Full-text paper

MAGLEV REQUIREMENTS FOR TUNNELS

(Emergency Concepts, Security Exits, Cross-section Design, Guideway Types in the tunnel, Sonic-Boom-Effects, Shocks)

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key words

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Abstract

In contrast to lines running above ground following new subject-matters are to be considered for those running through tunnels:

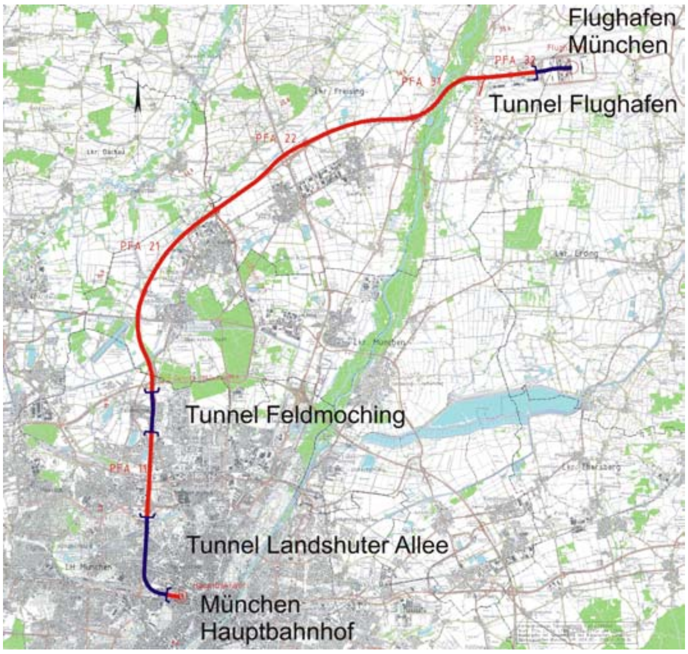
- Aerodynamic cross sections
- Guideway types of tracks
- Anti-shock measures
- Space requirement for the technical installations of the system
- Emergency concept
- Tunnel construction details

1. Introduction

In the line variants studied so far for magnetic levitation trains, it has generally been assumed that the trains would run above ground. The already existing test tracks for magnetic levitation trains as well as the one being in use in Shanghai are built above ground.

Should further magnetic levitation lines be built in the future – and should they pass through urban areas – it will become increasingly necessary to lead the lines through tunnels due to existing structures on the surface (buildings, roads, etc.).

Lines with tunnel sections are currently planned for the magnetic levitation train, which will commute between the main station of Munich and the airport.



Picture 1: Overall plan magnetic levitation train Munich

Since the route in planning lot 1 will mainly run through inner-city areas and will connect the airport in planning lot 3, three tunnel structures will become necessary:

Tunnel Landshuter Allee:	L =	4,202 m
Tunnel Feldmoching:	L =	1,632 m
Tunnel Airport:	L =	1,130 m

In addition to the planning works for a line running above ground, new subject-matters are to be considered for these tunnel structures. These new subject-matters will be presented in the following, using the planned magnetic levitation line in Munich as an example.

2. Aerodynamic cross sections

2.1 General

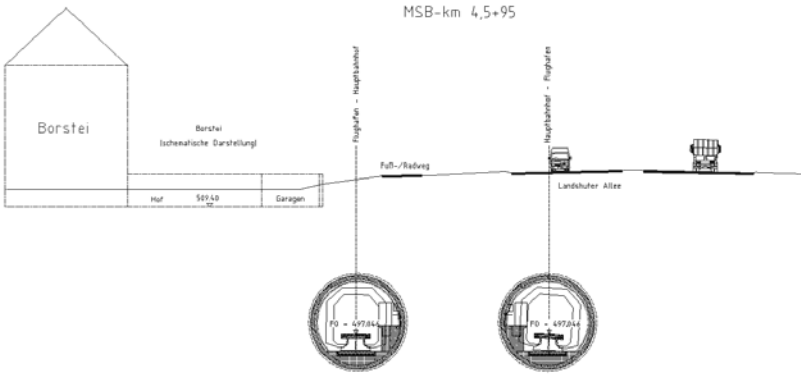
The structure of the vehicle and the designed high speeds require that specifications are to be made for the aerodynamic cross sections. On their basis the tunnel cross section itself can be planned. To reduce these cross sections, the built-in units have to fulfill high demands. Built-in units for example, which require a lot of space such as walkways at the side should be planned as "transparent" as possible so that any reduction of aerodynamic useful areas can be kept at the lowest possible degree.

