

# Study on stability of riprap sills and beds with solid transport.

Patricia Jiménez Puig

## ABSTRACT

Sills are structures that are placed perpendicularly buried in the bed of the fluvial course arranged to the direction of the flow, border to border and with level of coronation hardly superior to the level of the bottom of the river. Usually they work in group and its objective is to slow down the reduction of level of the bed due to the general erosion.

In this dissertation an alternative sets out that, guaranteeing at least the same effectiveness that the conventional sills, generates a smaller impact environmental. For it the behavior of the riprap sills in a channel of tests with sediment transport will be analyzed. The equipment is in the *Laboratorio de Hidráulica y Mecánica de Fluidos* of the ETSECCPB and is made up of a variable slope channel of 20 m of length, 0,60 m wide and 0,60 m of height, a circuit of water and another one of sediment recirculation. The material of the bed is sand of quarry of average diameter 0,722 mm and the stones of the sill have been selected from the criterion of Shields for the beginning of the movement. All the material has uniform distribution of sizes and the stones of the sills verify norms USACE on protection with riprap.

After reaching the profile of equilibrium with an approximated slope of 2,5 % introducing in the channel 10 l/s of water and 240 g/s of sediment is constructed, approximately in the centre of the channel, a sill of 0,40 m wide and minimum depth of 2 diameters. Later erosive disequilibrium are applied until the stones are unstable and begun to move being first in doing it the downstream ones. Then the critical tension of Shields for the beginning of movement will have been surpassed.

Due to the difficulty to determine where is exactly the limit between the rest and the movement, the two smaller stones of the 4 chosen, of average diameters 8,22 mm and 9,26 mm, always they surpassed the movement threshold although it was hoped at least that they remained stable in the equilibrium.

In order to be able to measure on a greater number of points in the zone of the sill photographs with a digital camera were taken and the curvilinear distortion was corrected applying the *Imcorrect* program to them, developed by group GITS. In order to measure the level of the water and the one of the bottom of the bed the program *calados* was elaborated, both in Matlab, that is based on the changes of intensity of color of pixels of an image to determine the interphases air-water, water-bed and bed-wall-plate.

The most important conclusion that it is deduced of these tests is that hole of local erosion is not generated downstream the sill. This phenomenon introduces a great advantage respect those to concrete that its durability determines this erosion to it while that the stones of the flexible structures are regrouped increasing the slope of the sill. Nevertheless in both cases the slope of equilibrium between these structures is minor who the one that would be obtained if they did not exist. It is also verified that the slopes obtained between riprap sills are straight unlike the ones obtained between concrete sills, which surely have certain curvature due to the existence of the hole.

The reduction of level of the sill is observed although it would be due to verify in future studies if the positioning of a granular filter would avoid or would diminish this reduction. In these tests the use of a fibres filter discarded because it facilitated the movement of the stones that when being given off caused the interference of the filter in the flow.

When selecting the stones with which to construct the sills is due to know a priori that reduction of level is tried to avoid and half of that reduction will be the  $D_{50}$  of the stones that will be due to place in the sill to be stable in the conditions in which this reduction happens.

In order to make the calculations of design can be used the equation of the energy and the one of momentum because both give good results although it is recommended to use the one of momentum in the cases in that the losses of energy cannot be considered well.

The comparison between the coefficient of experimental friction and the increase of tension respect the critical tension for the beginning to movement shows the existence of an additional friction due to the sediment transport.