

Maglev Guideway Structure Development by Max Bögl

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ABSTRACT: In the year 2001 the Max Bögl Bauunternehmung GmbH & Co. KG produced and installed “Hybrid girder” in the first operated Maglev airport link in Shanghai China. Since then Max Bögl has improved the girders by minimizing the amount of steel in the girders. Within this development the main focus shifted from the mere production of girders to the implementation of a fully equipped girder which leads to the “holistic guideway concept” with a high level of prefabrication under controlled conditions. In combination with optimized survey and installation processes fast erection on site for the guideway is possible. Compared to the original “Hybrid girder” concepts significant improvements with respect to costs, construction time and quality assurance could be achieved.

Recently several comparisons between rail-bound and Maglev high-speed-lines have been carried out by Max Bögl. It could be shown that the presumably expensive Maglev technology can be highly advantageous with respect to ecological aspects becoming more and more important as well as to competitive construction costs.

relating to grinding technology for concrete and the creation of new applications.

1 INTRODUCTION OF MAX BÖGL COMPANY

Max Bögl is a group of companies, which has successfully been active in a wide range of construction projects since 1929. Max Bögl has about 6000 employees, and has an annual turnover of approximately 1.4 billion euros. Max Bögl is an international enterprise, with its focus in Europe. It also has extensive activities in many other regions of the world including America, Brazil, China and Dubai.

Since 1995, Max Bögl has pioneered the technology of high-precision concrete grinding. Particularly the development of CNC steered grinding machines, which can achieve precision within an accuracy range of 1/10 mm.

The ballastless guideway system for high-speed railways (FF system Bögl), has been developed, and also the hybrid carrier for the Maglev. For over 10 years, extensive experiences and knowledge has been acquired

Great achievements of this period have been the implementation of the Hybrid girder developed by Max Bögl Company in the Shanghai maglev and the construction of the high-speed railway between Beijing and Shanghai using “FF system Bögl” / CRTS-II until 2011. The track length is approximately 1350 km, and construction of the guideway was completed in approximately 12 months.



Figure 1: Core data Max Bögl company

2 CONCEPTION AND DEVELOPMENT OF THE GUIDEWAY GIRDERS FOR MAGLEV

2.1 Steel guideway girder

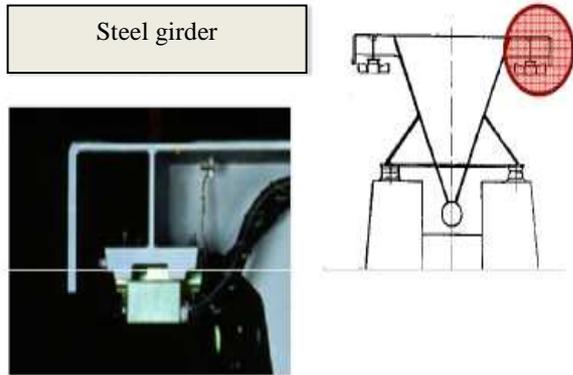


Figure 2: Steel girder functional level and cross-section

The first certified guideway girder for the Maglev was a girder made of steel. At that time, only by using steel could the demands for accuracy be met. However, the steel girder was expensive to produce and also required costly maintenance. In addition to the economic factors and lack of durability, steel girders produce vibration, excessive noise and unfavorable static behaviour.

2.2 Concrete guideway girder

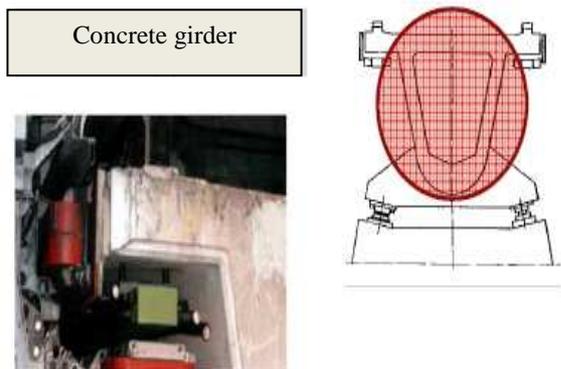


Figure 3: Concrete girder functional level and cross-section

In order to avoid the disadvantages of a steel girder, a concrete girder was developed for the Maglev. This was intended to eliminate the disadvantages of the steel structure. A major characteristic of the concrete girder was the increased flexural rigidity and improved oscillation behavior and

temperature sensitivity compared to the steel construction. However, in the course of the development, problems were discovered with the durability of the concrete construction. Also, function levels and construction accuracy were not satisfactory. A substantial characteristic of the concrete girder was here to avoid as far as possible carrying construction made out of steel.

