Structural form and main technical requirements of Gabion retaining wall

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Abstract—Compared with the traditional retaining wall, the Gabion retaining wall has the advantages of good flexibility, strong durability and high strength. In order to better promote the application of Gabion retaining wall in highway engineering, this paper analyses the structure of Gabion retaining wall, put forward the main requirements of common materials of Gabion cage and Gabion fillings; According to the different heights of Gabion retaining walls, the requirements of foundation bearing capacity are put forward. Common foundation treatment methods are proposed for soil, stone and mixed soil and stone foundation. At the same time, the foundation drainage should also meet the corresponding requirements. The research results have been demonstrated on a highway in Guangdong province with good results.

1. Introduction

The traditional masonry retaining wall and concrete retaining wall require high bearing capacity of foundation and poor landscape effect. Some new retaining walls are important ways to realize the coordination between engineering and road environment [1]. The Gabion retaining wall is composed of stone cage and Gabion fillings. The cage is a rectangular cage made of iron wire. Each unit has the same size and is filled with pieces of stone or pebbles. Even in the case of large deformation of the Gabion, the retaining wall can still provide a better supporting role. Gabion retaining wall can adopt different combinations to form different appearances, to achieve harmony with nature, can plant vegetation beautify the slope effect.

Gabion retaining walls are commonly used abroad, such as near Wollongong in New South Wales, Australia, Gabion retaining walls on highway 95 near Ousley Hill, the Neive to Alba railway in Cuneo province, Italy, and the industrial zone in Ontario, Canada, some slopes in Hong Kong are also reinforced and protected by Gabion retaining walls. In European and American countries, the reinforcement technology of stone cage is comparatively mature [2].

In recent years, the technology has also been applied in China, and has the ability to produce high-strength, anti-corrosion stone cage structure. At present, the Gabion retaining wall is mainly used for river bank protection in China [3]. Although the gabion retaining wall has been initially applied, its theoretical study is not enough.

The application conditions of the Gabion retaining wall are: 1) the unstable section of the foundation; 2) the section with higher requirements for the landscape; 3) the section where the retaining wall site is eroded by the water flow, which leads to the settlement of the structure; 4) the
protection of the immersed embankment; 5) the slope is too large and the stability is poor; 6) the project lacks stone materials, which must be transported from other places, or cannot be used as masonry retaining wall or concrete masonry wall.

2. Advantages of gabion retaining wall
The gabion retaining wall has the outstanding advantages of good flexibility, strong durability, high strength, strong permeability, ecological environmental protection, strong reliability, low cost, beautiful appearance and so on.

(1) Flexibility
The most important advantage of stone cage is good flexibility, each unit and the whole has a strong flexibility. Each element has a different settlement deformation. The utility model is especially suitable for the section where the foundation is unstable and the retaining wall is eroded by water or waves, which results in the settlement of the structure. It can allow settlement, distortion, bending, and can adapt to different ground shapes without affecting the integrity of the structure.

(2) Durability
The stone cage is made of high-strength Wire Mesh, which is filled with hard stones. Many stone cages are connected together to form a solid integral structure, which can bear certain structural displacement and keep the structural integrity and good durability.

(3) High strength
Stone Cage with resistance to Earth pressure or water erosion force, with a certain grid tensile strength, corrosion resistance.

(4) Highly permeable
Stone cage can freely pervious, in the stone cage before and after will not produce water head, water drainage mainly rely on infiltration and evaporation. No additional drainage system is required. POROSITY is around 30. In addition, the soil can be filled in the pores between the cages, plants can grow in the cages, can also enhance drainage.

(5) Integrity
The stone cage has a unique integrity, all the elements of the cage are interconnected, when the settlement occurs, the whole cage structure may absorb and absorb part of the deformation, can minimize the impact of local damage.

(6) Ecological and environmental protection
Stone cage use natural stones to maintain stability and provide strength, and can be combined with greening, accelerate the restoration of vegetation, ecological and environmental protection.

(7) Low cost
The stone cage retaining wall is very economical, the construction is simple, the equipment needed is less, hardly needs the large-scale mechanical equipment, to the worker quality request is lower, to the foundation adaptiveness is strong, the required block stone can be natural block stone or the block stone in the abandoned side excavated by engineering. In addition, the stone cage requires little maintenance.

(8) Beauty
Compared with traditional masonry structure, stone cage can produce good visual effect. In fact, the longer the Gabion retaining wall is built, the better it will blend with the vegetation, and even be completely integrated into the surrounding natural environment.

