CETRA^{2022} 11-13 May 2022, Pula, Croatia
7th International Conferenceon Road and Rail Infrastructure

ACCESS ROADS TO THE PELJEŠAC BRIDGE

Miroslav Šimun, Ante Goran Bajić, Sandra Mihalinac, Đivo Šapro
Zagreb University of Applied Sciences, Department of Civil Engineering, Croatia

Abstract

The construction of the Pelješac bridge is a capital project of the Republic of Croatia with the support of the EU, thus realizing the long-standing plan of establishing a strong road connection of all parts of Croatian territory. Prior to the construction of the Pelješac Bridge, the land of the territory of the Republic of Croatia was separated, which belongs to neighboring Bosnia and Herzegovina, and on a road distance of 9.25 kilometers had to cross the state border twice, which during the summer months due to the tourist season led to large traffic jams. The separation of state territory has made it difficult to invest in infrastructure in the south, and economic and tourism progress has been slow. The construction of the bridge with the accompanying infrastructure will enable the road connection of the previously separated land parts of the Croatian territory. The Pelješac Bridge is one of four phases of a much larger and more complex project called "Road Connection with Southern Dalmatia". As part of this project, a total of 32.53 kilometers of roads will be built with accompanying facilities (viaducts, bridges, tunnels, underpasses, rest areas and reservoirs). The goals that will be achieved by this project are to increase the level of transport system service and traffic safety and to shorten road travel between northern and southern Croatia.
The paper provides an overview of all details of planned and constructed sections according to the main project of the Pelješac bridge and its access roads, the process of structural design of pavement structure with reference to the program of quality control and quality assurance of materials and works.

Keywords: road design, pavement, quality control program, quality assurance program

1 Introduction

Dubrovnik-Neretva County is the only Croatian county whose southeastern part of the territory is not connected with the rest of the Republic of Croatia. Due to its isolated position, it deserves special attention and treatment in the spatial connection with other parts of Croatia, but also in the interconnection with the rest of Europe. The construction of the "Pelješac" bridge over the Channel of Mali Ston, between Komarna (Cape Međed) on the mainland and Brijesta (Oštri vrh area) on the Pelješac peninsula, and connections to the Adriatic tourist road D8 near Raba on the mainland and near Zaradež to Pelješac road D414, connects the entire Dubrovnik-Neretva County, which will contribute to the development of Dubrovnik, the Pelješac peninsula, and Croatia will merge into a complete road system [1].
Access roads stretch from the Pelješac bridge to the D8 state road on land and from the Pelješac bridge to the D414 state road (the so-called Pelješac road) on the Pelješac peninsula, ie the beginning of the Sparagovići - Doli section below the access roads. The route of access roads is laid within the corridor defined by the spatial plan of the Dubrovnik-Neretva County. The Pelješac Bridge construction project itself consists of four phases that include access roads with a total length of 32.53 km together with ancillary facilities [2]. The construction of the Pelješac Bridge and the accompanying road infrastructure will shorten the travel time

DOI: https://doi.org/10.5592/CO/CETRA.2022.1490

and passengers will no longer have to pass two customs controls at a distance of 9.25 km [3, 4]. Figure 1 shows the entire section of the access road to the Pelješac bridge with all its constituent infrastructures and together with the main part of this demanding project (Pelješac bridge). The complexity of the access road section is visible in the process of breaking through the bridge shown in Figure 2, as well as the breaking through of the 1290 m long Supava tunnel in Figure 3.

