MSB-TRACK-2010 -Recent Development in Guideway Design

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ABSTRACT: Within the scope of the development program “WEP20” of the German Federal Ministry of Transport, Construction and Urban development (BMVBS) the companies Ed. Zueblin AG, Zerna and Spiekermann developed a new, cost-efficient guideway. The status of the project was previously discussed at the Maglev conference 2006 in Dresden. Meanwhile the testing of the guideway on the test track has been accomplished. The paper discusses the test results and the advantages of the new guideway “MSB-TRACK-2010”. A short overview of the manufacturing costs and maintenance costs will be given.

1 INTRODUCTION

With the object of promotion of the magnetic levitation system, the German Federal Ministry of Transport, Construction and Urban development (BMVBS) had 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. This means an approval certificate from the German Railway Authority must be obtained.

The companies Züblin, Zerna and Spiekermann were assigned to develop this new guideway.

The design and development was divided into four different phases.

The first phase comprises of the tendering, the second phase incorporates the design.

The installation of the system on the Transrapid test facility in Emsland (TVE) began in Spring 2006 and was completed by May of the same year (Phase 3).

In the fourth phase the experiences which were made during test phase are incorporated in the final design.

Figure 1. MSB-TRACK-2010 at the Test facility in Lathen, Germany.

2 ADVANTAGES OF THE GUIDWAY

2.1 Load bearing behavior / Constructionphase

A new guideway for the Transrapid system was developed in Germany by the construction company Züblin. This guideway is fundamentally different due to a new foundation system. Unlike conventional guideways, the MSB-TRACK-2010 is designed as a continuously supported reinforced concrete beam, much like a rail. The main advantage of the system deals with the bearing structure, which avoids any gap or inclination of the track; thus, only a small ground pressure results from the new foundation. Local soil subsidence is compensated by the system (Fig 3). A pile foundation is not necessary. Nevertheless if unacceptable deformations occur, these can be equalised using a system of adjustable bearings.

The system has three main components:

- The guideway beam
- The bearings
- The precast guideway slab

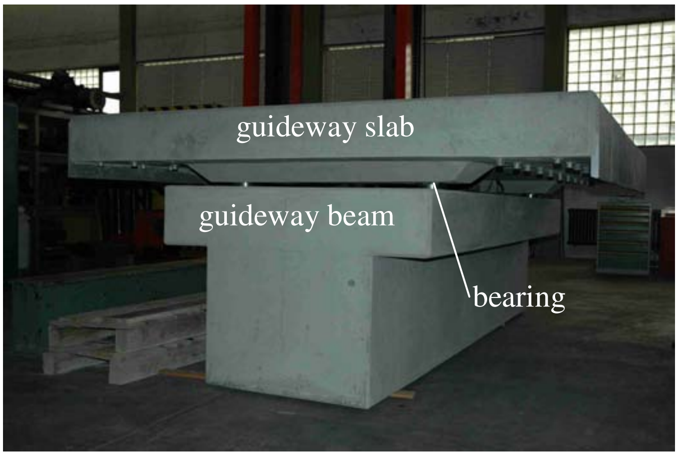
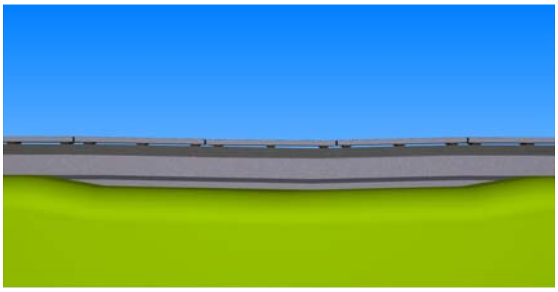


Figure 2. Components of the MSB-TRACK-2010

Constraining stresses resulting from strain caused by shrinkage, creep and differences in temperature is compensated solely 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.

A major advantage is the simple and economic production process. The requirements concerning the production tolerances of the guideway beam is not higher than for normal concrete structures which were built on site. The guideway slab is prefabricated and meets the high demands for tolerances on the guidance-levels. It can be placed exactly on the guideway beam. Inaccuracies in the fabrication of the beam can be compensated by the bearings. This leads to a very cost effective production.