Twin track tunnel cross sections are to be preferred due to aerodynamic reasons. They could however cause higher technical problems, costs and the necessity of keeping up with higher safety-engineering standards.

2.2 Magnetic levitation train Munich

The intended design velocity represents an essential criterion for the aerodynamic cross section and thus for the tunnel dimensions. To reduce the effects of the magnetic levitation train within inner-city areas, the design velocity is also limited up to v = 250 km/h for the tunnel structures. On the basis of this design velocity, a minimum cross section of 36 m² (without built-in units) has been determined for single-track tunnel tubes and a minimum cross section of 70 (without built-in units) for twin track tunnel tubes.

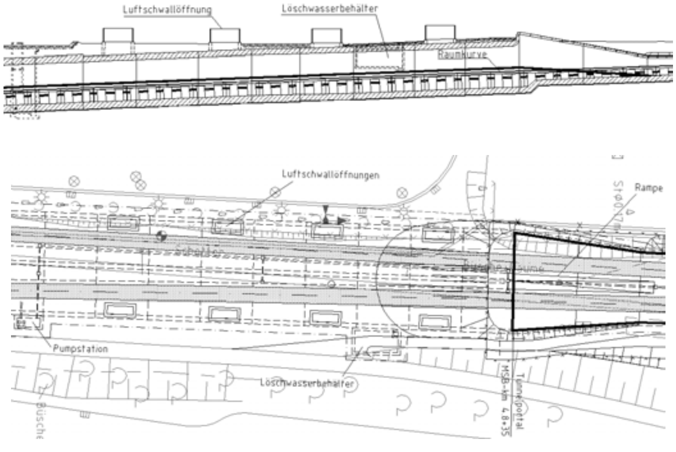
Based on an earlier analysis of the structural feasibility, in connection with the appropriate construction costs, it has been decided in the planning phase to build the single-track tunnel tubes.



Picture 2: Cross profile 1 (minimum overburden)

The sonic-boom aspects were considered in another analysis dealing about the aerodynamic situation at the portal areas. This analysis showed that structural measures are already necessary at the tunnel's entrance in order to avoid this sonic-boom effect at the tunnel's exit. In comparison with normal tunnel cross sections, the tunnel cross sections therefore need to be enlarged over a length of approx. 60 m by a factor of about 1.5 at the entrance area.

To prevent the air flow, which is carried along with the magnetic levitation train, from streaming into the tunnel tube at the portal, the tunnel roof at the portal areas is to be provided with so-called air flow openings. With an entrance velocity of 250 km/h, a total of 8 air flow openings, each with size of 8 m² is to be provided.



