MAKING DATA BANK FOR OPERATING TUNNELS

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Abstract: *This article describes the key components of the data bank for tunnels: general data, data on the execution stage, data on environment, data on land, the status of technical data, methods of investigation, diagnosis, mode of collection of this information and how to integrate the information into the database*

Keywords: *tunnel, data bank*

1. Introduction

Tunnels for railway communications represent - without doubt - the most representative category of underground constructions, due to the value, size, economic and social role.

In Romania, at the moment, railway tunnels sum approximately 74.5 km in length, 71.6 km metro and road tunnels about 2 km.

Railway tunnels are the most important branch tunnels for communication routes, both by length, number (193 Tunnels) and the composition and diversity of the types of terrain traversed.

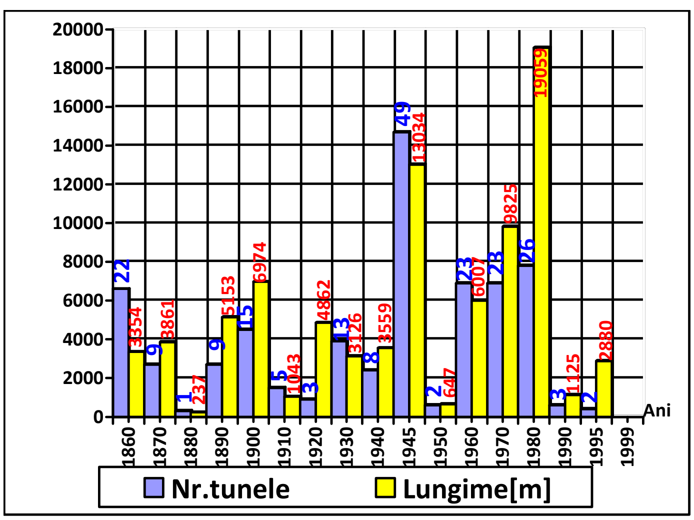

Fig. 1. Evolution of construction of tunnels in Romania

The first railway tunnels were made in Romania, between 1856-1863, the Oravița - Anina by Austrian company St.E.G. (Königliche-Kaiserliche Privilegierte Österreichische Staats-Eisenbahn-Gesellschaft or the Privileged Imperial Society and Royal Austrian State Railway Company) and in service at December 15, 1863. The 14 tunnels carved in stone are in use today, with restrictions on the use of rolling stock due to low gauge.

2. Characteristic elements of tunnel

Access of communication path to the tunnel is through the trenches of access that can be quite long and bordered by walls or short and supported by wings.

Figure 2 presents the features of a longitudinal tunnel. At the end of the tunnel is realized two building blocks called portals which act for taking over massive pushes in the longitudinal direction and having an aesthetic role, being an architectural achievement that fits with the environment. Also portals connect tunnel and trenches access.

The tunnel itself is composed of building blocks called rings whose length depends on the nature of the rocks traversed and the method of execution used.

Wing is the connecting link with the walls of the tunnel access trenches, being built of concrete or masonry.

Tunnel axis is the axis of symmetry in the vertical plane of usable section of the tunnel. For railway tunnel in line, this axis coincides with the axis of rolling track, but for and curved tunnels, the tunnel axis is different from the axis of rolling track to ensure gauge framing.

Niches (refugees) are special arrangements, executed outside gauge and serve both housing workers that work on the communication path maintenance, and for storage of materials necessary for local repairs. The niches are arranged alternately on the both sides of the communication path at a distance of not more than 50 m along the tunnel. They are arranged in the lining of the tunnel or outside it when the gauge permits. At long tunnels larger rooms are provided at intervals of about 2-3 km, required for storage of materials and equipment, installation of telephones and for surveillance of traffic through the tunnel, etc. Road tunnels must be equipped with safety cabinets for parking of vehicles, the distance between these niches is 700-800 m.

