



DETAILED DESIGN OF STAGE A KRIŽEVCI-KOPRIVNICA RAILWAY CORRIDOR

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Abstract

Due to its great geological and transport position, Croatia is part of important international transport corridors and was included in the Trans-European Transport Network when it joined the European Union. The next ten years will be marked by investments in railway infrastructure projects worth an estimated 4.4 billion euros. One of the most important and financially challenging investments are the RH1 and RH2 corridors. Part of the RH2 corridor is the Križevci-Koprivnica line, which runs under the M201 railway line. The construction of the Križevci-Koprivnica line is divided into four stages. The subject of this article is the description of the substructure, drainage and objects of Stage A from Križevci station to Lepavina station. The biggest horizontal reconstruction is expected in front of Lepavina station. The reconstruction of the horizontal and vertical geometry will allow passengers to travel faster, up to 160 km/h. Major infrastructural investments in railways are just around the corner and will bring benefits, both to individuals and society. Future rail passengers can expect safer, more comfortable and faster transport. Better mobility of passengers and goods will promote the development of Croatian regions as well as demographic and economic progress.

Keywords: railway, detailed design, infrastructure, Križevci, Koprivnica, transport

1 Introduction

Either through its road, rail or sea corridors, Croatia has become part of important international transport routes due to its favorable geographical position as a country on the Adriatic Sea, in Central Europe and on the river of Danube. The country proved its strategic geographical position with the construction of the first railroad line, which was opened on April 24, 1860 in Kotoriba, where Croatia's first railroad station was located. The importance of this line is reflected in the connection of Croatia to the European railroad network through the connection with Budapest and the main line Vienna-Trieste.

With the accession to the European Union in 2013, Croatia became part of the Trans-European Transport Network (TEN-T network). As a member Croatia has a goal to establish a connection of the basic transport infrastructure network with the Trans-European networks and corridors.

The fact that the Gradec-Sveti Ivan Žabno section is the first completed newly built railroad line in Croatia after 50 years speaks volumes about the need for revitalization of Croatian railroads to increase capacity, speed and safety. A challenging decade is ahead of Croatia with major investments in railroad infrastructure, most of which will be financed with European Union funds.

2 Railways in Croatia

TEN-T's Core network consists of nine corridors connecting 94 major European ports and 38 major airports to railroads and roads in European capitals with a main goal in development of 15,000 kilometers of rail infrastructure to provide satisfactory speeds for freight and passenger trains [1].

Two corridors of the basic transport network run through Croatia, the Mediterranean Corridor (road-rail corridor) and the Rhine-Danube Corridor (river corridor). The Mediterranean Corridor is particularly important for the development of railroad infrastructure in Croatia.

According to [2], 89.5 % of the entire rail network in Croatia consists of single-track lines, and the remaining 10.5 % are double-track. Only 37.1 % of the network is electrified. It is important to note that 52 % of the total length of the railroad is designed for train speeds greater than 100 km/h, but only 17 % of the total length at these speeds can be achieved. In Addition, 6 % of the network is closed for operation. This facts indicate the limited capacity and transport performance of the railroad system in Croatia. It is a consequence of the dilapidation of the railway infrastructure and exceeding the service life of the railway superstructure, which forced HŽI to reduce speeds to ensure traffic safety.

It is clear that Croatia has long neglected its railroad infrastructure, which could no longer be maintained by basic measures, but required extensive investment work. This ultimately led to reduced speeds or complete exclusion of the railroad infrastructure from traffic. It is important to note that the local railroad network is in a much worse condition than the international and regional railroad network, in which more has been invested.

With the signing of the Transport Development Strategy of the Republic of Croatia for the period until 2030 in 2017, Croatia has paid a great attention to railroad infrastructure, the development of which has a direct impact on the development of the country's economy.

The estimated value of the planned projects is 4.4 billion euros in the length of about 750 km of renovated lines [1]. The greatest activity is expected for RH1 and RH2 corridor. While on the RH1 corridor the length of double-track lines will increase by 82 kilometers, on the RH2 corridor the length of double-track lines will increase by at least 190 kilometers [1], including the section Križevci-Koprivnica-Hungarian state border described in this article.

3 First stage of Križevci-Koprivnica railway corridor modernization

The railroad connection between Croatia and Hungary was established in 1870 with the construction of the Zakany-Zagreb railroad line via Koprivnica and Križevci. The construction was initiated by the Hungarian Parliament. According to [3], the single-track railroad line ran mostly on plane terrain, had a quite straight direction and passed through the northwestern outskirts of the town of Koprivnica, where the station building was located. The railroad was classified as the 1st category railway with speeds of up to 100 km/h.

