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Stepwise mitigation of the Macesnik landslide, N Slovenia

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Abstract. The paper gives an overview of the history of evolution and mitigation of the Macesnik landslide in N Slovenia. It was triggered in 1989 above the Solčava village, but it enlarged with time. In 2005, the landslide has been threatening a few residential and farm houses, as well as the panoramic road, and it is only 1000 m away from the Savinja River and the village of Solčava. It is 2500 m long and up to more than 100 m wide with an estimated volume in excess of 2 million m^3. Its depth is not constant: on average it is 10 to 15 m deep, but in the area of the toe, which is retained by a rock outcrop, it reaches the depth of 30 m. The unstable mass consists of water-saturated highly-weathered carboniferous formations. The presently active landslide lies within the fossil landslide which is up to 350 m wide and 50 m deep with the total volume estimated at 8 to 10 million m^3. Since 2000, the landslide has been investigated by 36 boreholes, and 28 of them were equipped with inclinometer casings, which also serve as piezometers. Surface movements have been monitored geodetically in 20 cross sections. This helped to understand the causes and mechanics of the landslide. Therefore, landslide mitigation works were planned rather to reduce the landslide movement so that the resulting damages could be minimized. The construction of mitigation works was made difficult in the 1990s due to intensive landslide movements that could reach up to 50 cm/day with an average of 25 cm/day. Since 2001, surface drainage works in the form of open surface drains have mainly been completed around the circumference of the landslide as the first phase of the mitigation works and they are regularly maintained. As a final mitigation solution, plans have been made to build a combination of subsurface drainage works in the form of deep drains with retaining works in the form of concrete vertical shafts functioning as deep water wells to drain the landslide, and as dowels to stop the landslide movement starting from the slide plane towards its surface. Due to the length of the landslide and its longitudinal geometry it will be divided into several sections, and the mitigation works will be executed consecutively in phases. Such an approach proved effective in the 800 m long uppermost section of the landslide, where 3 parallel deep drain trenches (250 m long, 8 to 12 m deep) were executed in the autumn of 2003. The reduction of the movements in 2004 enabled the construction of two 5 m wide and 22 m deep reinforced concrete shafts, finished in early 2005. In Slovenia, this sort of support construction, known from road construction, was used for the first time for landslide mitigation. The monitoring results show that the landslide displacements have been drastically reduced to less than 1 cm/day. As a part of the stepwise mitigation of the Macesnik landslide, further reinforced concrete shafts are to be constructed in the middle section of the landslide to support the road crossing the landslide. At the landslide toe, a support construction is planned to prevent further landslide advancement, and its type is still to be defined during the procedure of adopting a detailed plan of national importance for the Macesnik landslide.

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1 Introduction

The mitigation of large and deep landslides is a complex task. After their triggering, some important steps should be made before effective technical mitigation measures can be performed in the field. First, if necessary, any immediate relief actions should be carried out in order to save lives and keep damage as low as possible. If the damage potential (buildings, infrastructure, land) is present and if the first assumptions of the causes show a possible technical mitigation, field observations and measurements should be carried out. The most common field investigations and measurements can be divided into surficial investigations (engineering geologic survey and mapping, geodetic measurements, geophysical measurements, measurements of surficial deformations on the landslide surface, etc.), and subsurface investigations and investigations in boreholes (ground water table measurements in piezometers, measurements for

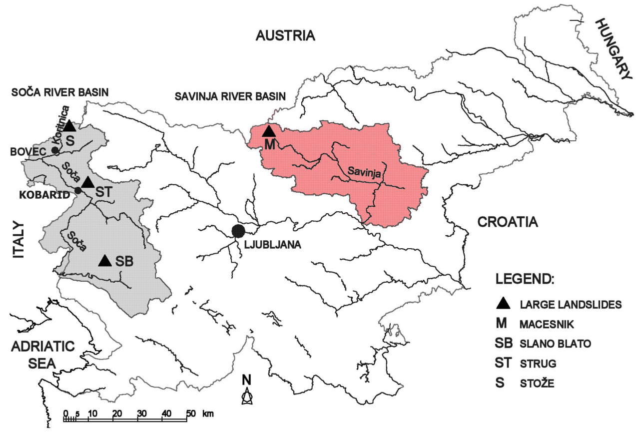

Fig. 1. The position of the Macesnik landslide in the Savinja River basin.

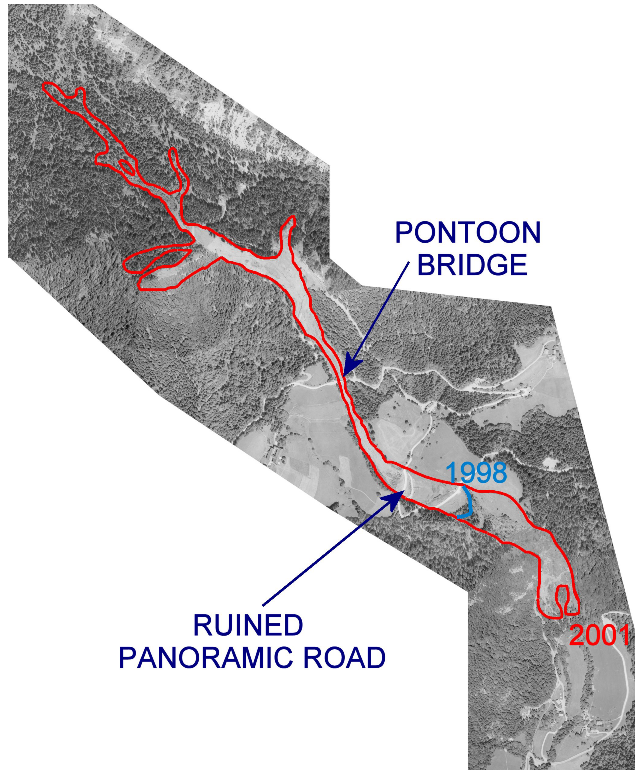

Fig. 2. Aerial view of the contours of the Macesnik landslide in 1998 and 2001.

determining the depth of sliding, measurements with inclinometers, water permeability tests, geomechanical tests on the cores, in situ geomechanical tests, etc.) (Ribičič and Mikoš, 2002).