Picture 3: Site plan / Longitudinal section: Air flow openings

3. Guideway types of tracks

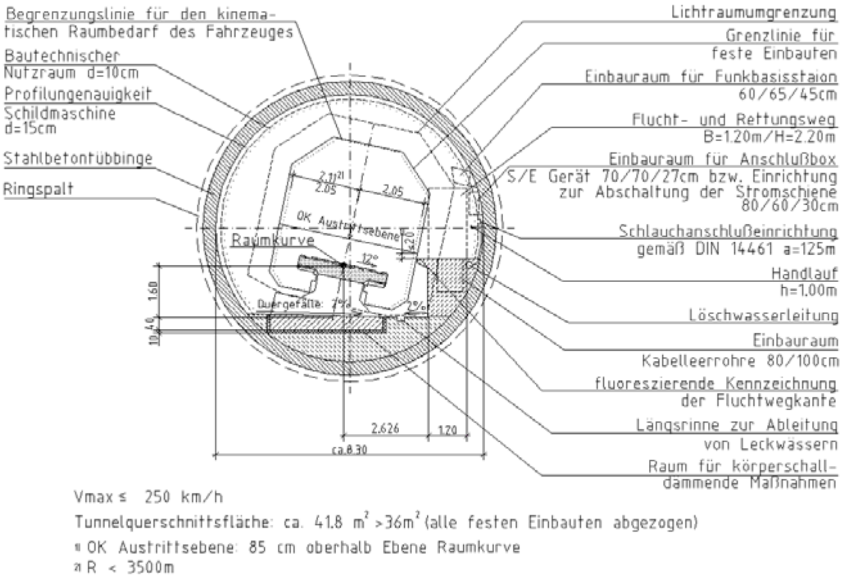
3.1 General

In contrast to guideways running above ground, the available space for them , for their installation and their maintenance is only very limited in a tunnel. This means that short and low guideway types are to be used if possible. The foundation of the guideways should also be as plane as possible due to structural reasons. Especially in case of tunnels driven mechanically via TBM and being lined with reinforced concrete segments (tubbings), additional structural measures are required for this plane positioning.

3.2 Magnetic levitation train Munich

Within the tunnel structures, the so-called carrier type III will be employed. This guideway is characterized by low heights in comparison with guideways in the open air. In dependence on the radii of the line and therefore on the transversal slope, the installation heights between the guideway and the substructure will vary between 1.35 - 1.60 m.

By providing the line with supporting discs on a regular interval and by building a base plate between the guideway and the substructure, an almost plane bed can be achieved.



Picture 4: Normal cross section tunnel

4. Anti-shock measures

4.1 General

If a tunnel underpasses existing buildings, additional anti-shock measures between the magnetic levitation system (guideway carrier) and the tunnel could be required.
To avoid any shock transmission from the magnetic levitation train to the tunnel and thus to the ground and to the building, additional design and anti-shock measures are required in the tunnel. On the one hand, these measures have to absorb the vibrations caused by the shocks, but on the other hand they also have to fulfill the high demands on the possible differential settlements of the used guideway types at the respective structural transitions.

4.2 Magnetic levitation train Munich

Since only a small part of the tunnel structures will underpass existing or future buildings, structural or anti-shock measures are only required at those areas, where they underpass these buildings directly according to the first anti-shock analyses.

In these areas between the guideway carrier or guideway substructure and the tunnel itself, a space of 10 cm is to be provided for measures insulating the structure-borne sound.

5. Space requirement for the technical installations of the system

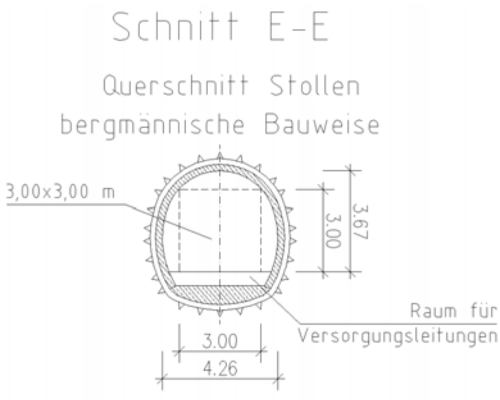
5.1 General

Compared with the design of tunnels for railway trains, those for magnetic levitation trains need some additional technical installations. This has to be considered during the planning process. Additional installations such as emergency power with generators and diesel tanks, switching stations for supplying the motor sections, transformer rectifier stations for supplying the busbar are to be considered. These installations are to be arranged as close as possible to the guideway i.e. at the tunnel. Due to structural and economic reasons it should however be also analyzed if they could be placed at the surface which means above the tunnel. They could be technically connected via operating or escape shafts.

