TRANSRAPID SHANGHAI – demonstration line
German high technology with Chinese boundary conditions

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Abstract

The routing of the track, the used guideway constructions as well as their production plants are described in this report. Parts of the planning activities will be explained which are required on the German side to cover the interface between German delivery parts and Chinese planning and production activities. Information about the absolutly short realization time for the erection of the guideway constructions will be given.

1 Introduction

In Shanghai is the first commercial TRANSRAPID operational line since December 2000 under construction. Laid out as an Airport link between the International Airport Pudong and the Long Yang Road Underground station.

Since August 2000 the preliminary project planning run for a high speed maglev route in the Chinese economy metropolis Shanghai. Until end of 2002 after approx. 700 days of planning and realization the TRANSRAPID should connect the new major airport Pudong with the Long Yang Road Station nearby the city centre of Shanghai on the double-track guideway of approx. 30 km and a operation velocity of 430 km/h. The official sign of the contracts for this first commercial route of the TRANSRAPID between Chinese government and the consortium of TRI, ThyssenKrupp and Siemens occured at 23rd January 2001. At a successful process of the project in 2002 the decision should fall in China for a long route of 1140 km as a combination Shanghai - Peking, as well as 180 km prolongation of the present planning route to Hangzhou.

2 Track routing

The TRANSRAPID track in Shanghai starts at the new builded Pudong International Airport. The entire 30 km between the Airport Station and the Long Yang Road Subway Station are constructed as double-track guideway with a center-to-center distance of 5.1 m. Behind the TRANSRAPID-Station Pudong International Airport two low-speed switches are arranged for changing the tracks. For the first kilometres in direction to Shanghai the double track guideway runs with low level in a height of approx. 2.7 m. From the Airport Station Pudong the guideway runs for a track length of 8.5 km straight on the 25 m wide free space between the elevated constructions of the both three-lane highway to / from the airport. The guideway rises from the low level up to switch 7 at a distance of approx. 4 km - the turnout to the Maintenance Area - up to height of approx. 8.5 m above ground. The turnout to the Maintenance Center is a route section approx. 3 km long, which is carried out as a single track in low level situation. Only the turnout from the main track and crossing of the highway occurred in a height of 16 m. Just before the maintenance hall the guideway is spread out by means of a 3-way low-speed switch in 3 maintenance- and/or washing tracks, which lead into the approx. 220 m long

maintenance hall.

Project dates

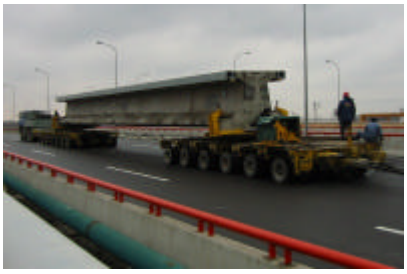
track length	30 km double track
generally center-to-center distance for track sections of approx. 27.4 km	5.10 m
generally surface height of the girders for track sections of approx. 20 km	8.00 – 11.50 m
min. / max. height of the space curve above ground in the main tracks	2.80 m / 13.50 m
hybrid guideway girder type I, L = 21.7 - 24.8 m	approx. 2500 pcs.
hybrid guideway girder type II, L = 12.4 m	approx. 50 pcs.
guideway girder on bridges, L = 6.2 m	approx. 60 pcs.
switches, L = 78.4 m	8 pcs.
substructures total	approx. 1380 pcs.
track to the Maintenance Center	3 km single track
stations	2
number of vehicles	3 vehicles with each 6 sections
max. operation speed	430 km/h
travel time	8 min
minimum distance of the vehicles	10 min
daily operation time	18 hours