2.3 Hybrid guideway girder

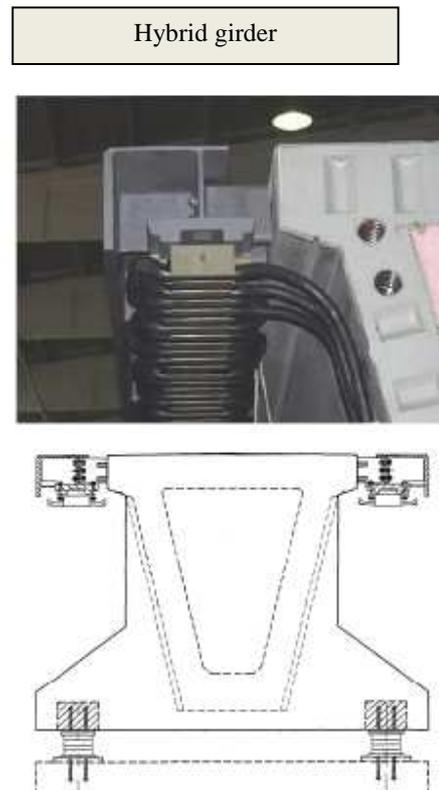


Figure 4: Hybrid girder (Shanghai) functional level and cross-section

Between 1996 and 1999, the first hybrid girder using a modular construction method was developed. This eliminated the unfavorable characteristics of the original concrete girder. By using a modular construction method to manufacture the 'function level carrier for the stator belt', the side leading rail and the slide strip, an economic standard building method with high accuracy could be achieved.

Function levels were integrated in the function level carrier, and these were fastened

with steel consoles to the concrete girder. The steel consoles of the concrete girder were reworked using precision measurements and a milling oil-well drilling installation.

In 1999, the first production stage hybrid girder was constructed and tested on the technical test range in EMS country (TVE). Using the experiences gained during testing, a modified hybrid girder was developed and this design was used from 2001. It was used for the first commercial Maglev line in Shanghai which began operations in 2003.

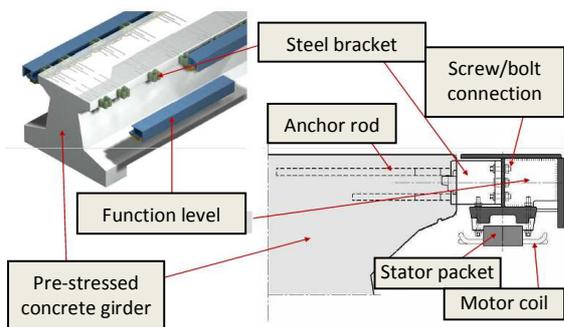


Figure 5: Hybrid girder functional level and cross-section

The experiences gained during the Shanghai project showed that further optimization of the hybrid girders would be possible. This result in Max Bögl Company developing a more advanced girder system using the experiences and know how gained from the construction of high-speed lines with “FF System Bögl”. The aim now was to optimize all stages of design and construction of the guideway system for the Maglev.

In 2004, the compact guideway girder was created, and by 2009 it was a completely equipped, developed, modular ‘holistic guideway system’ for the Maglev.

2.4 The “holistic guideway system”



Figure 6: Holistic Hybrid girder fully equipped

2.4.1 Types of girders:

The “holistic guideway system” consists of 3 carrier types, these have been certified by the German railway Federal Office (EBA):

Type I : Girder length 24.8 m;
for elevated construction

Type II : Girder length 12.4 m;
for elevated construction

Type III : Girder length 9.3 m;
for construction at grade, in tunnel
and on primary carrying structures
like bridges.

