New Guideway Design For Urban Maglev In Korea

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ABSTRACT: The practical use of the urban maglev transit is afoot in Korea since 2006. The maglev adopts EMS system and the target speed is 110km/h. The project consists of three parts – the system engineering, the reformation of vehicle, and the development of infrastructure. Authors are participating in the development of infrastructure. This paper is mainly focused on the development of the guideway. There are a few considerations for the guideway design such as; the running stability of the vehicle, the ride comfort, the structural safety, and the construction cost. The running stability is the most severe guideway design criterion differently than the conventional wheel-on-rail system due to difficulties in the active levitation control. In addition, when the maglev system is adopted in urban area, the rapid construction and the aesthetic appearance also become important requirements. A new guideway is developed considering above requirements. The new design is the composite structure of a precast concrete slab and a concrete(or steel) open box girder. The steel twin block rail support is mounted on the slab. In this design, the precast concrete slabs function as the upper flange of the box girder and the base for the track assembly (rail and rail supports) simultaneously. The twin block rail supports reduces the weight of the track assembly and provides a wide and flat surface of the slab that can be used as the maintenance and emergency pass. The detailed installation method and the verification of the structural behavior of the proposed structure are introduced in this study.

1 INTRODUCTION

Korean government initiated a project for urban maglev commercialization to construct the first commercial maglev line of the Incheon International Airport region by the year 2012. It would be a test bed for the expansion of the urban maglev system. A maglev guideway is an elevated structure that guides and supports the maglev vehicles. The existing maglev test line in Korea combines conventional prestressed concrete(PSC) box girder and transverse beam sleeper of mono block type in Fig. 1. But the guideway for the Incheon line has different shape as shown in Fig. 2.

The maglev system dose not have wheel differently than other land transportation systems. The maglev moves sustaining constant air gap and non-contact with rail surface by use of attraction or repulsion force of ferromagnet or electromagnet. The Korean maglev adopts a EMS(electro magnetic suspension). Because there is no wheel in maglev, maglev environmentally friendly operates without noise, vibration, and dust by friction between wheel and rail. In downtown the guideway structure should be constructed as an elevated structure, actually it is more economic than underground tunnel structure. The soundproofing wall is not required for noiseless system. Because propulsion and levitation module moves with enveloping the quideway super structure, derailment or overturning is almost impossible. Therefore any protective wall is not needed. By these reasons the volume of a super structure could be minimized.

The slenderness and the accelerated construction are considered as key points to build such railroad infrastructure in urban area. The volume of structure is minimized to reduce the dead load and pre-cast construction is adopted for rapid construction. Twin block type is adopted as a rail support to diminish added mass instead of transverse sleeper beam. The guideway girder is composite of the PSC U-type girder and the pre-cast concrete slab for the straight line, and the open steel box girder is adopted instead of PSC U-type girder for the curved section. The pre-cast concrete slab plays an important role as it combines the functions of the sleeper beams and the upper flange of box girder. The shape of the proposed guideway girder is similar to the concept design reported in the Colorado Maglev project.

This paper introduces specs of the Korean maglev vehicle and the proposed guideway system.

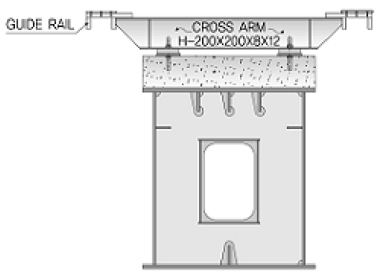


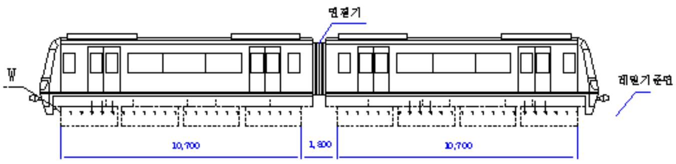
Figure 1. Transverse beam type mono block sleeper

(a) straight line (b) curved line

Figure 2. Proposed guideway girder with twin block for Incheon line.

2 DEVELOPED MAGLEV IN KOREA

There are two test vehicle models of UTM01 and UTM02 in Korea. Now upgraded commercial model is being developed in another part of the same project. The vehicle length, width, and the track gauge for the commercial model are 12m, 2.7m, and 1.85m, respectively.