Behind the turnout to the Maintenance area the guideway runs further between the both tracks of the highway. The horizontal radius is 2300 m for a length of 2 km with a maximum cant of the girder surfaces of $\alpha = 12°$. Then a long almost straight part follows with horizontal radii from $R_H = \infty$ or 4000 m

and 8000 m. At track kilometre 21.3 - about 8.5 km away from the airport - the routing changes from between the highway tracks to the north side of the straight eight-lane highway and runs next for 10 or 11 km with a height of about 8 to 10 m above ground along the highway. In this area of the track the maximum operational speed of 430 km/h is achieved. Then two mutual radii with $R_H = 4500$ m and $R_H = 1300$ m follows up to just before Long Yang Road Station. The gradient height of the double-track guideway rises up to 13.5 m above ground. Also in this area the guideway gets a cant of the girder surfaces of maximum 12°. Directly in front of the Long Yang Road Station in the height of 13.5 m a crossover - consisting of four switches - is arranged to change the tracks. The center-to-center distance to go into the platforms of Long Yang Road Station is here 12.1 m. After 8 minutes of levitation time arrived at the approx. 210 m Long Yang Road Station in Pudong, it is possible to go to the final destination in the hypermodern finance center Pudong or to change onto the subway and to go into the old Shanghai on the opposite side of the Huangpu River.

3 Guideway constructions

In the summer 2000 during the preparation of the feasibility study for the first application line in Shanghai Chinese engineers have been presented the different construction types of guideway girders proved on the TVE test facility by the respective developer companies. The decision of the Chinese delegations was made in favour of the hybrid guideway girder. This type of guideway girder is as two-span girder with span lengths of approx. 31 m, developed by a German consortium consisting of the companies Max Bögl, Gebr. von der Wettern and Cronauer Beratung Planung in the years 1997 to 2000. The main structure of the German prototype girder is a monocellular box girder with a height of approx. 2 m. Over the supports cross beams are extended from the longitudinal girder side in order to be able to remove the high lateral actions during curve rides economically to the substructures. The cantilever of the hybrid guideway girder - arranged at the girders upper side - consists of the function units with a length of approx. 3.1 m are constructed completely of steel. At these function unit girders the levitation and guidance system of the TRANSRAPID with the in a system-technical way narrow tolerance requirements is fixed. From this girder type also a variant with a span length of 2 x 12.4 m and an overall height of approx. 1.0 m is in evolution in Germany.



These products were basis for the Chinese developments of the guideway girders. The monocellular box girder with cantilevers became to double-T shaped hybrid guideway girder with box girder section. The 2.8 m wide lower flange was complemented for the increase of the lateral stiffness of the guideway girders. The hybrid guideway girder type Shanghai, designed as single-span girder for the mounting situation has a span length of approx. 25.0 m and a height of 2.2 m. The mounting weight of one girder is approx. 165 t. At the girders the possibility is prepared to couple two single-span girders with steel strap constructions to a double-span girder. This structural system allows a considerable reduction of the deformation due to the temperature gradient from uneven warming of the girder surfaces. The modifications at the 2 x 12.4 m hybrid guideway girder consisted in the alternation of the double-span girder onto a single-span girder with approx. 12.4 m span length and simultaneous increase of the girder overall height of the solid cross-section of 1.0 to 1.4 m.

The substructures of the double-track guideway in a Shanghai standard distance of approx. 25.0 m are frame constructions in guideway cross direction, consisting from columns and cross- and tie beams as well as the foundation plate to take in the high lateral forces. The bad subsoil in Shanghai - strong ground shifts only in a depth of approx. 30 to 40 m, partly in 60 m - required to put the entire guideway of 2 x 30 km and the maintenence track of 3 km on pile foundations. For that round prestressed concrete hollow piles with a generally diameter of 600 mm were supplied in lengths of 12.0 m onto the construction site and rammed into the ground in a step-by-step way. At the joints the piles were welded to each other by means of steel fittings.

4 Production plant

In September 2000, many months before the final project decision and the contract signatures, the Chinese engineers began with the planning of a production plant for the manufacturing of the hybrid guideway girders. Starting from the plannings being present in Germany already for the manufacturing plant of the hybrid guideway girder for the project Berlin - Hamburg, the necessary adaptation occurred to the design dates and production capacities as well as the available plot geometry for a possible order of the production lines. The necessary numbers per day which result from the total project requirements combined with the time schedule are the essential parameters for the design of the production plant. Due to the documents from the feasibility study a plot approx. 200 m wide and 2000 m long was found at the route, on which the production plant at track km 11.7 - 13.4 between the Long Yang Road Station and the Pudong Airport could be constructed.