Having collected sufficiently detailed field data, planners can first select the types and design of mitigation works and then assure the needed budgeting and the construction of planned mitigation works. This is followed by the final step of landslide mitigation, which is the assessment of the effectiveness of the landslide mitigation works.

The landslide mitigation works may be classified into two categories, namely control works and restraint works (SABO, 2005). The control works involve modifications of the natural conditions of landslides such as topography, geology, ground water, and other conditions that indirectly control parts of the entire landslide movement. The restraint works rely directly on the construction of structural elements.

The landslide control works involve measures such as surface drainage control works (drainage collection works and drainage channel works); subsurface drainage control works, which may be shallow (i.e. interceptor under drains, horizontal gravity drains, interceptor trench drains) or deep (horizontal gravity drains, drainage wells, drainage tunnels); soil removal works (mainly performed in the head part of small to medium size landslides); buttress fill works (mainly soils from soil removal works used in the lower part of a landslide as a counterweight to the landslide mass); river structures (i.e. check dams, ground sills, or bank protection to stop channel degradation or bank erosion).

The landslide restraint works involve measures such as small diameter pile works (i.e. driving steel piles filled with concrete); large diameter cast-in-place pile works (i.e. piles with several m in diameter filled with reinforced concrete); anchor works (anchored thrust blocks); retaining wall works (crib walls instead of conventional concrete retaining walls used for small and secondary landslides).

Also in other general mitigation strategies (e.g. U.S. national strategy, Spiker and Gori, 2000), dewatering of the landslide is a key mitigation measure, which must be continuously well maintained. This important aspect should not be overlooked in order to ensure the longevity of the mitigation works. Nevertheless, drainage wells have been widely used as a landslide control work, quite often in combination with horizontal drain borings in order to drain groundwater even more effectively (Nakamura, 1988; Wichter et al., 1988; Beer et al., 1992; Peila et al., 1992; Tsao et al., 2005; Shou and Chen, 2005).

For large landslides the planned mitigation works are normally a combination of different control and proposed restraint works, and their construction is rather timely and physically complex, usually executed in phases. In the paper, a stepwise mitigation of the Macesnik landslide, triggered in N Slovenia in 1989, is presented as an example of such a mitigation approach.

2 The evolution of the Macesnik landslide

The Macesnik landslide above the village of Solčava (642 m a.s.l.) near the border with Austria in N Slovenia is named after a nearby farm house holder. It was triggered in 1989 on the south slopes of Mt. Olševa (1929 m) in the headwaters of the Jurčef Torrent, during a wet period causing large flooding in the Savinja River basin (Fig. 1). It was the first large landslide in a row of large landslides triggered in Slovenia in the last decade and a half. Because

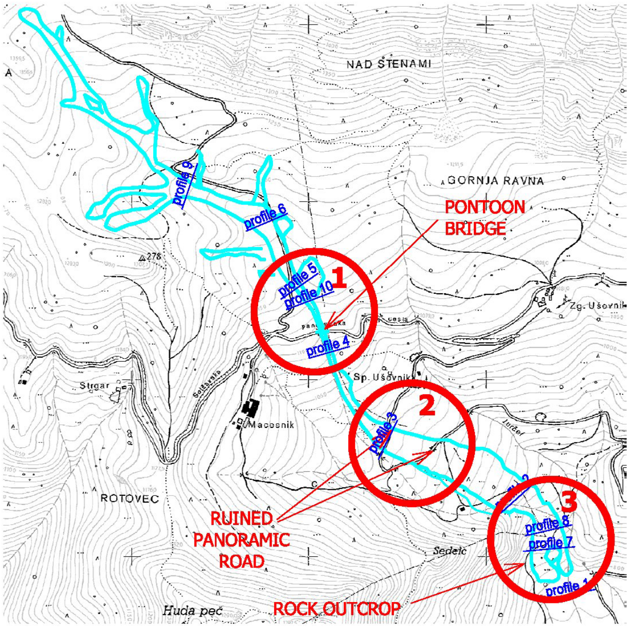

Fig. 3. Topographic map of the Macesnik landslide with the contours of the landslide and cross sections ("profiles") for regular measurements of the surface displacements.

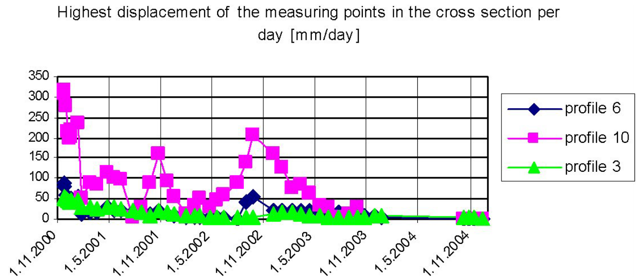

Fig. 4. Time distribution of the surface displacements of the Macesnik landslide in the period 2000–2004 in three cross sections (profile 6 – in the upper part of the landslide, profile 10 – in the area of the pontoon bridge, and profile 3 – in the area of the turn on the panoramic road).

it was triggered on a forested slope above 1200 m a.s.l., it had initially no direct influence on the residential buildings, farm houses and the local infrastructure. For this reason, till 1994 no remediation activities were underway in the landslide area. In the period between 1994 and 1998, the landslide enlarged, partially retrogressively into the hinterland, and it especially advanced on the slope. Surficial drainage of the landslide by earthen ditches and prefabricated concrete "canalettes", carried out and maintained in this period, was unsuccessful and did not help to stabilise or at least slow down its advancement (Vlaj and Žigman, 2001). Consequently, the landslide destroyed the state road (called Panoramska cesta) Solčava (642 m) – Sleme (1308 m) at the altitude of ca 1110 m, and a new pontoon steel bridge had to be built instead. In 1996, the landslide advanced again and destroyed a turn on the same state road at the altitude of 1000 and 980 m, respectively (Fig. 2). In 1999, its further advancement was stopped by a large rock outcrop. In 2005, the toe of the landslide has stayed at the altitude of 840 m (Fig. 2), and the landslide crown is situated at the altitude of 1360 m. Its present length is 2500 m with a width of 50 to 80 m in the upper part and well over 100 m in the lower part. As a precaution measure, a mechanical alarm system was established below the landslide toe and connected to the regional early warning and alarm center in Celje.

