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ENGINEERING FEASIBILITY OF GABION STRUCTURES OVER REINFORCED CONCRETE STRUCTURES

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Abstract - *Gabions commonly used in civil engineering for earth retention and erosion control. Gabions are usually rectangular in shape, compartmented baskets which are made of galvanized wire mesh. The compartments of gabion are filled with stones. Special type fasteners are used to close and secure the Gabions. This prevents movement of the stone and maintains the integrity of the system. They are available in different sizes that can be easily connected to create any required configuration like gabion wall , gabion mattresses, apron , river training works and gabion cladding. Gabion constructions are economical than the RCC constructions. The percentage cost savings by gabion ranges from 33% to 66%, since less time is required for the construction. The most important characteristic feature of gabion is that it can use different combinations of filler materials ,if quarry stone is not available. But, in most of the cases the filler material remains locally available in abundance . In the construction of RCC walls, as the work involves multiple parameters like cost of transportation, cement, sand, aggregate, labour, shuttering etc. adopting RCC structure becomes further expensive. This finally paves the way for gabion structural construction. Adoption of gabion is sustainable. Gabions remain flexible under the action of external loads and cab be adopted for projects over unstable foundations, making them distinguished as compared to rigid structures They have tremendous strength and demand little maintenance cost. Gabions are permeable in nature, reducing the need for costly drainage provisions. Gabion promotes growth of vegetation consequently reducing erosion. GSI wire mesh used in gabion has superior strength, durability and flexibility. Gabions can also have PVC coating. Gabion structures have impressive life span. The life expectancy of gabions depends on the durability of the wire used, irrespective of the durability of contents of the basket. The gabion structure will fail when the wire fails. Gabion wire of galvanized iron has life span of 50-60 years.*

Key Words: Gabion, Economical, sustainable, wire mesh, aggregates, permeability, flexibility

1. INTRODUCTION

A gabion is simply a wire mesh cage or basket filled with stones. Gabions are quite useful in construction works. Some examples are, to protect earth embankments, to line channels, to protect bridge abutments. A gabion is like a wire mesh cage or basket filled with stones or any other suitable material. Gabions are useful in diverting a river and to protect river banks. . The standard gabion basket consists of a single piece of wire mesh that can be assembled to form a rectangular box with a lid.

1.1 Classification

Based on size, wire mesh basket of gabion is of two types, namely:
1. Full-height (standard), one-metre gabions
2. Half-height, half-metre gabions.

Based on the purpose, gabion has following types:
1. Mass Gravity gabion Retaining
2.Gabion Faced Reinforced Soil Walls
3. Gabion Revetments
4. River gabion Walling
5. Free Standing gabion Walls
6. Gabion Cladding
7.Gabion mesh wire Rock fall Protection
8 .Gabion Outfall and Structures
9. Gabion weir Structure

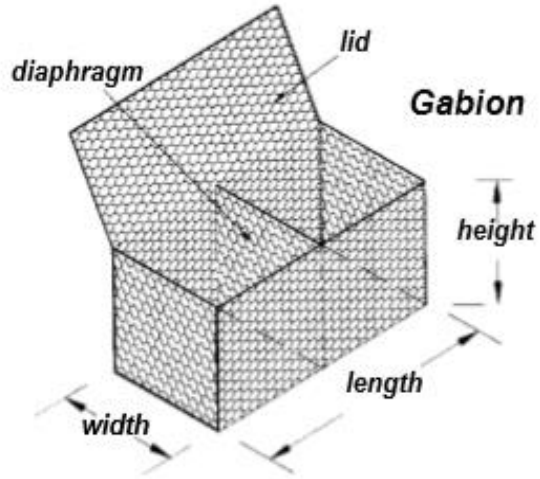

Fig -1: Schematic diagram of Gabion Basket with diaphragm.

1.2 Materials Used In Gabion

The materials used for the construction of gabion are coarse aggregates, red soil, sand, quarry dust, steel mesh and other materials.

1. Steel Wire Mesh: Gabion boxes are made with double twist or tripple twist hexagonal wire mesh. Tensile strength of mesh can be obtained by conducting tension test on steel mesh using universal testing machine (UTM).Tensile strength is of the order of 25 kN/m, with breaking load of 1.75 kN.

2. Coarse Aggregate: The coarse aggregates of size 20 cm–30 cm are commonly used .Coarse aggregate for this purpose is collected from a stone quarry. Properties of these aggregates are evaluated using different test in the laboratory according to IS specifications.

3. Fill Materials: For model studies river sand and Quarry dust are used as filler material. However, quarry can be used alone or in combination with coarse aggregates.

4. Geotextile: In case of gabion retaining walls we need special type of materials on the fill side to prevent entry of back fill soil into gabion basket, these materials are called geotextile filters. These geotextiles also prevent out flow of quarry dust. The properties of geotextile material approximately are: Tensile strength = 8-10 kgN/m, Elongation = 27%, Pore Size = 145-150 µm, Mass per Unit Area = 1.25 N/m2, Permeability =90-100mm/s

Fig -2: Hexagonal mesh (top), square mesh (bottom).