The production hall has measurements of the outline in a larger way 100 x 200 m and a height of approx. 12 - 14 m. In the hall all trades are put, that are used for the production of the prestressed concrete box girder as main structure. In front of the hall the concrete plant was built up. The 2nd third of the ground is needed as a storage area for the hardening of the concreted girders. The large area is necessary so that a majority of the deformations from creeping and shrinking of prestressed concrete girders can fade away by storage over a period of 5 - 6 weeks. To assemble the prestressed concrete girders with the TRANSRAPID-specific construction elements a fully air-conditioned equipment hall was built. For the transportation of the guideway girders within the factory travel lifts (mobile cranes) with 400 t permissible load were produced in Italy. In order to be able to realize the ambitious time schedule, for the production of the factory in the spring 2001 only 4 months were available. Already with these first realization measures it was to be recognized how the Chinese manager wants to handle this unprecedented billion-difficult mammoth project in record time. Equipped with all political authorities, he disposes of infinitely personnel and material. The "Chinese arithmetic" is valid for him, after which time and capacity is possible to replace any against each other.

5 Basic determinations

The consulting, training and basics determination for the route planning, fine alignment, the guideway girder in hybrid construction, the substructures, the subsoil as well as the production plants occurred in January until March 2001 in a training center in Munich, where the German specialized planners, being integrated into the Berlin - Hamburg project, worked together with the Chinese experts. The experience from the project Berlin - Hamburg concerning the planning up to the realization of an application line were adapted onto the boundary conditions of Chinese resources and date ideas. At the same time

the route alignment, prepared in the autumn 2000 by Chinese side, were checked for compatibility for the system and the guideway construction and modified so far as necessary.

6 Switches / crossovers

Beside to the vehicles and the operation system the German consortium, consisting of Siemens, ThyssenKrupp and Transrapid International, delivers guideway-sided the stator packs with their windings, the power rails as well as the steel bending girders of the switches including the drives. The remaining guideway girder, substructures and foundations are made out by the Chinese side in complete responsibility on the basis of the preparation described in the preceded chapter.

Special cases are here the sections of the tracks in which the steel bending girders of the switches are arranged, because these are also supplied by the German consortium. The interface between the Chinese designers and the German engineers was suited in this case on upper edge of the substructures below the switch constructions. A very intensive and closely interlocked coordination was here necessary, because the German evolutions for standard solutions had to be adapted onto the specific alignment boundary conditions and the surrounding in Shanghai. The processing of statically constructive concepts of the interface switch - substructures, considering the stability and the maglev specific requirements as well as the necessary cable routing, proved as most extremely extensive, because the information from the parallel Chinese plannings at the beginning of the project were available only very slow-moving in Germany.

7 Dates

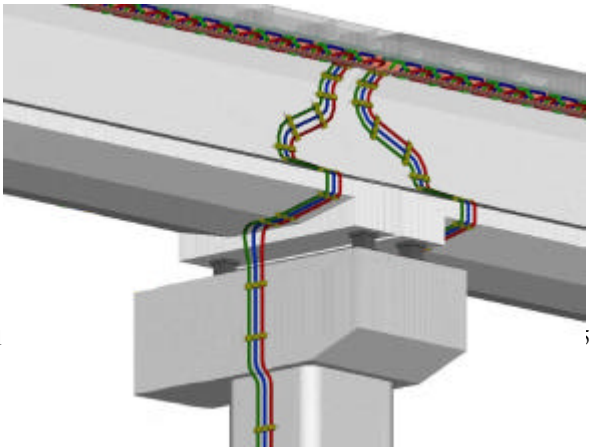
For all project participants the VIP-run on track B on 01.01.2003 was committed already during the contract negotiations as an irrefutable date. This leads for German conditions to exorbitantly high building work within the scope of this project. For example to drive the piles below the foundations into the subsoil all available pile driving rigs were concentrated for the foundation engineering of this project. In a period of 3 months approx. 50 to 60 pile driver inserted approx. 20000 piles with single lengths between 40 and 60 m in the ground. This information is valid only for the route and still increases itself through the necessary pile-driving for other infrastructure measures as the production plant and bridges (e.g. for the mounting road).

