SECTION 500 – STRUCTURES

512.00 Gabion Structure.

General. Gabion structures are woven or welded wire mesh baskets filled with rocks that are normally used to structurally retain earth similar to retaining walls or to assist in sediment and erosion control. Their use requires both sound engineering design and proper construction for the application to be successful. They have been used in various forms since the beginning of recorded history.

There are five major steps of work involved in gabion structure construction:

- The foundation preparation.
- The assembly, or set-up, of the gabions.
- Placement of the gabions into the proposed location.
- Placing the rock fill in the gabions
- Closing the gabions, backfilling, and finishing.

On any given project all four of these operations could be occurring simultaneously. It is the responsibility of the inspector to insure that each is being performed properly. To accomplish this task the inspector must have some background in the recommended methods of handling the gabion material during each of these phases.

Construction Requirements.

Preconstruction Phase. Upon being assigned to a given project the inspector should study the plans and specifications thoroughly. If any questions arise during this study the inspector should contact the Engineer and have them addressed.

The project specifications should require the gabion manufacturer to certify that their gabions meet the project requirements in all respects, or call attention to any deviations there from. The inspector should contact the State Geotechnical Engineer to verify that the technical information supplied by the Contractor satisfies the specifications. Refer to the QA Manual Section 270.00 for acceptance requirements. If discrepancies exist, the inspector must be satisfied they are acceptable to the designer and the Resident Engineer. This will save a great deal of time later in the execution of the project.

The inspector must obtain from the Contractor a copy of the gabion manufacturers' printed recommendations for installation of the units and be satisfied they are acceptable to the designer and Resident Engineer. Contractor designs can be constructed only after review and approval by the Resident Engineer after consultation with the appropriate HQ Construction/Materials personnel.

Gabion Assembly. The inspector should ensure the gabions delivered to the project have not been damaged during shipment. Check for damage caused by improper handling by forklifts and for excessive abrasion caused by tie-down chains. If any doubt exists as to the effects of any damage noted, the inspector should notify the Contractor to contact the gabion manufacturer for recommendations on repair or replacement.

A color stripe on the side of the folded gabion is normally used to identify the size.

The gabion fill rock, geotextile and/or granular filter media must have the appropriate inspection, testing and/or certification to be certain they satisfy the project specifications. Each of these items, and the backfill, is critical to the satisfactory performance of the gabion structure.

When the gabions are received they must be unfolded and assembled per the manufacturer's written recommendations and as approved by the Resident Engineer. Generally when first unfolded any units with a finished length over 6 feet will have an extra shipping fold. The crease caused by this fold must be removed or the unit will not be full length. One of the easiest, and most successful, methods of removing this crease is to back-stretch it over a 2x4 timber and walk along the sides.

The next operation is to connect the back and front panels of the gabion to the ends and diaphragms. The base wire fabric has heavier wires (2 gauges heavier) woven into it at the break lines forming the front, bottom, back and lid. The short extended length (about 4 inches long) of the top selvedge wire of the ends and diaphragms should pass under, and loop twice around the heavier wire between the lid and back panels. The extended wires of the end panels should be wrapped around and to the outside so as to lock the ends and prevent them from leaning into the unit. The bottom corners of the ends may have to be re-formed slightly to permit the top wire to pass under the heavier wire.

Using approximately 5 ft. lengths of the lacing wire, cut from the coils provided with the gabions, lace the front and back panels to the diaphragms and end panels. A lacing pattern of "single loop – double loop – single loop", with the loops being spaced approximately 4 to 5 inches apart, will develop the same strength as the body of the space gabion mesh. The ends of the lacing wire should be looped three times around the connected seam to prevent unraveling. (**Note: only wire supplied by the gabion manufacture is to be used in gabion construction. Gabion wire has a special coating which is not available in the local hardware store or supply houses**). Use 6 or 8 inch pliers for lacing.

Again, the connection of the gabions must be per the manufacturer's written recommendations, and as approved by the Engineer. Depending on the type of structure and the physical conditions of the project the assembled units can be formed into larger modules by attaching several units together. If this form of construction is employed the inspector must make sure the corners and top and bottom edges of the units are properly aligned and laced to each other.