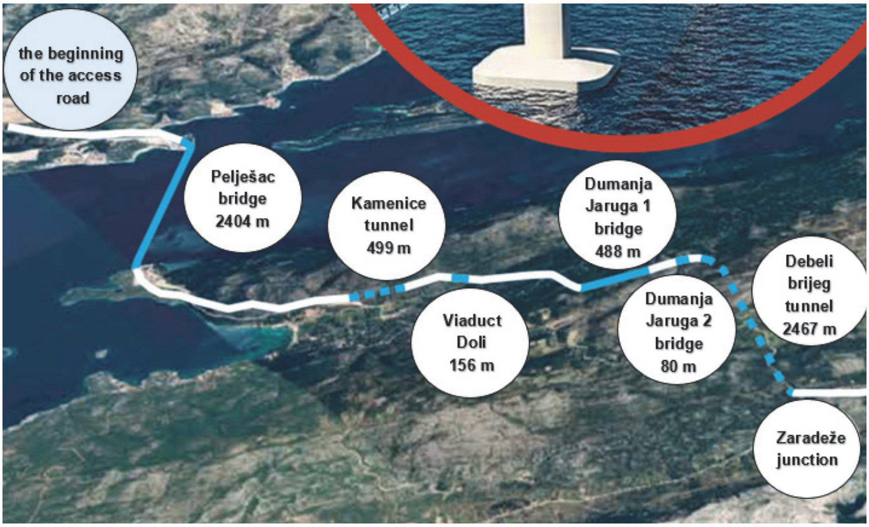

Figure 1 Sections of access roads to the Pelješac bridge with all infrastructures [5]

Figure 2 Access road penetration process [4]

Figure 3 Breaking of the Supava tunnel [4]

2 Road construction facilities

The road is designed as a state road of the 1st category reserved for motor vehicle traffic [1]. The technical elements were selected for the design speed 90 km/h, so that the width of one traffic lane is 3.50 m, and the edge lane 0.50 m without stop lanes. The road is designed as a single-lane road with two traffic lanes, one for each direction of travel, without semergency lanes. Lay-bys with a telephone call system (TCS) are provided for stopping emergency vehicles. The transverse slope of the pavement is single-pitched, in the direction of 2.5 % and the maximum applied transverse slope is 5.8 % in a bend with a radius of 450 m. The free profile above the road is 4.8 m from the highest elevation of the pavement. The section of access roads mostly passes through configurationally demanding hilly terrain, which resulted in a large number of facilities in the route (viaduct, two bridges, four underpasses) and two tunnels.
The underpass at the Duboka junction is designed as an integral frame with a superstructure, total length 33.65 m. It consists of a wall on foundations that are integrally connected to the slab, while the wings are dilated and all structural elements are reinforced concrete.
The 25, 598 m long D8 underpass has a span of 25.6 m in the direction of the designed road, while the span perpendicular to the abutment axis is 14 m [6]. On the rear wall of the abutment, an overhanging bench for supporting the 30 cm thick transition plate was made. On the vertical concrete surfaces of the abutments and wing walls that are covered with embankment, waterproofing should be reported and protected with cork [6].
The underpass in the Zaradeža junction is 11.6 m long, and consists two 13 m long abutments that are integrally connected to the slab and four retaining walls.
The Dumanja Jaruga I bridge has a span of 488.0 m, a width of 11.7 m wide and a total length of 518.75 m [7]. Access road pavement at the site of the bridge is 8.0 m wide and consists two lanes of 3.5 m wide. To the left and right traffic lane edges are marginal strips 0.5 m wide. This is followed by a low prefabricated curb 7.0 cm high and measuring 50x25 cm, behind which a steel fence is placed in a space of 50.0 cm wide. The steel fence is anchored in a concrete pedestrian path with a minimum thickness of 22.0 cm and a transverse drop of 4 % to ensure rapid drainage of water to the drains. The pedestrian service path is protected by a 1.0 m high pedestrian fence. The required space for anchoring the pedestrian fence is 25.0, and the width of the monolithic cornice is 35.0 cm [7]. The Dumanja Jaruga II bridge has a span of 80 m, a width of 11.7 m and a total length of 92.64 m.
The Kamenica tunnel is designed for a speed of 80 km/h, and the planned method of tunnel construction is the New Austrian tunnel method NATM. It is constructed with one tunnel pipe, and the estimated length of the tunnel is L=499 m. The cross section of the tunnel has a clear span of 56.17 m² and meets the requirements for free profile defined byelaw on basic traffic safety conditions to be met by rural public roads and their elements, Official Gazette of the Republic of Croatia, No. 110/01, and the requirements for the free profile defined according to the Austrian RVS guidelines [8].
Also, the specified cross section allows the accommodation of all necessary devices and equipment, and allows natural ventilation. The cross section was selected for a speed of 80 km/h. Inspection walkway are provided on each side with a width of minimum 85 cm and are raised from the traffic area of the tunnel by 15 cm. Below the inspection walkways are channels for the installation of the necessary tunnel equipment [8].
The Debeli Brijeg tunnel is constructed with one tunnel pipe L=2467 m long and with a service tunnel 2462.3 m long [9]. The tunnel is designed for a speed 80 km/h. The planned method of tunnel construction is the New Austrian Tunnel Method NATM. Inspection walkways are provided on each side with a width of minimum 85 cm and are raised from the traffic area of the tunnel by 15 cm. Below the inspection walkways are channels for the installation of the necessary tunnel equipment [9].