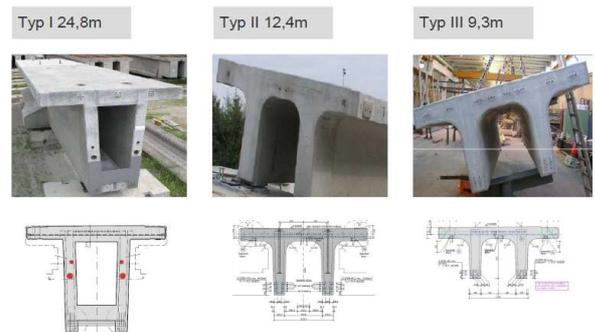


Figure 6: Hybrid girder Type I; II and III

All 3 girder types are manufactured in compact construction. The stator packages, side leading rails and slide strips can be fixed without additional steel consoles directly at the cantilever. The contact areas are generally manufactured with an oversize in the blank and grinded later by mechanical treatment on an accuracy measure within the range of 1/10 mm.

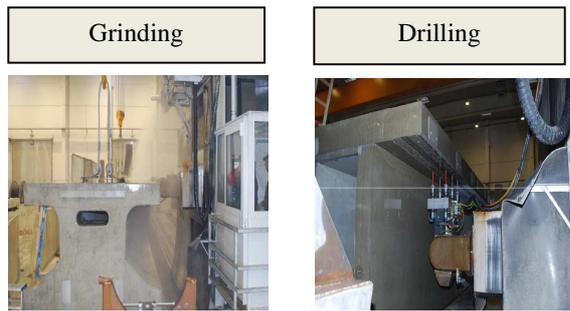


Figure 7: Grinding and drilling of functional levels

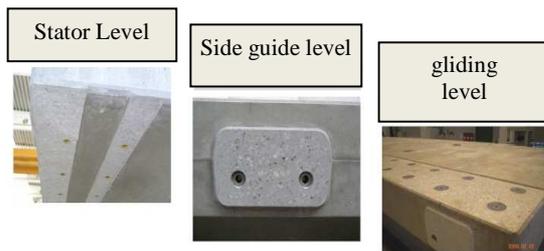


Figure 8: Finalized treated functional levels

This technology was developed in house by Max Bögl and is already successfully used within the precast “FF System Bögl” for high speed railways and modified for the production of Maglev girders. In the implemented high speed lines, which use the “FF System Bögl” results for the track geometry are as follows:

- The stator packages are precisely attached directly on the lower surface of the cantilever at grinded supporting benches.
- The side guide rail consists of a 3 cm thick steel sheet, which is screwed in modules of 3m length directly onto the grinded support consoles of the girders.
- The gliding plane is grinded into the concrete and coated with a special material. By this construction method the usage of expensive and maintenance-susceptible steel is only used, where it is absolutely necessary for the operation of the Maglev.

Depending on the horizontal design of the track geometry and the carrying structure the different girder types are arranged. The

production of the girders takes place straight and this makes it possible to produce economic girder blanks. Individual girder blanks, which are expensive to manufacture are avoided.

The mechanically grinded girders provide highly precise „outside geometry “.

2.4.2 Equipment of the girders in the factory:

For the Shanghai project, the cables were in-wound after the installation of the girders at the side. This approach proved to be pedantic and susceptible to errors. As a result, Max Bögl Company looked for a more economical solution using as far as possible automated equipment under controlled conditions in the precast factory.

The result of this development was a completely equipped girder, which is delivered to the location and needs only to be connected after installation. The advantage here is that the girders are ready for use immediately after they are connected and energized. In this way finalized parts of the track can be used, and it is possible to have ‘construction gaps’ without preventing the functionality of already installed sections of guideway .