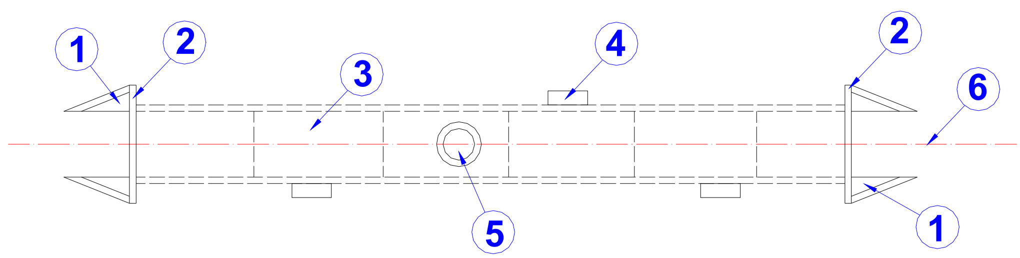

Fig. 2. Characteristic elements of tunnel
1 - wing, 2 – portal, 3 – ring, 4 – niche, 5 – ventilation shaft, 6 – tunnel axis

Ventilation shaft is a special building, vertical, in the shape of basket, placed in the tunnel axis or on sideway, withe the purpose of aeration and tunnel ventilation between the interior and exterior.

Figure 3 presents the cross section features of a tunnel.

Soffit is the inner contour of the lining of tunnel or unlined free section of the tunnel.

Tunnels cross sections can be of different types: horseshoe, circular, rectangular. In the case of single track tunnels most used type is horseshoe section.

Useful inner section or circulation gauge (free movement) is the free cross geometric contour, in vertically plane, perpendicular to the longitudinal axis of the rolling track. Inside it is not allowed for access any part of the construction of the tunnel or fixed installations, apart from means of transportation on that route. The gauge traffic must comply with the standards in force for each route of circulation.

The gauge that must be provided within a tunnel must be larger than the dimensions of the largest of vehicles circulating on the respective communication path. The extra space is needed for the following reasons: the existence of irregularities and inevitable deviations of shape and size of construction, any inaccuracies in the construction of the tunnel, oscillations of the vehicle during the journey, the movement and deformation of construction products by rock pressure or other reasons, the possibility of mounting installations in the tunnel, the need to implement maintenance and repairs works during railway traffic,the possibility to allow, in exceptional cases, the passage of convoys through the tunnel.

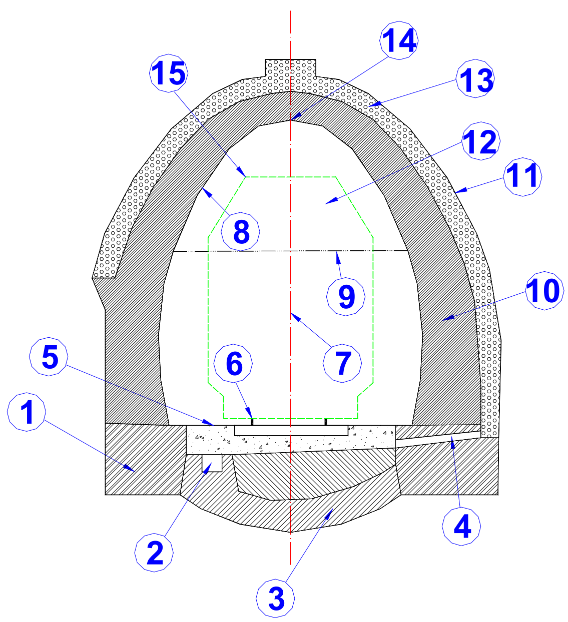

Fig. 3. Characteristic elements of tunnel
1 – foundation, 2 – water discharge channel, 3 – slab foundation, 4 – barbacana, 5 – banchina, 6 – rolling track, 7 – tunnel axis, 8 – soffit, 9 – vault birth, 10 – lining, 11 – extrados, 12 – calotte, 13 – stone mattress, 14 – dome, 15 – gauge

Foundation slab is built between the tunnel element that support raceway. They can be flat or dome-shaped, made of concrete, reinforced concrete or stone masonry.

Barbacana is a cross hole accomplished through foundations, to evacuate water from seepage behind the liner.

Banchina is an element of concrete, executed above the foundation and slab to the rolling tracks. It is placed on both sides of the driveways and serves for movement of maintenance staff and for placement of different installations of the tunnel.

The liner is a constructed element securing the excavated contour and is the free of exploitation section of the tunnel. The liners can be monolith, prefabricated or with two components, one precast outside and one monolithic inside, or both monolith.

Extrados is outer surface of the liner and connects the tunnel with the environment.

Bolt is the top of the liner to the soffit, the height of this item is important when upgrading tunnels (electrification of the line).

Displacement "Δ" is the distance by which the tunnel axis is moving from the center of the track towards the inside of the curve. It is calculated according to the gauge inclination due of superelevation of track and curve radius.

