2 ½ x 3 ¼	0.086	0.126	0.70
Selvage		0.105	0.145	0.80
Lacing and Internal Connecting Wire		0.086	0.126	0.70

Type of Wire	Mesh Size Inches	Wire Diameter Inches	Total Diameter Inches	Galvanized Coating Oz./SF
Spiral Binder		0.105	0.145	0.80

## 2. Rock Requirements

Rock shall be sized to at least 85 percent of the rock particles, by weight, within the predominant rock size range shown in Table 3.

**E. Table 3, Rock Requirements**

Gabion Basket or Mattress Height	Predominant Rock Size Inches	Minimum Rock Dimension Inches	Max. Rock Dimension Inches
18 or 36 Inch Basket	4 to 8	4	9
12 Inch Basket or Mattress	4 to 6	3	8
6 or 9 Inch Mattress	3 to 6	3	6

Prior to delivery to the site, the Contractor shall inform the Engineer in writing of the source from which the rock will be obtained, and provide a sample by which the material was determined by the Contractor to meet the requirement.

## 3. Foundation Preparation

The foundation on which the gabions are to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. Surface irregularities, loose material, vegetation, and all foreign matter shall be removed from foundations. When fill is required, it shall consist of clean locally available sand and gravel as approved by the Engineer. Gabions and bedding shall not be placed until the foundation preparation is completed, and the subgrade surfaces have been inspected and approved by the Engineer. Compaction of bedding or filter material will be required as directed by the Engineer.

## 4. Assembly and Placement

Unless otherwise specified in the construction plan, the assembly and placement of gabions shall be in accordance with the following procedures:

**Assembly:** Rotate the gabion panels into position and join the vertical edges with fasteners for gabion assembly. Where lacing wire is used, wrap the wire with alternating single and double half-hitches at intervals between four 100mm and 12mm. Where ring type fasteners are used for basket assembly, install the fasteners at a maximum spacing of 15mm. Use the same fastening procedures to install interior diaphragms where they are required as directed by the Engineer. Interior diaphragms will be installed to assure that no open intervals are present that exceed three .9m.

**Placement:** Place the empty gabions on the foundation and interconnect the adjacent gabions along the top, bottom, and vertical edges using lacing wire, spiral fasteners, or ring fasteners. Wrap the wire with alternating single and double half-hitches at intervals between 100mm and 12mm or (4) to six (6) inches. Ring fasteners shall not be spaced more than 30mm apart. Spirals are screwed down at the connecting

edges, then each end of the spiral is crimped to secure it in place. Lacing wire will be used as needed to supplement the interconnection of welded mesh gabions, and the closing of lids.

Interconnect each layer of gabions to the underlying layer of gabions along the front, back, and sides. Stagger the vertical joints between the gabions of adjacent rows and layers by at least one-half of a cell length.

## **5. Filling and Backfilling Operation**

After adjacent empty woven wire gabion units are set to line and grade and common sides properly connected, they shall be placed in straight line tension and stretched to remove any kinks from the mesh and to gain a uniform alignment. Staking of the gabions may be done to maintain the established proper alignment prior to the placement of rock.

Internal connecting cross-tie wires shall be placed in each unrestrained gabion cell greater than 45mm in height, including gabion cells left temporarily unrestrained. Two internal connecting wires shall be placed concurrently with rock placement, at each 30mm interval of depth. These cross-ties will be placed evenly spaced along the front face and connecting to the back face. All cross-tie wires shall be looped around two mesh openings and each wire end shall be secured by a minimum of five 180 degree twists around itself after looping.

The gabions shall be carefully filled with rock, either by machine or hand methods, maintaining alignment, avoiding bulges, and providing a compact mass that minimizes voids. Machine placement will require supplementing with hand work to ensure the desired results. The cells in any row shall be filled in stages so that the depth of rock placed in any one cell does not exceed the depth of rock in any adjoining cell by more than 30mm. Along the exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat, compact placement with a uniform appearance.