(unit; mm)

Figure 3. Exterior of commercial model

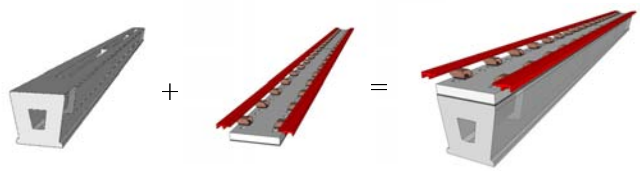
The first commercial urban maglev is Linimo in Japan. Table 1 shows design standards of guideway structure for these various maglevs.

Table 1. Design standard.

item	UTM01	This project	Linimo
Vehicle	2.2t/m	2.6t/m	2.3t/m
Design speed	-	110km/h	100km/h
DMF	i=15/(40+l)	Steel girder :0.15 Concrete girder : 0.1	Steel girder :0.15 Concrete girder : 0.1
Deflection ratio(live load)	l/4000	l/2000	$20<l\leq 25m$: l/1500 $25<l$: $(l/25)^{1/2}\times l/1500$
# of modules	3	4	5

The maximum vertical displacement is limited to 1/2000 of the span length. This limitation is much more conservative than general railroad train. Because the levitation stability is absolutely depend on the displacement of the guideway.

3 PROPOSED GUIDEWAY GIRDER



(1) (2) (3)

Figure 4. Proposed guideway girder with twin block for Incheon line.

Fig. 4 shows the proposed pre-cast guideway girder consisted by the composite of PSC U-type girder and pre-cast concrete slab. The standard type has 25m span length. In order to validate the proposed composite girder, a laboratory test was conducted on a prototype. Fig. 5 shows model drawing that is fabricated with 20m in length.

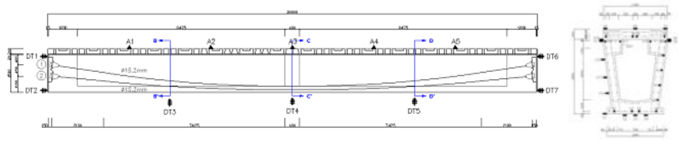


Figure 5. Laboratory test model

Figure 6. Static and vibration test

We could check the proposed guideway girder behaviors as one body beam from the static test. The fundamental natural frequency was 8 Hz in the result of vibration test. It is corresponding to 5.72 Hz for a girder 25m in length. The results accord with those of numerical analysis very well.

The guideway girder for curved section is shown in fig. 7. The curved guideway girder should be continuous more than 2 spans, so negative bending cracks can happens in the precast slab on a central support. To prevent these cracks the slab is pre-stressed before composite with the girder. And then rail and rail support bracket are arranged on the slab. We have tested curved section girder, but the results will be introduced in another chance.

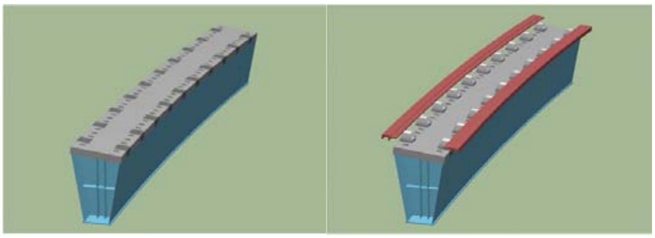
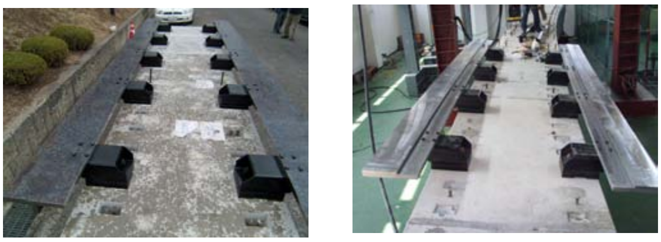


Figure 7. Guideway girder for curved section

4 PROPOSED RAIL SUPPORT SYSTEM

We have tested for construction possibility of the twin block track system as well as the static/dynamic performance of the girder. But the static/dynamic performance is not mentioned. The conceptual design is only subscribed in this paper. Fig. 8 shows installed rail support in a laboratory.