The damage on the cultivated land (forest, pastures) was considerable and was estimated at 0.5 Mio Euro. Until early 2005, around 5.0 Mio Euro was invested into the mitigation of the Macesnik landslide. The proposed final mitigation works as described in this paper will call for an additional 11.0 Mio Euro.

Below the landslide toe, a captured spring for the local water supply of the village of Solčava was placed under imminent threat, and several times the water in the system was found to be turbid and above the allowed limit of 2 NTU. Furthermore, the Macesnik landslide cut off the planned new water supply line from the springs below Mt. Olševa. Due to this situation, plans were made for another spring captation away from the landslide area to the west of the village of Solčava (300 inhabitants, effective water consumption of 20 l/s), which would be put into function for the local water supply. Apart from the mentioned state road and problems with water supply, no other vital infrastructure was destroyed. Despite that, the regular maintenance costs of the state road (occasional levelling of a road turn by crushed material) are high, but necessary, since for many farmers living at altitudes up to above 1300 m a.s.l. the road presents the shortest way to the Savinja River valley. Furthermore, the advancement of the landslide should be effectively stopped, not merely restricted, since it may destroy three farm houses located only 300 m below the present toe. Even the way along the Jurčef Torrent to the Savinja River and the village of Solčava is open and only another 800 m long. Possible damming of this large alpine river would cause a catastrophic flooding.

3 Field investigations and results

More intense mitigation of the landslide started in 2001, after a special law on large landslides was adopted in the Slovenian parliament, thus given fresh financial support. Immediately, the first systematic engineering geologic and geotechnical investigations on the landslide started. From then on regular measurements of the landslide surface displacements in selected cross sections across the landslide have been performed using classical surveying equipment such as laser distometer and reflectors (Fig. 3). The purpose of these regular measurements was on the one hand to follow the landslide dynamics, and on the other to be able later to prove the effectiveness of the planned remediation measures. Due to execution of remediation works in the field, some cross sections

Table 1. Relevant data on the landslide depth and the landslide base inclination are given by reaches.

Reach	Elevation (from – to)	Reach length (m)	Average base inclination (°)	Landslide depth (m)	Remarks
1	1360–1295	300	12	5–6	–
2	1295–1240	220	13	6–8	–
3	1240–1225	110	11	5–6	–
4	1225–1130	650	10	6–9	The pontoon bridge at the end
5	1130–1055	240	18	12–14	–
6	1055–1005	180	15	12–14	–
7	1005–990	85	9	12–14	Upper part of the turn on the panoramic road
8	990–940	235	15	14–24	Lower part of the turn on the panoramic road
9	940–840	300	13	18–24	–
10	840–810	40	–	–	Rock outcrop
11	810–800	60	10	7–9	–

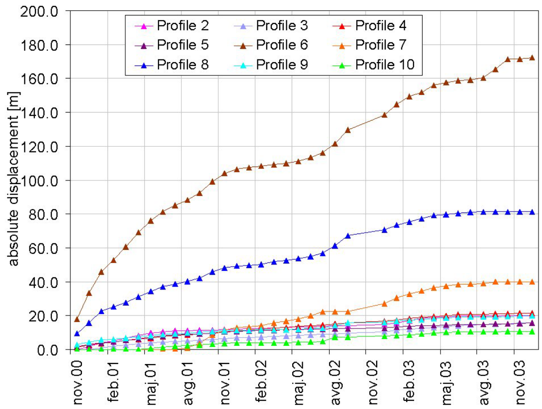

Fig. 5. Absolute displacements in measuring cross sections on the Macesnik landslide (see Fig. 3 for the position of cross sections).

were occasionally destroyed, and the number of measured cross sections changed in time. The time distribution of the surface displacements of the Macesnik landslide in the period 2000–2004 in selected cross sections (in the upper part of the landslide, in the area of the pontoon bridge, and in the area of the turn on the panoramic road) is given in Fig. 4. The mitigation works were made difficult in the past due to intensive landslide movements that reached up to 50 cm/day with an average value of 25 cm/day. This corresponds to the landslide moderate velocity class (4) after Cruden and Varnes (1992). An analysis of local precipitations, measured in the rainfall gauging station in the village of Solčava, showed a good correlation of the landslide displacement intensities and rainfall (Mikoš et al., 2005).

In several phases, all together 36 boreholes were drilled at and around the landslide. At the landslide, the majority of them remained intact only for a limited period of time due to intense displacements. Using boreholes data the total volume of the activated landslide was estimated at 2.5 mio m^3. The investigation proved that the Macesnik landslide was triggered within a much larger fossil landslide. This one was up to 350 m wide and up to 50 m deep with a volume estimated at 8 to 10 mio m^3. Taking this figure into account, around one quarter of the volume has been actived, leaving the possibility of future widening and deepening of the Macesnik landslide. Therefore, its fast remediation (inactivation within the present framework) should be even more stressed.

Out of 36 boreholes, 28 were equipped with inclinometer casings, which also served as piezometers. The borehole data were used to estimate the inclination of the base of the landslide and its depth along the landslide, as given in Table 1. The changes in the inclination of the landslide base (point data from boreholes) on the one hand explain the higher landslide depths (material accumulation) where the inclination dropped, and on the other hand different landslide dynamics (different relative displacements) as measured at its surface in the selected cross sections (Fig. 5). The highest displacements were measured below the pontoon bridge where there is a narrow section of the landslide and a sudden increase of the base inclination due to slope change.