Mechanically Applied Fasteners. Mechanically applied fasteners (rings or clips) can be used to connect panels, diaphragms or adjacent cells in lieu of lacing wire. Only Class 3 coated galvanized clips or rings should be used with galvanized gabions. Only stainless steel rings or clips should be used with PVC coated gabions. Hog rings must have a minimum overlap of 1inch when closed.

The Resident Engineer will have to decide, after studying all of the facts, whether or not to approve this method of assembly and/or construction.

Erection of the Gabion Structure. This section applies to 3 ft., 1.5 ft., and 1 ft. high gabions used in the construction of retaining walls, weir walls, stepped revetments, and flared transition zones between retaining walls and sloped revetments.

When gabion units, or modules, are placed into the structure the inspector must be concerned with the alignment, grade, stretching, and attachment of the individual units to each other. The alignment and grade are established by the field engineer or surveyor, but should be checked. The stretching and attachment of the gabions to each other are of primary interest to the inspector.

When several units, up to 100 ft., are in place and aligned, they should be stretched to tighten the wire fabric. This operation makes it much easier to control bulging during the filling operation. An anchor for the stretching operation can best be obtained by completely filling the end cell of the end unit. This may be accomplished either by machine or by hand filling. The inner tie wires (or stiffeners) shall be properly installed in both directions in this anchor cell (tie wires will be discussed later). The pulling force is then applied to the opposite end of the string. The attachment method for applying the pulling force should be such that the force is applied to at least 4 places on the heavy vertical selvedge wires forming the corners. The force should **NOT** be applied to the fabric of the end panel. While the stretching force is applied, the next to the last cell of the string is filled in the same manner as before. This will leave the last cell empty to provide for easier attachment of additional units. Subsequent gabions or gabion modules will be placed in the same manner with only the next to the last cell being filled during the stretching operation.

There will be times, depending upon the type of structure or the physical limitations of the project site, when it will be impossible to stretch the units. This will not affect the structural integrity of the structure. However, additional care will be needed during the filling operation to maintain alignment and prevent bulging.

Typical situations in which this can occur include:

- Counter fortes behind retaining walls
- The main wall of weirs or drop structures
- Curved or serpentine walls.

Gabion counter fortes and weir walls extend into narrow notches excavated into hill sides or stream banks which allow for very little working room. The shorter the radius of curvature of serpentine or curved walls, the more difficult it will be to apply a stretching force to a long string of gabions.

Seldom are the gabions stretched when used for thin splash/scour aprons or revetments. The desire in these structures is to have maximum flexibility to allow for structural adjustments which will compensate for scour and possible undercutting.

If gabions have to be placed on top of other gabions, they must be laced together on all perimeter edges. If the units are directly aligned on top of one another, this presents little problem since the workers can perform the work from the front and back of the structure. If, however, the top unit is off-set from the lower unit and extends out over the backfill, the worker will have to climb into the upper unit in order to lace the rear seam. This operation is most often overlooked by the labor crew, but it must be done.

The gabion units may be placed either as single units, modules of several units in a "string", or as modules of several units arranged in a rectangular "block". The method chosen by the Contractor will be a function of site conditions and the maximum reach of the type of equipment he plans to use to fill the units.

When the units are placed on top of a geotextile, care must be taken to insure the sharp edges of the bottoms of the diaphragms do not catch on the geotextile and pull it. This could open the overlap seam and expose the sub grade to the action of water. One method of preventing this from happening is to temporarily place thin plywood sheets on the geotextile and slide the gabion units into the correct position on the plywood. When the top edges of the units are properly aligned and "pig tailed" in position, the plywood is removed.

The geometric configuration of this type of structure may require some "cutting and fitting" to adjust for curvature of stream alignment, varying slope angles (and thus slope length) of stream banks, or angled wing walls of headwalls, etc. When a unit must be cut to fit an odd shape the cut must allow for a minimum 6 inches overlap to permit proper lacing. All cutting and fitting shall be by methods approved by the manufacturer and accounted for in the design.