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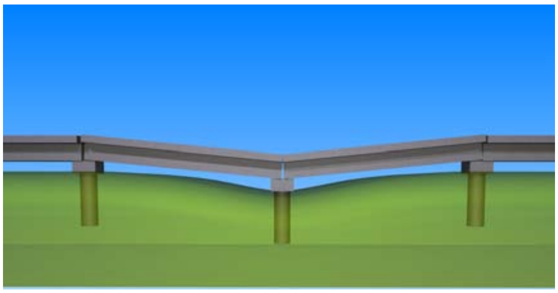

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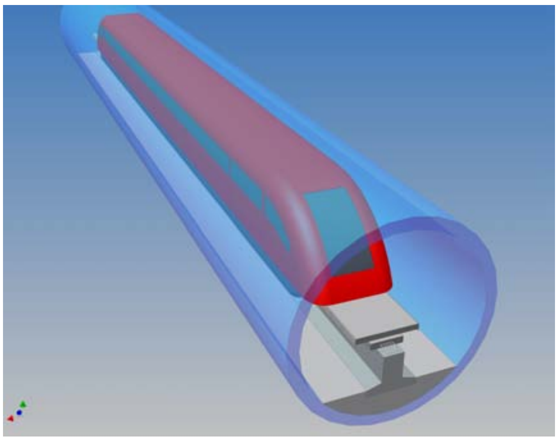
Figure 3. a) MSB-TRACK-2010 compensates local soil subsidence
b) Conventional guideway

2.2 *Fields of application*

Furthermore the MSB-TRACK-2010 provides the possibility of using under almost all conditions. Small bridges to cross animal lanes or farm tracks can be incorporated into the concrete beam system. For larger spans a prestressed guideway beam can be used to reduced the deformations. For bridges and for tunnel systems only the guideway beam has to be adapted. The slab can be used for all fields of applications.



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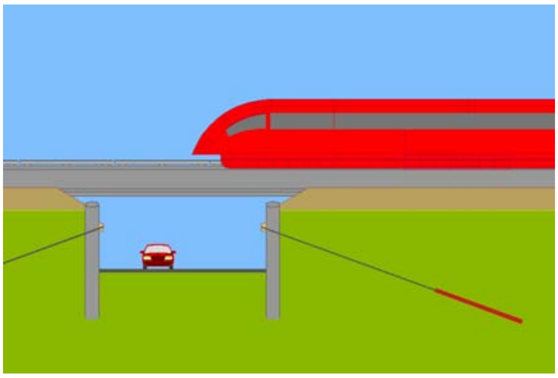

b)

Figure 4. Various application possibilities of the MSB-TRACK-2010
a) In tunnels
b) Crossing of farm track

A change over to other, conventional guideway types is also possible.

2.3 Maintenance

As well as in the construction phase and in load bearing behavior the guideway MSB-TRACK-2010 has advantages in the maintenance procedures.

Due to the three main components of which the guideway consists, the maintenance concept allows a simple change of the guideway slab which carries the levitation system.

If slabs or parts of the levitation system are damaged on the track they can be changed very quickly during the off-time and they can be repaired without time pressure at the workshop. No expensive and time-consuming reparation on the track is necessary. The repaired slabs can be taken into the stock where they are stored for the next change.

3 TEST RESULTS

Within the development program "WEP20" a prototype of MSB-TRACK-2010 was built and installed on the test facility in Lathen, Germany. Two fields of application of the MSB-TRACK-2010 were tested.

One field was the continuously supported reinforced concrete beam and the other one was to use the guideway on stilts. To study the behavior of the new guideway tests with the vehicles Transrapid TR08 and TR09 under realistic conditions were carried out. The test program includes strain measurements and acceleration measurements of the guideway slab, of the guideway beam and at the levitation system as well as measurements of temperature and subsidence. The test velocity of the vehicles were up to 117 m/s (420 km/h). ,

The Fig. 5 to Fig. 7 represent the various test results.

The comparison between the measured values and the predicted values (horizontal line in Fig. 6) shows a very good match. In summary, it has been shown that the results of the analysis of load bearing behavior and deformation behavior could be verified.

Fig. 7 shows the analysis of the strains at frequency range. Besides some excitation frequencies the measurements showed no resonance behavior of the guideway.