Data from the drilling cores show that the sliding mass was heteregeneous, mainly dark-grey stiff clay with layers of more permeable clayey gravels of different thicknesses at different depths. This interpretation was supported by the local engineering geologic map. In the investigated area, the following rock types were determined (Fig. 6):

1. Carboniferous siltstone, claystone, and sandstone with lenses and interbeds of quartzy conglomerate and limestone ("C").

2. Lower Triassic shale, siltstone, claystone and mud ("T_1"); Middle Triassic ("T_2") and Upper Triassic limestone and dolomite ("T_3").

3. Oligocene siltstone and tuffaceous shale ("Ol").

4. Quaternary talus slope and deluvium ("Q").

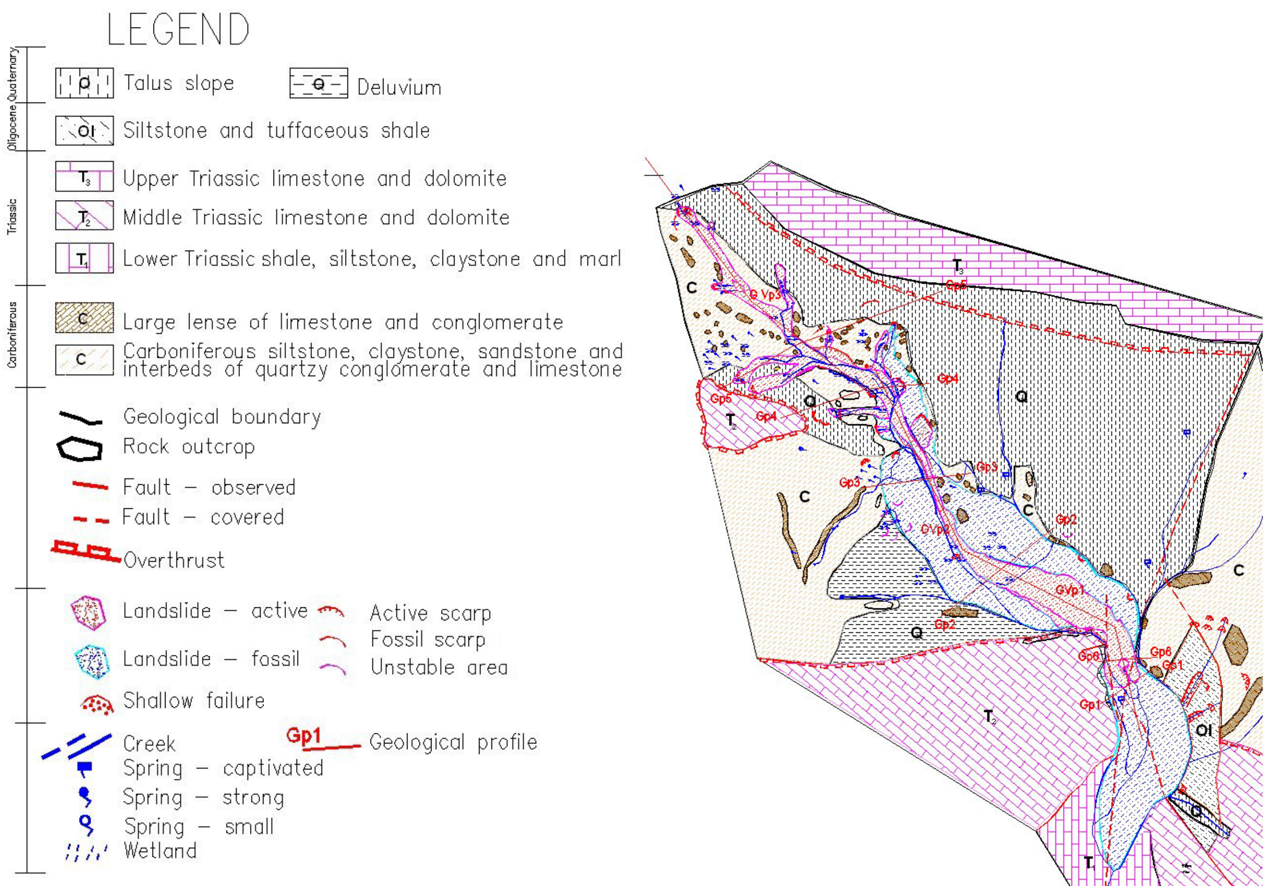

Fig. 6. Engineering geological map of the Macesnik landslide with a legend (modified from Vlaj and Žigman, 2001).

4 Planning and execution of the mitigation measures

Not knowing the exact values of water pressures on the sliding surface, one should plan the needed mitigation measures (such as lowering of water pressures and support structures) in a long and narrow landslide with increasing depth only in "ideal" conditions prevailing in separate landslide reaches (see Table 1). On the basis of the data from Table 1 it was concluded that:

- Lowering of ground water pressures by deep drainage trenches filled with gravels is technologically possible (up to the depth of 8 m) only in the upper part of the landslide above the pontoon bridge.

- The sequence of restraint structures on such a long landslide should be planned in such a way that there would be no overtopping by sliding mass from above or subsidence and sliding of mass away from the structures.

- On the basis of all the executed field and study investigations, field measurements, and field experiences, the planned mitigation of the Macesnik landslide will follow the division of the landslide by restraint and drainage works into 3 areas (Fig. 3):

  1. Upper part of the landslide with the area above and around the pontoon bridge (Fig. 7);
  2. Middle part of the landslide around the road crossing with the panoramic road (Fig. 8);
  3. Lower part of the landslide around and above the rock outcrop that temporarily stopped further landslide advancement (Fig. 9).

- Support structures should be formed by grouping several deep shafts made of reinforced concrete with supportive (as dowels founded in the stable ground below the slide plane) and drainage functions (as deep water wells). The supportive function of such a structure is well known in road construction (i.e. as part of a bridge), where it has so far been used only on stable slopes, taking only axial loads and no bending moments of a sliding mass.

