

# MSB-Track-2010

## A new guideway for the TRANSRAPID

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**ABSTRACT:** The German Federal Ministry of Transport, Construction and Urban development (BMVBS) has made the decision to advance the development of a new guideway for the Transrapid system. The companies Züblin, Zerna and Spiekermann were assigned to develop this new guideway, which means the start for a new generation of continuously supported guideways. It consists of a soil supported continuous beam and true to size precasted concrete slabs with adjustable bearings in between. The installation of the system on the Transrapid test facility was completed in June 2006 and the type approval is expected during spring 2007.

### 1 GENERAL

With the goal of further optimising of the magnetic levitation system, the German Federal Ministry of Transport, Construction and Urban development (BMVBS) has decided to advance the development of a new guideway for the Transrapid system. The main focus was to provide a cost-efficient guideway and to realise a workable system not only but also for the planned line in Munich, which means an approval certificate from the German Railway Authority must be obtained. Inter alia the companies Züblin, Zerna and Spiekermann were assigned to develop this new guideway.

The design and development is split into four different phases.

The first phase comprises of the tendering, the second phase incorporates the design and the third phase includes the installation of the system on the Transrapid test facility in Emsland (TVE).



Picture 1: First test set-up of the new guideway

The work began in Spring 2006 and was completed by June of the same year. However, operation started successfully by end of July. The guideway is currently undergoing test procedures. The experience gained and data collected during the ongoing phase four are incorporated into the final design.

The type approval is expected during for spring of 2007.

### 2 IDEA

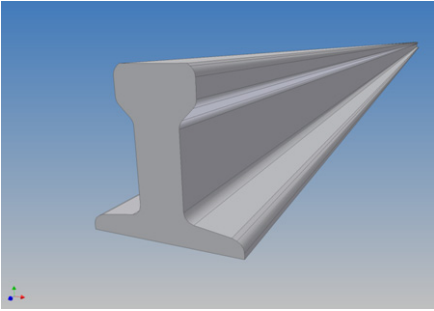
The new guideway has been named

#### ***MSB-Track-2010.***

The essential idea is based on the principal of the traditional railroad track. Similar to the Züblin slab track system, the guideway comprises of an endless reinforced concrete beam simply founded on the soil. Small piles at regular distances can guarantee continuous support should the soil not be capable of carrying the loads.

The actual guideway itself consists of true to size precast concrete slabs.

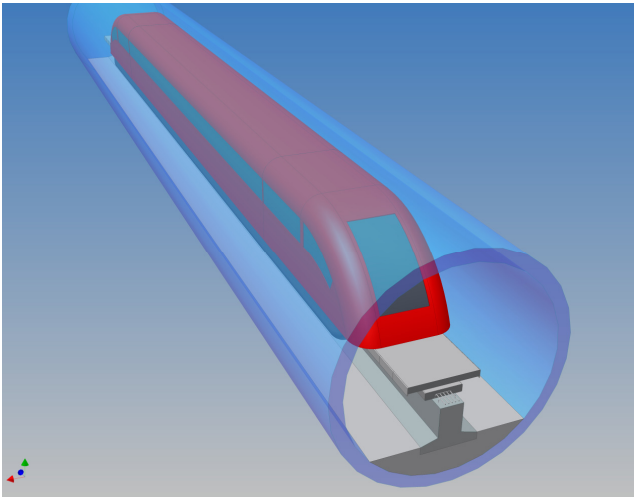
The system is continuously supported, unlike the solutions available up to now. This has the advantage that local subsoil deformation, both horizontal and vertical, do not lead to any discontinuity in the guideway. Any subsidence which occurs is reduced to uncritical long waved deformation by the beam. Nevertheless if unacceptable deformations occur, these can be equalised using a system of adjustable bearings.