3. The structure form and main material requirement of Gabion retaining wall

3.1. Stone cage
Stone Cage Net is generally made of twisted hexagonal wire Mesh Cage, wire diameter is based on the size of hexagonal and different [4]. The wire at the edge of the frame uses wire one size wider than the hexagonal Mesh.
In the application of Gabion retaining wall in highway construction, it is necessary to find a kind of iron wire with strong anti-rust ability to make Gabion net. After decades of application and comparison, there are two main anticorrosion methods for iron wire, zinc coating and PVC coating [5]. Gabions woven with galvanized iron wire are often used as permanent retaining structures in non-corrosive and weak corrosive environments or in Gabion retaining walls as temporary retaining walls; PVC coated gabions can be used as permanent retaining structures in polluted environments. If the landscape special requirements, you can also use the outer coating of colored resin film galvanized steel wire.

1) Galvanized wire

Galvanized iron wire is generally hot-dip galvanized iron wire, using high-quality carbon structural steel, by drawing, hot-dip galvanizing processing, galvanizing capacity is 30 ~ 300 mg/m². With a thick coating, corrosion resistance, strong coating firm and other characteristics. The suitable galvanized iron wire is selected according to the working environment of the Gabion, and the galvanized iron wire above 200mg/m² is also called heavy galvanized iron wire for the Gabion retaining wall under the condition of damp environment and riverbed.

| Wire diameter /mm | Wire diameter /mm | Weight of zinc coating / mg/m² | Weight of zinc coating / mg/m² | Weight of zinc coating / mg/m² | Weight of zinc coating / mg/m² |
|------------------|------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| 2.0              | 2.2              | 220                           | 220                           | 260                           | 260                           |

2) PVC wire

Further increase the stone cage corrosion resistance, you can use PVC iron wire. PVC IRON WIRE is made of high quality galvanized iron wire and plastic as raw materials. After deep processing, the plastic and galvanized iron wire are firmly bonded together. The thickness of PVC coating is generally 0.08 ~ 0.5 mm, with anti-aging, anti-corrosion, anti-cracking and other features, the service life is several times of hot-dip galvanized iron wire.

If PVC iron wire is used to weave the hexagonal Mesh, PVC wire of 3.0 mm to 4.5 mm outside diameter should be used.

The tensile strength of wire used for producing wire mesh of stone cage and wire binding is generally 350 ~ 500MPa.

The wire used as the binding wire shall be the same diameter and size as the wire used for weaving the Gabion, and the connection strength between the Mesh and the Mesh shall be greater than 30kN/m.

| Mesh size/ mm×mm | Ultimate tensile strength/ kN/m |
|------------------|--------------------------------|
|                  | Diameter of netting wire and lashing wire/ mm |
|                  | φ2.2 | φ2.7 | φ2.8 | φ3.0 |
| 60×80            | ≥38  | ≥44  |      |      |
| 80×115           | ≥38  |      | ≥44  |      |
| 100×120          |      |      | ≥36  | ≥38  |
| 120×150          |      |      |      | ≥36  |
3.2. Gabion fillings

(1) Flake stone

In order to fill the Gabion with flake rock, the first requirement is to have strong weathering resistance, that is, medium hard rock and hard rock with saturated compressive strength not less than 30MPA.

The size of flake stone should be decided according to the Mesh size of the cage. The diameter of flake stone is 8 ~ 30cm, and the super-size flake stone is allowed to exceed 5% of the lower limit and 10% of the upper limit. The maximum diameter of the flake should not exceed 1/3 of the height of the cage.

(2) Pebbles

The pebbles to be filled in the Gabion must be hard and clean, and the gradation should be in accordance with the following regulations: The particle size of the Gabion is about 5% from 2cm to 10cm, 15% from 10cm to 18cm, and 80% from 18cm to 30cm.

4. Requirements for foundation treatment of Gabion retaining wall

The stone cage retaining wall is usually stacked directly on the natural foundation, the foundation of the stone cage retaining wall should be levelled, the treatment can be carried out according to the requirements of the grouted chip stone retaining wall, and the bearing capacity of the foundation must meet the design requirements, the foundation of the gabion retaining wall should be inclined 6 degrees to the back. When the foundation excavation, if found that there is a discrepancy between the foundation soil and the design, it should be adjusted according to the actual situation.

4.1. Requirements for foundation bearing capacity

The gabion retaining wall is a flexible retaining structure. When the foundation deforms, the deformation will occur and coordinate with the foundation deformation. That is to say, when the non-uniform deformation degree of the foundation is small, the overall stability of the Gabion retaining wall can be ensured by its own deformation. However, when the uneven settlement of the foundation is larger than the bearing limit of the Gabion retaining wall, the retaining wall will also have larger deformation and lose its stability.