In 2002, the execution of the proposed mitigation measures mentioned above started from the upper part of the landslide in the downslope direction. In the upper part of the landslide above the pontoon bridge surficial peripheral surface drainage works were constructed, when possible, on stable ground around the landslide body (Fig. 10). On stable grounds a riprap made of up to 4 m^3/m' of pitched stones

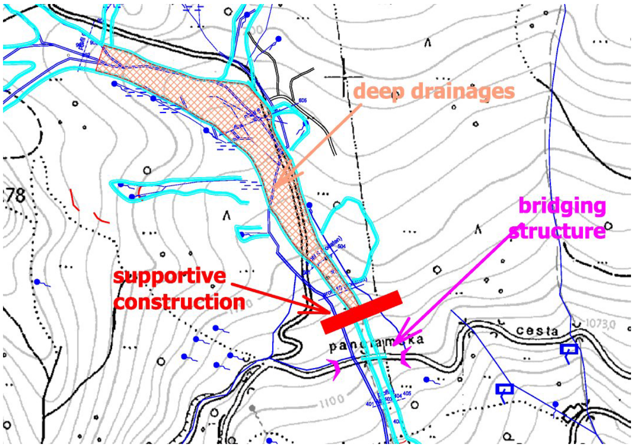

Fig. 7. Proposed remediation measures in the landslide area above and around the pontoon bridge.

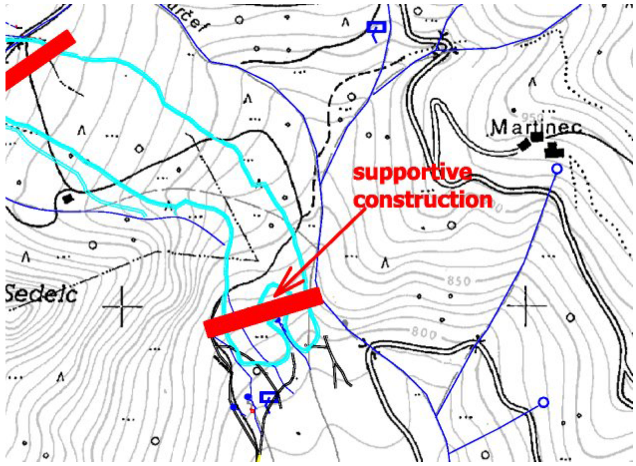

Fig. 9. The proposed location of a supportive construction around the rock outcrop at the toe of the Macesnik landslide.

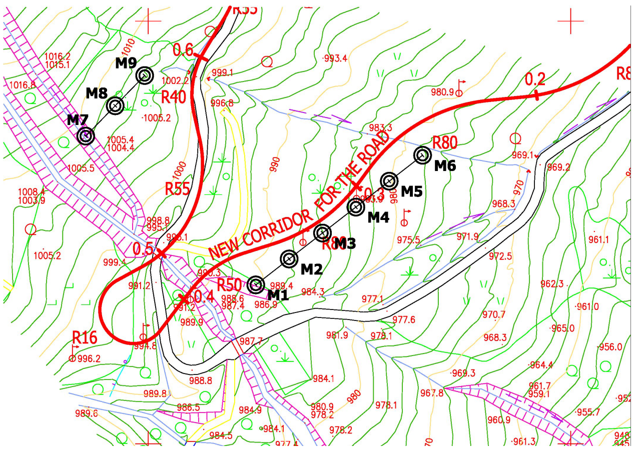

Fig. 8. Ground map of the middle part of the Macesnik landslide with a new corridor for the panoramic road and the proposed wells in two lines (M1–M6 & M7–M9).

Fig. 10. Executed peripheral surface drainage at the western landslide edge above the prefabricated bridge.

larger than 0.8 m was used to protect the drainage channel works, both on the channel bottom and on the channel banks, from high shear stresses of torrential flow at longitudinal slopes in excess of 60%. The conveyance of these channels was between 9 m^3/s and 15 m^3/s and was designed to be higher than the 100-year discharge (up to 6 m^3/s). Mainly the constant slope of the channel parallel to the ground was chosen, and only locally low sills were built for additional energy dissipation (Fig. 11). Due to the natural turbidity of water conveying fine silt fractions no impermeability of the drainage channels was sought for. On unstable grounds, half concrete sewer pipes and PEHD pipes were installed as a combination of drainage collection works and drainage channel works. They were sufficiently flexible to make the occasional but necessary maintenance easier. During the final phase of the mitigation these half pipes will be removed and replaced by ordinary riprap protecting the drainage channels. The collected surficial drainage water was conveyed to the natural channels of the Jurčef Torrent and its branches in its headwaters.

In summer 2003, above the pontoon bridge, subsurface drainage works in the form of 3 parallel deep drainage trenches filled with gravels (Figs. 12 and 13) were constructed to collect ground water and decrease the ground water table. The main aim was to slow down the landslide displacements in the area and to make possible the execution of planned restraint constructions above the pontoon bridge. In spring 2004, in the upper part of the landslide two additional deep drainage trenches were constructed (Fig. 14).

The deep drainage trenches were excavated to a depth of ~8 m, that is, to the impermeable rock layer. First, longitudinal trenches 3 m deep and 5 m wide at the bottom were dug with the slope of 1:1. Part of the removed material was transported to a dumping site, and part of it was stored close to the construction site and later used for the levelling of the landslide surface (Fig. 15). The digging of the trenches to the final depth of 8 m was executed in 6 m long sections. The vertical excavation was protected using 1-m wide hydraulic panelling. The drainage was executed using PEHD pipes

Fig. 11. Detail of the surface dewatering system on the stable grounds above the panoramic road – channel with a longitudinal slope of around 30%, protected with rip rap.

DN 400, filled with a gravel filter of 32–64 mm. The filter material together with the pipe was wrapped into a filter geotextile with a minimum tensile strength of 20 kN/m and with pores <0.15 mm. Near to the local springs, additional transversal drainage ribs were introduced. The measured average amount of drained water from the completed drainage trenches was between 1.5 and 3 l/min or between 2.16 and 4.32 m^3/day.

