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THE STABILITY OF GRAVITY RETAINING STRUCTURES

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Summary: *This paper investigates the potential for the use of gabion walls as retaining structures and their principal characteristics. The main reasons for this are many slopes and landslides made by cutting into terrains, which usually have to be secured with retaining structures. On the other hand the stability of retaining structures in flood prone areas has become a serious problem in many places. For this purpose it is necessary to apply appropriate types of retaining structures, that can address this problem. Hence, this paper presents an overview of the concept of building structures made of rectangular and hexagonal gabion types with stability control.*

Keywords: *retaining structures, gabion, stability control*

1.INTRODUCTION

The task of the retaining structures is to provide lateral support for the soil when required by the construction of a structure or by the landscaping works. In the recent period, contemporary gabion structures have been used for this purpose, apart from the classical rigid walls and flexible retaining structures. The occurrence of landslides next to the roads is a very frequent case in the snow thawing and soil defreezing periods The result of such processes is roads being covered up by soil or parts of the roads torn away from the structure. In these cases the implementation of gabions as retaining structures is

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very widely spread, because it restores the road to the original state in a quick, efficient and reliable way.
The modern gabion[1] is advantageously used for most other earth retaining structures: for hydraulic engineering works such as revetments, recovery landslides, for retaining structures next to roads, weirs and groynes. Their advantage lies in the fact that they are permeable (therefore releasing water pressures) yet have the stability of larger units then that of the individual stone size. They have a further advantage over concrete in that they are flexible and slight movement does not detract from the appearance or stability.

2. GABION RETAINING STRUCTURES

Gabions represent a special type of gravity retaining walls. They are cellular structures, i.e., rectangular cages made of zinc-coated steel wire mesh and filled with stone of appropriate size and necessary mechanical characteristics. Individual units are stacked, paired, and tied to each other with zinc-coated wire (or fasteners) to form the continuum. The only disadvantage of gabions lies in the limited life of the wire basket. This could however be overcome by re-surfacing with a new layer of gabions or mesh at a later date or using corrosion resistant wire. Fortunately this need rarely arises[1].
The choice of the materials to be used is fundamental for obtaining a functionally effective structure. In particular, the mesh must satisfy the requirements of high mechanical and corrosive resistance, good deformability and lack of susceptibility to unravel. The conventional gabion possesses some peculiar technical and functional advantages as follows:

- They are reinforced structures, capable of resisting most types of stress, particularly tension and shear. The mesh not only acts to contain the stone fill but also provides a comprehensive reinforcement throughout to structure.
- Gabins are deformable structures, which (contrary to popular opinion) does not diminish the structure but increases it by drawing into action all resisting elements as a complex reinforced structure, facilitating load redistribution.
- They are permeable structures, capable of collecting and transporting groundwater and therefore, able to attenuate a principal cause of soil instability. The drainage function is further augmented by evaporation generated by the natural circulation on air through the voids in the fill.

Gabions are permanent (and therefore durable) structures, with a virtually maintenance-free regime from effects no more severe than the natural aging of any other structure (with the exception of highly corrosive environments). Furthermore, their characteristics over time tend to gravitate toward establishing a natural state of equilibrium. They are easily installed, i.e. that deployment is possible without the aid of special equipment of highly trained personnel. This aspect is notably important on highways in river and marine reclamation, where rapid intervention to retain soil is often necessary or when post – deployment modifications are necessary[1].
The finished gabion structure, although not as expensive as concrete (about half the cost per cubic meter) is considerably more expensive than stone pitching. The stability is practically the same as that mass concrete, but is considerably better than that of tipped stone[1].

Figure 1 Gabion wall under landslide

Large gabions filled with the mixture of coarse natural and crushed stone were successfully used in consolidation of a big landslide occurring on the highway Niš - Beograd in the vicinity of the town of Aleksinac (Fig.1) in early 2013. On this occasion, a long retaining wall was made, consisting of five setback rows lining the glide plane and providing stability with their huge weight. (Fig.2). Due to the soil clearing works, construction of an adequate base structure and due to the enormous manual labor engaged for filling of the steel cages, the works continued for several months, during which period the traffic was slowed down and possible only on one lane of the highway.

Figure 2 Gabion wall

3. THE STABILITY CONTROL

Since gabions are essentially gravity structures, which rely on their weight to achieve stability against lateral forces, any increases in gravity function would entail increasing their individual masses. This solution may not only be inefficient from a material perspective, but also pose settlement problems.

Although retaining walls imply resistance to movement, some forms of horizontal and vertical walls yield are still anticipated[1]. This horizontal (sliding) and vertical movement is essentially a manifestation of the resultant pressures acting behind the wall surface[3]. The resultant pressure, P is always thought to act upon an inclined plane at a third of the wall`s height from its toe. Although its computed angle of inclination and height is specific of assumptions, depending on which classical theory was subscribed to during analysis. The fact that total resultant pressure, P, acts along an inclined plane suggests that P may be derived into its horizontal and vertical components.
Computations involved in gabion walls are no different from regular gravity earth retaining walls. During the stability control of these structures (Fig.3), it is necessary to calculate the sliding and toppling safety coefficient (factor of safety >1). As it is a simple calculation, it will not be further discussed in this paper.

