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## TRAFFIC AND TECHNOLOGICAL PARAMETERS OF THE GRADEC - SVETI IVAN ŽABNO RAILWAY LINE

### ABSTRACT

The paper studies the possibility of construction of a new railway track section from the existing stop Gradec on the railway line Zagreb - Koprivnica to the railway station Sveti Ivan Žabno on the railway line Križevci - Bjelovar, thus improving the importance of the Bjelovar region and shortening the route to Osijek by 16.5 km.

### KEY WORDS

Railway tracks, parameter, transport technology

### 1. INTRODUCTION

The town of Bjelovar, as a political, administrative, economic, and cultural centre of the region, regarding its geographical and urban position, belongs to the outer ring of towns (Varaždin, Koprivnica, Bjelovar, Sisak, Karlovac, Krapina) which encircle the Croatian metropolis - Zagreb. For a better connection between the towns in the ring and Zagreb, it is necessary to provide good quality traffic routes, both roads and railway lines, so as to reduce the travelling time to Zagreb to an acceptable duration.

The today rather unfavourable traffic connections bring Bjelovar further from Zagreb at a distance of 89 km by rail (2 hours by train) and 86 km by road (about 1 hour and 45 minutes ride by the public transport).

Bjelovar is connected with the railway lines of the Hrvatske željeznice (Croatian Railways) by the railway line Križevci - Bjelovar (in the length of 32.4 km) built in 1894, and by the line Bjelovar - Kloštar (in the length of 28.6 km) which was opened in 1900 (closed in 1986 as unprofitable and reconstructed during the war).

The closing of certain sections of the tracks results in re-orientation of passenger and cargo flows to road traffic, which offered transportation service of higher quality.

Today, the transport of passengers and cargo by railway is slowly growing. In order to make the railway attractive again, the level of transportation service

needs to be improved. This implies primarily the reduction of the travelling time, and more frequent trains. The price (which is substantially lower in railway traffic than in the road traffic) did not play a decisive role in choosing the traffic service, but it was the traffic elements of bus transport frequency and shorter travelling times that played the crucial role.

The train travelling time between Bjelovar and Zagreb can be substantially shortened if the existing railway tracks from Sveti Ivan Žabno to Gradec (Vrbovec) are modernised as planned.

### 2. ANALYSIS OF THE CURRENT CONDITION

The existing tracks Bjelovar - Križevci is 32.5 km long with the maximum vehicle loading capacity of 160 kN.

The section of the tracks from the railway station in Bjelovar to the railway station in Sveti Ivan Žabno, in the length of 18.8 km, is laid at the height above sea level of 120 - 125 m and it maintains this height, with minor oscillations, along its whole length. The gradient ranges from 8-9‰, and the rail resistance is 10 daN/t. There are four sharp bends of 300-400 m radius.

From the railway station in Sveti Ivan Žabno to the railway station in Križevci, in the length of 13.7 km the track parameters are less favourable. The gradient is 10‰, the rail resistance 12 daN/t. This section has 14 bends of 250-400 m radius.

Regarding the condition and equipment of the tracks, the maximum speed limit for transporting passengers is 50 km/h, and for cargo trains 30 km/h.

The current level of safety is unsatisfactory. The tracks Bjelovar-Križevci crosses 39 roads (1 regional road, 6 local ones and 32 dirt roads).

The traffic volume has been determined based on the statistical data and commercial evidence of the Croatian Railways. In order to find the maximally real data on traffic in the Bjelovar region, a survey was car-

ried out among the companies that have their headquarters in the area of the town of Bjelovar.

The bus transport in the Bjelovar region is very well developed. The buses from the bus station in Bjelovar towards Križevci, Koprivnica, and Zagreb, transport on average, daily, in both directions, about 2,000-2,200 passengers, that is 750,000-800,000 passengers annually.

Based on the obtained results, it may be concluded that the passenger railway traffic has a tendency of slight increase over the recent ten years, at an average annual rate of 3.9%. Today, 8-9 steam trains travel daily along the Bjelovar - Križevci railway line, and they transport on average 1,000-1,200 passengers daily in both directions, amounting to 350,000 - 400,000 passengers annually. According to the survey, the railway is mainly used by students, less by workers, office employees and farmers.

### 3. TRAFFIC AND TECHNOLOGICAL FEATURES OF THE NEW TRACK

In order to shorten the journey by railway towards Zagreb, and to eliminate the return drives from Bjelovar via Križevci towards Zagreb, the construction of a new section has been suggested, from the railway station Sveti Ivan Žabno to the railway station Gradec.

Fast suburban traffic parameters have to be fulfilled, since high-quality traffic connections may turn Bjelovar into a satellite town centre of Zagreb on the outer ring of the suburban traffic zone (journey of about 1 hour). Therefore, the speed parameters on the new section from the railway station Gradec to the railway station Sveti Ivan Žabno have to range between 100 and 120 km/h.