The landslide above the pontoon bridge was slowed down to such an extent (Fig. 4) that between the pontoon bridge and the lower end of the deep drainage system (Fig. 7) two 22 m deep reinforced concrete (RC) shafts were designed and installed in late 2004 and early 2005 (Fig. 16). Because each shaft should have a twinfold function, i.e. a supportive function (dowel-like, Fig. 17) as well as a drainage function (like a deep water well), the following requirements had to be fulfilled during the design and execution:

– The depth into the solid rock below the sliding surface should be at least 20% of the total shaft's depth (Fig. 18).

– The primary coating (during digging) should take all loads of the landslide (F≅1.10).

Fig. 12. Execution of deep drain trenches.

Fig. 13. Detail of deep drain trenches.

– The primary coating of the shaft should be adequately perforated so that ground water could infiltrate into the central part of the shaft – to ensure its function as a deep water well.

– The primary coating of the shaft should be separated from the landslide masses by using an adequate geosynthetic material. From it the water should be able to enter

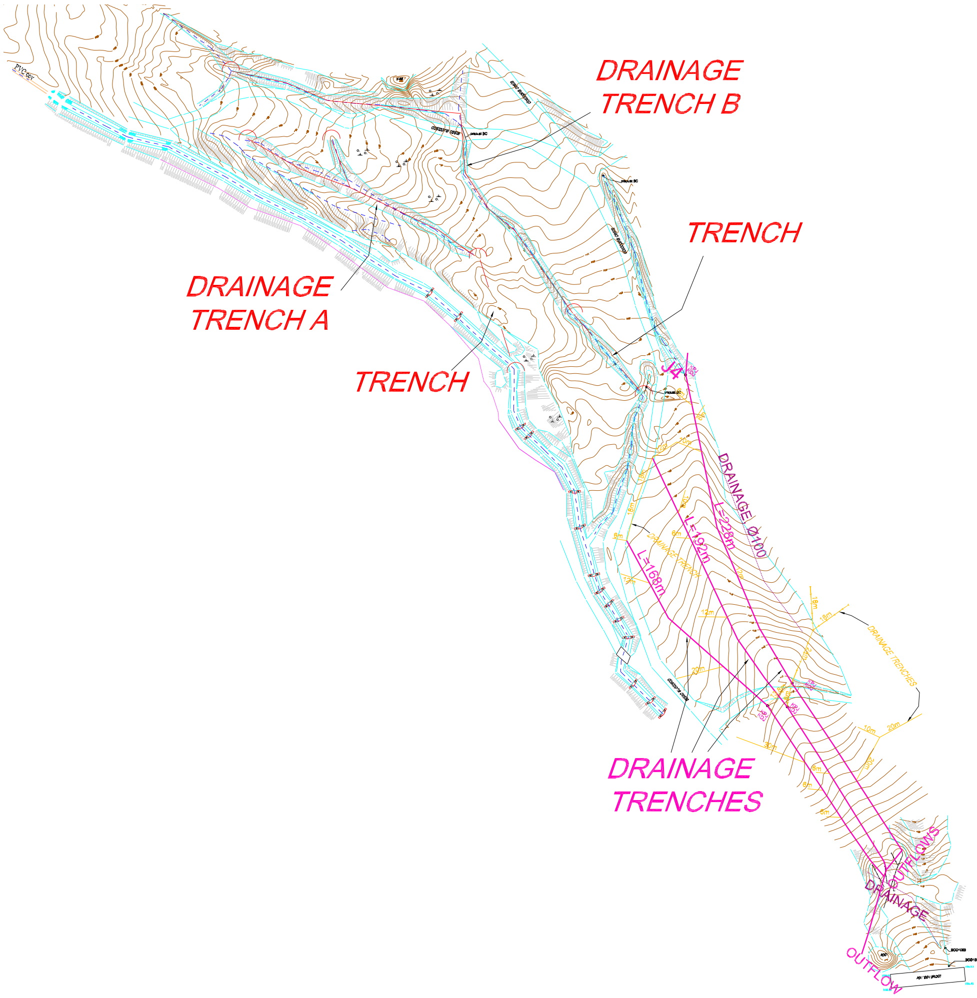

Fig. 14. Deep drainages built in 2003 and 2004 to slow down the landslide displacements and to make possible installation of a supportive construction (isolines are given for 1 m).

Fig. 15. Stabilised part of the Macesnik landslide above the pontoon bridge by introducing several deep drainages and peripheral and central surface drainage.

Fig. 16. Execution of a RC well just above the pontoon bridge.

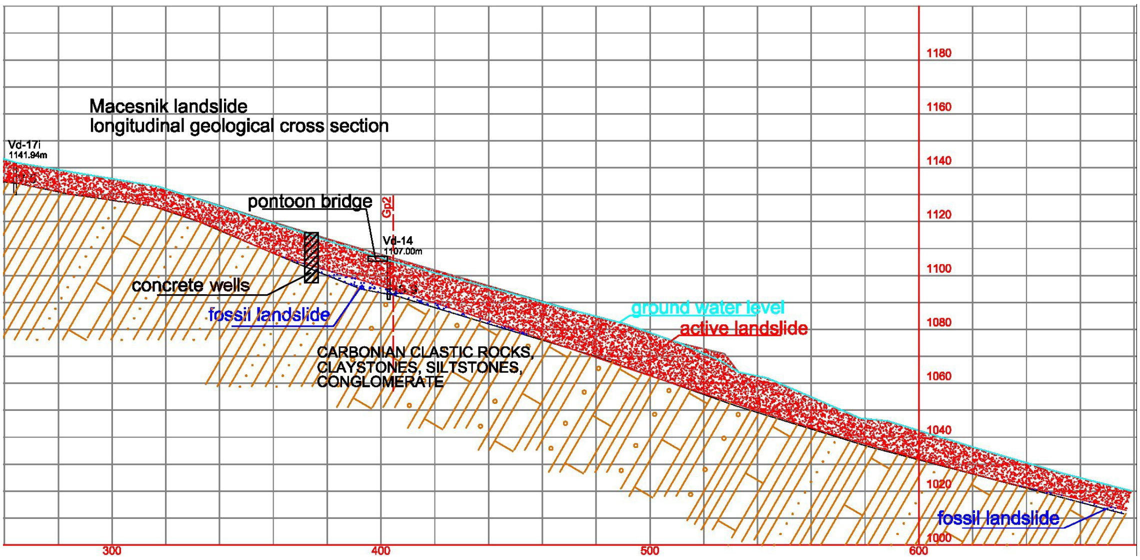

Fig. 17. The Macesnik landslide geological longitudinal profile "Gvp2" (see Fig. 6 for location) in the area of the pontoon bridge.

the central part of the shaft through the perforations of the primary coating.

