

## **MORPHOLOGICAL ADJUSTMENTS TO HYDROLOGIC CORRECTION WORKS AND EROSION CONTROL IN A MEDITERRANEAN FLUVIAL SYSTEM: RÍO CHICO (VÉLEZ RUBIO, ALMERÍA)**

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### **ABSTRACT**

The Mediterranean fluvial systems, characterised by irregular and high intensity rainfall, are extremely vulnerable environments. These natural systems are altered by human activities, causing morphological adjustments and numerous, serious environmental problems in recent decades. A clear example of this is the river Chico, which has been submitted to an intense alteration, both hydrologic and morphologic. Dams and ripraps have been the constructions used most, although they have not always been effective, in many cases generating changes in the sedimentary flows and in the processes of erosion. On the contrary, the smaller-scale works carried out present a better integration in the riverbed, have performed well and have not provoked big local alterations. The absence or decrease of these works in the riverbed would yield a greater fluvial space, guaranteeing the recovery of the natural values.

### **MATERIAL AND METHODS.**

The study area of the river Chico has been divided into two stretches differing markedly in terms of location and morphology: I. Ravines in the head part of the river II. The river – ephemeral channel. The head stretch has a river bed in the shape of V and consists of three sub-stretches defined according to position, steepness of the ravine and works of hydrologic correction. The ephemeral channel stretch presents a slightly less embedded river bed, with a section in form of a trough and great mobility of the deep load. This stretch also consists of three sub-stretches differentiated by the type of work carried out on the river and its main morphologic effects: II.1. Upper sub-stretch,

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dominated by stone riprap protection of the margin and the alternation of small sedimentary wedges and large puddles of erosion, associated with the construction of crossings and dams for retention of sediments; II.2. Middle sub-stretch, with margins re-grown by means of soil moats and intense human occupation of the river margins, which produces serious problems of incision; and II.3. Lower sub-stretch, completely channelled, with walls of hydraulic masonry, submitted to processes of vertical sedimentary accretion in the bed.

The field works consisted principally of the description and measurement of the existing transverse and longitudinal works in the river bed, and of the recognition and delimitation of the forms of alteration of the river bed. For each of these geoforms the geometric characteristics and state of evolution have been monitored, in accordance with the distance to the structure in question, in order to determine their grade of influence. The location of the structures installed in the river bed and the delimitation of the consequent altered forms of the bed have been carried out by means of a GNSS receptor. The contours corresponding to the above mentioned forms, as well as the limits of the margins that have suffered lateral erosion and the perimeters of obstacles to the current or of certain artificial forms that affect the flood flows, have been analysed spatially by means of GIS. Thus were obtained the sectors and stretches of river bed that present different types of morphologic adjustments, regarding the site and the characteristics of every structure.

## **MAIN ACTIVITIES AND GEOMORPHOLOGICAL EFFECTS.**

The works that have been carried out recently in the Chico river are great and varied. Most of them are transverse structures for retention of sediment (dams and crossings), whose purpose is to reduce the slope of the bed and, with it, the speed of the current, the transport of the sedimentary load and thus its erosive potential. The longitudinal works (ripraps), principally designed for the protection of the margins, are also very extensive along this fluvial course.

The hardest structures are the ripraps of cemented blocks, whose mechanical resistance to the current is very superior to that of the alluvial materials of the margins; therefore, they displace the forms of erosion immediately up- and downstream of them. No less important are the effects provoked by the dams of masonry and of gabions (baskets of rectangular prismatic form with wire mesh, filled with stones blocks, sometimes extracted from the same riverbed), as well as terracing, erosion puddles, loss of lateral spurs and progressive incision of the bed. Downstream of this type of riprap, in the ravine stretch of the river, are installed ripraps - constructed along curved external margins by means of blocks of limestone rock. Their most visible effect is the formation of deep local ruts in the contact areas with the natural slope of the margin. Such installations are still present further downstream in the ephemeral channel stretch of the river (II), together with other structures derived from the human occupation of the floodplain, and even of the riverbed, and with the modification of

the transverse section of the global fluvial system. Among the last-mentioned structures, stand out, for example, the construction of moles in the middle stretch (II2) and the channelling of the lower stretch (II3). Both these works prevent the river from managing its own space, losing a large part of its natural functions and of both its lateral and longitudinal continuity.

Downstream of the moles stretch the segments with ripraps become frequent, which not only protect the low parts of the margin, but also are used as a foundation for other containment works or as reinforcement and protection of highways and paths next to the margin. There are also ripraps that shape the second line of defence, protecting the flood channel. But the most significant visual and geomorphologic effects in this stretch are due to the final channelling.

In spite of having increased initially the slope of the river bed, from 3.0 to 3.7 %, and the speed of the current, the processes of vertical sedimentary accretion of the bed dominate those of linear erosion. The effects of all these infrastructures combine with those of others that are more specific (buildings, highways, ditches, etc.) that invade the fluvial space, provoking a deep morphologic alteration of the river bed, the denaturalization of its banks and the interruption of the longitudinal and transverse continuity of its ecosystems.