The Stone Cage Retaining Wall has strict requirements on the settlement of the foundation, and the bearing capacity of the foundation should be tested before the construction of the stone cage retaining wall, the bearing capacity of foundation should meet the requirements of different heights of retaining wall:

1) When the height of retaining wall of Gabion is less than 8 m, the bearing capacity of foundation should not be less than 150 KPA;
2) When the height of retaining wall of Gabion is 8 ~ 20 m, the bearing capacity of foundation should not be less than 200 KPA;
3) When the height of retaining wall of Gabion is more than 20 m.

4.2. Requirements for foundation treatment

(1) Soil Foundation treatment method

Before the construction of the Gabion retaining wall, the surface of the original ground should be cleaned up to remove the trees and other sundries. In general, 30cm depth of topsoil should be cleared from the cultivated land, and the hole should be filled with soil that meets the requirements of the code, and then be compacted according to the code. When the foundation is loose soil and the water content is high, the heavy compaction degree should be not less than 93% before compaction, when the strength of the original soil of the foundation does not meet the requirements, the replacement should be carried out, and the replacement depth should not be less than 30 cm. When the foundation is soil (such as gravel soil, Sandy soil, Sandy soil, clay, etc.) , it should be even and compacted, in order to improve the strength and uniformity of the foundation, it should be set up a transition layer.

(2) The treatment of Stone Foundation
It is generally considered that the stone foundation is ideal and its bearing capacity is large, which can provide better support guarantee for the stability of the Gabion retaining wall. However, it is necessary to ensure the smoothness and strength uniformity of the Stone Foundation. If it is found that there are holes and cracks in the rock layer, the opening of the cracks should be filled with cement mortar or small stone concrete, etc. If the base rock has exposed weak interlayer, should be in its cover protection.

(3) The treatment method of soil-stone mixed foundation
For the Mixed Foundation of Rock and fine-grained soil, the main problem is due to the difference of strength and bearing capacity, so the strength of fine-grained soil should be improved. The concrete treatment method is to flatten the rock and set the transition layer in the fine-grained soil. For the type of Mixed Foundation, the key of foundation treatment is to ensure its strength uniformity and smoothness.

(4) Soft ground treatment
If the bad foundation (expansive soil, saline soil, Loess, etc.) is encountered, the technical measures such as desilting, drainage and consolidation, riprap, replacement or composite foundation should be adopted to reinforce the foundation according to the specific engineering conditions. The most commonly used method is replacement.

4.3. Drainage requirements for foundations
Because the Gabion retaining wall is filled with rubble or pebbles, the pores are larger, and water can easily enter the foundation from the slope or subgrade through the retaining wall, which will wet the foundation and affect the stability of the foundation. Therefore, when the stability of the foundation is affected by surface water or groundwater in the base area of the retaining wall, the necessary measures such as drainage, interception and so on should be taken, or permeable materials such as rubble, sand gravel or block stone should be installed in the base of the retaining wall to provide a permeable layer, its thickness should not be less than 30 cm to prevent water on the foundation of the adverse effects.

5. Demonstration works
The project is based on the Guangdong section of the Daqing-Guangzhou Expressway, which has complex topography, fragile ecological environment and high requirements for ecological environment protection. Select a representative section on the highway for demonstration. Section K160 + 700 ~ + 790 of D4 is located on the slope, which is a half-filled and half-excavated roadbed with a maximum height of 11.5 m on the right side. In order to improve the landscape effect of embankment, the reinforced earth-stone cage retaining wall is adopted. The effect is shown in Fig. 3.

![Fig. 3 Field photos of Gabion retaining wall](image)

6. Conclusions
In this paper, the structural form and main technical requirements of Gabion retaining wall are analysed, the main conclusions are as follows:
1) Compared with the traditional retaining wall, the Gabion retaining wall has the advantages of good flexibility, strong durability, high strength, strong permeability, ecological and environmental protection, and strong reliability, low cost and beautiful appearance.

2) The Gabion retaining wall is composed of stone cage and Gabion fillings. General Use of corrosion resistance of strong iron wire to make stone cage net, commonly used galvanized iron wire and PVC iron wire. Gabion fillings are generally flake and pebble. The main materials shall meet the corresponding requirements.

3) The foundation of Gabion retaining wall should be level off, and the foundation bearing capacity must meet the design requirements. According to the height of Gabion retaining wall, the requirement of foundation bearing capacity is put forward. Common ground treatment methods are put forward for different ground conditions such as soil, stone and soil-stone mixed ground. At the same time, the foundation drainage should also meet the corresponding requirements.

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