3. Making bank data for tunnel in service

In the operational phase of tunnel, the manager must ensure maintenance of tunnel in operational parameters. For this he is supported by the totality of knowledge about the tunnel, accumulated over time, which is the database for tunnel or file tunnel.

Data are collected about tunnel: before construction starts (topographical, geological, geotechnical studies, etc.), during construction, during exploitation (surveys, investigations, repairs, etc.).

The main components of the database for tunnels are: general data, data on project execution stage, environmental data, data on land, data about the technical condition, methods of investigation, diagnosis.

In making the database tunnel participate specialists from various areas: engineers of roads, construction and hydraulic engineers, geotechnical, geology, and geodesy engineers. These, in addition to programmers, analysts and programmers, make a contribution to development and updating information about tunnels. Intervention of specialists in geodesy is to the technical data on the state of the tunnel, that information can be collected only by measurements. The resulting information is then analyzed by railway specialists that can take an informed decision on the need for interventions on tunnel, the scale of these interventions, the implications of intervention on traffic and not least the costs and funding opportunities.

This information are collected periodically, the timing of investigations is made by the manager of the tunnel and consists of: achievement of longitudinal profile of rolling track, preparation of soffit survey with mapping of apparent defects, checking the gauge of the tunnel by achieving cross surveys executed always in the same sections.

Achieving the necessary products for a database involves executing tunnel surveying and topographic measurements of high precision, contributing to a more accurate analysis of the shape and position of the parts of a tunnel.

Precision geodetic measurements using - usually - GNSS technology, aim to establish in national geodetic framing the tunnel site.

Topographical measurements with high accuracy, using precision electronic total station, using photogrammetric technology, using terrestrial laser scanning technology, aim to determine the coordinates of all the characteristic points of topographic elements required for the topographical plans, of reports, profiles, etc..

Precision leveling measurements using electronic or digital precision levels, aim to determine accurately the heights of characteristic points of topographic elements of the tunnel.

The combined measurements comprise the topographical methods with terrestrial laser scanning methods. The method uses detailed surveying of external elements combined with automated measurements of the inner walls to obtain the 3D model of the tunnel. For this purpose, a part of surveying measurements are used for position and orientation of the laser scanned sections, using an automated software carried out for this purpose. The advantages of this method are high accuracy and reduced time working in the field measurements. This method yields detailed plans (sections of the tunnel), topographic plan, topographical profiles, including 3D model of the tunnel.

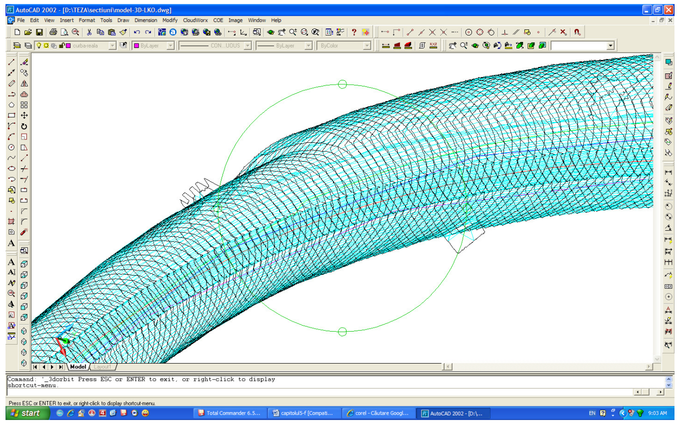

Fig. 4. 3D model of the tunnel

The longitudinal profile is carried out along the axis roller track, the standard scales are 1: 100, 1: 200 and 1: 500 for the length and 1:10, 1:20, 1:50 for heights.

In addition to the known elements of longitudinal profile, such reference plane, partial distances, heights, there are specific elements such as track mileage, ring type, ring length, NTS heights, ring number, etc.

The need to verify the gauge is justified by the possibility of liner distortion in time, or horizontal and vertical displacement of the raceways, which can lead in overcoming gauge circulation and very serious accidents.

The conducted mapping plan of the soffit with apparent defects (Figure 5) is the most important piece in the action of collecting data on the tunnel. It runs at 1: 100, 1: 200 and 1: 500 depending on the size of the tunnel and gives a suggestive image of the defects and their changes over time, constituting an essential element in establishing the diagnosis of tunnel.

