Developing Railway Link in Central Region of Romania

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Abstract. An intersection of European Railway Corridors is present in our country by geographical meanings, conducting to a need of developing infrastructure and connecting it to the European Corridors. The railway link between the Romanian Regions is developing and has just a few sections that need to be made in order to have the entire IVth Pan European Railway Corridor from Romania rehabilitated. The Central Developing Region from Romania contains the railway section between Brasov and Sighisoara cities that is rehabilitated for the maxim design speed for passenger trains of 160 km/h and 120km/h for freight trains. The maximum design speed imposes new curves with bigger radius resulting in new routes along the section. The actual and proposed route of double track railway section between Brasov and Sighisoara is analysed and the rehabilitation works along with it. The tunnels cross section and possible difficulties in realising and execution of them are presented and analysed. Conclusions regarding the proposed art works and future problems that can be solved in this stage – preparation stage that can assure better and safe construction and exploitation of the railway are made in final.

1. Introduction
By the geographical position, Romania represents an intersection zone of European Railway Corridors, which connects north Europa to south Europa and also the west and the east of Europa.

In order to integrate the Romanian Railway Corridors in the IVth Pan European Railway Corridors for the maximum speed for passengers’ trains of 160km/h and for freight trains of 120km/h are left to finish only two sections along the IVth Pan European Railway Corridor from Romania, one is Predeal - Brasov and the second is Brasov – Sighisoara.

The IVth European Railway Corridor along Romania is composed of:

- 800 Magistral, between Constanta and Bucharest that links three regions from Romania, South – East Region ↔ South – Muntenia Region ↔ Bucharest – Ilfov Region, is completed and it is in exploitation;
- 500/300 Magistral, between Bucharest and Ploiesti, links two regions from Romania, Bucharest-Ilfov Region ↔ South – Muntenia Region, is completed and it is in exploitation;
- 300 Magistral, between Ploiesti and Coslariu that links South – Muntenia Region ↔ Central Region and contains the last two sections that need to be rehabilitated;
- 200 Magistral between Coslariu and Curtici that links Central Region ↔ Vest Region, it is in rehabilitation;
The paper deals with the railway line section between Sighisoara and Brasov, where are proposed a series of art works and a new route for accomplishing the maximum design speed.

A map of all railway lines and magistral distribution from Romania is presented below, in figure 1.

![Figure 1. Map of railways of Romania [1]](image)

2. Brasov – Sighisoara railway in Central Region of Romania

2.1. Actual railway route

The actual railway route between Brasov and Sighisoara passes in Central Region of Romania along the administrative county of: Brasov ≈ 97.75 km – 75.04%, Mures ≈ 2.43 km – 1.87% and Harghita ≈ 30.09 km – 23.10% and the designed new route will pass through Covasna County. The exploitation of the line started in April 1873, then was doubled between 1970 – 1974 and electrified between 1981 – 1985.

The effective length of the present rail line is 130.27 km, measured between head input signal X Brasov – km 169+120 and head input signal Y Sighisoara – km 299+392, with the following passenger stations: Brasov – km 169+864; Apata – km 207+698; Racos – km 230+833; Rupea – km 244+805, Cata – km 253+414, Sighisoara – km 298+470, figure 2. [2]

The route has double track railway line and in the plan, the minim curve radius is of 274 m, on Beia – Mureni interval. In the longitudinal profile, the maximum declivity is around 13.7% and the interval contains two single-track railway tunnel of 660 m – Beia I and Beia II tunnels. [2]
The general view of topography along the actual route develops from 560 m quota – Brasov station to 316m quota – Sighisoara station on:
- meadow river Olt from Brasov depression with the Maierus, Hoghiz – Venetia Archita corridors;
- meadow river Tarnava Mare and Homorod.