2. Engineering Feasibility of Gabion over Reinforced Concrete

2.1. Economical: It is not always economical to construct structures using reinforced concrete cement. Introduction of gabion based construction proved breakthrough in civil engineering**.** From the economic studies conducted so far **[Lee et al. (1973), Collin (2001), Koerner et al. (2001)]**, it can be seen that the walls with gabion facing and geotextile as reinforcement in cost effective. Indian railways in 1999 performed overall cost study for gabion wall and RCC wall. From the test they concluded that with the increase in the height of wall the cost spent in case of gabion is less as compared to RCC wall. The reduction in cost ranges from 33% to 66% as compared to reinforced concrete. This is only true if the fill stones are locally available. In case fill materials are not available, there arises need of suitable alternate material which must be locally available. The material adopted should fulfil all standards of strength and stability. For example in hilly areas quarry stone is easily available. Use of gabion at these places proves economical. Hence the RCC construction in hilly places, keeping in view cost of transportation, cement, sand, and shuttering should be dropped. We can use mixture of stones and the waste material like quarry dust and red soil. Using red soil may solve various disposal problems.

One thing should be noted that while using red soil and quarry dust as fill material, the mix has tendency to leak down .To avoid such leakages the mix of red soil ,quarry dust and stones should be packed in gabion baskets using geotextile lining. This method of gabion construction is called as a modified form of soil filled gabion walls.

2.3 Permeability: Gabion are highly permeable structures. The fill material has large number of voids which allow movement of water through its body. This characteristic feature of gabion helps in dissipation of hydrostatic pressure, consequently reducing chances of failure of structure. It has been found that most of the water retaining structures fail due to inadequate drainage characteristics, which can be appreciably reduced by using gabion retaining structures.

2.3 Flexibility: Gabions have outstanding flexibility. This property of gabion is useful in foundation works. The settlement related problems are addressed using gabion in the form of Gabion mattresses and Gabion Links. The combination of fill encased by GSI wire mesh adds tremendous flexibility. The mesh has hexagonal or nearly square shaped holes, which are fastened in double or triple twists.

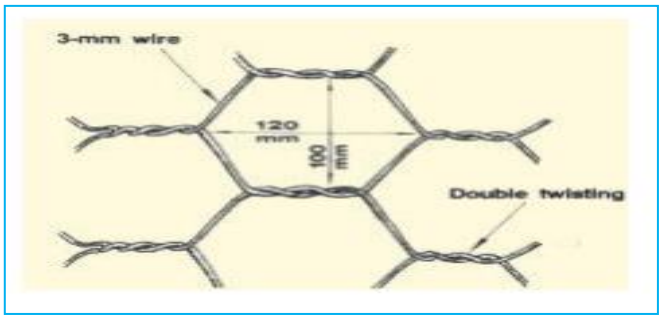

Fig -3: Arrangement of hexagonal mesh wire of gabion basket showing double twist.

The flexible gabions can tolerate settlements and deformations unlike rigid structures. This encourages use of less expensive gabions instead of expensive rigid foundation treatments which are brittle.

2.4 Durability: The mesh wire of gabion decides the serviceable life of whole structure. The most common trend is use of zinc coated mesh wires. These coated mesh wires are designed in such a way that they can survive in hostile environments. These zinc coated mesh wires have greater quality control unlike reinforced concrete. Sometimes the additional coating of PVC is done to enhance the probability of survival in harsh environments. PVC coating of any desired color can be done. It has been found that the zinc coated wire mesh has life span of about 50-60 years approximately. It is interesting to note that the PVC coated wires have three times more protection capacity as compared to the zinc coated wires. A market brand of Gabion wire, called Maccaferi has useful life of 100 years.

These gabions are less susceptible to cold weather cracking or frost action as compared to reinforced concrete.

2.5 Hydraulic stability: Weir is used as a hydraulic structure to reduce water velocity if there is sudden change in the bed levels along the length of river. The accumulation of water on the upstream side comes down with certain energy and has tendency to degrade the downstream side. The gabion aprons are quite effective in reducing the degradation or scouring on downstream side. The thickness of apron depends on the turbulence of flow released from the upstream side. Gabion aprons are simpler for mild sloppy beds. A stepped type of concurrent gabion drops are used for steep slopes called as cascade structures. In general we can say that gabion aprons can effectively sustain the turbulence of the water as compared to reinforced concrete. Hence, due to wire mesh and stone aggregates, gabion has an appreciable hydraulic stability unlike rigid RCC structures.

Fig -4: An Apron of Gabion, protecting the stream bed from being scoured.

