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Vasko Gacevski, University in Skopje, gacevski@gf.ukim.edu.mk
Riste Ristov, Ss. Cyril and Methodius University in Skopje, ristov@gf.ukim.edu.mk
Ivona Nedevska, Ss. Cyril and Methodius University in Skopje, nedevska@gf.ukim.edu.mk
Zlatko Zafirovski, Ss. Cyril and Methodius University in Skopje, zafirovski@gf.ukim.edu.mk
Slobodan Ognjenović, Ss. Cyril and Methodius University in Skopje, ognjenovic@gf.ukim.edu.mk

COMPARATIVE ANALYSIS OF EXCAVATION AND TUNNEL SOLUTIONS FOR THE ROAD DRENOVO - RAEC

Abstract

When withdrawing the route of the expressway Drenovo - Raec, the axis of the road is forced to stretch near or through the mountain massifs. This created a general dilemma, whether to make classical excavations or tunnel constructions in certain locations. Considerations were also made for the decision on high embankments or viaducts. The characteristic location presented in this paper is located between the existing national road and the river Raec. For this location, a comparative analysis of the variant solutions for excavation and tunnel was made and the main parameters that affect the final solution were indicated.

Keywords: road, route, excavation, slopes, tunnel, analysis.

КОМПАРАТИВНА АНАЛИЗА ИСКОПА И ТУНЕЛСКЕ РЕШЕЊА ЗА ПУТ ДРЕНОВО - РАЕЦ

Сажетак

Приликом повлачења трасе аутопута Дреново - Раец, осовина је принуђена да се протеже у близини или кроз планинске масиве. То је створило општу дилему да ли на одређеним локацијама радити класичне ископе или тунелске конструкције. Разматрано је и о одлуци о високим насипима или вијадуктима. Карактеристична локација приказана у овом раду налази се између постојећег магистралан пут и реке Раец. За ову локацију урађена је упоредна анализа варијантних решења за ископ и тунел и назначени су главни параметри који утичу на коначно решење.

Кључне ријечи: пут, траса, ископ, косине, тунел, анализа.

1. INTRODUCTION

The intensive construction of the road infrastructure in Macedonia started with the realization of the project A1 Prilep - Gradsko. As part of this project, three sections have been developed, two of which are full expressway, and the middle section is a three-lane road.

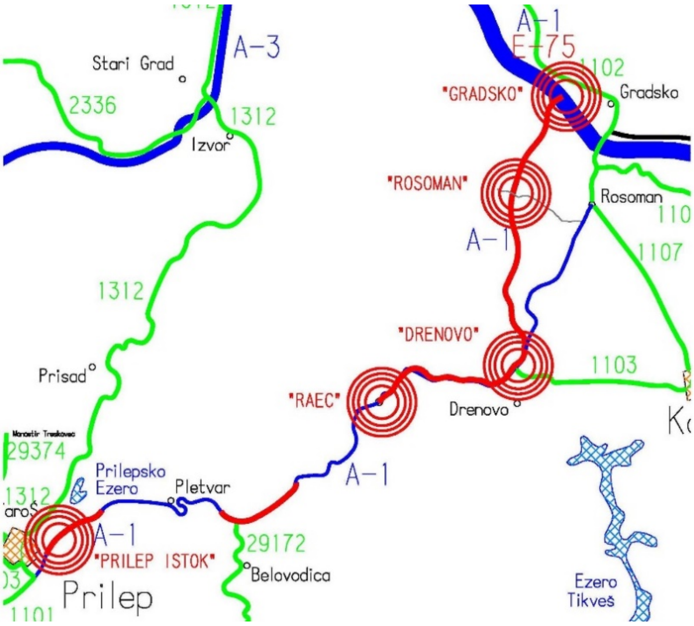

Figure 1. *Overview map of sections*

The critical section which is analyzed is the section between Raec and Drenovo. The length of this section is 7 km and the road is a reduced highway with the total width of both roads of 25.4 m. The reason for this solution is the possibility for physical separation of the roads in the part of the tunnel constructions.

