The use of gabions in hydraulic applications

**HISTORY OF GABIONS**

Using a basket containing manageable small stones, instead of a single heavy, large stone which is difficult to move, is an old concept that has been well known to mankind for a long time. First records of the use of this system go back more than 2,000 years, when the Egyptians used cylindrical willow baskets filled with small stones to protect the banks of the River Nile from erosion.

Those characteristics were maintained until the nineteenth century, when willow was replaced by gabions made of wire netting. The word “gabion” has its origins from the Italian word “gabbione”, which means “big cage”.

Officine Maccaferri was the first to undertake industrial production of gabions in 1894. The first major work using factory-made gabions was in fact in that same year in the River Reno. Gabions remain in use up to this day.

Over the years, and as technology developed, improvements to gabions have been on-going to meet the increasing demands from customers. As an illustration of such evolution, the original square, simple-twist mesh was replaced by a hexagonal double-twist mesh. The wire was also being protected by an increasingly thicker zinc layer, and also by the introduction of PVC coating.

**DEFINITIONS**

A flexible gabion structure is a combination of wire netting and stone fill. To fill the gabion, all types of durable stone can be used, preferably those with a high specific weight and good resistance to the atmospheric agents (water, wind, ice, etc).

The ideal size of stone varies between one and two times the smaller dimension of the mesh opening (see “b” in the figure alongside). The gabion void index is defined as being the percentage between the stone fill volume and the total capacity of the gabion. The use of regular dimension stones, possibly between 1 and 2 b, gives a minimum void ratio, thus providing a better distribution of the existing strains, and maximum support capability of the structure. The average specific weight for a gabion, when considering a void content between 30% and 40%, is approximately 1,700 kg/m³.
TECHNICAL AND FUNCTIONAL CHARACTERISTICS

The acceptance of gabions in various types of work for more than a hundred years is due to the following characteristics, which give gabions an enormous advantage over other possible solutions:

Monolithicity
A gabion structure is made by various elements linked through continuous fastening. The latter ensures mesh continuity and allows regular distribution of the imposed forces among the three dimensions (width, height and depth), as well as ensuring that the whole weight of a structure is equal to the sum of the weights of each element.

The settling of soil, transported by water, in the voids between stones, and the eventual appearance of vegetation, increase monolithicity, improving the static characteristics of the structure over time. Gabion works can therefore be considered as single, homogeneous and monolithic structures.

Flexibility
The constituent materials of gabions give high flexibility to the structure when compared to other types of solutions. The wire netting assures resistance to tension on the structure, which therefore may absorb loadings not predicted at the time of design. This is one of the most important characteristics of gabions — the structure deforms, but its resistance is not decreased, because while following land movements the structure maintains the same loadings on the soil.

Flexibility is particularly necessary where the work is done over unstable land or where, as in the case of rivers, there is the possibility of settlement due to erosion, or where phenomena such as swallow holes may occur.

Another advantage of flexibility is that any eventual collapse of gabion structures does not happen suddenly as in the case of rigid structures, but does so gradually and can be seen clearly, allowing for decisions to be made in good time in most cases.

Flexibility, within technically acceptable limits, therefore gives gabion structures the capability of deforming while maintaining its function, whereas rigid or near rigid structures would collapse in similar situations.

Permeability
Empty spaces between stone fill-in gabions allow fluid movement through them. For this reason gabion works are not generally affected by hydraulic pressure and therefore work much more efficiently under such circumstances. As for hydraulic works, like in canal and river bank support, gabions allow water flow in both directions, i.e. river-land and land-river, without forming an impermeable barrier.

The fact that the installation of a gabion structure does not change the usual fluid movements at the site or the physical characteristics of the adjoining soil, is of great value.

Simplicity and economy
Being simple, Maccaferri gabions do not require a skilled labour force or special equipment. Ordinary tools are usually needed, such as pliers, tweezers, crowbars and other easily available tools. Rapid construction, resulting in immediate use of the completed gabion structures, is possible, together with the possibility to easily change or enlarge the structure. It is therefore also possible to be built in stages.