The last layer of rock shall be uniformly overfilled 3 to 5mm for gabions and 3mm for gabion mattresses to allow for rock settlement. Lids shall be stretched tight over the rock fill using only approved lid closing tools. The use of crowbars or other single point leverage bars for lid closing is prohibited. The lid shall be stretched until it meets the perimeter edges of the front and end panels. The gabion lid shall then be secured to the sides, ends, and diaphragms with spiral binders or lacing wire wrapped with alternating single and double half-hitches in the mesh openings. Ring fasteners spaced not more than 30mm apart may be used for lid closure.

Any damage to the wire during assembly, placement and filling shall be repaired promptly in accordance with the manufacturer's recommendations or as directed by the Engineer or replaced with undamaged gabion baskets. Backfilling of gabion excavation shall be carried out in 30mm layers with each layer compacted to 90% soil compaction density.

## **F. METAL FABRICATION**

This section relates to the fabrication of all miscellaneous metal, gates, railings, fasteners and other metal deliverables in the project and includes instructions on material supply, cutting, welding, painting and placement. A listing of applicable regulatory requirements follows:

AISC, "Specifications for the Design of Cold-Formed Steel Structural Members."

AWS, "Structural Welding Code, D1.1."

SSPC, "Steel Structures Painting Council."

### **1. Submittals**

All steel and cast iron and all steel fasteners, all welding rods, all primers and all paint submittals shall include product data including brand names, name of producing foundry, drawing profiles, fabrication and

installation directions. Submittals shall indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.

Submit certification that manufactured products (including bolts, nuts and washers) that meet or exceed specified requirements. Certification numbers must appear on product containers for bolts, nuts and washers and the numbers shall correspond to the identification numbers on the Manufacturer's Certificate. The Manufacturer's symbol and grade markings must appear on bolts, nuts and washers.

## **2. Delivery, Storage, And Handling**

Store steel materials and other metals, either plain or fabricated, above ground on platforms, pallets, skids, or other supports. Keep material free from dirt, grease, and other foreign matter and protect from corrosion.

## **3. Materials**

- a. Steel Sections: ASTM A992, hot-dip galvanized for exterior use.
- b. Steel Pipe: ASTM A53, Type S, Grade B, Schedule 40 typical unless otherwise noted. Pipe used
- c. Steel Tubing: Cold formed, ASTM A500; or hot rolled, ASTM A501; seamless.
- d. Cold-Rolled Carbon Steel Sheets: ASTM A653. Provide "Commercial" galvanizing, for exterior use.
- e. Bolts, Nuts, and Washers: ASTM A307. Provide zinc-coated fasteners for exterior use or where built into exterior walls.
- f. Drilled Anchors for Use in Concrete: Use anchors with a current ICC evaluation report appropriate to the application.
- g. Welding Materials: AWS D1.1; type required for materials being welded.
- h. Primers: Prime paint for ferrous metal shall be as specified in Division 09 Section "Painting" [Tnemec Series 4] or an approved equal free of chromate or lead.

## **4. Fabrication**

The Contractor shall:

- a. Verify dimensions on site prior to shop fabrication. Coordinate metalwork with adjoining work for details of attachment and fit. Be responsible for fabrication detailing and correct fitting of iron/steel members to each other and to their supports.
- b. Use materials of size and thickness shown or, if not shown, of size and thickness to produce strength and durability in the finished product for the utility intended.
- c. Fabricate items with joints tightly fitted and secured. Make exposed joints butt tight, flush, and hairline.
- d. Grind exposed welds flush and smooth with adjacent finished surface. Ease exposed edges to small uniform radius.
- e. Fit and shop assemble in largest practical sections, for delivery to site and handling through existing openings.
- f. Provide components required for anchorage of metal fabrications. Fabricate anchorage and related components of same material and finish as metal fabrication, except where specifically noted otherwise.

## **5. Welding**

All surfaces shall be clean, free of rust, paint, and foreign matter of any kind. Burned edges to be welded shall be chipped clean and wire brushed before welding. Clamp members as required, space and alternate welds, as may be necessary to prevent warping or misalignment.

**Weld Metal:** Weld metal shall be thoroughly fused with the base metal along surfaces and edges of the union. Penetration shall be 1/8 inch (4 mm) minimum and shall be into the root of the joint. All gate welding shall be continuous bead welds and no spot or tack welds shall be allowed.