– After digging out the shaft and completing its primary coating with a thickness between 30 and 50 cm to the prescribed depth, the installation of a reinforced concrete foundation plate would follow.

– The prescribed safety factor for the shaft (F>1.25) will be reached only after the execution of the reinforced concrete secondary coating with the thickness of 80 cm.

– From the central part of the shaft an outlet pipe (horizontal drainage) should be installed in order to make possible the gravitational outflow of infiltrated water from the well.

The RC shafts were executed in two phases. First, from the ground surface to a depth of 22 m in steps of 1 m, the primary coating was done. This was separated from the landslide mass by a drainage composite (Enkadrain). The outflow of the drained water from the drainage composite into the shaft was enabled through openings in the primary coating and at every 5 m of the depth to a separate circumferential drainage (Fig. 19). For the drainage PEHD pipes DN 125 were used and reinforced by steel rings. The height of a single ring of the primary coating was 1 m, the thickness of the ring was 30 cm at its top and 20 cm at its bottom, respectively. The dimensions of the rings of the primary coating, the concrete quality and the reinforcement were computed in such a way that the primary coating would take over all the loads from the landslide mass at the computed safety factor F=1.05. In the second phase, the 4 m thick concrete foundation plate and the 80 cm thick concrete secondary coating of the shaft were completed.

On the basis of the performed stability analyses (Plaxis® 3-D; computational mesh on Fig. 20), for each RC shaft with

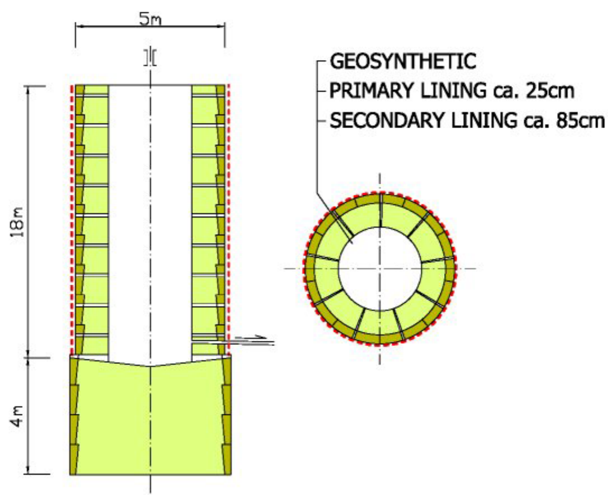

Fig. 18. Vertical cross section of the RC well.

a diameter of 5 m, concrete walls of the thickness of 25 cm (primary lining) respectively 80 cm (secondary lining), and the length of 22 m (18 m of the landslide mass and 4 m of rock base) the following maximum loads were determined:

– axial forces 4350 kN

– bending moments 37 650 kNm

– shear forces 9160 kN

– maximum contact (compressive) stresses 1540 kN/m^2.

The total allowed loads for the RC shaft were determined using the 10 m axial distance between both shafts and the total landslide width of 30 m in the cross section where shafts were constructed. In the stability analyses of the secondary

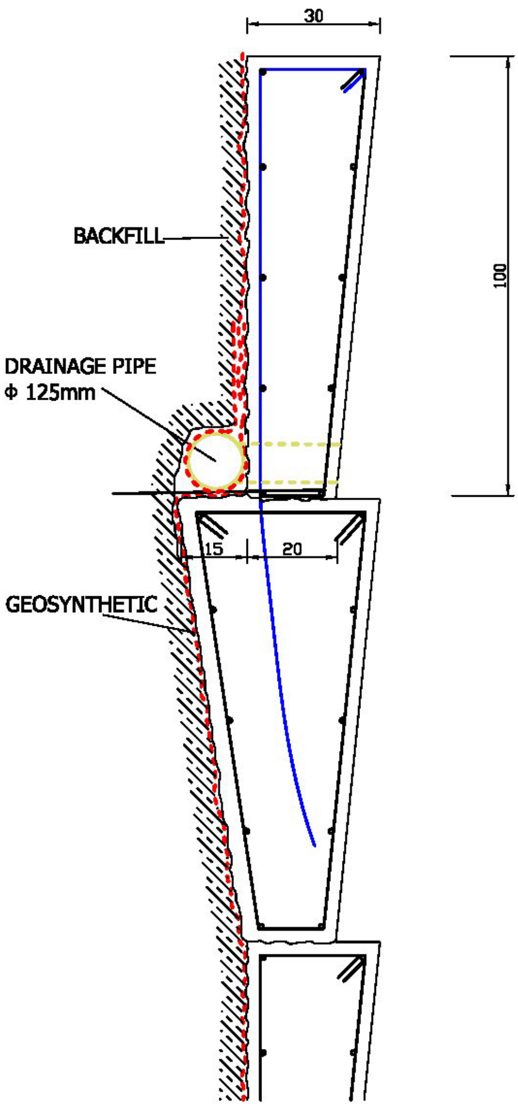

Fig. 19. Detail of the RC well.