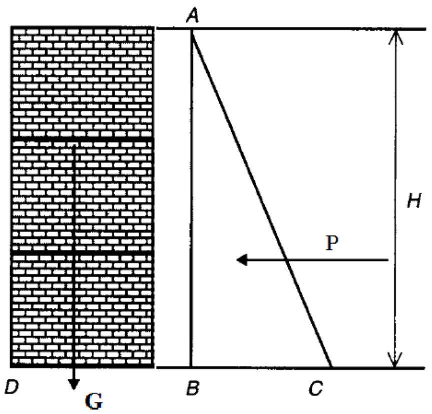

Figure 3. Gabion wall and acting forces [4]

4. SOME RESEARCH OF DIFFERENT TYPE GABION WALLS

Apart from the standard rectangular walls, some researchers and manufacturers considered other forms of these retaining structures as well. A simple observation of naturally occurring structures (bees nets or crystalline arrangement for metals) suggests that in any structural continuum, interlocking properties and individual unit shape determine overall structural properties and individual unit shape determine overall structural performance. An extrapolation of this hypothetical principal in cellular based retaining structures, e.g., gabion walls suggest the following possibility that a hexagonal-shaped gabion displays better strength capabilities as opposed to the conventional rectangular-shaped gabion.
Ramli M. & others[1] realizes experimentation investigating the hexagonal gabion`s responses to external load vis-a-vis the traditional design would be examined. They prepared 129 gabion samples for constructing the twin simulation walls, comprising 50 hexagonal units. All samples were formulated by hand, utilizing two types of bars for the

frame. Gabion samples was filling by hand, whereby selected crusher-run stones between 25 and 50 mm. Two sets of retaining walls (Fig. 5) composed of each gabion type were constructed for evaluating the mechanical responses of the conventional gabion wall versus the hexagonal wall external load. The walls were of 1.80 m height and 1.75 m width and spaced 1.8 m from each other. Each wall was build with a stepped front-face and smooth back face that reduces the wall thickness by 50% at three – fifths of wall height from its base to top.

Figure 4. Two type gabion unit[1]

Figure 5. Different types of gabion walls [1]

The basis for comparing both walls is visual deformation, i.e., changes in horizontal and vertical displacements of an arbitrary point (both walls had a matrix of 220 points on a specified number of horizontal and vertical gridlines superimposed on each wall. A digital theodolite was used to determine the horizontal displacements of all principal points as a function of their viewed angular shift[1].
Both walls were loaded with an equal load in the same combinations and at the equal heights H. The researchers monitored the deformations of the characteristic points, and after processing the results, reached certain conclusions:
The hexagonal gabion exhibits better overall structural integrity than the conventional gabion terms of deformation resistance and susceptibility to collapse. The shear behavior exhibited by each wall illustrates the principal link between unit configuration and overall stability when cellular units are built into continuum. Comparison of average deflection between both walls suggests that the hexagonal-configured wall deforms under more controlled outcomes compared to its rectangular counterpart. This invariably suggests that lateral deformation exhibited by an interlocked gabion system is more stable than a conventional paired system.

5. CONCLUSION

Numerous theoretical and practical researches up to date have shown the potential for usage of various forms of gabion retaining walls. In [1] only one possibility for usage of hexagonal gabions was dealt with in detail, where all the advantages of the model selected in this way were proved. In practice, majority of manufacturers already defined their patents in the production of steel cages of various forms. However, the downside of these retaining structures is that the filling in with the stone entails extensive manual labor which becomes increasingly expensive. Nevertheless, a large number of investors uses this type of supporting structures for various decorative purposes, as fences or as landscaping decoration. It is important to mention that in those situations, it is necessary that the bedding is well prepared in terms of evenness and compactness, so as to prevent irregular settling of these heavyweight structures, which would, in turn, mar their esthetic characteristics.

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СТАБИЛНОСТ ГРАВИТАЦИОНИХ ПОТПОРНИХ КОНСТРУКЦИЈА

Резиме: *У раду су приказане основне карактеристике и могућности коришћења потпорних зидова од габиона. Главни разлог томе су многе косине и клизишта настале засецањем терена, које се морају обезбедити потпорним конструкцијама. Са друге стране, угрожавање стабилности потпорних конструкција у подручјима склоним поплавама постаје озбиљан проблем у многим местима. С тим у вези потребно је изабрати одговарајући тип потпорног зида који ће одговорити задатом проблему. Отуда овај рад представља преглед концепта грађења потпорних конструкција од габиона правоугаоног и шестоугаоног облика са контролом стабилноти*

Кључне речи*: потпорне конструкције, габиони, контрола стабилности*