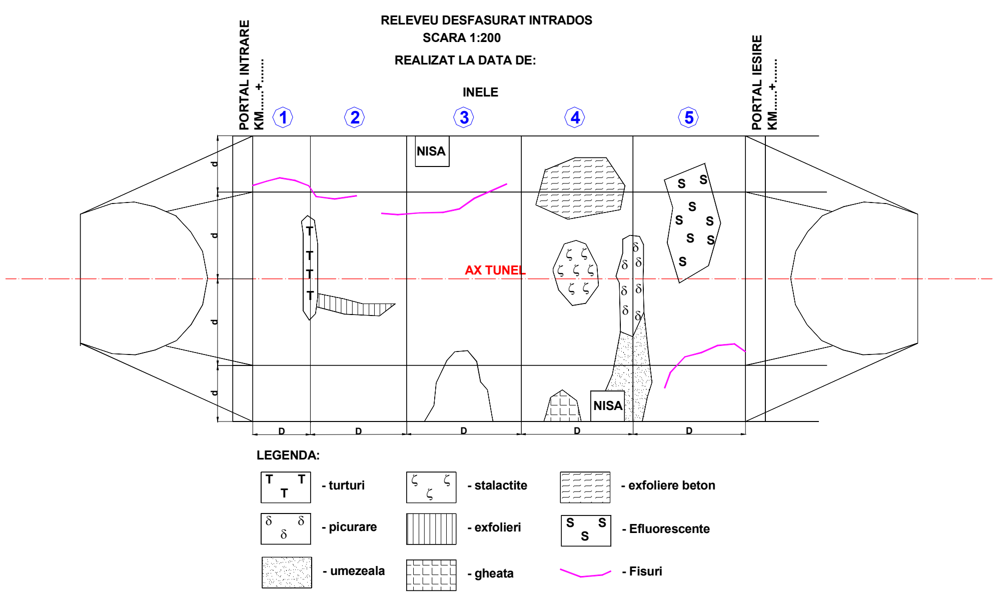

Fig. 5. The conducted mapping plan of the soffit

Measurements of transverse surveys (Figure 6) runs every two years for tunnels which have no problems or at more frequent intervals set by the administrator of the tunnel for tunnels with major developments in time. They always run in the same section to be compared with each other, can run in new sections, which will be resumed later if the situation on the ground requires it.

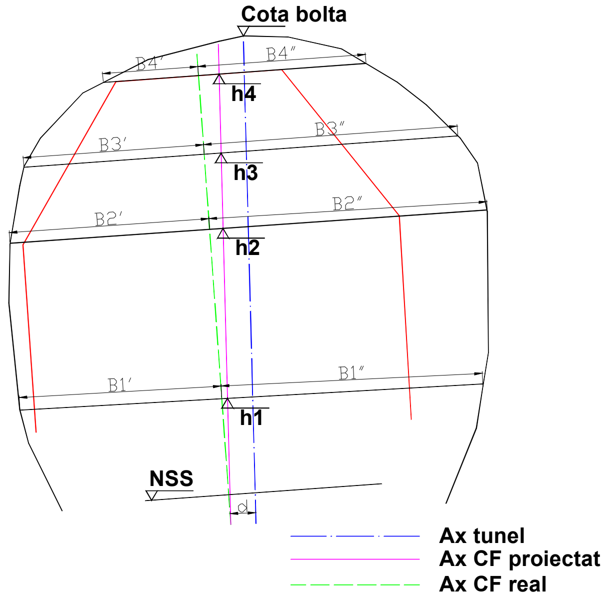

Fig. 6. Measurements of transverse surveys

For each stage of measurements is running a gauge measurements sheet (Figure 7) containing: the number of rings, position in kilometers of the section in which the measurements are achieved, the year in which the measurements are performed, etc.

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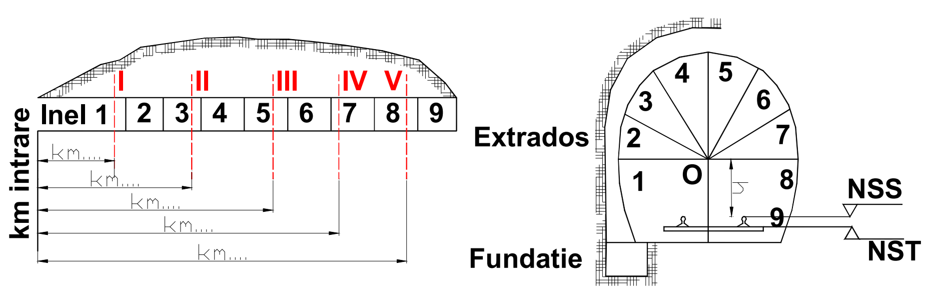
masurare intrados la tunelul......................., linia....................., km.....................

sectiune longitudinala **sectiune transversala**



Distance from the center O in 1, 2, 3, ...