For the rehabilitation of the entire railway, the line between Brasov and Sighisoara was divided into three sections, mainly for economical and funding reasons with the following [2]:
- section 1: Head X Brasov – km 169+120 – Head Y Apata – km 208+088.954;
- section 2: Head Y Apata – km 208+088.954 – Head X Cata km. 253+414;
- section 3: Head X Cata – km. 253+414 – Head Y Sighisoara – km 299+392;

The present railway line does not accomplish the technical conditions for a competitive speed train circulation. Speed restrictions being used along the route so a passenger train does this section of approximately 130km in about 170 minutes (figure 2), or in terms of a technical speed of 57km/h – 135 minutes. After the rehabilitation, the technical speed should grow up to 110 km/h and the trip duration will decrease to about 60 minutes, resulting in a reduction of about 45%.
2.2. Proposed railway route and tunnel cross sections

The proposed route has the length of ≈112.54 km, being shorter with ≈16.58 km, resulting in a reduction of ≈12.84%.

After improving the line characteristics, the new route will pass the Administrative Counties with the following lengths: Brasov – 30.17km, km 170+296 – km 200+470; Covasna – 1.10km – km 200+470 – km 201+570; Brasov – 48.43km – km 201+570 – km 250+000; Mures – 19.47km – km 250+000 – km 269+740; Harghita – 0.66km – km 269+740– km 270+130; Mures – 12.71km – km 270+130 – km 282+842. The total length of route along Brasov County - 78.06km – 69.85%, Covasna County – 1.10km – 0.98%, Harghita County – 0.66km – 0.59% and Mures County – 32.18km – 28.59%.

The length of route on a new axis of 62.14 km – 55.46% and the length of current route rehabilitated of is approximately 50.13km – 44.54%. In addition, are included new tunnels with a total length (single track - 24.12 km and double track tunnels – 1.50km) of 25.62km – resulting in 12.05% from the newly designed route, all distributed on the three sections with the new following kilometres positions:

- section 1: Head X Brasov – km 170+285 – Apata – km 208+090 (figure 3);

![Figure 3. Section 1 Brasov - Apata [2]](image)

- section 2: Apata – km 208+090 – Cata – km 231+692 (figure 4);

![Figure 4. New route around Sighisoara tunnel [2]](image)
The second section of the interval has many new art works – bridge and tunnels, from which we will present two new twin single track tunnels: [2]

- Ormenis I – single line track tunnel – track I, with a total length of 6913.97 m using the tunnel boring machine (TBM) and Cut and Cover method of execution between km 213+158.38 – km 220+072.35 (figure 6);
- Ormenis II – single line track tunnel – track II, with a total length of 6917.97 m using the tunnel boring machine (TBM) and Cut and Cover method of execution between km 213+136.17 – km 220+053.84;
- Homorod I – single line track tunnel – track I, with a total length of 5153.92 m using the tunnel boring machine (TBM) and Cut and Cover method of execution between km 226+538.99 – km 231+692.91 (figure 5);
- Homorod II - single line track tunnel – track II, with a total length of 5135.19 m using the tunnel boring machine (TBM) and Cut and Cover method of execution between km 226+537.28 – km 231+657.47.

![Figure 5. Typical cross section of Homorod tunnels [2]](image)

![Figure 6. Typical cross section of Ormenis tunnels [2]](image)

- section 3: Cata – km 231+692 – Sighisoara – km 282+842;

The old and the newly designed route for section three with the present stations are presented below, in figure 7:

![Figure 7. New route around Sighisoara tunnel [2]](image)
The route for section three has a series of art works like: [2]

- Beia I, single track tunnel with the length of 644.58m which can and will be used, was built between 1977-1979, has an inner radius of 3.80m;
- Beia II, single track tunnel with the length of 662.89m which needs to be extended with a length of 35 m, using shallow execution method – Cover and Cut method, designed between km 249+641.07 and km 249+676.07, having the cross section from figure 8;
- Mureni, double track railway tunnel with the length of 740.42, between km 265+685.90 – km 266+426.32 using both methods of execution – shallow and typical underground, having the cross section from figure 9;

**Figure 8.** Cross section tunnel Beia II [2]  
**Figure 9.** Cross section tunnel Mureni [2]

- Archita I, single track tunnel with the length of 503.22m, between km 251+894.78 – km 252+398, that uses both methods of execution from the surface and natural tunnel (figure 10 and 11) [2];
- Archita II (figure 10 and 11), single track tunnel with the length of 232.67m, between km 253+657.89 – km 253+890.56 that uses both methods of execution from the surface and natural tunnel (figure 10 and 11) [2].
3. Results and discussions

The location of our country in Europe and for European Union is a major advantage and a high responsibility because with a judicious development of Constanta Port, South – East Region, modern railways and roads routes, we can be an important gate for all kinds of products that need to be delivered with cheap, eco-friendly and fast transport anywhere to and from EU.