5.2 Magnetic levitation train Munich

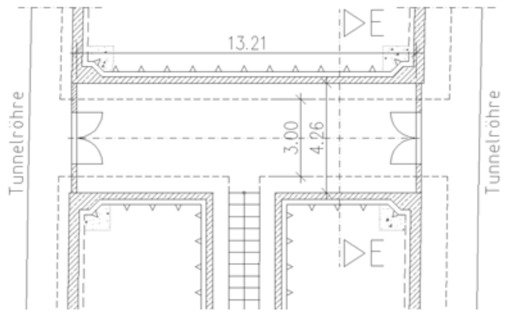
It was possible to find a compromise between the requirements for the system facilities and those for the structural facilities. The magnetic levitation train Munich does not need generators for emergency power in the tunnels and above all, it does not need any diesel tanks in the tunnel. A large risk of fire can thus be avoided in the tunnel.

The required switching stations, which will supply the motor sections, will be located in the cross gallery with a clear dimension of 3.0 x 3.0 m² between the two tunnel tubes. The length of the cross gallery will amount to approx. 13.0 to 16.0 m due to the existing clearance between the tunnel tubes.



Picture 5: Standard cross section gallery of the operational rooms

Two switching stations can be combined in these cross galleries. In order to be able to enter the operational rooms not only from the tunnel tubes, such an access will also provided from the required escape shafts.



Picture 6: Horizontal projection gallery of the operational rooms

In contrast to the switching stations, the transformer rectifier stations, supplying the busbar, will be arranged in the operational rooms above ground.

These stations will be arranged in the direct area of the escape shafts. It will thus be possible to connect the stations with the guideway in the tunnel via cables going through these escape shafts.

Due to fire protection requirements, the required cables will be laid out underneath the existing walkways within the tunnel tube, needing a space of 80/100 cm.

6. Structural emergency concept

6.1 General

New standards are to be determined for the emergency concept of the magnetic levitation train's structural elements. It is not imperative that the emergency concepts, valid in the respective countries for railway traffic, apply for magnetic levitation trains since they have a high-class system engineering on the one hand and higher fire loads in the tunnels on the other hand in comparison with the railway traffic.

A structural emergency concept has therefore to be determined with respect to the project. This concept needs to consider the length of the escape routes for the passengers rescuing themselves but it also has to include the maximum lengths for the squads rescuing passengers.

Furthermore the walkways in the tunnel has to be adjusted to the vehicle design and the width of the walkways has to be determined. The size of the escape galleries and the escape shafts is to be determined together with the rescue squads and the official authorities; the respective situation on the ground is to be analyzed.

6.2 Magnetic levitation train Munich

Based on an overall safety concept for the magnetic levitation train system, the concrete demands on the structural elements for escape measures are to be determined when planning the tunnel structures.

The approval authorities have developed a guideline concept for fire and civil protection. This guideline has been compiled analogously to the rules valid in Germany for railway traffic.

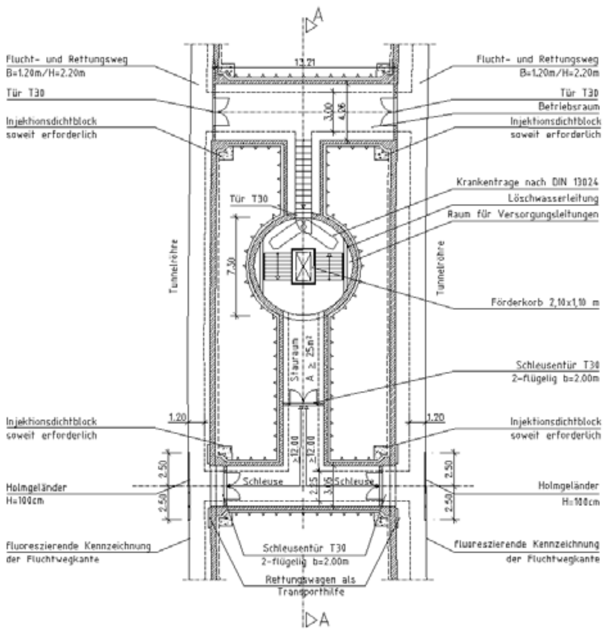
The magnetic levitation train will have an walkway with a width of 1.20 cm next to each guideway. The clearance of the walkway will be at least 2.20 m high. The walkway will be equipped with a handrail at a height of 1.00 m; towards the guideway the escape route will be marked in a fluorescent manner.