Figure 9: In-Winding of cables in Shanghai

Fully equipped girder out of factory

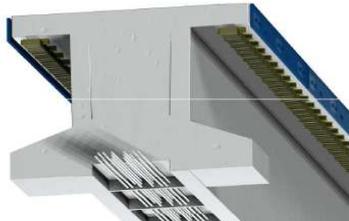


Figure 10: Fully equipped girder with cables

Connecting the cables



Figure 11: System of connecting cables at side

Mounting of girder Typ III



Figure 12: Mounting of fully equipped girder

Bearing



Figure 12: Detail view of bearing connection

2.4.3 Installation and adjustment of the girders:

Horizontal alignment usually requires the installation of girders with elevation. An adjustment of the girders to the necessary elevation takes place in the bearing bases or via wedge-shaped finished units, the so-called support wedges with integrated lower base plates.

To follow the different parameters of the horizontal alignment, only a small number of different precast wedge-shape units are necessary, and these can be produced economically. The support wedges are connected to standard elastomeric bearings which can be simply produced. If settlement occurs after the installation, a correction can be made by adjusting the bearings, or if necessary the bearing can be replaced.

3 SPECIAL RANGES

3.1 Switch

Max Bögl is keen to offer a complete system solution for the Maglev guideway. For this reason a flexible 'Turnout' made out of special concrete has been created and produced. At present, extensive research on a prototype is taking place at our factory.

Flexible concrete switch

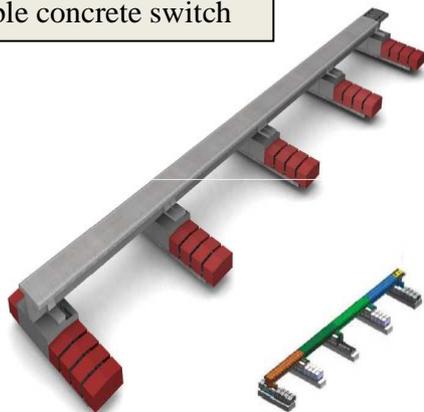


Figure 13: Animation of flexible concrete switch

Prototype „flexible concrete switch“



Figure 14: Prototype of flexible concrete switch

3.2 Noise protection:

Noise control and noise emissions are increasingly important considerations in projects with high-speed guideways. In addition to the economic and environmental advantages, reductions of sound emissions can be achieved through the development of the compact guideway system. In the comparison to the Shanghai guideway, it is possible to achieve a noise reduction by 6 dB.

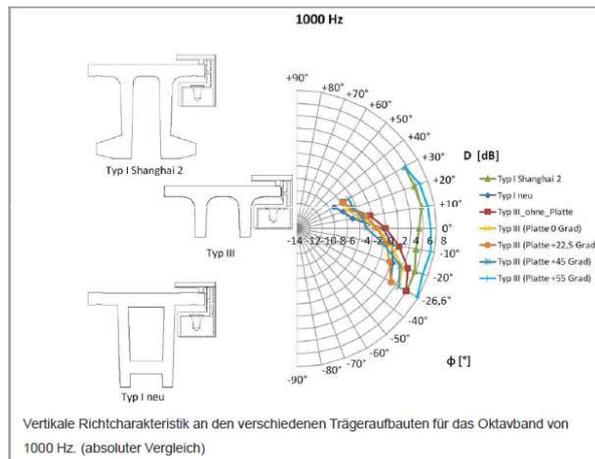


Figure 14: Result of noise measurements by Max Bögl

3.3 Vibrations:

Particularly in inhabited areas and within tunnel ranges, vibrations and impact sound and their resultant noise load can create problems. By using mass - spring systems, Max Bögl has achieved a reduction in oscillation values of up to 90%.

Mass-Spring-System



Figure 15: Mass-spring-system with elastomeric bearing

Mass-Spring-System in tunnel

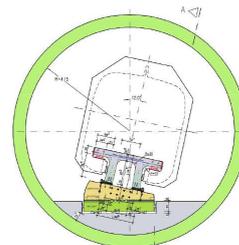


Figure 16: Cross-section of mass-spring-system in tunnel

4 VIEW OF ECONOMY AND COMPETITIVE POWER

4.1 General:

The “holistic guideway system” developed for Maglev has been extensively optimized from production through to installation, with both technical and economic improvements compared to the guideway system used in Shanghai.