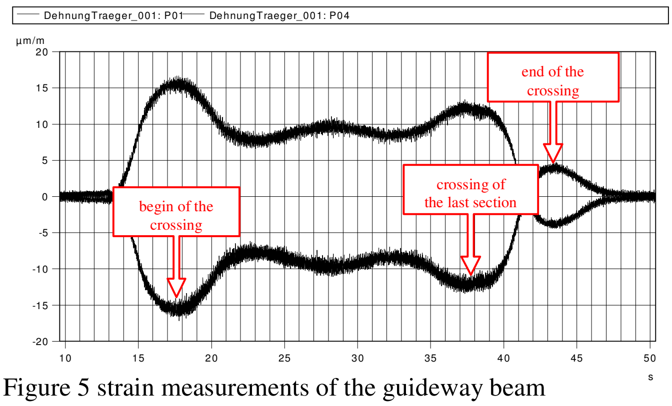

Figure 5 strain measurements of the guideway beam

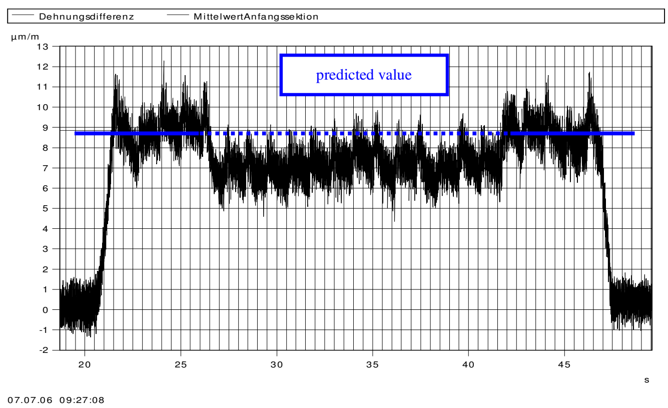

Figure 6 strain measurements of the guideway slab

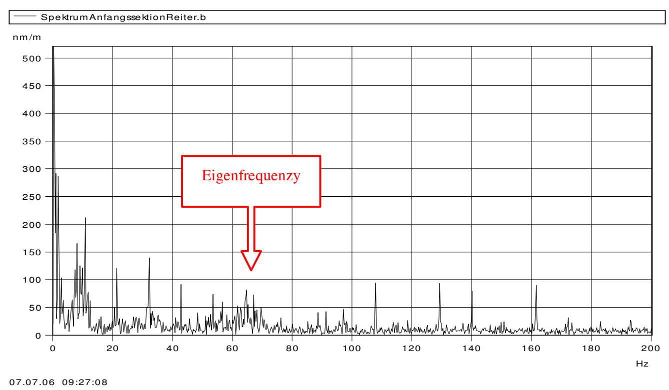

Figure 7 Analysis of the strains at frequency range

4 ACOUSTIC EMISSIONS AND VIBRATION PROTECTION

4.1 Continuous beam – Acoustic emsission

The Protection of the environment from noise pollution is an important factor for the acceptance of the public transportation in housing areas. Especially the maglev system is known as a transportation system with less acoustic emission. But nevertheless the acoustic emissions should be reduced further.

In advance of the development of the MSB-TRACK-2010 comparative analyses of the acoustic emissions showed a significant difference between guideways on stilts and guideways at ground level. The red areas in Fig. 8 are representing an increasing and the green areas a decreasing of the acoustic emission of a guideway at ground level. Indeed the acoustic absorption of the surrounded soil has an positive influence but the main difference is based on the design of the MSB-TRACK-2010. The guideway slab is placed on a solid guideway beam with closed sides. There the acoustic emissions will nearly be absorbed directly at the acoustic source. The surrounding soil absorbs the rest.

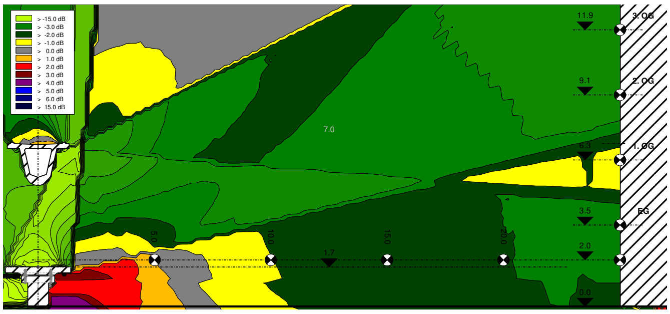

Figure 8 Differences of the acoustic emissions for guideways on stilts and guidways at ground level

The measurements of the acoustic emissions at the prototypes on the test facility in Lathen show a positive behavior of the MSB-TRACK-2010. The oscillation level could be determined to 75 dB (distance 8 m) in levitation mode (0 m/s) and 68 dB at speed of 50 m/s.

