Dynamic Amplification Factors of an Urban Maglev Guideway

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Summary

The Korean urban maglev project has been initiated with the intention to build a commercial line by the year 2012. The optimized guideway has been proposed and the relevant tests are currently being conducted. However, the dynamic amplification factor (DAF) for the maglev guideway has not been determined for the guideway design criterion. As the maglev load is distributed rather than concentrated, further examination of the dynamic behavior should be conducted. This study is to identify the DAF of the proposed urban maglev guideway. For this purpose, moving load analyses were performed up to the maximum speed of 110 km/hr by 10 km/hr increments. A field test was conducted on the maglev test track to verify the finite element model. Guideway deflections and accelerations were measured for various vehicle speeds and a DAF was computed.

Keywords: Maglev, guideway, impact factor, deflection, FEA, mode, natural frequency

1. Introduction

A maglev guideway is an elevated structure that supports the maglev trains. The maglev test track in Korea utilizes conventional prestressed concrete (PSC) box girders topped by transverse steel sleeper beams which in turn support the steel rails. Various tests are being conducted on the test track in Korea. Recently, the Korean government initiated a program for urban maglev commercialization to complete the commercial maglev line of the Incheon International Airport region by the year 2012. The guideway for the Incheon airport line will be called "Standard guideway"; it is shown in Fig. 1. The standard guideway consists of precast concrete U girders with two precast deck slabs. Precast deck slabs play an important role as they combine the functions of the sleeper beams and deck slab. Steel rails are installed on cantilever supports on the precast deck, as shown in Fig. 1. This concept is similar to the concept design reported in the Colorado Maglev project , except that the standard guideway has cantilever sleepers for detailed adjustments.

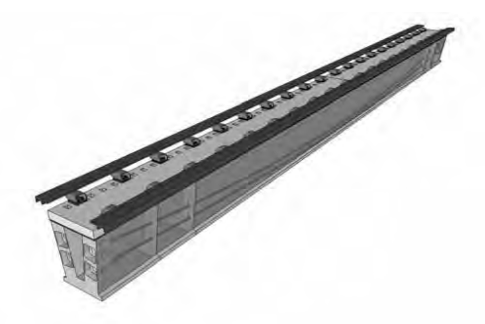

Fig. 1: Standard Maglev guideway

This study seeks to determine the DAF for a standard maglev guideway under maglev train loading. The finite element (FE) modeling of a guideway was carried out in three dimensions. The FE model used in this study was then verified by experimental results obtained by testing the PSC box girder guideway on the maglev test track. Finally, the DAFs of the standard guideway were calculated up to the maximum commercial vehicle speed of 110 km/h.

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2. FE Modeling of the Maglev guideway

A detailed FE model of a maglev guideway is adopted in this study. The guideway girder and a deck slab are modeled by shell elements. Steel rails are modeled by beam elements and the prestressing tendons are idealized by truss elements. The prestressing forces are specified as an initial stress in each truss element used to model the prestressing tendons. The full composite action between structural elements is assumed using rigid links. The modal method was used because the target structure was expected to behave linearly. In the transient modal dynamic analysis, the natural frequencies of the guideway are first extracted using an eigenvalue analysis. The guideway response is then simulated based on a subset of the eigenmodes of the guideway.

In order to validate the proposed FE model, a field test was conducted on a guideway of the maglev test track. The proposed FE modeling technique was validated by comparing its results with those obtained from the field tests. Results of a deflection under a moving load and modal frequencies for a maglev guideway are compared against those obtained numerically. As can be seen in Fig. 2, the FE model is able to reproduce the experimental results very well. The numerical maximum deflection at the mid-span location effectively reproduces the experimental values with an error rate of 1.5%.

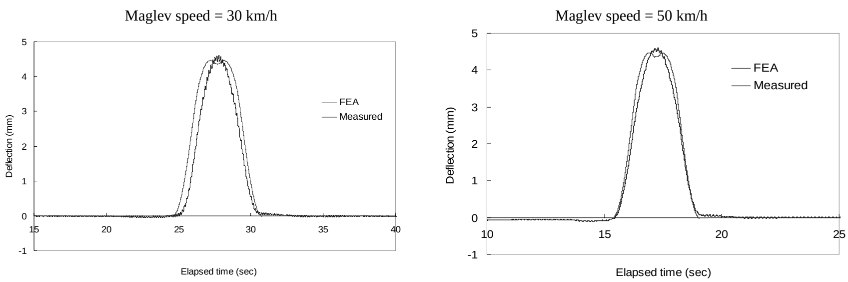
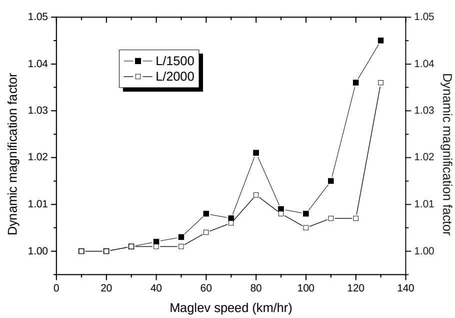


Fig. 2: Comparison of deflection histories

3. Dynamic Response of Standard Maglev Guideway

The validated FE model of the maglev guideway was extended to model the standard guideway for the Incheon airport line. Two optimized sections were investigated according to the deflection limit (L/1500 and L/2000). Fig. 3 shows the DAFs against different maglev speeds. The increases in deflection are 4.5% for the L/1500 guideway and 3.6% for the L/2000 guideway as the train speed increases from 10 km/h to 130 km/h. The current design guideline, which is based on the Japanese Maglev guideline, adopts a DAF of 1.10 for a concrete guideway. However, numerical simulations revealed that the current guideline is too conservative for the proposed standard guideway. It was shown that the DAF for the standard maglev guideway is less than 2% up to the maximum commercial speed, which implies that dynamic amplification is not severe in the proposed maglev system.



[1] Fig. 3: DAF vs. maglev speed