



CHALLENGES IN RECONSTRUCTING STATE ROAD DC101 IN CROATIA

Ante Barišić¹, Ana Čudina Ivančev², Vesna Dragčević², Tamara Džambas²

¹TRG d.o.o., Croatia

²University of Zagreb, Faculty of Civil Engineering, Croatia

Abstract

This paper presents the process and analyses the problems related to the reconstruction of the state road DC101 in Croatia. DC101 is located on the island of Cres in Primorje-Gorski Kotar County. The reconstruction included the construction of a third traffic lane on a section approximately 1.4 km long. To avoid the busy summer season, construction work was carried out during the autumn. Despite this, there was high traffic intensity on the construction site. Therefore, it was necessary to ensure traffic safety and safe working conditions. In addition to the difficulties that arose during the earthworks, unforeseen situations not anticipated in the documentation also occurred on site, requiring additional design solutions. For example, a section affected by an unstable landslide was identified, necessitating an additional solution to preserve stability and ensure traffic safety, as well as the continuous progress and safety of construction works. Otherwise, these unplanned works would have been carried out much more easily. Although the affected section of the road is relatively short, a complex reconstruction was undertaken. Given all of the above, this paper highlights the challenges contractors may face during road reconstruction under heavy traffic, where the project involved extensive earthworks and where numerous unforeseen works additionally appeared, all to optimise the construction of the designed solution.

Keywords: road, construction works, earthworks, reconstruction, challenges

1 Introduction

The reconstruction of a 1,370 m section of two-lane two-way state road DC101 in Croatia, which leads to the Merag ferry terminal on the island of Cres in Primorje-Gorski Kotar County was undertaken (figure 1) [1]. The purpose of the reconstruction was to add a third traffic lane. The Merag–Valbiska ferry line connects Cres with the island of Krk and is particularly busy during the summer months. According to the Ministry of the Sea, Transport and Infrastructure, this was the busiest ferry line in Croatia in terms of vehicles transported in 2013, with 367,208 vehicles [2]. In 2024, this number increased to 540,038 vehicles and 1,279,475 passengers [3]. This is significant, as the high traffic volume during construction work posed a considerable challenge. Due to the limited space on the construction site, there was insufficient room for manoeuvring construction machinery, especially excavators, when loading materials. Trucks had to be loaded on the only available traffic lane, except during the first phase of construction, which further slowed the work and increased the risk of traffic jams. In addition, the constant presence of vehicles and passengers required additional safety measures and coordination between the contractor, Jadrolinija employees, and traffic services.



Figure 1 Cross section: a) before reconstruction, b) after reconstruction [4]

The reconstruction involved adding a third lane for vehicles waiting for the ferry. To create the additional traffic lane, the road had to be widened towards the cutting side. The construction works included excavation, roadway widening, construction of a storm drainage system, installation of traffic signals and equipment, and geotechnical works for slope protection. Further emphasis was placed on the earthworks, especially excavation and protection of the cutting slope.

2 Challenges on the construction site

The terrain at the site is extremely hilly, with numerous rock cuts and slopes exposed to weathering and erosion, posing a potential risk of landslides. The geological composition of the route consists predominantly of Lower Cretaceous and Upper Cretaceous limestones, locally overlain by scree breccias and alluvial deposits, creating a complex geotechnical profile characteristic of the karst areas of the Adriatic islands [5]. The excavation methods used are described below.

2.1 Excavation methods

The excavation was carried out using a hydraulic hammer with an excavation basket or by drilling and blasting [6]. The choice of method depended on the lithological composition of the rock mass, the degree of material wear, the required precision, and the need to accelerate progress. Due to demanding technical conditions, the strength of the rock mass, and the accelerated pace of work on certain sections of the DC101 state road, conventional mechanical excavation methods proved insufficiently effective. Therefore, parts of the route were excavated using the drilling and blasting method to overcome the resistant rock mass and further accelerate progress in line with the planned construction deadlines. Blasting was carried out during the day, with physical traffic closure, evacuation of the construction site, and supervision by trained personnel. The maximum available time for blasting was 60 minutes, corresponding to the interval between two ferry crossings. Blasting was used to accelerate progress and because mechanical excavation was inefficient.