Between the tunnel lining and the primary support, a layer of waterproofing made of PVC foil protected by geotextile is envisaged. PVC foil with a signal layer, made in one piece, 2 mm thick, is envisaged. The insulation is placed on a layer of non-woven geotextile with a minimum weight of 500 g/m^2. The base is made of a layer of shotcrete of optimal thickness and strength. The shotcrete base must be dry before applying the waterproofing layer. The cross section of the service tunnel has a clear opening of 23.73 m^2 and meets the requirements for the free profile. The width of the service tunnel is 3.6 m with 0.85 m wide sidewalks on both sides at the level of the road. The service tunnel is performed only in the primary insurance.

3 Structural design and quality control of pavement construction

Structural design or dimensioning of the road pavement structure implies a procedure in which individual layers of the pavement structure are selected so that they can withstand traffic loads and other environmental influences for a longer period of time (20 years). The main goal of the structural design of the pavement structure is to protect the natural soil, ie the placenta from the effects of high and concentrated stresses caused by the traffic load over the wheels of the vehicle on the placenta. At the same time, the layers of the pavement structure must be strong enough to provide a solid support for traffic load and to provide a driving surface of acceptable driving quality with adequate resistance to deformation, cracking and smoothing, and desirable light reflectance and low noise. Only such a pavement structure has the prerequisites for safe, comfortable and economical traffic during the project life of the pavement, thus protecting the bed from the effects of traffic and climate and ensuring that no material inside the pavement suffers unacceptable deterioration.
The project described in this paper is a structure with a flexible pavement structure and asphalt cover layer, so it is rational to predict that in the project period of 20 years the pavement cover will need to be renewed at least once to improve driving quality and preserve the substance of the structure [9]. Structural design of pavement structures primarily depends on [10]:

- Load capacity of the placenta,
- Traffic load,
- Quality (equivalence) of materials (structural number),
- Climatic and hydrological conditions (regional factor),
- Driving ability of the pavement,
- Project period.

The structural design of the pavement structure was performed using the method for structural design of flexible pavement structures according to HRN U.C4.012 [11], and the verification of stresses and strains in such a specific structure was performed using the computer software BISAR PC. The traffic load for the whole section is expressed by the total number of transitions of equivalent standard ESOO axles 82 kN in both directions of travel. The input data selected for sizing the structure of the pavement structure of the main route are:

- project period of 20 years
- total traffic load 5.10 x 106
- bearing capacity CBR = 10 %
- driving capacity of the road at the end of the project period p = 2.5
- regional factor R = 2.0

The total thickness of the pavement structure, dimensioned according to the traffic load and the bearing capacity of the placenta, is 46.5 cm, ie 3.5 cm of the SMA splitmastic asphalt cover layer, 5.0 cm of the bonding layer and 8.0 cm of the AC and 30.0 cm asphalt concrete bearing layer of unbound crushed mechanically compacted material.