Because of the standardisation of gabions it is possible to produce effective structures with only a few technical instructions. Stone fill for the work is usually easily found near the site.

Gabions also do not require special foundations, only simple levelling of the foundation, which has considerable cost saving advantages.

In some cases the only materials that need to be transported to the site are the gabions and the fastening wire, therefore reducing transport costs, especially at difficult-to-reach sites.

Versatility
Gabion structures match local needs and conditions perfectly. While they can be built using mechanical means, they are also very suited to labour intensive projects.

Theses structures can be built in any climate – low or high temperatures, drought or rainy season, and under different environmental conditions, such as in the presence of water, at remote sites, and on poor soils with low bearing capability.

If stone is not available, gabions can be filled with bags of sand or a sand-cement mix, or with concrete blocks, bricks, and so forth, and if a smooth surface is needed, the final face can be covered with mortar.

Should there be a need for a rapid integration with the local natural environment, seeds can be scattered inside the gabions.
Environmental integration

Gabion structures are the least damaging to the environment, as they are built with stone. The structure integrates with the environment over time as empty spaces between stones become filled with soil and seeds, and as vegetation grows, harmoniously covering the structure and eventually re-creating the pre-existing environment. Gabion structures therefore do not significantly change the ecosystems in which they are erected. They do not stop the natural flow of water nor the flourishing of native plant species. As a consequence they do not create any harm to biological communities, whether these be in rivers (from plankton to fish), or on land (from decomposing micro-organisms to local animals).

Social characteristics

As has already been said, because of the simplicity of the gabion method, it allows recruitment of an unqualified work force, usually hired on site, which is sometimes a far more important social benefit than the final work itself.

Durability

- Dry walls (stone walls) prove that gabion works may last for hundreds of years, even after the wire netting rusts away.
- It is important to note that, in the case of a break in any single wire, the double-twist prevents the unravelling of the mesh and movement of stones out of the gabion.
- Heavy zinc coating, or GalFan, of wires assures that eventual deterioration of the netting by rusting happens very slowly under normal conditions.
- Under severe chemical conditions or in a maritime environment, where corrosion is a more severe process, it is possible to extend wire life considerably by making use of PVC coating.
- The life of a gabion structure is not measured by wire netting durability. Experience has proved that gabions are simply receptacles for stones, necessary only to guarantee the shape of the whole structure. It is well known that after some time void spaces are filled and cemented with soil and plant roots, thus creating a uniform solid structure.
- With the passage of time gabion structures provide a natural balance with the environment so that subsequently the structure carries lighter pressures than experienced at the time of construction.
- It is possible then to say that gabion structures could be considered as permanent installations.

EXAMPLES OF GABION STRUCTURES

Gabion structures may be divided as follows:
- Support structures
- Lining structures
- Mixed structures
- Other

Support structures: These are structures which have to support loads (thrusts) either by means of their own weight or by the action of the mesh tension together with the soil reinforcement (Terramesh), or even both.

Lining structures: These are made of thin elements to cover large surface areas, for example to create a lining that would protect stable land from possible erosion. As in the case of water courses, for instance, lining structures prevent soil from the river bed from being eroded away by the force of the water. The thickness and geometric shape of the lining are calculated according to water velocity and soil characteristics. Stability and resistance in highly inclined edges and slopes are assured by anchoring the lining to the soil using stakes, thus preventing eventual slipping.

Mixed structures: These are structures in which both characteristics (support and lining) act together.

CONCLUSION

Maccaferri River Analysis (MAC.R.A.) software has been developed to provide engineers with a rapid and efficient tool with which to conduct the stability analysis of watercourse cross-sections with respect to both water flow and wave motion. A supplementary programme, GAWAC, enables the engineer to analyse the stability of the structure as a retaining wall. Additional technical information on design and applications is also available in the Maccaferri Digital library.

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