This speed may also be achieved on the section Sveti Ivan Žabno - Bjelovar if several bends of radius  $R=300$  m are corrected. The critical point remains

only the entrance into Bjelovar, where the current track parameters permanently limit the speed. At the Bjelovar - Kloštar section, the mentioned parameters also need to be taken into consideration in order to provide unique parameters along the whole section from Gradec to Kloštar via Bjelovar (in accordance with the track Dugo Selo - Botovo).

This connection would shorten the train travelling from Zagreb towards Osijek by 16.5 km, since the distance by railway line from Gradec via Koprivnica to Kloštar is  $40.9 + 35.2 = 76.1$  km, and the distance by railway line from Gradec to Kloštar (via Bjelovar) is  $30.9 + 28.7 = 59.6$  km.

This shorter route would be of primary interest for the passenger traffic, but also for the cargo traffic by trains with the total mass of ca. 1,000 t.

Bjelovar, Sveti Ivan Žabno, Križevci (if the existing section from Sveti Ivan Žabno to Križevci stays in exploitation) and Gradec (as the new connecting railway station on Dugo Selo - Botovo track) will participate in the future conditions of traffic regulation.

Several versions for solutions have been taken into consideration when selecting the route between the railway station Gradec and the railway station Sveti Ivan Žabno. In planning the route, the terrain configuration was considered so as to reduce the earthwork to a minimum. The track parameters have been chosen for a speed of 120 km/h, only the bend exiting from the railway station Gradec is planned for speed of 100 km/h (radius 500 m).

The length of the track section (from the middle of the railway station building Gradec to the middle of the railway station building Sveti Ivan Žabno) amounts to 12,173 m. The track is mildly laid along the terrain, the maximum gradient amounts to 7‰ in a length of 1,200 m.

Two stops are planned along the track. The stops are planned in the vicinity of road crossings between villages, so as to provide easier access for passengers.