**Weld Quality:** Welds shall present a uniform surface, free of imperfections, without undercutting or overlapping, and free from excessive oxides, gas pockets, and nonmetallic inclusions. Welds shall be made with the proper number of beads or passes to secure sound, thoroughly fused joints. Provide backup bars, temporary backup bars, or backup welds for full-penetration butt welds. Each deposit shall not exceed 1/2 inch (12 mm) of weld for each pass of bead. Preceding layers shall be cleaned by wire brushing or preening to remove scale and slag before placing new weld material.

**Faulty and Defective Welding:** Welding showing cracks, slag inclusion, lack of fusion, bad undercut, or other defects ascertained by visual or other means of inspection, shall be chipped out and properly replaced.

## 6. Finish

Contractor shall follow these steps for metal finishing:

**Cleaning:** Thoroughly clean mill scale, rust, dirt, grease, and other foreign matter from ferrous metal prior to galvanizing, hot-phosphate treatment, powder coating, priming and/or painting. Remove scale, rust, and other deleterious materials before applying shop coat. If required by the Engineer, the Contractor shall clean off heavy rust and loose mill scale in accordance with SSPC SP-6, "Commercial Blast Cleaning." This is required for Tnemec primer painting. The Contractor and Engineer shall agree on raw metal preparation prior to finishing operations. Remove oil, grease, and similar contaminants in accordance with SSPC SP-1, "Solvent Cleaning."

**Shop Priming:** Shop-paint metal work except members or portions of members to be embedded in concrete, surfaces and edges to be field welded, and galvanized surfaces.

- i. Immediately after surface preparation, brush or spray on primer in accordance with the paint manufacturer's instructions at a rate to provide uniform dry-film thickness of 2.0 mils for each coat. Use painting methods which will result in full coverage of joints, corners, edges, and exposed surfaces ; and
- ii. Apply one shop coat to metal items, except apply two coats to surfaces inaccessible after assembly or erection. Change color of the second coat to distinguish it from the first.

**Finish Painting:** Two coats of finish metal paint shall be applied to all gates with application instructions and thicknesses of coats as recommended by the manufacturer. Color shall be bright green as approved by the Engineer.

**Touch Up:** Contractor shall keep primer and finish paint on site so that when gates are scratched during transport and or during installation, they will be repair painted on site. Such touch up shall be done with three coats and as approved by the Engineer.

## 7. Installation

Contractor shall follow these steps for metal part installation:

**Fastening to In-Place Construction:** Provide anchorage devices and fasteners for securing metal work to in-place construction, including threaded fasteners for concrete inserts, through bolts, lag bolts, screws, and other connectors as required.

**Conceal fastenings where practical.** Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Form joints exposed to weather to exclude water.

**Cutting, Fitting, and Placement:** Perform cutting, drilling, and fitting required for installation of metal work. Set work accurately in location, alignment, and elevation, plumb, level, true, and free of rack, measured from established lines and levels. Provide temporary bracing anchors in formwork for items which are to be built into concrete or similar construction.

Fit exposed connections accurately together to form tight hairline joints. Weld connections which are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Grind exposed joints smooth and touch up shop paint coat. Do not weld, cut, or abrade the surfaces of exterior units which have been hot-dip galvanized after fabrication and are intended for bolted or screwed field connections.

Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, and methods used in correcting welding work.

**Corrosion Protection:** Protect dissimilar metals from galvanic corrosion by pressure tapes, coating, or isolators as acceptable to Engineer.

**Grouting:** Do grouting of frames, plates, sills, bolts, and similar items with non-shrink grout.

**Alignment:** Verify alignment of items with adjacent construction. Coordinate related work.

**Handrails:** Secure steel handrails with bracket. Unless otherwise noted, locate brackets 6 inches (150 mm) from ends of handrail, 6 feet (1.8 m) on center maximum, and space brackets equidistant at each handrail. Where bracket is fastened to stud wall, provide steel plate backing securely fastened to studs; toggle bolt secured to gypsum wallboard is not acceptable.