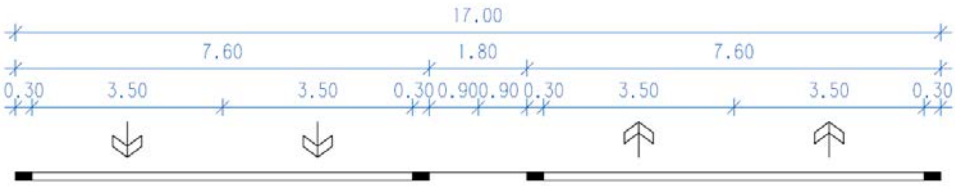

Figure 2. *Geometric cross section*

Characteristic of this part is that the axis must pass through a narrow gorge. The subject section that is being analyzed is right next to the beginning of the route between two bridge constructions which are two fixed points through which the route must pass. It should be noted here that the area where the analysis is done belongs to the highest environmental protection area (at the level of national parks).

2. DESIGN SOLUTIONS

With the geological characteristics and the disposition of the route, it is possible to prepare two variant solutions with complete excavation with a height of over 40 m and a tunnel solution with a middle overlay of about 30 m. The geological profile of the terrain at this location consists of three zones:

- Zone 1 - strongly cracked to crushed limestone;
- Zone 2 - weakened limestone;
- Zone 3 - relatively compact limestone.

2.1. DESIGN SOLUTION 1 - EXCAVATION

With this Technical Solution, the subject zone is designed as a classic cut, by applying the necessary measures for stabilization and protection of the slopes, ie designing the geometry of the slopes in accordance with the analysis and calculations and their protection. Due to the fact that the excavation is unusually high, the first and last berm (seen from below) are widened by 2 m, for safety reasons, but also to reduce the negative visual effect when driving, ie to get the impression that it is an excavation with lower height. The excavation is 170 m long with a slope of 5:1, and the berms are 9 m high and 3 m wide. The protection of the slope from surface landslides is planned to be performed with a steel mesh, anchored at the top of the slopes and additionally tightened with finishing weights in the lower part. On the higher side of the terrain, a concrete trapezoidal ditch with dimensions 0.5x0.5x0.5m is provided with sufficient capacity to receive surface water from the surrounding terrain [1]. When making this solution, there is no need to expand the separation lane and on this part the profile will remain with a fixed width as the cross-section profile shown above (Figure 2).

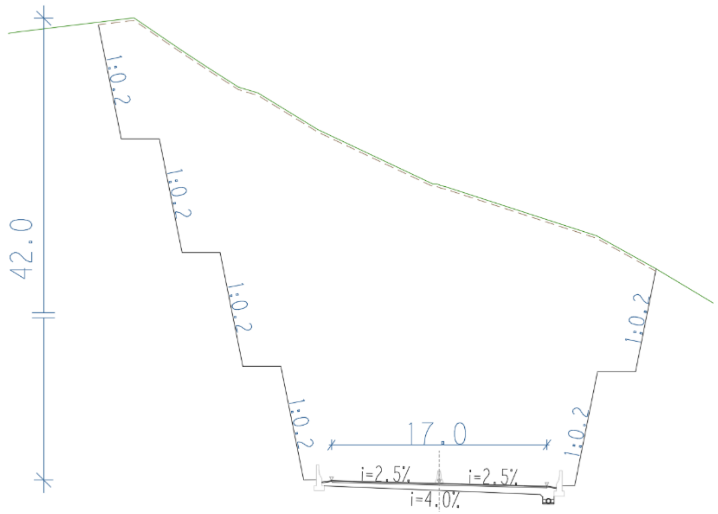

Figure 3. *Cross section excavation profile*

2.2. DESIGN SOLUTION 2 - TUNNELS

The second project solution consists of two tunnel pipes with an average length of 145 m. The tunnels have a longitudinal slope of 0.3% and a maximum transverse slope of 2.5%. The width of the lane is 2x3.5 m and the edge lanes on both sides are 2x1.00 m. According to the Bieniawski Tunnel Classification (RMR - System), rock masses in these sections are classified into categories III and IV. Several types of substructure are envisaged including: anchors, sprayed concrete, steel arches and final concrete cladding. The New Austrian Tunneling Method (NATM) has been chosen as the general method for tunnel construction. The entrance-exit portals are made with Cut & Cover up to the first 20 m, with a slope of the portal slopes of 3: 1. The project tunnel solution also includes two classic retaining walls located on the outside of the tunnel pipes to the terrain [2].