The MSB-TRACK-2010 shows the lowest acoustic emission compared to other guideways.

4.2 Mass-spring-system –vibration protection-

As well as the minimization of the acoustic emissions the protection of the buildings from critical vibrations is also a must for modern transportation systems. Especially for tracks in tunnels the vibration on the surrounding properties has to be considered. The most effective protection has the so called mass-spring-systems.

Zueblin developed a mass-spring-system for the MSB-TRACK-2010. This system is often installed at the high-speed route of the German railway. The solid guideway beam of the MSB-TRACK-2010 provides an ideal mass for the system. The mass of the beam and the continuously, but now elastic supporting represent the elements of the mass-spring-system. Even with an extreme soft supporting the continuously beam do not allow any breaks or misalignments in the guidance units.

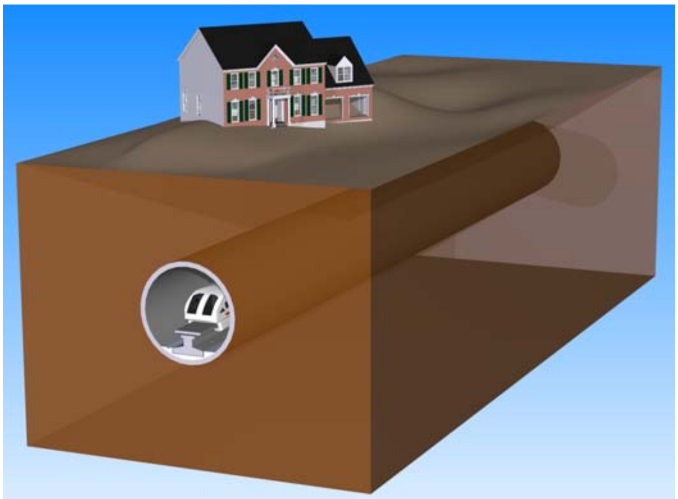

Figure 9 3D illustration of the guideway in a tunnel

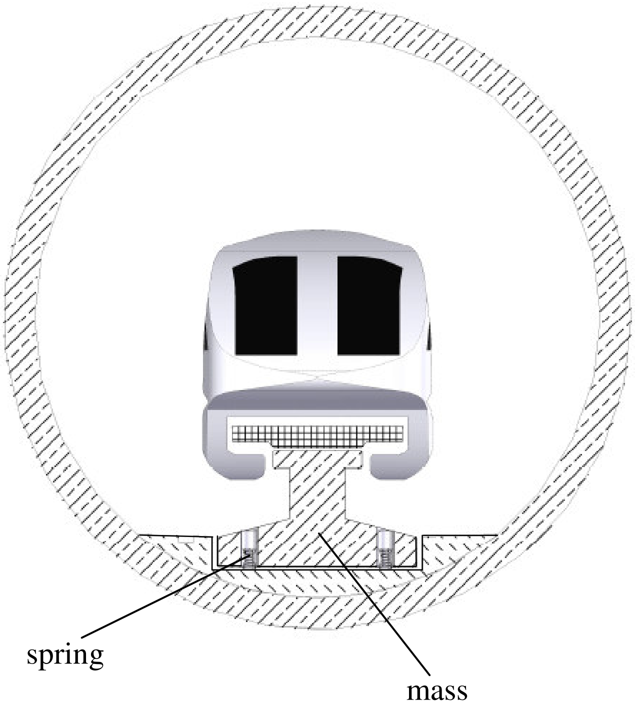

Figure 10 cross section of the guideway with a mass-spring-system

The design of the mass-spring-system is based on measurements of vibrations at the test facility. Fig. 11 illustrates a typically measured frequency range of the vibration emission. The eigenfrequency of vibrations-sensitive buildings are between 12-16 Hz. This frequency range should be dampened, although the amplitudes of the emission are much smaller compared to conventional guideways.