With the modernization of the Križevci-Koprivnica-state border corridor, it will become part of a large project to build a double-track railroad line for a mixed traffic from Hungary to the port of Rijeka. The estimated total value of the project is 350 million euros [1], where the Connecting Europe Facility (CEF) has played an important role in co-financing the project. The revitalization of Križevci-Koprivnica-state border rail line will help to increase the maximum speed of passenger trains up to 160 km/h and the maximum speed of freight trains up to 120 km/h Also, the corridor will be shortened from 43.2 kilometers to 42.6 kilometers [4]. The entire project is divided into four stages in terms of organisation and implementation:

- Stage A: Križevci station (excl.) - Lepavina station (incl.)
- Stage B: Lepavina station (excl.) - Koprivnica station (incl.)
- Stage C: Koprivnica station (excl.) - Novo Drnje station (incl.)
- Stage D: Novo Drnje station (excl.) - state border

The subject of this article is the detailed design of Stage A with emphasis on the existing and planned condition of the substructure, drainage and buildings with accompanying photos. Stage A of the section Križevci-Koprivnica modernization includes a section from the station Križevci (exclusive) to the station Lepavina (inclusive) in the length of 17.5 km [5]. The largest reconstruction of this section is expected before Lepavina station, where the existing railroad line will be abandoned over a length of about 5 km and the construction of a new double-track railroad line and the reconstruction and extension of Lepavina station are planned. The mentioned significant reconstruction of the railroad line can be seen in the following figure, where the existing railroad alignment is shown in black and the newly planned railroad alignment is shown in red. This part of Stage A helped to increase the speed of passenger trains on the redesigned track in front of the station and through Lepavina station by increasing the radius of the curves.

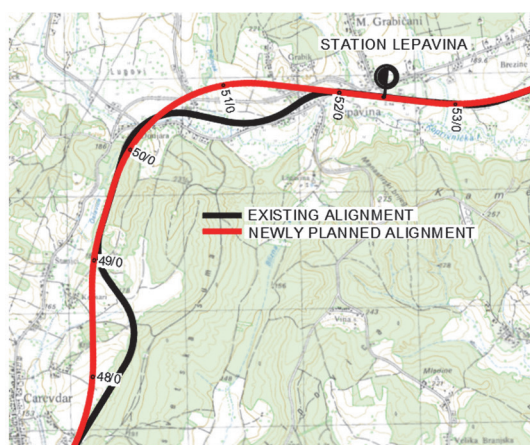


Figure 1 The largest reconstruction of Stage A railway corridor

Cengiz Insaat Sanayi ve Ticaret A. S. was selected as the contractor, with whom a contract for the works was signed on 12 March 2020 in the amount of 322.4 million euros. The companies Centar za organizaciju građenja d.o.o. and DB Engineering & Consulting GmbH were selected for supervision services with a contract of 5 million euros [4]. It should be noted that most of the work is performed under the traffic that takes place on the existing track. This type of construction is especially demanding for contractors.

3.1 Subgrade

The existing railroad on this section is mostly in the fill-slope embankment. They are mostly about 2 to 3 m high, except on the part of the railroad from Vojakovački Kloštar to Carevdar, where the embankments are up to 15 m high. The railroad line passes partly through agricultural land and settlements and partly through the forest. The sub-ballast upper width varies from 5.7 m to 6 m. The embankments are narrow and low in places and, in some places, not wide enough. Geotextiles are laid throughout the whole corridor. The embankments are constructed with a slope of 1 : 1.5, while the embankment slopes range from 1 : 1.5 to 1 : 2 [5]. In addition to the surface of subgrade, the subgrade includes a layer 30 to 50 cm deep, whose geomechanical and load-bearing properties are taken into account in the design. Mixed materials were used for the construction of the subgrade. The level of the subgrade is a double slope of 5 % [5]. The sub-ballast, at least 40 cm thick, is placed on the previously prepared subgrade with a slope of 5 %.

Construction of the embankment is carried out in accordance with the geotechnical design, depending on the types of cross-sections in which the embankment is installed. Depending on the type of material used, the material is compacted using vibratory rollers and compactors and compactors. Filling is carried out in layers no thicker than 30 cm. The slope of the embankment is usually 1 : 1.5, and at all stages of construction the embankment must have a slope of 5 % to ensure adequate drainage. The base of the embankment is rounded with a tangent arch of at least 2.5 m. In addition to the construction of the new substructure, work is also planned to rehabilitate the substructure of the existing railroad line, taking into account the results of the compressibility modulus test from the second Ev2 load cycle. The detailed design explains the procedures for constructing new embankments, extending existing embankments, and improving the subgrade of new and existing embankments [5].



Figure 2 Railway soil-subgrade preparation, 12/06/2021

3.2 Drainage

Drainage along the existing rail line was accomplished with earth and concrete ditches. On the flat part of the railroad line, the longitudinal slope of the channel is about 0.6 %, and minimum channel slopes of 0.1 to 0.2 % were used. In the hilly part, the slope of the channel is about 1 %. The earthen channels are at least 0.2 m deep below the subgrade and 0.35 m wide. The drainage of the stops Majurec, Vojakovački Kloštar and Carevdar was drained with Ø150 mm plastic drainage pipes below the platform. There are 21 drainage culverts on the section in question, which together with the drainage channels form the railroad's drainage system [5].