Figure 1 - Railway route Gradec - Sveti Ivan Žabno

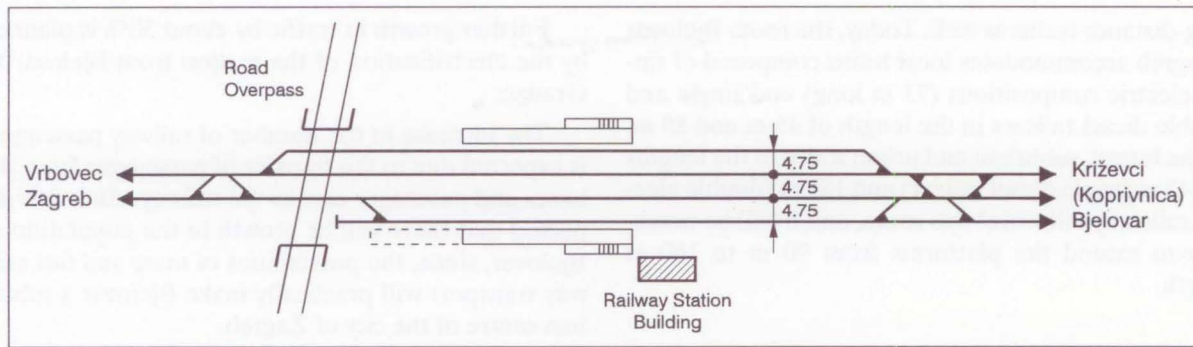


Figure 2 - Railway station Gradec

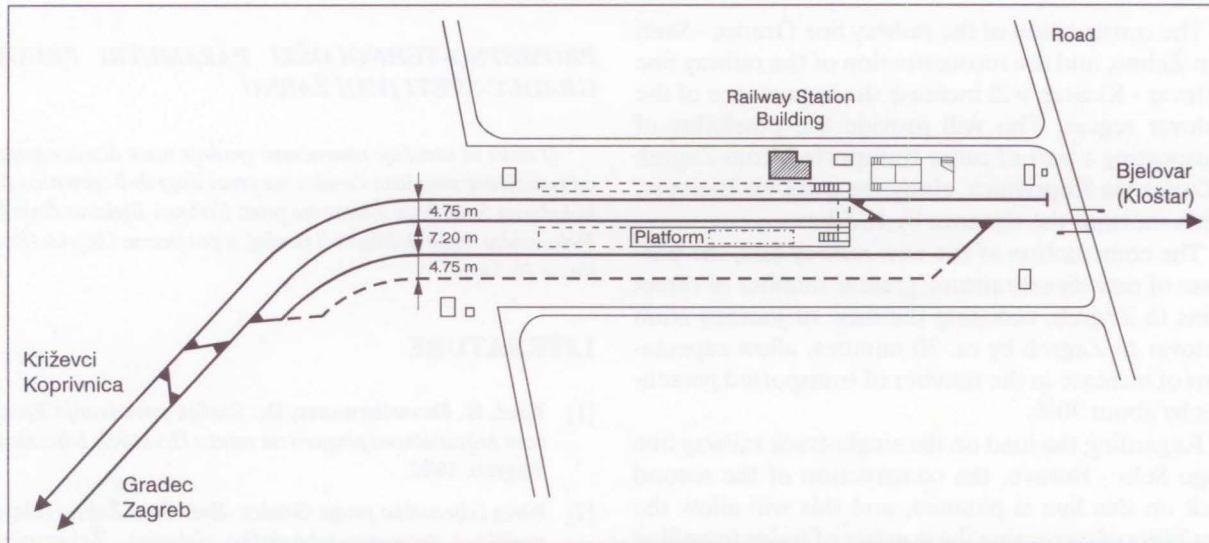


Figure 3 - Railway station Sveti Ivan Žabno

The first stop *Salajci* is planned near the crossing of the railway line and the road Lubena - Salajci, and the second one *Haganj* near the crossing of the railway line and the road Zagreb - Bjelovar. Later, a third stop *Remetinec Križevački* is planned to be constructed near the crossing of the railway line and the road Lubena - Remetinec Križevački.

All the crossings of the existing roads with the railway line are planned at two grades, so that there will be no conflicts between the railway and road traffic.

In planning of major objects, the construction of a bridge of 28 m span is planned over the canal "Globovnica", 3 overpasses in the length of 8-10 m (over the road Cugovac - Lubena - Salajci, Cugovac - Remetinec Križevački, and over the road Zagreb - Bjelovar). Two minor underpasses are also planned along the track.

### 3.1. Traffic organisation in new conditions

In order to separate the traffic from the main railway line Dugo Selo - Botovo towards Bjelovar, and further towards Kloštar and Osijek, it is necessary to

construct a new railway station Gradec and to reconstruct the railway station Sveti Ivan Žabno.

The electrified railway line Dugo Selo - Botovo, with the planned new railway station Gradec as the connecting railway station of the new railway line Gradec - Sveti Ivan Žabno, will have a variable role. In the conditions of single-track connecting lines it will have the role of regulating traffic on the main route Dugo Selo - Botovo and the connecting route Bjelovar - Sveti Ivan Žabno - Gradec. In the conditions of construction of the second track on the line Dugo Selo - Botovo, its role in traffic regulation on the double-track line will be reduced, and it will be fully in function as regulating the traffic on the connecting route.

The traffic analysis on the section from Gradec to Bjelovar leads to a conclusion that the traffic can be expected of trains of maximum mass between 1,000 and 1,200 tons and maximum length of 500 m, so that traffic regulation requires the necessary usable track length of up to 540 m.

The length of platforms at railway stations and stops has to allow admission of trains riding along this track. It is planned that only local (suburban) trains will stop at the train stops, and at the railway stations

long-distance trains as well. Today, the route Bjelovar - Zagreb accommodates local trains composed of single electric compositions (73 m long) and single and double diesel railcars in the length of 45 m and 89 m. In the future, suburban and urban trains in the lengths of 143 m (triple diesel railcar) and 155 m (double electric railcars) will travel this route, and it will be necessary to extend the platforms from 90 m to 160 m length.

#### 4. CONCLUSION

The construction of the railway line Gradec - Sveti Ivan Žabno, and the reconstruction of the railway line Bjelovar - Kloštar, will increase the importance of the Bjelovar region. This will provide the possibility of transporting a part of cargo transported from Zagreb to Osijek via Koprivnica, along the track via Bjelovar, which shortens the distance by 16.5 km.

The construction of the new railway line, the purchase of new diesel railcars, greater number of direct trains to Zagreb, reducing the time of journey from Bjelovar to Zagreb by ca. 30 minutes, allow expectations of increase in the number of transported passengers by about 70%.

Regarding the load on the single-track railway line Dugo Selo - Botovo, the construction of the second track on this line is planned, and this will allow the possibility of increasing the number of trains travelling from Bjelovar to Zagreb.

Further growth in traffic by about 30% is planned by the electrification of the section from Bjelovar to Gradec.

The increase in the number of railway passengers is expected due to the transfer of passengers from the buses and passenger cars to the railway. Also, it is expected that there will be growth in the population of Bjelovar, since, the possibilities of mass and fast railway transport will practically make Bjelovar a suburban centre of the city of Zagreb.

#### SAŽETAK

##### **PROMETNO-TEHNOLOŠKI PARAMETRI PRUGE GRADEC-SVETI IVAN ŽABNO**

*U radu se istražuje mogućnost gradnje nove dionice pruge od postojećeg stajališta Gradec na pruzi Zagreb-Koprivnica do kolodvora Sveti Ivan Žabno na pruzi Križevci-Bjelovar čime bi bjelovarska regija dobila veći značaj, a put prema Osijeku skratio za 16,5 km.*

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