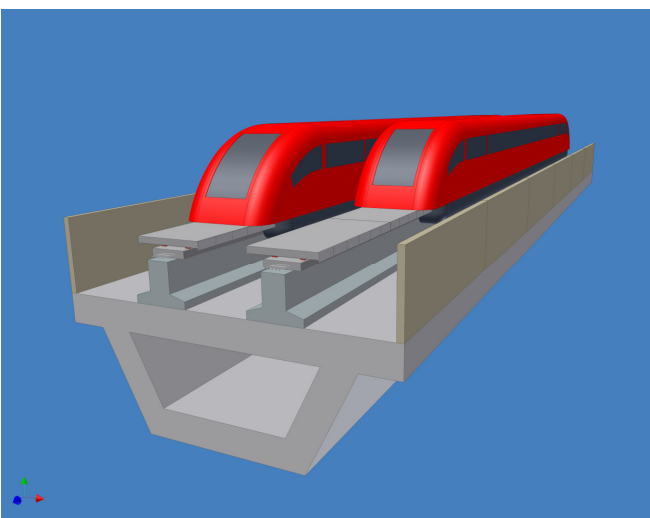
Picture 2: From railway track

The system can be constructed according to all the known route planning parameters as defined in the the german guidelines. The transverse gradient lies between  $2^\circ$  and  $12^\circ$ .

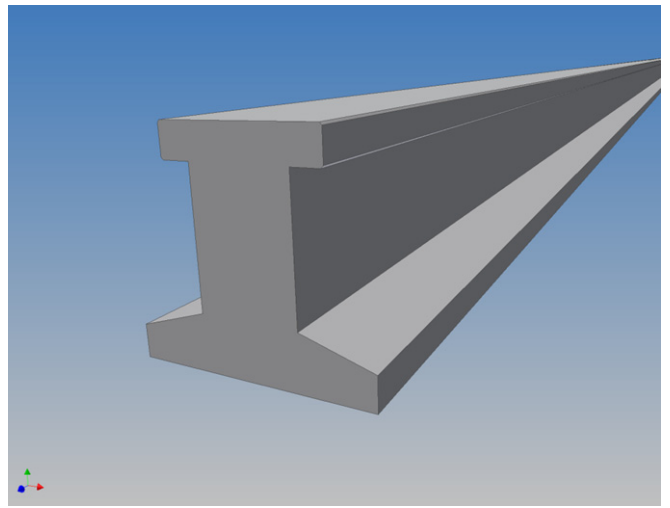
Another major advantage of the system is the simple and very economical production process and the possibility of using it under almost all conditions. The guideway slabs can be used on the regular beam at ground level as well as in every tunnel and on every bridge by means of a modified beam.



Picture 3: *MSB-Track-2010* in a tunnel



Picture 4: *MSB-Track-2010* on a bridge



Picture 5: to the guideway beam

### 3 SYSTEM

The system has three main components:

- the guideway beam
- the bearings
- the precast guideway slab

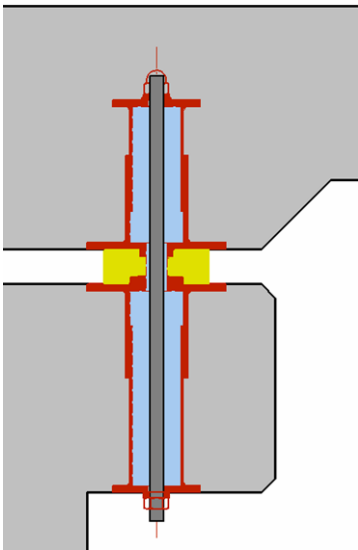
#### **The guideway beam**

The guideway beam is a continuous reinforced concrete beam, poured in situ. It is constructed without joints. Constraining stresses resulting from strain caused by shrinkage, creep and differences in temperature is compensated alone by cracking and the elastic dilatation of the concrete beam. The reinforcement guarantees small crack widths. There is almost no dilatation parallel to the longitudinal axis of the guideway. Local soil subsidence is compensated by the system. Small bridges to cross animal lanes or farm tracks can be incorporated into the concrete beam system.

#### **The bearings**

The guideway slab is supported by a total of six non-compressible steel bearings. Due to the small dimensions of the slab, each individual bearing does not have to compensate any large deformations and are therefore constructed as rigid vertical bearings. One bearing parallel and two perpendicular to the guideway carry the horizontal loads.