The first step in developing of the railway infrastructure was made, but needs to be amplified, more, for sustaining the Regional need of transport, for freight or passenger transport, in our country and also for Europe with the rehabilitation of the 9th European Railway and Road Corridor from Romania must be accelerated.

The rehabilitation of railway in Central Region of Romania, between Brasov and Sighisoara, is the most expensive section and difficult until now because the present and future route passes through an area with mountains and protected environment and it must continue to facilitate people’s access to transport.

The new route had to permit passenger trains to travel with a maximum speed of 160km/h, so the present route was a redesign for maximum speed and that needed new curves radius along the route, resulting in new works for more than half of the entire proposed route.

We can see that the percentage of railway development along the Counties changed, with the improvement of the railway geometrical characteristics and was reduced in Brasov County from 75.04% (present) to 69.85%, in Harghita from 23.10% (present) to 0.59% and in Mures increased from 1.87% (present) to 28.59%, however, the passenger stations remains the same.

For the new route, an important percentage of works is represented by new railway tunnels – 12.05% - the length being the most important in our country after 1990, that way it is important of a realistic and correlated tunnel cross section with the proposed route and execution technology.

The proposed cross sections are similar with some differences that were necessary because of the execution technology and have a series of deficiencies of conception that can be repaired in this stage – preparation stage. Those were found, analysed and fixed during the execution of Sighisoara and
Danes tunnels [3] or, in this same stage for Turdas tunnel [4] [5], on other sections along the rehabilitated railway corridor. Based on the experience of analysed tunnels can be made some suggestions and recommendations in order to avoid the same difficulties, execution and technological problems before the execution starts in the future section.

The main problems can be fixed with new ground investigations and geotechnical studies, where it is necessary to define the free water level; stratification – a precise geological longitudinal profile; underground water and water composition – aggression; identifying the presence of swelling soil.

From applying the national and international regulations – UIC – International Union of Railways, and norms regarding the inner rolling gauge and the interior free cross section correlated with the maxim speed for passenger trains of 160km/h [6] can be optimised the free cross section.

Also, another general issue for the proposed cross sections are the position and location of water evacuation canal and central canal, that with the taking into consideration of the national regulations – Instruction 314/1989 and other foreign regulations and recommendations from The French Tunnelling and Underground Space Association or the UIC can be fixed and their position moved.

4. Conclusions

One of the major project of investment in our country, maybe the first, is the rehabilitation of IVth Pan European Railway Corridor from Romania that crosses the country from East (Constanta) to West (Curtici) Romania, connecting five regions: South - East Region ↔ Bucharest – Ilfov Region ↔ South – Muntenia Region ↔ Central Region ↔ North West Region from the total of eight Regions, being a great vector in the development of freight and passenger transport.

From another point of view, the developing of the transport infrastructure from Romania influences the social life of citizens and with the new available fast railway route can work and travel anywhere in the Romanian Regions more easy and safe, with reduced costs and no need for relocation. In addition, another Romanian phenomenon – a major quantity of young people are leaving Romania for jobs in Europa, can be reduced and fought with the modern, economic and ecological infrastructure that is being built.

The section from the Central Region from Romania, between Brasov and Sighisoara presents major provocations for the Romanian engineers involved and will be a great addition for our country. The proposed route is shorter than the present ones and permits the design speed circulation to be accomplished.

The last section that needs to be rehabilitated is the most complicated because of the geographical position in South Muntenia Region, where the IVth Pan European Railway Corridor from Romania passes the Carpathian Mountains. In 2003 [7] and 2005 [8], different solutions were studied and proposed new routes for this section with various cross sections for tunnels.

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