(a) straight line (b) curved section

Figure 8. Establishment test of twin block track system

PSC U type girder | Precast concrete slab

Carry to the site

Installing rail support and rail on the slab (temporary rail support)

Establishing the slab on the girder

Installing the girder and the slab on piers

Control position of the rail support

Composite the slab and girder by mortar

Minute control line shape of the rail

Finish

(a) straight line

Open steel box girder | Precast concrete slab

Carry to the site

Installing open steel box girder on piers

Installing rail support on the slab (temporary rail support)

Establishing the slab on the girder

Pre-stress tendons inside slab

Control position of the rail and rail support

Composite the slab and girder by mortar

Minute control line shape of the rail

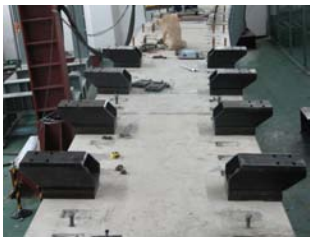
Finish

(b) curved section

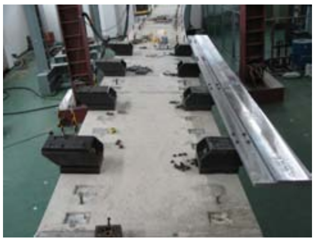
Figure 9. Construction sequences

In the case of twin block system, because there is no cross beam which makes keep gauge before and after installing track, somebody could concern about the arrangement of gauge between both rails. In order to cope with this difficulty and to control lateral position of rail, we introduce the temporary rail jig as shown in fig. 10.

Figure 10. Temporary rail support jig



(a) installing rail support block



(b) assembling right rail

(c) temporary rail support jig

(d) assembling left rail

(e) adjust gauge and bolt

(f) remove temporary jig

Figure 11. Scene of rail installation using temporary support jig

Fig. 11 shows the process that the rail and rail support blocks are established on the curved guideway girder. We can adjust the gauge to the correct distance using the temporary rail support jig.

5 TRACK ALLIGNMENT ERROR

Because traveling stability depends on precision of track irregularity absolutely. The allowable track alignment error is very low. There are 6 types of track irregularities as shown in fig. 12.

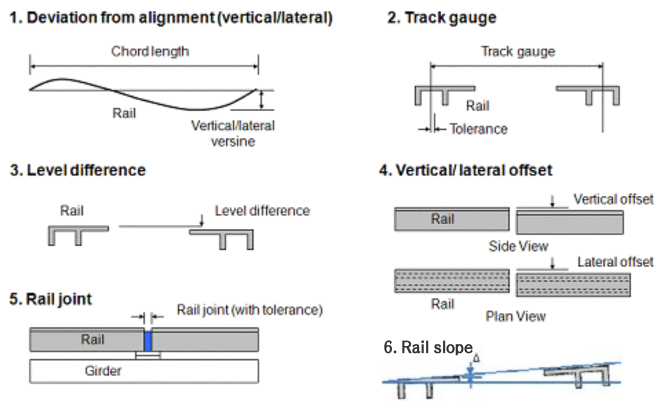


Figure 12. Track alignment errors

The 1st, 2nd, 3rd and 6th errors are should be controlled in rail level. Other two types are in the level of civil structure construction and they can be controlled somewhat by rail expansion joint. These allowable track alignment errors absolutely depend on the capacity of the active levitation control system.

Table 1. Allowable errors

item		Construction error	Maintenance criteria
alignment	Vertical	2mm/10m cord	5mm/10m cord
	Lateral	2mm/10m cord	5mm/10m cord
Track gauge		±2mm	±5mm
Level difference		2mm	5mm
Error in rail slope		1mm	2mm
offset	vertical	1mm	1mm
	lateral	0.5mm	1mm

These values are almost 30~50% of those in HSST.

Figure 13. Detail of rail support bracket

Wedge of plates are introduced to control subtly rail in vertical direction as shown in fig. 13. Total secondary dead load of this twin block system is about 40% lighter than that of transverse sleeper of the mono block type. Furthermore upper surface of the guideway girder is flat without any obstacle. So it could be used as an emergency path or a maintenance path.

6 CONCLUDING REMARKS

There is a project to put an urban maglev system to actual use in Korea. This paper introduces a guideway system that is proposed as a part of the project. The guideway system has a rail support bracket of twin block type and a composite girder of open box(steel or PSC) girder and a precast concrete slab.

In this paper, the shape and composite behavior of the girder is shown in outline. We can find the composite girder works as a one body beam. Also a twin block rail support is proposed to reduce the second dead load(about 40%) of the girder. It makes reduce the volume of the girder and a sub structure.

It is possible to adjust the alignment minutely during the construction and/or operation using this bracket. It is demonstrated that the twin block system is can be easily established under the real situation.

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