Furthermore, the tunnel structures of the magnetic levitation train will be provided with the following fire and civil protection equipment:

- Transport aids at the emergency exits to relieve the rescue squads
- Emergency telephones at the escape galleries
- Electrical connections every 125 m
- Fire alarm systems
- Fire fighting water pipe with hose connections every 125 m max.
- Escape route marking every 25 m max.
- Emergency lighting (tunnel safety lighting)
- Facilities for radio communication with authorities and organizations with safety tasks

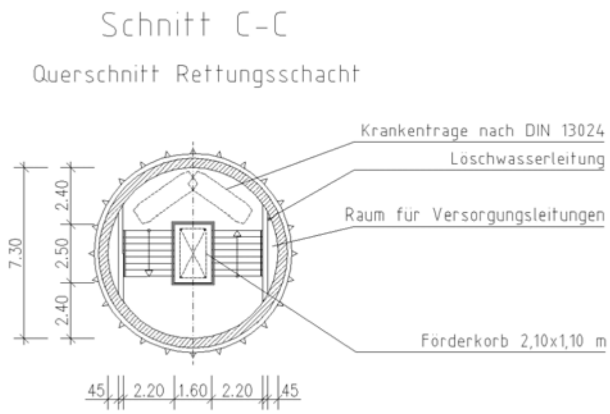
On the basis of the 20 minutes given maximally to the passengers to rescue themselves and on the basis of the possible arrangement of the exit shafts at the surface the tunnel Landshuter Allee for example will need 8 emergency exits with a distance of nearly 600 m.

There will be a space of at least 25 m² in front of the stairs, where people with a restricted degree of mobility and being not able to use the stairs can stay until the rescue squads arrive.



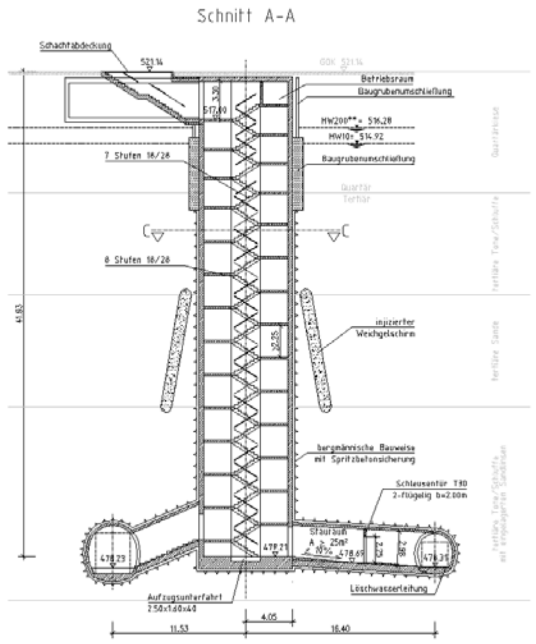
Picture 7: Horizontal projection escape shaft (on tunnel level)

The escape shafts will be equipped with top having a minimum width of 2.20 m. All shafts with a height of more than 30 m will be equipped with a cage having a size of at least 2.10 m x 1.20 m.



Picture 8: Normal cross section espace shaft

There must be enough space available for the rescue vehicles at the top of the emergency exits. The public road network system covers this need mainly in the case of the magnetic levitation train Munich.