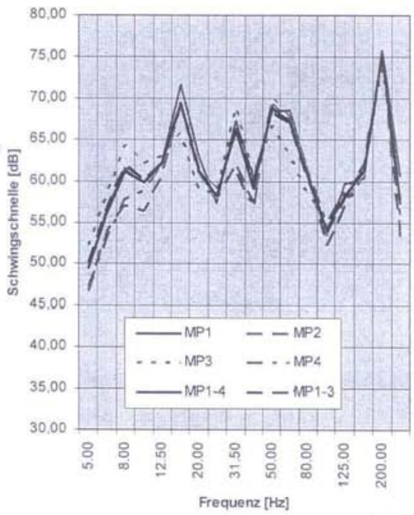

Figure 11 frequency range of the measured vibrations between guideway and ground

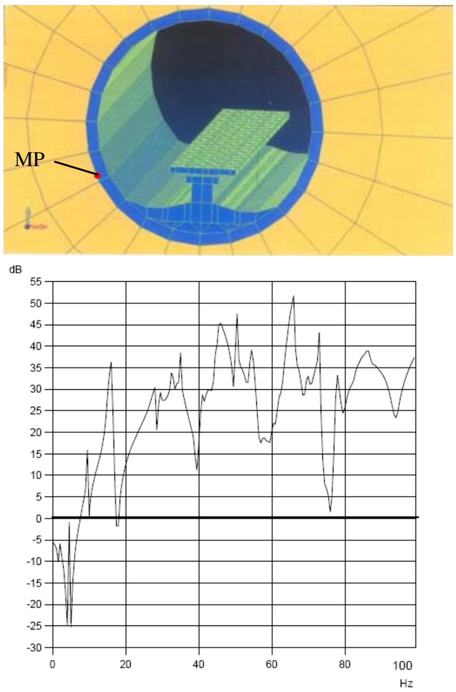

Figure 12 FE-Model and the affectivity of the mass-spring-system

To minimize the subsidence due to the soft supporting a mass-spring-system with 5 Hz eigenfrequenzy was chosen. Fig. 12 shows the result of a finite-element analysis. One can see, that the frequency rang between 10 Hz to 18 Hz could be substantially reduced.

5 COSTS IN COMAPRISON TO CONVENTIONAL GUIDEWAYS

The advantages of the new guideway are being reflected in the production costs (Fig. 13). Compared to conventional guideways on stilts the costs are reduced by 38%. The most cost reductions are due to the no longer required stilts and the involved pile foundation. A significant simplification of the guideway leads to a cost effective production process. E.g. the MSB-TRACK-2010 uses a minimum of built-in units.

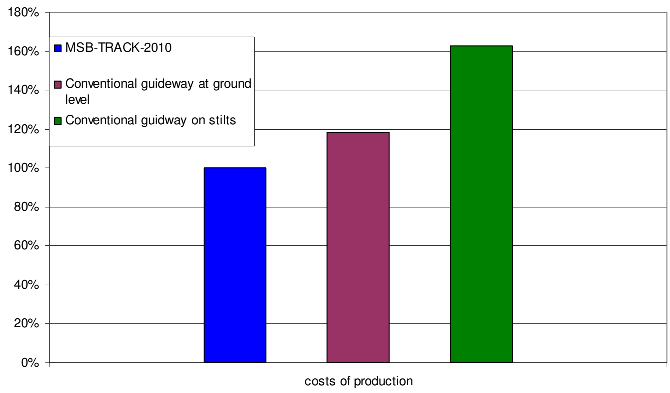

Figure 13 Costs of production in comparison to conventional guideways

The high precise fabricated part of the guideway has a better resistance against climatic influence due to the high strength concrete of the slab. A minimum of the steel built-in units and nearly no steel surface lead to a guideway which is easy to maintain. A very quick change of the guideway slab during the off-time decreases the maintenance costs as well.

6 SUMMARY

The company Ed. Zueblin AG developed a new, cost-efficient guideway. The MSB-TRACK-2010 is a continuously supported reinforced concrete beam. It provides advantages compared to conventional guideways regarding maintenance and load bearing behavior. Furthermore, no pile foundation is necessary. The guideway covers a large field of applications. One can use it under almost all conditions.

An extensive test program was carried out at the test facility in Lathen, Germany. The MSB-TRACK-2010 showed no noticeable problems and no resonance behavior. The guideway confirms its excellent appropriateness.

7 REFERENCES

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