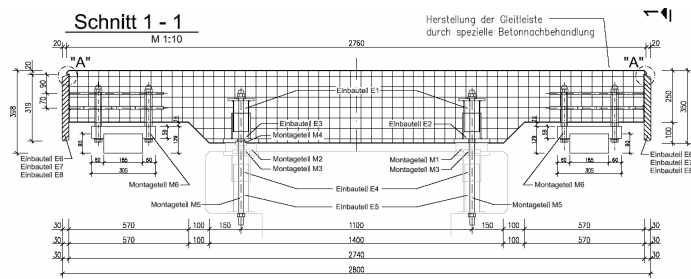
Anchor plates which are milled to their nominal dimensions with extreme precision can be found both in the guideway slab and in the guideway beam. The guideway slab is then bolted to the beam. One great advantage of the system is that both the bolts and the bearings are replaceable.



Picture 6: Bearing system

### The guideway slab

The guideway slab has the well proven dimensions of 6,192 m x 2,80 m. The guideway slab consists of a massive 25 cm thick concrete slab. The slab is strengthened by a haunch in the region of the supports. The relatively small dimensions of the slab allow for a constraint-free support on the steel bearings. The guide-rail on the side and the stator pack fastenings are anchored in the concrete by means of steel butt strap joints.



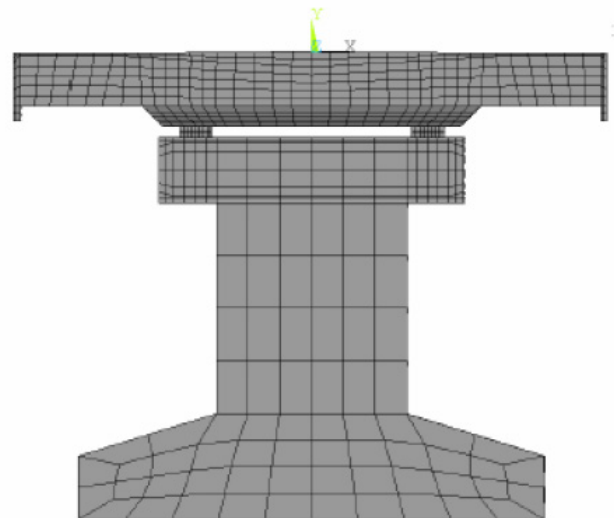
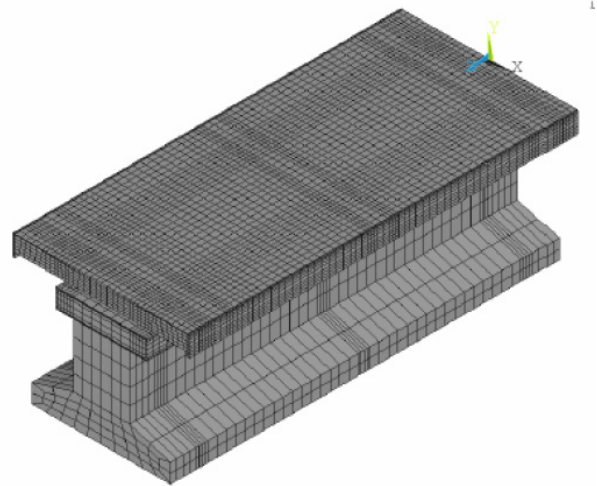
Picture 7: Overview of a typical guideway slab

In order to meet the high demands for tolerances on the guidance-levels, they are milled after production in the precast-concrete-plant. Using these measures a reference surface is provided which has extremely small tolerances. Eight different types of slabs can be produced, with the only difference being the individual machine milled radius of the side guide-rail. The vertical curvature is realised by bolting the slabs to the guideway beams. The resulting containing stresses are compensated relatively fast by concrete creep and shrinkage.

