



Deep shafts (dowels) as an effective structural mitigation measure on large landslides in Slovenia

B. Pulko (1), **M. Mikos** (1), R. Fazarinc (2), A. Petkovsek (1), B. Majes (1)

(1) University of Ljubljana, Faculty of Civil and Geodetic Engineering, Ljubljana, Slovenia,

(2) Water Engineering Ltd., Ljubljana, Slovenia (matjaz.mikos@fgg.uni-lj.si / Fax: +386-1251-9897)

Large and deep-seated landslides ask for heavy constructions that stabilise such unstable slopes. Usually, this kind of structures cannot be built in fast moving landslide masses. One option is to build them during dormant phases of a landslide (dry periods without rain or cold winter time). The other is to slow down the landslide movement to be able to build large supporting structures, such as supporting walls or similar concrete structures. In order to slow down a fast moving landslide (> 10 cm/day) it is often necessary first to drain surficial waters by a drainage system and then to lower groundwater level. The latter measure can be done by digging deep drain trenches. They may go as deep as 6 to 8 meters in rather wet soils, where we should not use additional berms in order to dig deeper. In the case of deep-seated landslides (> 10 m deep), such limited depths do not allow us to come to the sliding surface to efficiently slow down the landsliding. In such cases deep shafts (dowels), known from road construction as a kind of supporting structure for large viaducts and bridges, may come under consideration. Their advantage is that once they are built, they are retaining as well as draining structures. We used them on two large landslides in Slovenia: the Macesnik and the Slano Blato Landslides, respectively. We built two shafts on the former and three on the latter one in order to stabilise the upper part of these over 1 km long landslides with a total volume of the order of 1 mio m³. The shafts were made out of armoured concrete, 5 m in diameter and over 20 m in height in order to reach the sound rock below the sliding surface. For their design the field and laboratory data on geological conditions as well as landslide material properties were used in a numerical model to estimate design loads. Under such labile conditions, their construction was a challenge, but they proved as effective structural measure to stabilise the two

large landslides in their upper part. This fact was proven by a clear decrease of measured displacements of the landslide masses after their completion. Further shafts are planned to be constructed on both landslides in order to gradually stabilise the whole landslide. Even though they were built as a temporary measure, they are definitely part of the final remediation.