Planned realization periods of guideway components

production plant Shanghai including foundation measurements	02 – 07 / 2001
pile foundations for the guideway	06 – 09 / 2001
substructures	07 / 2001 – 01 / 2002
production of the guideway girders	08 / 2001 – 05 / 2002
mounting of the guideway girders	11 / 2001 – 06 / 2002
production of the main cable channel	08 / 2001 – 07 / 2002
installation of the motor winding – track B	06 – 09 / 2002
commissioning of the first line section including vehicle	09 – 12 / 2002

8 Cable routing – Interface coordination systemtechnique

The motor winding appertaining to the system engineering is supplied by German side and mounted by Chinese side. The super vision occurs by German engineers. In this field the interface was to be covered again between the Chinese realization and the German delivery and checking jobs. On basis of the Chinese design



planning the global cable routing at the guideway constructions was planned on German side and were coordinated with the Chinese engineers as well as by means of local dates. The same one is valid for the arrangement of the motor windings within the stator packs. Also here very much detailed conditions were elaborated from German side concerning the project specifications of the Shanghai route.

9 Resume

The different planning steps and their depth and the available periods for these works between China and Germany as well as the strongly different manner of negotiations led at the beginning of the project to high friction losses. The mutual sense corrected in the course of the project considerably, because both parties have the same target: VIP-run dated 01.01.2003.

10 Vision

If the Shanghai project should become a success, so these projects be up for realization in near future:

Shanghai – Pudong Int. Airport		30 km
Metrorapid NRW		78 km
Munich – Munich Int. Airport		37 km
Baltimore – Washington		60 km
California Project		130 km
Shanghai – Peking (Beijing)		1140 km
Shanghai – Hangzhou		180 km
Pittsburgh Airport – Pittsburgh – Greensburg		76 km
Amsterdam – Groningen	(with ring) 348 km	(without ring) 184 km
Hamburg via Bremen – Amsterdam		(without ring) approx. 480 km

10 References

1. Grossert, E.: *The Maglev system TRANSRAPID – an engineer construction of high quality*, 16th int. conference on magnetically levitated systems and linear drivers, Rio de Janeiro, Brazil 2000
2. Fechner, H., Grossert, E.: *Die Magnetschnellbahn – ein Ingenieurbauwerk von hohem Rang*, Edition ETR - Eisenbahntechnische Rundschau 2000
3. Grossert, E.: *Development and deployment of guideways for the TRANSRAPID*, TRB Transportation Research Board, Washington, USA Jan. 2000
4. Grossert, E.: *TRANSRAPID Berlin – Hamburg, Fahrweg und Fertigungsstätten*, Bautechnik (1999) H. 2
5. Schwindt, G.: *TRANSRAPID Guideway - Technical Standards,* 15th International Conference on Magnetically Levitated Systems, Yamanashi, Japan 1998

6. Grossert, E.: *Guideways for TRANSRAPID - The guideway in its modular form*,
15th International Conference on Magnetically Levitated Systems, Yamanashi, Japan 1998
7. Fechner, H.: *Der Weg ist das Ziel – Konzept ´97 der Transrapidstrecke Berlin - Schwerin - Hamburg*,
Eisenbahntechnische Rundschau 46 (1997) H. 12, S. 773 - 780
8. Fechner, H.: *Der TRANSRAPID – Umweltfreundliches Schweben zwischen Hamburg und Berlin*,
Eisenbahntechnische Rundschau 45 (1996) H. 7/8, S. 471 - 478