## 4 DESIGN

The design of each individual load-bearing component is done on independent subsystems. In order to verify the chosen assumptions, the connecting

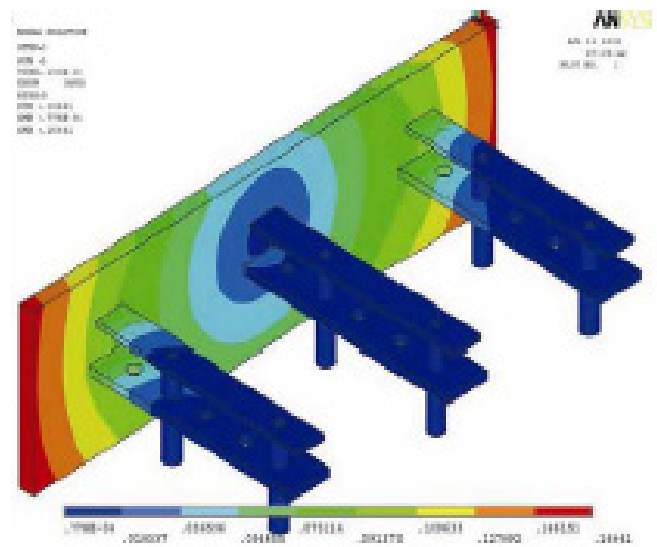
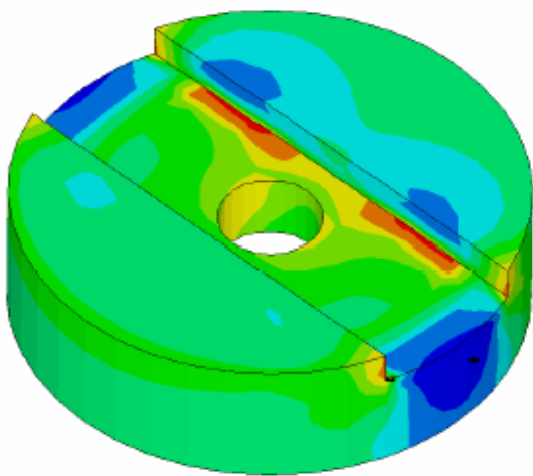
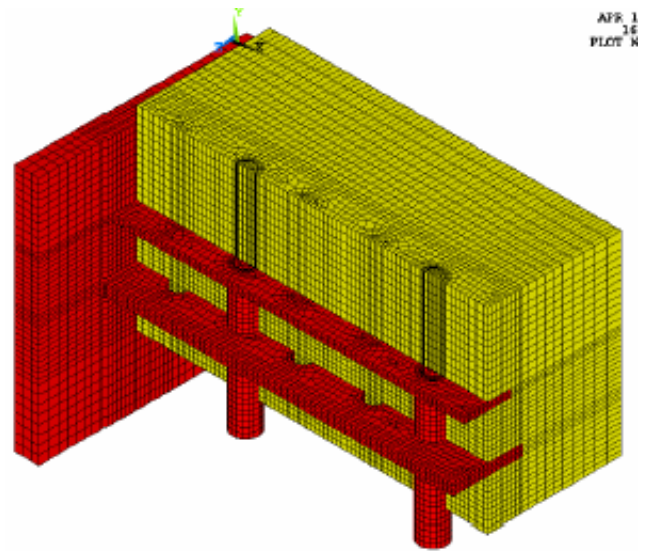
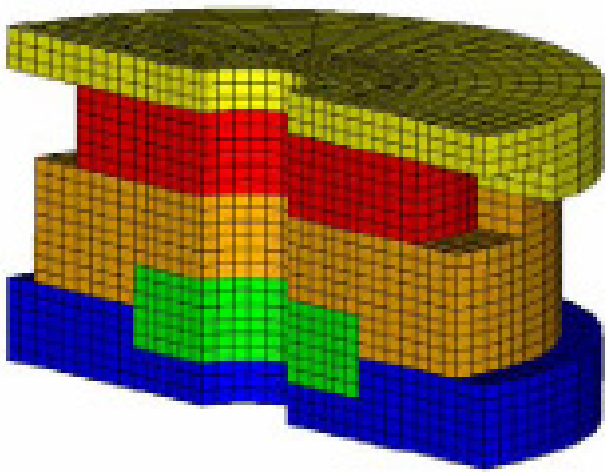
forces between the individual components were calculated with the help of a complex finite element model which represents a 6.20 m long section of the guideway slab. As well as taking the concrete beam and slab into account, the main embedded steel items (sliding surface, guidance-rail, stator-pack-anchorage) of the load-bearing structure were also considered in the model. Rigid bond is considered between the concrete and the steel items.