As for the drainage of the redesigned railroad, the subgrade should be constructed with a gable slope of 5 %, which drains the water into the railroad ditches along the railroad, and at the stops with a slope to the drainage pipe between the tracks.

Along the railroad line, depending on the morphology of the terrain, the construction of railroad channels and culverts is planned. For most of the line, trapezoidal earth ditches are planned, while in some sections concrete were used. Concrete ditches were used in locations where there was a lack of space, in cut-slopes to reduce excavation, and in locations where the longitudinal slope of the trench was too low for the adequate drainage. As part of Stage A of the open railroad, construction of 18 culverts is planned. The culverts will be interconnected by railroad channels and will be part of the railroad's drainage system with drainage and separators [5].

At the stops Majurec, Vojakovački Kloštar and Carevdar, drainage is planned in the form of a PE-HD Ø200 mm and Ø250 mm drainage pipe, which will be laid below the level of the railroad subgrade between the tracks. In addition, the construction of manholes with dimensions Ø600 and Ø1000 mm are planned [5].

3.3 Objects

As reported by [6], the bridges did not meet the requirements for load bearing capacity and usability according to the rank of the railroad. The analysis of each bridge showed that building a new bridge for both tracks is cheaper than strengthening and upgrading existing bridge for a new track.

Thus, on the Križevci-Lepavina section, the existing Glogovnica steel bridge and the Koprivnička concrete bridge will be replaced with completely new bridges. Three railroad viaducts will be built, Vojakovački Kloštar, Carevdar and Komari, of which the Vojakovački Kloštar and Komari viaducts will be passages for animals. The viaducts also differ in the height of the piers and the number of spans. The longest viaduct is the 645-metre-long Carevdar at the intersection of the railroad with the Križevci-Koprivnica high speed road. From Križevci to Lepavina, the Križevci viaduct, the Vuk viaduct, the Vojakovački Kloštar viaduct, the Lepavina 1 viaduct and the Lepavina 2 viaduct are being built.

3.4 Train stops, stations and underpasses

On the Križevci-Lepavina section, the reconstruction of the Majurec, Vojakovački Kloštar and Carevdar train stops and the reconstruction of the Lepavina train station are planned. Future design of train station Majurec and train stop Lepavina can be seen on the Figure 4. Pedestrian underpasses in the form of closed reinforced concrete frames are planned at all stops and stations. The frames of the pedestrian underpasses will be built in two phases - first, part of the underpass will be built under the future new track, and then part of the underpass will be completed under the existing track [6].



Figure 3 Left-train station Majurec, right-train stop Lepavina, vizualisation [7]

4 Conclusions

In a short e-mail interview with contractor, the technical head of the office answered several questions.

About question on a difference between working in Turkey and working in Croatia technical head of the office stated: „Works are solution oriented and more pragmatic in Turkey. In Croatia, the rules are more important.“ and emphasized that working hours in Turkey are longer than in Croatia. Also, technical head of the office mentioned that „Covid is negatively affecting our work.”.

When asked about what would he like to emphasize about the Križevci-Koprivnica project, he noted that „Project is building on running line and that makes the work harder. We have one open railway line and we will add one more. Meanwhile, the other line will be running. Considering the number of engineering structures, it is understandable how difficult the job is. Also, we have to stop the work sometimes because of the environmental reasons. Especially on Drava Bridge.”

According to a newspaper article from Jutarnji list [7], Drava bridge is also mentioned as the most demanding object in this project. Lower structure of the bridge will be built of reinforced concrete, while the upper will be similar in shape and steel. Due to these works on the construction site, an additional 90 workers are expected after the arrival of the steel structure from the factory. According to information from HŽI [4], completion of the section Križevci-Koprivnica-state border work can be expected in 2024.

The project “Reconstruction of the existing and construction of the second track on the section Križevci-Koprivnica state border” will introduce great changes in the urban activity of the cities of Križevci and Koprivnica. The project will not only enable the achievement of train speeds of 160 km/h, but will also provide an additional increase in traffic safety and a significant increase in capacity, while saving time and improving the quality of travel. Zagreb will be reachable from Koprivnica in 45 minutes which will significantly impact daily migrations between Zagreb, Križevci and Koprivnica. Multimodal transport system will become more expressed.

In addition to passenger transport, a transport of goods is also being revitalized. The reconstruction of the existing line and the construction of a new line will allow the movement of large freight trains with a length of 750 meters, whose movement on this line was previously unsafe. The competitiveness of Croatian companies such as Podravka and Belupo will be ensured, as investments in railroad infrastructure have a positive impact on the country’s economy.

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