Year	Section	1	2	3	4	5	6	7	8	9
2009	I	3.308	2.865	2.842	3.231	3.427	3.299	3.006	2.834	3.219
	II	3.786	3.651	3.702	3.916	3.801	3.409	3.067	2.865	3.203
	III	3.857	3.637	3.595	3.755	3.658	3.529	2.970	2.898	3.266
	IV	4.303	3.803	3.702	3.606	3.341	3.038	2.636	2.637	3.160
	V	3.262	2.895	2.931	3.517	3.623	3.338	2.833	2.716	3.044

Year	Section	1	2	3	4	5	6	7	8	9
2010	I	3.310	2.863	2.845	3.230	3.427	3.301	3.000	2.831	3.223
	II	3.784	3.653	3.700	3.918	3.803	3.411	3.065	2.863	3.200
	III	3.855	3.639	3.592	3.753	3.656	3.527	2.972	2.901	3.264
	IV	4.302	3.805	3.703	3.604	3.343	3.037	2.635	2.635	3.161
	V	3.260	2.893	2.930	3.515	3.621	3.341	2.836	2.717	3.042

Fig. 7. Gauge measurements sheet

Data values of misalignment of the elements tunnel and assigning values of gauge is done to verify the actual position of the axis tunnel, and contains the following elements: misalignment ΔT between the axis of the tunnel and the runways axis, ΔCFp misalignment between the existing axis of the track and the designed axis of the runways, minimum horizontal distances that separate gauge to the tunnel soffit, Gd (right gauge), Gs (left gauge);

If the the gauge tolerances are exceedes, caused by misalignment of runways axis respect to its designed axis, it is set out the runways axis on the design position.

Table 1, Misalignments and gauges

Km	Rost rings	ΔT [mm]	Gd [mm]	Gs [mm]	ΔCFp [mm]	ΔCFa [mm]
598+938.10	PI/1	203	158	526	126	
598+942.10	1/2	174	205	508	113	
598+946.60	2/3	164	158	526	121	
598+950.00	3/4	169	293	569	93	
....	....	....	....	....	......	
599+018.50	15/16	282	269	1262	21	
....	....	....	....	....	......	
599+038.50	20/21	188	294	1277	34	
....	....	....	....	....	......	

4. Conclusions

The difficulty in tunnels is given by the actual knowledge of the technical condition, due to the following factors: we can observe and follow only the underside of the elements of track, the archive documents, particularly in old tunnels, do not allow the knowledge for design and realization of linings, it is not possible to know precisely the strength of a lining, if it is more or less degraded.

The modernization works of tunnels have also their own specific given that their significance can not be estimated accurately only on the basis of preliminary studies, their implementation is difficult due to the nature and conditions of implementation.

Creating a database for tunnels associated with a CAD environment brings indisputable advantages and ease of data manipulation and in decision making on interventions tunnel.

The most important advantages are: the ease with which the conducted plan of the tunnel is carried out, we can highlight the evolution of defects, information is stored on categories and types, there is a possibility to plot plans on different scales as needed, can overlap easy surveys and profiles for viewing different phenomena and differences, the possibility of automated analysis on various criteria such as linear defects, plane defects (wetlands, areas of scrub).

According to the queries of the database and information collected periodically it can make decisions on how to act on the tunnel to be restored to the normal operating parameters.

These actions can be: preventive having the role to eliminate the causes of nonconformities, defects or unwanted situations; corrective role to eliminate existing defects, to prevent recurrence and emergency actions that occur in the event of severe damage, natural causes (earthquakes, landslides, floods) or artificial (fire, derailment of collision).

Maintaining tunnels in operating parameters during their operation involves the creation, maintenance and operation of a comprehensive data bank of the tunnel, with textual and graphs information on all operation parameters of the building and adjacent facilities, conducting maintenance and repair, works of modernization.

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