Picture 8: Discretisation in the finite element calculation

Steel bearings are used to support the concrete slab on the beam. Therefore vertical as well as horizontal forces have to be transmitted. To design the bearings a three-dimensional finite element model has been established. The single components are added together using special contact elements which allows the transmission of friction forces and pressure forces only.

The picture shows an example of the model and results of the stress calculation.



Picture 9: Model and results of the finite element calculation of the bearing

The most important load bearing items are the steel butt straps to anchor the guide-rail on the side and the stator pack fastenings permanently within the concrete slab. Both type of anchorage are connected in the interior of the concrete. The guide-rail-anchor consists of totally six butt straps which are retained by the sleeves used for the stator pack fastenings. Simultaneously the stator pack fastening is fix upside of the steel butt strap using a screw nut.

The anchorage system was also designed using an finite element calculation. The model and typical results of the stress calculation are shown in the picture below. No critical amount of stress was reached.

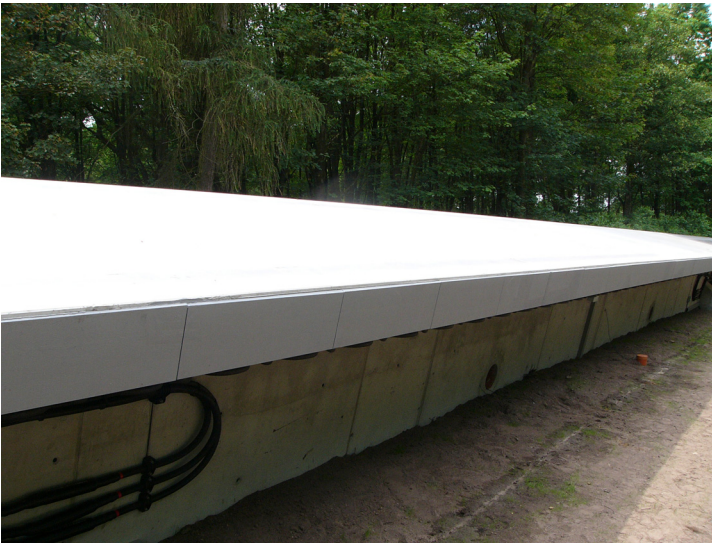
Picture 10: Finite element model of the guide-rail anchorage in the guideway slab.

## 5 TESTING DONE ON THE TRANSPRAPHIC TEST FACILITY (TVE) IN GERMANY

In the spring of 2006 the prototypes were installed at the Transrapid test facility in Emsland (TVE). A total of two track sections of the original TVE, each 24,80 m long, were replaced by these new prototypes.

The first section is situated on the so-called south loop with a transverse gradient of 20 % and a radius of approx. 1000 m. The maximum speed of the vehicle in this section is 217 km/h.

To minimise the problem with the settlement of the different bearing systems the foundation soil was substituted within a deep of approximately 2,50m.



Picture 11: MSB-Track-2010 on the Transrapid test facility Emsland (TVE), Germany

The concrete beam was produced in situ (using concrete grade C30/37), the precast concrete guideway slabs were mounted, adjusted and fixed to the bearings using grout.

The precast elements were produced in a special formwork with tolerances of  $\pm 0.30$  mm. The C60/70 grade concrete used was self-compacting.



Picture 13: MSB-Track-2010, mounted on a precast beam on the TVE



Picture 12: Installation of the guideway slab in the “south-loop”-section

The second section was installed on the straight portion of the track where the maximum speed of 420 km/h is reached. The guideway slabs are mounted on a beam which simulates the use of the **MSB-Track-2010** on a bridge.

The set-up was put into operation in July 2006. The results of measurements taken showed no deviation from standard values taken. The guideway turned out to be very insensitive to vibrations.