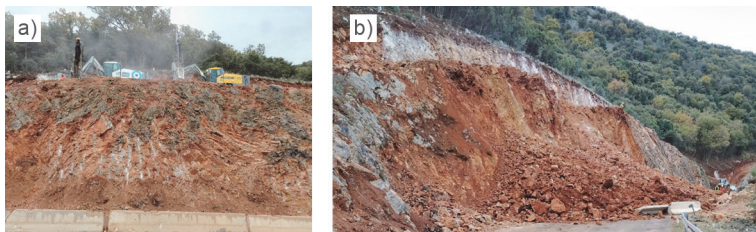


Figure 2 Excavation by drilling and blasting: a) drilling of anchors and boreholes, b) result of the first blast

The initial blasting was the most demanding and resulted in the separation of a large rock mass that covered the entire road, as shown in figure 2. Subsequently, the blasting parameters were adjusted by reducing the number of explosives, resulting in more moderate breakages and reducing the risk of prolonged road closure. Due to the identified instabilities, particularly in areas affected by seepage breccias, rehabilitation and slope protection measures are planned.

2.2 Slope protection

The designed solution included three types of slope protection: (1) hexagonal double-twisted wire mesh, (2) self-drilling anchors and shotcrete, (3) hexagonal mesh reinforced with anchors and steel cables. Of these, only type 2 protection was applied as designed on sections with increased landslide risk. This method combines deep anchoring with surface protection using shotcrete, achieving slope stabilisation and preventing the shedding of surface material and the erosive effects of atmospheric influences. To reduce costs and accelerate the work schedule, a modified type 3 protection was implemented, in which, instead of installing steel cables, the mesh is fixed using base plates and nuts on the anchor rods. Compared to the originally designed type 3 slope protection, the modified type 3 protection allowed for faster execution and simplified organisation, while maintaining satisfactory system functionality. The combination of active stabilisation with anchors and surface retention with mesh ensures long-term slope stability and road safety.

Rockfall protection barriers are an active measure to protect the road from falling large stone blocks and material shed from the natural terrain above the slope. Unlike protective nets, which passively retain smaller rock fragments from the slope, barriers serve as a physical barrier to larger broken blocks, thereby protecting the road, vehicles, and road users. The high slopes along part of the route required additional safety measures, and debris protection barriers provided effective protection for the road and all users. Figure 3 shows the types of protection implemented.



Figure 3 Protection on slope: a) type 2, b) modified type 3, c) rockfall protection barrier

3 Changes and additions to the design solution

During the execution of the works, it was necessary to make changes to the design solution due to unforeseen site conditions, work being carried out under heavy traffic load, and the need to accelerate execution. The changes and additions to the design solutions related to the creation of a bench, the rehabilitation of the rockslide that was outside the original scope, and the rehabilitation of the landslide are presented below.

3.1 Bench

Due to insufficient space for the excavator, it was decided not to construct the bench at a height of 6 m and a width of 2 m. Instead, a gentle slope was formed for the cut. This altered the project design and accelerated the execution of the works. The change in the design is shown in figure 4.