The use of prefabricated sections manufactured under controlled conditions in the precasting plant can minimize errors and can reduce the construction period for the guideway by about 33%.

Additional measures taken to improve sound emissions and oscillation make the Maglev system economically and technically acceptable in sensitive areas.

As a result of the recent advances, together with the possibility of better ‘bundling’ the maglev with highways than the wheel-rail system, the Maglev system offers now a competitive and technically developed product with even more flexible planning parameters (minimum radii and maximum upward gradient to 10%).

With different projects in the year 2010 and 2011 it could be demonstrated by plausibility and feasibility studies that the Maglev System compares very favourably with wheel-rail systems and the statement „too expensive“ is no longer applicable.

4.2 Maglev Tenerife:

The following example is taken from a plausibility investigation by Maglev Tenerife (Spain).

The company INECO examined 2 possible routes for a wheel-rail system in the year 2009 [1].

Max Bögl, Thyssen Krupp, Siemens, IABG and IFB presented a modified proposal, offering the Maglev System in 2010 [2].



Figure 17: Top view on island Tenerife with proposed routes for Maglev (Google Earth)

4.2.1 Core data of the examined routes:

4.2.1.1 South route from Guagass to Las Americas

	Wheel/Rail	Maglev	Change
Route length	79,5 km	78,2 km	-2%
Stations	7	7	+/- 0%
V_{max}	220 km/h	300 km/h	+36%
V_{ave}	115 km/h	146 km/h	+27%
Max.	3,5%	10%	+186%
R_{min} bei 200	1,4 km	0,7 km	-50%
R_{min} bei 300	3,2 km	1,6 km	-50%
travelling	41,5 min	32,0 min	-23%
Tunnels	23,2 km	5,2 km	-77%
Guideway at grade	50,7 km	15,5 km	-69%
Guideway	0 km	53,9 km	
Guideway on primary structures (bridges)	5,6 km	3,6 km	-36%

Table 1: Core data Tenerife Maglev – South route

4.2.1.2 North route from Los Realejos to Santa Cruz

	Wheel/Rail	Maglev	Change
Route length	38,3 km	36,7 km	-4%
Stations	7	7	+/- 0%
V _{max}	160 km/h	230 km/h	
V_{ave}	67,7 km/h	92,0 km/h	+36%
Max.	7% (??) (4%)	10%	
R _{min} bei 200	1,4 km	0,7 km	-50%
R _{min} bei 300	3,2 km	1,6 km	-50%
travelling	32,5 min	23,9 min	-26%
Tunnels	19,3 km	0,5 km	-97%
Guideway at grade (dam/cut)	17,9 km	1,0 km	-94%
Guideway	0 km	34,8 km	
Guideway on primary structures (bridges)	1,1 km	0,4 km	-63%

Table 2: Core data Tenerife Maglev – North route

The Maglev system offers higher cruising speeds and thus shorter travel times. It can also be stated that using the Maglev system would substantially reduce the expensive construction of tunnels and bridges, as well as the amount of land required for cuttings and dams.

Due to the smaller space requirement of the Maglev System, a substantially better bundling with already existing traffic routes could take place via optimization and adjustments in the design.

The ecological impact of the Maglev system is smaller than that created by the wheel-rail system, it can also be stated that the prognosticated capital required for the wheel-rail system would also fully finance a Maglev System.

This assessment was further confirmed by an independent third party feasibility study for the Maglev project Tenerife in February 2011 [3].

5 SUMMERY

Max Bögl has continued to develop the guideway system for Maglev despite unfavorable political circumstances.

Developments in recent years mean that the ‘holistic guideway system’ offers a compact construction. Added to the environmental advantages, this makes the Maglev system an attractive alternative to the wheel-rail system.

Recently, rail bound high-speed lines, designed for a speed of 350 km/h have suffered an enforced commercial reduction of speed to 300 km/h, in order to lower energy consumption, lower material abrasion and lower operating costs.

The Maglev System now offers a very attractive means of providing a mass transport system. When investment and operating costs, and the impact on the environment are taken into consideration, the Maglev system is a competitive alternative to rail bound high speed systems.

6 REFERENCES

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