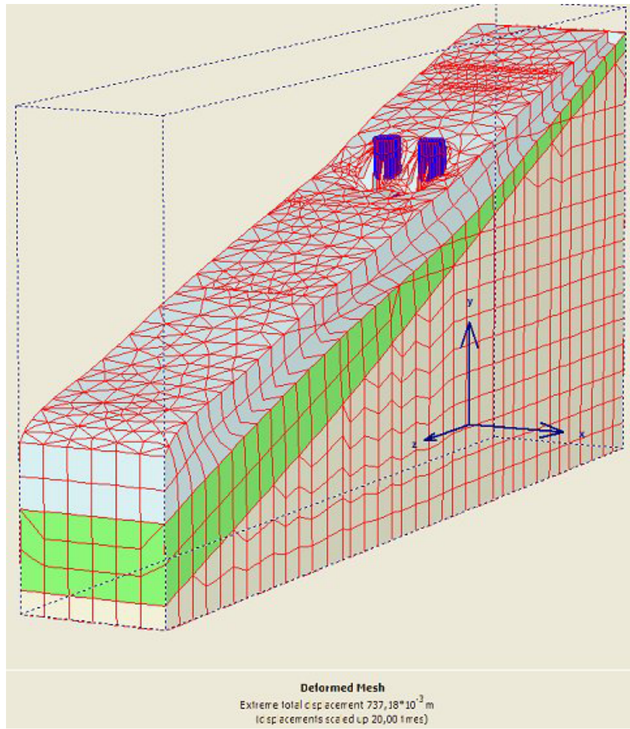

Fig. 20. Computational mesh and deformation of the RC well.

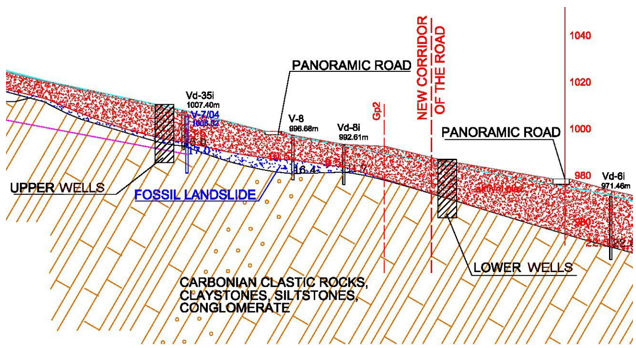

Fig. 21. The central longitudinal section of the Macesnik landslide with the new corridor for the panoramic road and the proposed wells.

coating the landslide depth of 16 m and the total soil saturation were taken into account. The full soil shear strength (φ'=24.6° and c′=1 kPa) was used, multiplied by the safety factor of F=1.35 (Eurocode 7).

The executed remediation (stabilisation) measures in the upper part of the Macesnik landslide (above the pontoon bridge) made it possible for the landslide displacements in this part to be slowed down to less than 1 cm/day. This corresponded to the landslide slow velocity class (3) after Cruden and Varnes (1992). Furthermore, also displacements in the lower two parts of the landslide effectively slowed down, but stayed in the moderate velocity class.

The Macesnik landslide is deep in its middle part (area 2 on Fig. 3), where it is twice crossed by the Panoramic road. In the place of the present upper road turn the landslide depth is more than 16 m, and in the place of the lower road turn the depth is more than 22 m, respectively. In this area, two lines of support structures made of reinforced concrete shafts are proposed. In order to stabilise the part of the landslide where the road crosses it twice, 3 RC shafts are planned in a line above the upper road turn (M7, M8, and M9) and 6 RC shafts are planned in a line below the lower road turn (M1 through M6). The new road corridor in this area (Figs. 21, 22) is a prerequisite for an optimal depth of the planned RC shafts. The technical characteristics of these RC shafts will be quite the same as for those executed earlier above the pontoon bridge.

The execution of the further proposed remediation (stabilisation) measures will follow in phases from the upper part into the downslope direction.

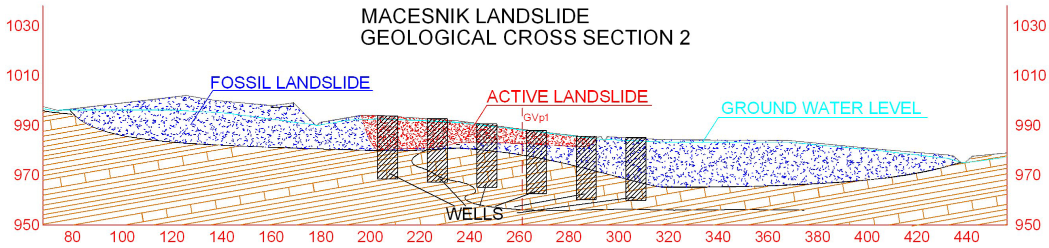

Fig. 22. Cross section of the Macesnik landslide just above the proposed lower line of wells M1–M6.

5 Conclusions

After several years of unsuccessful mitigation of the Macesnik landslide in the mid-1990s using classical surface drainage works, its further mitigation after 2000 proved to be much more effective and oriented towards the final solution. The main conclusions which can be drawn from the stepwise mitigation of the Macesnik landslides are as follows:

1. Reinforced concrete shafts proved to be an effective way of remediating a landslide such as the Macesnik landslide after it was efficiently slowed down by a system of deep drainage trenches. The combined effect of the RC shafts in their twin function, i.e. the supporting function of a dowel and draining function of a deep water well.

2. On the Macesnik landslide, N Slovenia, RC deep shafts were constructed for the first time in Slovenia, having a twinfold function of supporting and draining. The construction proved to be highly successful. In one year after their completion, geodetic measurements at the shafts' top have shown no displacements. There are no horizontal displacements even of the inclinometers embedded in the secondary coating of the RC shafts.

3. The measurements of the quantity of ground water that gravitionally flows from the RC shafts have indicated an effective draining of the landslide mass with low permeability around the shafts and effective lowering of water pressures in the landslide mass. Following the first example, this technology was successfully used in another case, namely at the Slano blato landslide, W Slovenia.

4. The total estimated costs for the mitigation of the Macesnik landslide are running at 16 mio Euro. During its stepwise mitigation in a top-down (slope) approach it may happen that some of the proposed measures will be left out or executed to a smaller extent.

5. If the mitigation will not be executed within a reasonable period of a few years, the landslide dynamics of the lower landslide part may call for new technical solutions and thus also for new financial sources.

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