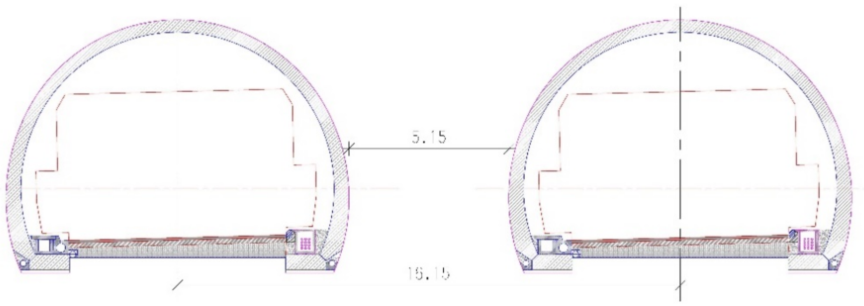

Figure 4. *Cross section of tunnel solutions*

3. COMPARATIVE ANALYSIS OF VARIETY SOLUTIONS

The following factors are taken into account in the comparative analysis: performance, maintenance, safety and environmental impact. The comparison is made for the same climatic-hydrological conditions, the same traffic load and the possibility of performance by parties. The analysis is made by assessing the advantages and disadvantages of both variant solutions.

3.1. EXCAVATION

3.1.1. Advantages

- Easy, fast and relatively safe performance;
- No need for specialized mechanization and staff;
- The projected part of the route in the situational solution remains the same;
- It is not necessary to redesign the facilities that are adjacent to that part of the route;
- Satisfactory safety in the exploitation phase.

3.1.2. Disadvantages

- Increased excavation;
- Need for new landfills;
- Unfavorable visual effect; Possible additional means for protection of the slopes from erosion;
- Increased means for maintenance, in terms of local landslides in conditions of high waters and winter maintenance;
- Additional expropriation;
- Adverse environmental impacts.

3.2. TUNNELS

3.2.1. Advantages

- Minimal excavation;
- No need for additional landfills;
- High reliability in the exploitation phase;
- Minimal maintenance;
- No further expropriation;
- Beneficial impacts on the environment.

3.2.2. Disadvantages

- Increased risk in the construction phase;
- Specialized mechanization and staff;
- Short distance between tunnel pipes (which affects increased costs);
- Difficulties in construction of the entry-exit portals;
- Increased construction time;
- Necessary relocation of adjacent structures (bridges, viaducts);
- The designed road axis changes;
- Higher cost for construction;
- Additional operating costs for electricity supply and substation.

3.3. ADOPTED SOLUTION

Both solutions have certain advantages and disadvantages, and in terms of the financial part, the tunnels are about 10% more expensive than the excavation. But although the difference in cost is greater and the time period for construction is longer, here the biggest factor for the final decision will be the one for the environment. Thus, the final solution that would pass the route through the hilly massif is a tunnel.

4. CONCLUSION

From the presented comparative analysis between a classic excavation and a two-pipe tunnel solution, it can be seen that from a financial and time point of view the excavation is a more acceptable solution, but since the most important factor in the final decision is the environmental impact, the more expensive solution is adopted. The final decision for the adopted solution should be made in coordination with the Consultant / Auditor and the Investor. According to the specific example, the following general conclusions can be drawn:

- The choise between two or more solutions, whether it is a comparison between an excavation-tunnel or an embankment-bridge, one should always make an appropriate analysis and consider all relevant factors that would influence the solution;

- In the analysis, the most important factors required in the given situation should be defined first, whether it is a financial, time, safety or environmental aspect;
- It is best to make such analyzes at an early stage of the design, to avoid any unforeseen effects on the project;
- The determination of the final geometry of the road should follow after the adoption of the solution from the comparative analysis.

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