## **DISCUSSION AND CONCLUSIONS .**

The intense anthropological intervention in the Mediterranean fluvial systems of the Iberian Peninsula has its maximum manifestation and geomorphologic impact in the semiarid regions. The systems of ephemeral drainage are particularly fragile to human impact, whose impact in the last few decades is evident in a very significant way through alteration of their natural balance and spoilage of their hydromorphologic quality. A clear example of this is the river-ephemeral channel Chico - submitted to an intense modification of its hydrologic regime and morphology. In this case, as in many others of the Mediterranean fringes, the activities that affect the fluvial processes correspond to three main targets: 1. Control of the erosion; 2. Prevention of and protection from floods; and 3. Use of the bed as a movement or access route.

For the control of the erosion a series of sediment retention dams and ripraps have been installed, located principally in the open-ravines river head area. Due to the extraordinary geomorphologic activity of this stretch, the above mentioned works not always have been effective, and even have supposed in many cases a deep alteration of forms and processes that affect the whole river bed, longitudinally as well as transversely (local changes of the slope, sudden changes in the hydraulic geometry, with expansion of the river bed upstream of the dams and narrowing downstream, rapid adjustments of the erosion-sedimentation balance, alternation of sedimentary wedges and large erosion puddles, appreciable modification of the load and of the transport of sediments in suspension, etc.). Similar morphologic effects have been revealed by other authors in torrential basins submitted to an intense hydrologic

modification. In particular, the changes observed in the bankfull levels before and after the dates of construction of the retention dams have proved to be an excellent indicator to evaluate the degree of narrowing downstream, derived from the above-mentioned works. A clear example of this is constituted by the new bankfull created by this type of dam along the analysed stretch. The narrowing process on the original bed begins with the formation of a large puddle on the foot of the structure, which develops downstream, associated with a tongue of alluvial effusion, composed by materials proceeding from this excavation. This fact, already stated in numerous cases, has special importance in river beds with sand beds and gravels, like that which characterises the high part of the river Chico. The bed becomes unstable and does not recover its level and balance profile until, once the dike is refilled, the longitudinal continuity of the deep transport is restored again. The texture of the materials of the bed has also suffered substantial changes in this stretch, which affect notably the roughness of the river bed and the hydrodynamic conditions of the current. The above mentioned parameter stops exercising a gradual influence as regards the longitudinal slope of the bed and very unequal values of friction are adopted according to the geoforms caused by the dams. Some of these structures, formed by gabions, have been destroyed or show symptoms of breakage, subsidence or lateral erosion, which make them lose stability - increasing the risk of sudden morphologic and sedimentary changes in the whole stretch.

Upstream of the dams the morphosedimentary dynamic is quite different. As its filling increases, the local and general slope of the river bed diminish, the deep transport capacity also diminishes and the larger materials have major difficulty of penetrating into the dam. Thus, the sedimentation model, as happens in other modified river beds with strong tractive loads, tends to become simplified from the base to the top of the sedimentary wedge; that is to say, from the initial filling phase to that of silting. The transverse works of lesser size, crossings or walls, present a better integration in the bed, which they modify slightly without creating big local alterations. On the other hand, the longitudinal works designed for the protection of the margins (ripraps and revetment walls) affect especially the sedimentary flows and the processes of lateral erosion downstream. The lateral ripraps also have an important presence in the upper stretch of the river—ephemeral channel, where many of the features of the head ravine stretch persist. The most common thing is that the constraint of the side dynamics caused by this type of structure provokes incision processes in the bed. Nevertheless, in this stretch of the river Chico the bed shows a strong superficial reinforcement, due to the presence of abundant thick material (gravels, shingle and blocks), which inhibits or prevents vertical erosion. Consequently, the energy of the current tends to accumulate in a downstream direction until the end of the ripraps - then, the high erosionability of the materials that compose the non-reinforced margins, together with the action of a locally intensive flow, produce drastic morphologic effects, often undesirable (rapid regression of the margin, local expansion of the river bed due to side erosion, collapse of the structures, digging and loss of the spurs of the dams and

crossings). Such effects are potentially dangerous when they risk the stability of bridges and highways.

In the middle stretch the main alteration is imposed by the construction of side moles that provoke a complete disconnection of the river bed and the floodplain. In the bed long ruts of linear incision occur together with areas compacted by the passage of vehicles. The final stretch, channelled in its entirety, is the most unnatural. The river bed has lost all its lateral connectivity, the base level has been modified, the slope has increased and the bed suffers a continuous vertical sedimentary accretion that necessitates tasks of 'cleaning and maintenance'. In the absence of such structures and activities (dams, crossings, ripraps, moles and channelling) the river Chico would have greater fluvial space, in which it could develop its hydrological and geomorphological functions, thus guaranteeing the recovery of its natural state.