# REMEDIAL WORKS AGAINST DEBRIS FLOWS AFTER THE 2000 FLOODS IN VALLE D'AOSTA

Paolo Di Pietro[1], Marco Tinti[2]

## BACKGROUND

In the Aosta Valley the flood event of October 2000 will be remembered as one of the heaviest events occurred over the last 250 years, in terms of destruction, loss of human lives, magnitude and spreading of the morphological changes on the territory.
The effects were by far worse than two previous flooding episodes of September 1993 and July 1996.
Further to the exceptional rainfall occurred on October 12-16, equivalent to 28-55% of the yearly average precipitations, with a peak in Cogne up to 454 mm, a vaste region of the territory went through a geological rejuvenating particularly relevant in some watersheds.
Landslide occurrences concentrated mainly among the mid reaches of the main valley. Particularly relevant were mudflows with detachment of the vegetative cover, due to their heavy debris flow and vast flooding of the conoid in the area near the village of Fenis.
Superficial landslides were followed by large debris flows ranging from some thousands of m3 to millions of m3, with serious threats to the safety of the houses and the nearby infrastructures. The villages most severely damaged were Miseregne, Fenis, Rovarey and Nus.

## OVERVIEW OF THE INTERVENTIONS

Depending on the location on the slopes, different treatments were used for the recovery works. Starting from the uphill side downwards, the interventions included flexible catch fences to prevent the large rocks from falling down from the top of the hillside.
Along the slope a combination of various consolidation works was made; firstly a series of gabion retaining works was laid perpendicular to the main slope. In order to harmonize these structures with the surrounding environment, vegetative pockets, using jute netting to hold vegetative pockets followed by a hydroseeding treatment were used.
A drainage channel was laid to control and convey the rainfall run off along the maximum gradient line. Additionally, in order to safely and better control the flow conveyance, lateral timber piles (obtained using the logs from trees chopped by the flow) and drainage works were also laid in a fishbone pattern perpendicular to the flow direction. Ultimately, to prevent surface erosion, on the upper and steeper hillside, biodegradable blankets made with natural fibers were also used, and followed by hydroseeding.
On the lower side, where the gradients are less steep, the soil surface was cleaned, and just graded and seeded.

[1] Project Manager, Officine Maccaferri S.p.A., Via Agresti, 6, 40123 Bologna, Italy
(tel. +39 051 6436000, fax +39 051 236507, email: paolo.dipietro@maccaferri.com)
2 Forestry Engineer, Geosistemi, Strada Calcini, 6/8, 14030 Castagnole M.to, Asti, Italy (tel. +39 0141 292620, email: info@geosistemi.it )

At the toe of most sites, reinforced soil embankment barriers were built with the purpose to deflect the mudflows reaching the valley bottom, protecting the housings nearby. Their height (4.5m) and overall size (slopes at 65 degrees, with a 2m top width) were designed to withstand the impact load of the debris for a design event equivalent to the one observed in October 2000.

Advantages of building reinforced soil embankments were twofold: a) compared to conventional earth filled embankments they require a limited base width (sloping the sides at 65 degrees) hence a lesser amount of fill, b) due to their ability to incorporate vegetative soil they allow a naturally green face to develop along their slopes which will soon turn the structure to blend with the natural surrounding. Furthermore, the vegetation growth will provide additional strength to the embankment through the rooting and the overall vegetation establishment. Appropriate drainage measures were also used to ensure the stability of the embankment's foundation.

## SUMMARY AND CONCLUSIONS

Since the year 2001, the training works of Fenis, Miseregne, Rovarey and Nus in the Aosta Valley were subject to constant monitoring from the local authorities. Results have been satisfactory and encouraging, because they showed that the principle of diversifying the type of structures from the top of the hillside downwards, depending on the location where the landslides originated, is a fundamental issue when dealing with vast areas subject to unpredictable and hazardous debris flows. Another positive reason was that all structures and systems used were particularly suitable for incorporation of soil bioengineering techniques. This aspect was fundamental to provide an ecologically balanced recovery.
Particularly successful in this regard were the vegetative embankment barriers which turned into green soon after the first season.
In more recent years, the ever increasing need to address debris flows issues in natural water courses, has posed the question in several other countries whether the same approach used in this project scenario may be used elsewhere for similar cases, or at least provide some sensible engineering guidance in this regard.
Since technical literature on debris flows is still un-chartered for the most part, it is believed that, as a first step, the engineering community should start sharing the knowledge gained from the field experience, as a tool to perhaps move soon into a more in-depth knowledge phase where the results from experience, the monitoring the new other projects that will come along, will provide a common working ground.

**Keywords**: Debris Flows, Drainage Works, Ecological Systems. Embankment Barriers.