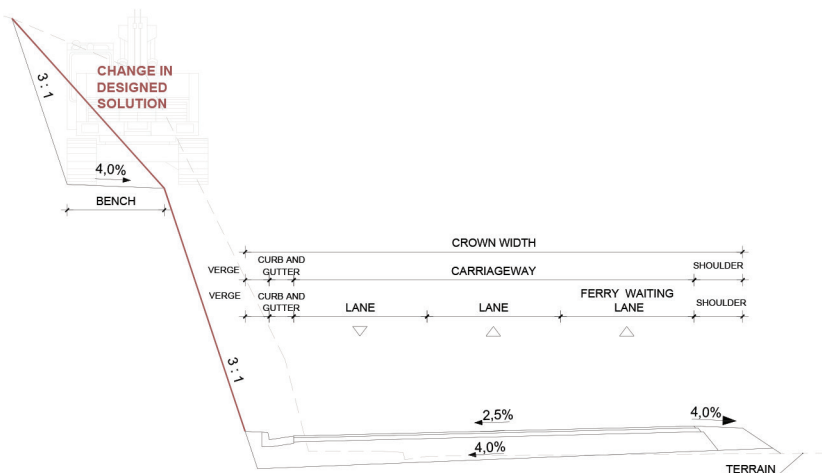


Figure 4 Change in cut slope

3.2 Rockslide

Rehabilitating the rockslide was the greatest challenge during reconstruction. The rockslide was located outside the project boundary and was therefore not included in the design. Several field solutions for rehabilitation were considered. The first option was to install an energy barrier to intercept the activated blocks of rock mass before excavation. However, at the top of the slope, there were 1 to 2 m of accumulated rock blocks, probably fallen from the rock (figure 5). Because of this, energy barriers and anchors would not function as intended. The second option was to create a 5:1 slope on the cut without a bench, at a height of 6 m. This intervention would require entering loose material composed of separate blocks, which would endanger safety and pose a risk to the movement of people and machinery immediately below the slope.



Figure 5 Accumulated rock blocks

Therefore, the chosen solution was to construct a ramp to provide access to the top of the slope and to remove unstable material. During ramp construction, additional hazards were identified, so an auxiliary serpentine ramp was built from the existing platform. Unstable rock blocks were removed and broken up from this ramp. For traffic safety, a physical traffic stop was implemented after each ferry departure. This was necessary because, during the work, rock blocks fell onto the road, damaging and passing over the New Jersey-type concrete barriers (figure 6).



Figure 6 Work on ramp construction

After constructing the working plateaus and removing unstable blocks, the lower level of the slope was excavated at a 5:1 gradient, with a cutting height of approximately 8 m. Excavation was carried out using drilling and blasting methods. An additional design solution was implemented to provide slope protection type 2 (anchors, reinforcing mesh, shotcrete) and to install an energy barrier with a capacity of 2000 kJ, 5 m in height and 90 m in length, set at an inclination of 80 degrees (figure 7). This example shows that challenges arising at the site are often impossible to predict through design solutions. The implemented solution ensures long-term protection and stability of the roadway, with the constructed working plateaus serving as benches to stop possible rock blocks, and the installation of the barrier providing ongoing protection for the roadway.



Figure 7 Energy barrier

3.3 Landslide

The landslide occurred in the border zone between Lower Cretaceous and Upper Cretaceous limestones, and rehabilitation was carried out on a section slightly less than 30 m long (figure 8). The design solution involved replacing the bedding material and constructing supporting gabion walls in the embankment. However, it was found that further measures are required to rehabilitate the cut.



Figure 8 Landslide

The rehabilitation involved removing soil to a depth of 2 m below the slope face, down to the rock base, to provide a quality foundation for the reinforced concrete beams. The works began with the installation of two layers of shotcrete, with a Q188 reinforcing mesh placed between them. Following this, IBO anchors with a diameter of 51 mm and a length of 9 metres were installed. The upper anchors were drilled and injected first, while the lower anchors, with a length of 6 metres, were installed after the beams were placed, through pre-prepared openings. The beams were placed vertically, each with two holes for anchoring, with cross-sectional dimensions of 0.40 × 0.60 m and lengths ranging from 2.5 to 5 metres. Fourteen reinforced concrete beams were installed to ensure the stability of the landslide and prevent further movement of the terrain (figure 9).