Picture 9: Longitudinal section escape shaft

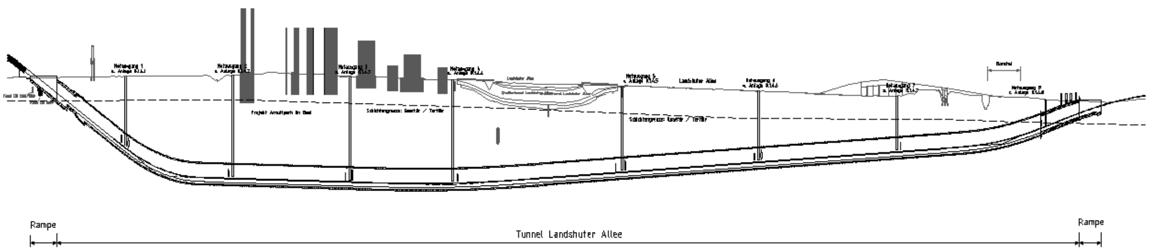
7. Tunnel construction details

7.1 General

On the basis of the aforementioned requirements for the tunnel structures, the structural details regarding the construction method are to be determined. First of all the geological and hydro-geological situation is to be analyzed and possible construction methods such as mechanical driving (TBM) or shotcrete method (NATM) are to be compared with each other. Special construction measures such as escape galleries and escape shafts are to be considered. In case tunnels will be built in the inner city possible logistical concepts are to be analyzed extensively in terms of costs, deadlines, site traffic etc. so that the optimal concept can be determined.

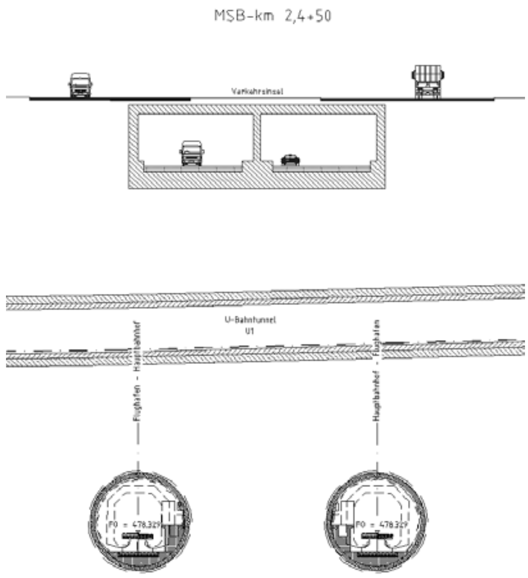
7.2 Magnetic levitation train Munich

The tunnels for the magnetic levitation train Munich lie in the quaternary and tertiary soils with a high groundwater horizon. In the area, where the tunnels are built by cut & cover quaternary gravel and sand dominate, where they are built by underground mining tertiary sands, silts and clays dominate.



Picture 10: Longitudinal profile tunnel Landshuter Allee

The construction by cut & cover will therefore have watertight construction pits. Sheet pile walls as well as curtain walls will be employed. The structure itself will be built with reinforced concrete.
Since the tunnel tubes driven by underground mining lie in depths of up to 40 m the NATM is not possible due to the high water pressure.



Picture 11: Cross profile 2 (maximum overburden)

The tunnel tubes will therefore be mechanically driven (TBM) and will have a circular shape.

The tunnel tube will be lined with prefabricated segments (tubbings) and will have a sealing frame.

A total of 4 driving machines will be used for the three tunnels.

The escape shafts will be built down into the quaternary soils from the surface, protected by a curtain wall. Their further sinking down into the tertiary cohesive soils will be done according to the shotcrete tunneling method. The cross and longitudinal galleries will also be built according to this method.

Depending on the local situation, the construction of the galleries and shafts require further measures such as lowering the groundwater, icings or injections. These additional measures are to be coordinated intensively with the approval authorities regarding the environmental good water.

Based on these construction methods used for the tunnel structures, the logistical construction concepts in terms of costs, deadlines, construction site traffic etc. have been developed.

8. Closing words

In comparison with a magnetic levitation train running above ground, additional subjects need to be considered when leading such a train through a tunnel.

With the example of the magnetic levitation train Munich it was possible to show that the questions and problems arising from these subjects can be solved.

It will thus be made possible to plan and build future magnetic levitation trains also in the direct inner-city area.