The input data selected for dimensioning the structure of the pavement structure of the node are:

- project period of 20 years
- total traffic load 8.05 x 105
- bearing capacity CBR = 10 %
- driving capacity of the road at the end of the project period p = 2.5
- regional factor R = 2.0

The total thickness of the pavement structure dimensioned according to traffic load and bearing capacity is 37.0 cm, ie 4.0 cm of cover layer and 8.0 cm thickness of AC asphalt load-bearing layer and 25.0 cm thickness of load-bearing layer of unbound crushed mechanically compacted material. The verification of the new pavement structure for the node and the main route was made using the experimental nomogram for the number of equivalent axles TUK and the regional factor R. The thicknesses of the new pavement structure are obtained from the relation:

$$SNP = a_1 \cdot d_1 + a_2 \cdot d_2 + a_3 \cdot d_3 + a_4 \cdot d_4$$

where is:

SNP - structural number of the pavement structure

a_1, a_2, a_3, a_4 - replacement coefficients, which depend on the type of material of individual layers of the pavement structure

d_1, d_2, d_3, d_4 - thicknesses of individual layers of pavement structure (cm).

Figure 4 shows the adopted structure of the pavement structure of the main route of access roads to the Pelješac bridge and tunnels, and Figure 5 shows the adopted structure of the pavement structure of Duboka, Brijesta and Zaradeža junctions together with the proposed road D414 and local road L69030.

The quality of placenta and mechanically compacted bearing layer and constituent materials for the production of asphalt, bituminous mixture and derived asphalt layer must be tested according to prescribed Croatian standards and applicable legislation, and control is performed in authorized laboratories [12].

Flowing control is performed to control the technological process, and is performed by the manufacturer in its own or authorized laboratory registered for quality control. Types of current tests and their frequency depend on the type, quantity and purpose of materials, and include testing of compressibility modulus, degree of compaction, testing of composition and granulometry, physical and mechanical properties of individual layers of pavement structure and testing of height, position and slope by geodetic survey [12].

Control tests are the responsibility of the investor, are conducted for the purpose of confirming current tests and are, as a rule, twice less frequent in volume than the contractor's quality control of materials and works.

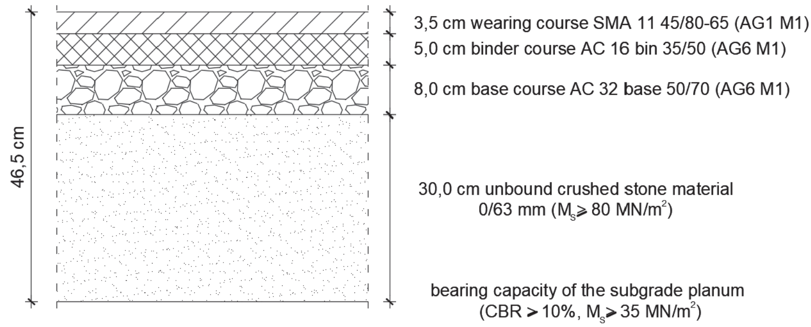

Figure 4 Pavement structure of main route and tunnel (made by Author based on [12])

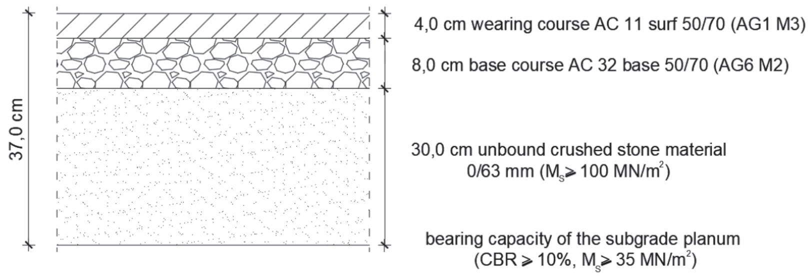

Figure 5 Node pavement structure (made by Author based on [12])