Figure 9 Placing beams on previously constructed anchors

4 Discussion and conclusion

The reconstruction of the DC101 road section highlighted the exceptional complexity of carrying out works in conditions of limited space, high traffic loads, and challenging geotechnical circumstances. The analysed geological profile required mechanical excavation with a bucket excavator and hydraulic hammer, as well as drilling and blasting, which were necessary to accelerate progress and overcome the compact rock mass. Slopes were protected by combinations of wire mesh and anchors, as well as shotcrete, reinforcement mesh, and anchors. Particularly challenging were zones affected by rockfalls and landslides, where standard design solutions required refinement or adaptation to actual site conditions. In these circumstances, the importance of making technical decisions based on real conditions was demonstrated. However, the authors of the paper believe that the rehabilitation of rockslide and landslide could have been approached differently. Alternative solutions and suggestions are listed below:

- A possible method for rehabilitating the rockslide is to use the existing field road above the landslide, which would provide access to the top of the slope. Rehabilitation would involve constructing four or five benches, each 6 metres high, with embankments 4 to 5 m wide and serpentines at the ends of the embankments to provide access to the lower benches. In this way, all unstable blocks would be removed, and excavation would reach solid rock, thus eliminating the problem of instability. The constructed embankments would serve a dual function: they would provide access for excavating individual benches and act as

barriers to prevent rock blocks from detaching due to erosion. This solution would be more financially advantageous, and the problem would be eliminated rather than merely mitigated.

- For landslide rehabilitation, two alternative options are proposed. The first option involves applying multiple layers of shotcrete and reinforcing mesh – specifically, three layers of shotcrete and two layers of reinforcing mesh – while anchors are arranged in a 1.0 × 1.0 m or 1.5 × 1.5 m grid. This approach creates a significantly stiffer slope lining with improved connection to the rock mass, and the system has increased resistance to movement along the sliding surface. The advantage of this solution is greater homogeneity of the entire supporting structure and improved force distribution within the landslide zone.

The second option involves constructing a continuous horizontal reinforced concrete beam directly on the sliding surface, at the interface between the unstable material and the solid rock mass. Anchors would be drilled and injected through the beam to ensure a solid connection to the stable base, while the beam and anchors would absorb the sliding forces (figure 10). Unlike the implemented solution, in which the sliding surface between the vertical reinforced concrete beams is stabilised with shotcrete and reinforcing mesh, the horizontal beam would allow the direct transfer of sliding forces to the rock mass. Additionally, the beam could be covered with a layer of humus or by installing geogrids filled with humus material, enabling the rehabilitation to blend more naturally into the environment and reducing the visual impact.



Figure 10 Landslide rehabilitation with horizontal beam

In conclusion, the methods and technologies applied enabled the safe and successful completion of the road reconstruction, while ensuring long-term slope stability and traffic safety. This reconstruction project provides valuable insights for future interventions in similar geological and traffic conditions, emphasising the importance of combining technical precision with practical adaptability on the construction site. Field experience clearly indicates the importance of anticipating the method of road construction under heavy traffic loads and short construction deadlines already during the design phase.

References

- [1] Kursar-Hlača, M.: Rekonstrukcija državne ceste DC101 Dionica 001 od km 9+500 do km 10+870, do trajektnog pristaništa Merag, Rijekaprojekt d.o.o., September 2022.
- [2] Agencija za obalni linijski pomorski promet, <https://agencija-zolpp.hr/novosti/promet-putnika-i-vozila-u-2013-godini/>, 09.01.2026.
- [3] boljani.info, <https://boljani.info/bolska-kronika-arhiv/2025/2025--ii>, 09.01.2026.
- [4] Google Maps, <https://www.google.com/maps>, 07.01.2026.
- [5] Grošić, M.: Rekonstrukcija državne ceste DC101 Dionica 001 od km 9+500 do km 10+870, do trajektnog pristaništa Merag, Geotehnički elaborat, GEOTECH d.o.o., June 2018.
- [6] Mintas, I.: Opći tehnički uvjeti za radove u vodnom gospodarstvu Knjiga 2, za Institut IGH d.d., University of Zagreb, Faculty of Civil Engineering, Zagreb, 2012.