2.6 Sustainable: Extensive construction in Civil Engineering fields has resulted into ecological imbalance. Each passing day the carbon emission into atmosphere is drastically increasing. Both developed and developing countries are in the race of rapid construction. To fulfil the time bound need of construction various types of cements are manufactured on daily basis polluting our environment. Moreover reinforced concrete needs fine angular aggregates which are processed, thus adding crusher dust to atmosphere. These issues related to RCC type of construction renders it unfit for healthy environment. In these circumstances we need an alternate which can be constructed quickly and essentially should be sustainable. Using gabion constructions reduce emission of carbon dioxide by 70%-80%. Then and only then we can proudly say that civil engineering has contributed both in the fields of technology and Sustainable development.

2.7 Alternate material: In the construction of gabion we have wide choice of fill materials depending upon the economic conditions of project and locally available material. However this is not always possible in case of RCC construction. RCC constructions are bound to the certain conditions which are to be fulfilled at any case. Suppose we cannot replace cement in RCC by any other alternate material, so is the case with steel reinforcement. The wide scope of materials and their combinations for gabions makes them perhaps the most suitable engineering construction materials in certain conditions like retaining walls, hydraulic structures etc. Various material combinations for Gabions are explained in details

1. Quarry dust alone
2. 50% coarse aggregate and 50% quarry dust (core)
3. 50% coarse aggregate and 50% red soil (as core)
4. Red soil alone
5. Coarse aggregates alone
6. 50% coarse aggregate and 50% quarry dust (layer)

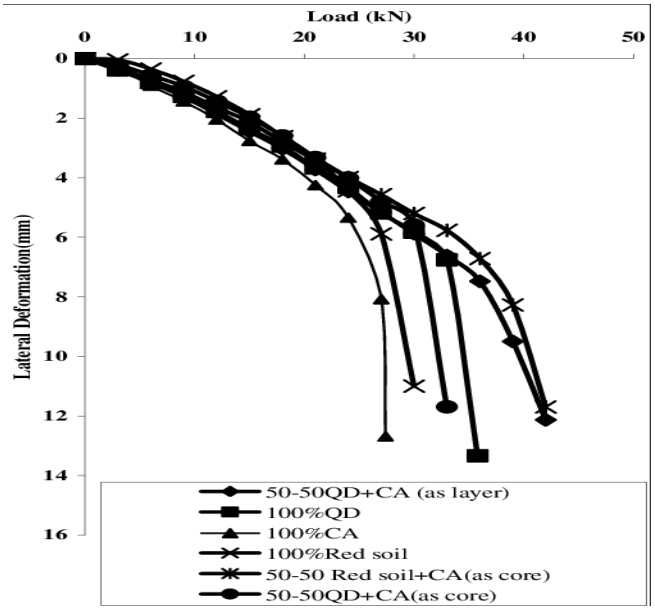

Fig -5: Load verses deformation for different material combination.

From the tests conducted on gabion for Load verses deformation as shown in figure 4, the following conclusions can be drawn:

For 50-50% combination of coarse aggregates and red soil the deformation produced is less when external applied load is increased.

For coarse aggregates alone the deformation is more. This is due to the large voids which are present in coarse aggregates (as core).

The change in load carrying capacity for different combination of materials as compared with 100% coarse aggregates at 5mm deformation is found to vary as:

For 50-50% combination of red soil and coarse aggregates (core), load carrying capacity increases by 31.32%.

For 50-50% combination of quarry dust and coarse aggregates (as core), load carrying capacity increases by 16.55%.

For 50-50% combination of quarry dust and coarse aggregates (as layer), load carrying capacity increases by 18.5%.

Hence, 50-50% red soil and quarry dust with coarse aggregates (core) separately, 50-50% red soil and coarse aggregates have more load carrying capacity by 13.12%.

And, 50-50% of coarse aggregates (as layer and core) and quarry dust; the load carrying capacity remains almost same

3. CONCLUSIONS

Outstanding characteristics of Gabion in certain circumstances where reinforced concrete cannot survive much make them more purposeful.

Interestingly, in construction of retaining walls if the cost reduction is of the magnitude of 33% to 66%, there is nothing bad in choosing gabion retaining walls. More over in developing countries where economic resources are limited these types of walls prove economical.

In hydraulic water diversion systems these gabions are permeable, reducing the hydrostatic pressure. Hence chances of failure of retaining structures are reduced.

The gabion aprons are flexible. The flexible gabions can tolerate settlements and deformations unlike rigid structures. They are quite effective in reducing the degradation or scouring on downstream side. The thickness of apron depends on the turbulence of flow released from the upstream side. Gabion aprons are simpler for mild sloppy beds.

These gabions are useful in making this planet worth sustainable, reducing emission of carbon dioxide by 80%.

One of distinguished property of gabion is that it can use various material combinations as a fill. Combination of 50-50% combination of red soil and coarse aggregates has less amount of deformation.

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