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Empirical evaluations of the effectiveness of drainage systems of 13 landslides in the Northern Apennines (Italy)

G. Biavati (1)

(1) Dipartimento di Scienze della Terra e Geologico-Ambientali, Università di Bologna, Italy. (biavati@geomin.unibo.it / Phone +39 051 2094565)

Drainage systems are commonly used in mitigating unstable slopes. Tipically, they are designed on the basis of empirical observations, as the physical context is hardly supported by theoretical schemes. The prediction of their effect on pore pressure and hence slope stability has been largely discussed in literature. As physically-based models are often difficult to apply in practice, it is useful to observe the behaviour of stabilized slopes, in order to infer the role of drainage systems and improve future projects. In the Northern Apennines trenches and well drains are widely used for landslides stabilization. Approximately 80 % of Emilia-Romagna region (Northern Apennines, Italy) landslides can be classified as reactivated complex translational or multiple roto-translational slides that often evolve in slow or moderate velocity earth flows. Most of failures involve the weathered surficial horizon of clay shales formations (commonly known as “scaly clays”) because of their poorer mechanical properties respect to the underlying bedrock. Landslides usually occur (more than 90% of cases) as partial or complete periodic reactivation. Historical data on major landslides suggest that reactivations occur with relatively long return period (30-100 years). According to the Italian Landslides Inventory (IFFI, 2004), mitigation systems in the Province of Bologna consist of drains for the 75% of the analyzed cases. The present study shows cases of drain mitigation measures (trench drains and well drains) realized on 13 active landslides in the Valley of the Reno River (Bolognese Apennines). The areal extension of these landslide bodies, referred to their last reactivation phase, varies from 14.000 m2 to 700.000 m2. The influence of mitigation measures was studied by comparing the state of activity mainly through inclinometric readings and direct evidences of movements before and after the mitigation measures. The longer moni-

toring period is of 6 years. The rate of movement reduction has been compared with the distance from drains to the monitored points (inclinometers) and with the ratio between landslide shear surface depth and drain depth. In order to evaluate drain effectiveness, landslide evolution history has been considered as the most significant parameter. Two situations can be encountered: 1) for landslides in a very slow and constant rate stadium of movement (mm/month), a comparison between movements previuos and after the settlement of drains is feasible: analysis of available data shows a decrease in velocity; 2) if a slow or moderate movement (m/month) has recently occurred, the study on the effectiveness of mitigation needs a longer monitoring period. To check drains efficiency, their water discharge has also been considered. The effectiveness of drains on landslide hydraulic conditions has been more thoroughly evaluated considering the pore pressure readings collected with transducers before and after performing the drains on the Castiglione dei Pepoli landslide. The collected data show a marked decrease in pore pressure values in the very near of the drains. In order to confirm the observed trends and evaluate also the drain distance of influence both on rate of movement and on pore pressure, a specific monitoring campaign is requested for future research.