Filling Gabions Cells. The rock used to fill gabions must be of sound rip-rap quality, preferably graded from 4 to 8 inches in size, and roughly cubical in shape. This will allow for the maximum amount of machine filling. There will be some minus 4-inch material present, due to breakage in transit, but this should be limited to a maximum of about 5%. No minus 4-inch material should be permitted on any exposed face of the structure since it can fall out, be washed out, or pulled out, thus creating a void in the structure. Soil (picked up from the bottom of the rock pile) shall not be permitted to remain in the structure as a seam or "block". Some dirt or fine material is inevitable, but the amount must be minimal. Soil should be brushed or manipulated in a manner so as to provide for the required point to point contact of the large rock fill. Excessive amounts of sand/soil will wash out and create large voids in the gabion structure.

Rock should be placed in 1 ft. lifts in the gabion structure, moving from cell to adjacent cell. A row of 5 to 8-inch-size rock should be hand-placed against the exposed face(s) during the filling to present a pleasing appearance and minimize the size of exposed voids. The first fill layer is then leveled to permit the installation of the inner tie wires. When at all possible, the maximum difference of the rock level in adjacent cells should not exceed 1 ft. When 1.5-foot high gabions are used in a retaining wall or weir

wall configuration they shall have the inner tie wires, placed only at mid-height. One foot high gabions, in the same situation, do not need the inner tie wires, but should be filled in half height lifts.

Inner tie wires or stiffeners are needed to help brace exposed, or temporarily unsupported, faces of the gabions. In a long retaining wall configuration they are placed transverse to the long axis of the wall. Only the end cells, or temporary end cells, will need inner tie wires in both directions. The inner cells of walls which have thick layers, say 9 or 12 inches (or more), do not need the inner tie wires if the adjacent cells are filled in 1 ft. lifts uniformly.

After the first 1 ft. lift of rock is laced and the inner tie wires installed, the second layer and inner ties and then the third layer are placed using the same sequence of operations. The last layer should be filled approximately 2 inches above the top of the gabion to allow for subsequent settling of the rock fill. The top should be roughly leveled (no large humps or voids), and the lid closed, and then attached to the tops of the cell diaphragms, ends, and fronts.

Backfilling behind the Gabion Structure. The inspector should be very familiar with the entire project specifications involving the type of backfill material and degree of compaction required.

Backfilling any gabion structure is performed in the same manner as in any other type of construction. Most care is needed to ensure the gabion mesh wires are not damaged or broken by contact with the compaction equipment.

Caution should be exercised when backfilling a single long “string” of gabions (as in a retaining wall). To achieve the normally specified degree of compaction, the compactive effort may be sufficient to push the gabions out of alignment. If the gabions are not embedded below grade, or laced to gabions which are embedded, alignment control may become a problem. One possible solution would be to place a temporary fill in front of the gabion string to help hold alignment. Sheets of plywood can be used to keep the temporary fill from infiltrating the voids of the front face of the gabions. When compaction is completed, the temporary fill may be removed. This method may cost a little in time and effort, but it is far cheaper, and much more satisfactory, then trying to push the filled gabion string back into alignment.

The degree of compaction of backfill around gabions placed in notches in stream banks (weirs), or around gabion counter fortes for retaining walls, is critical to satisfactory performance of the structure. If doubts arise the Resident Engineer and the design engineer should be contacted immediately.

Driving on Filled Gabions. There are times when the Contractor will request permission to drive equipment on top of gabions which have previously been filled. The answer to this question is not a simple “yes” or “no”. It depends on many factors, namely:

- Type of Structure
- Type of Equipment
- Type of Protection to be given the gabions
- Manufacturer’s Written Instructions
- Requirements and Specifications and the design engineer.

The last two factors above are the most important. The design engineer should be consulted before any answer is given. It is also wise to contact the gabion manufacturer for any recommendations as to the type of protection required.

Safety. During construction, and especially after completion, the entire structure must be inspected for protruding wire ends. All loose ends of the wire should, at all times, be turned back into the structure to prevent possible injury. This is especially important along the top edges of the units since workers are continually leaning over them thus exposing themselves to possible eye injury.

Documentation for Pay Quantities. The diary should be used to verify the activity date and acceptable completion of the work. Complete field notes will be required for the computation of structural excavation and compacting backfill. The dimensions of the gabions should be measured in the field and the pay item entered on the diary or the pay item report. Gabions will be measured and reported to the nearest 0.1 ft^3 of filled gabion complete in place.

Reports. Test reports as required per QA Manual, Section 270.