4 Conclusion

The project of building the Pelješac Bridge and access roads is extremely important for connecting the separated parts of the Croatian territory. With this infrastructure project, the territory of the Republic of Croatia becomes united and complete, which leads to positive impacts on the economic and tourist development of these once traffic-isolated parts of Croatia.
Regarding the construction of access roads to the Pelješac Bridge, the biggest problems and the most demanding works have occurred and performed on facilities located on the section of the access road (tunnels, viaducts, bridges, underpasses). Due to the large number of them on the section of the access road and the required large amount of mechanization and human resources, the construction was significantly more difficult, and the time period was significantly extended. Also, the configuration of the terrain on the Pelješac peninsula for breaking through the access road was demanding, but fortunately the soil was of exceptionally good homogeneous quality and high usability as a road construction material. There were no problems with watercourses on the route, nor was there a need to strengthen the soil. In the structural design of the road, the layers are made according to the necessary regulations and conditions for performance (wear layer, bonding layer, bearing layer and bedding) depending on the traffic load. It can be noticed that this is a large number of pavement structures with different types of asphalt and types of bituminous mixtures and aggregates, which are described in this paper.

References

[1] Glavni projekt Institut IGH d.d; GP 0245/05 72110-GP-162-2020; PELJ-GP-A 0010A 3A, Zagreb, travanj 2021.

[2] Hrvatske ceste, Pelješki most, Zagreb, 01. ožujka 2021. Dostupna na: https://hrvatske-ceste.hr/hr/most-peljesac, 3.11.2021.

[3] Bogdan, A.: Kapitalni projekt Republike Hrvatske, GRAĐEVINAR 71 (2019) 12, pp. 1193-1200

[4] Povezana Hrvatska, Cestovna povezanost s jugom Hrvatske, Pelješki most, https://povezanahrvatska.eu/projekti/peljeski-most/, 20.2.2022.

[5] https://www.jutarnji.hr/vijesti/hrvatska/prvi-put-cijela-ruta-kako-ce-izgledati-put-prema-jugu-preko-peljeskog-mosta-sve-ceste-tuneli-vijadukti-i-manji-mostovi-na-novom-putu-do-dubrovnika-7723545, Zagreb 15. kolovoz 2018., 5.11.2021.

[6] Glavni projekt Institut IGH d.d, PELJ – GP - T 0010 - Projekt podvožnjaka, GP 0245/05 mapa 40, Zagreb, studeni 2016. Dopuna siječanj 2017.

[7] Glavni projekt Institut IGH d.d, PELJ – GP - T 0060 – Projekt mostova, GP 0245/05, Zagreb, studeni 2016. Dopuna siječanj 2017.

[8] Glavni projekt Institut IGH d.d, PELJ – GP - T 0010 - Projekt tunela Kamenice, GP 0245/05 2810 – 823 – 07 104, Zagreb, studeni 2016. Dopuna siječanj 2018.

[9] Glavni projekt Institut IGH d.d, PELJ – GP - T 0021 - Projekt tunela Debeli brijeg, GP 0245/05 2810 – 823 – 07 106, Zagreb, studeni 2016. Dopuna siječanj 2018.

[10] Glavni projekt Institut IGH d.d, GP 0245/05 72110-GP-162-2020, PELJ-GP-A 0040 12, Zagreb, travanj 2021.

[11] Hrvatski normativni dokument, HRN U.C4.012 – Dimenzioniranje novih asfaltnih kolničkih konstrukcija, Hrvatski zavod za norme

[12] Glavni projekt Institut IGH d.d, GP 0245/05 72110-GP-162-2020; PELJ-GP-A 0040 12, Zagreb, travanj 2021.