Development of guideway sidewall using ultra high strength fiber reinforced concrete

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ABSTRACT: In the Superconducting MAGLEV System, a lot of ground coils are installed for propulsion, levitation and guidance of the vehicles. Four types of guideway sidewall have been installed to examine the structural safety performance through running tests on the Yamanashi Maglev Test Line. The latest type is so called self-standing guideway sidewall with a cross-section of reverse T-shape. To meet the purpose of further cost reduction, its weight was reduced in comparison with former types of guideway, which brought easy handling and precise installation. This paper focuses on newly developed guideway sidewall for the further weight reduction using ultra high strength fiber reinforced concrete (UFC). No rebars are used in the guideway taking advantage of the mechanical properties of UFC, which makes the cross-section thinner. Thus the weight of new guideway reduces by 42 % compared with the self-standing guideway. The structural safety was verified through the various loading and running tests.

1 INTRODUCTION

1.1 *Introduction*

The running tests on the Yamanashi Maglev Test Line were began in April 1997. Four types of guideway sidewall (Figure 1) have been examined the structural and safety performance through running tests on the Yamanashi Maglev Test Line. The latest type is so colled self-standing guideway sidewall whose cross-section is a reverse T-shape. To meet the purpose of cost reduction, its weight was reduced in comparison with former types of guideway, which brought easy handling and precise installation. This paper focuses on newly developed guideway sidewall for the sake of further weight reduction using a ultra high strength fiber reinforced concrete (UFC).

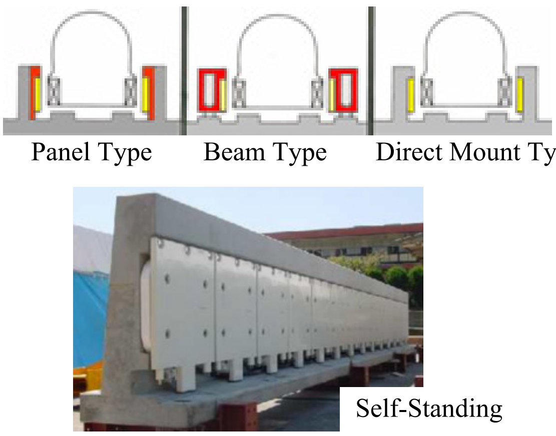

Figure 1: Conventional Types of Guideway Sidewall

2 FEATURES OF NEWLY DEVELOPED GUIDEWAY

2.1 *Mechanical properties of UFC*

Table 1 shows comparisons with UFC, the ordinary concrete and the high strength concrete. UFC has high compressive strength, as well as high tensile strength. Its fresh property demonstrates excellent self-leveling performance. In addition to the ultra high strength, the ductility is realized due to fiber bridging effect. For the new type of guideway, the organic fibers were applied to decrease the running resistance of vehicle owing to magnetic field.

Table 1: Comparisons of Mechanical Properties of UFC

Item	Unit	UFC	Ordinary concrete	High strength concrete
Density	g/cm^3	2.46	2.3	2.4
Compressive strength	N/mm^2	150	36	60
Flexural strength	N/mm^2	27	5	9
Tensile strength	N/mm^2	8	3	4
Static modulus of elasticity	kN/mm^2	48	25	40
Abrasion resistance	mm	1.5	8.0	2.3
Drying shrinkage	10^{-6}	0	600~800	400~600

2.2 Structure of guideway sidewall

The cross-section of newly developed guideway sidewall is based on that of self-standing guideway. No passive reinforcement by rebars is applied in this guideway sidewall, which makes the wall members extremely thin. The sidewall thickness was only 70mm, and the vertical rib was set up outside the sidewall to increase the rigidity (Figure 2). Since the guideway sidewall became thinner, the amount of deformation caused by the change of temperature was thought to be larger than that of the conventional self-standing one. Therefore, we calculated the deformation and checked whether it was in the allowable level or not. For the case that the difference in temperature between the front side and the back side was 20 degrees, the maximum deformation of guideway sidewall was at least 2mm (Figure 3). We also computed the natural frequency of the guideway sidewall and confirmed that it would not vibrate sympathetically due to train running. Thus the weight of new guideway sidewall resulted in reduction by 42 % compared with that of the self-standing one. It should be noted that the new guideway sidewall must improve the efficiency of the installation and the maintenance, which will lead to the reduction of installation and maintenance cost.

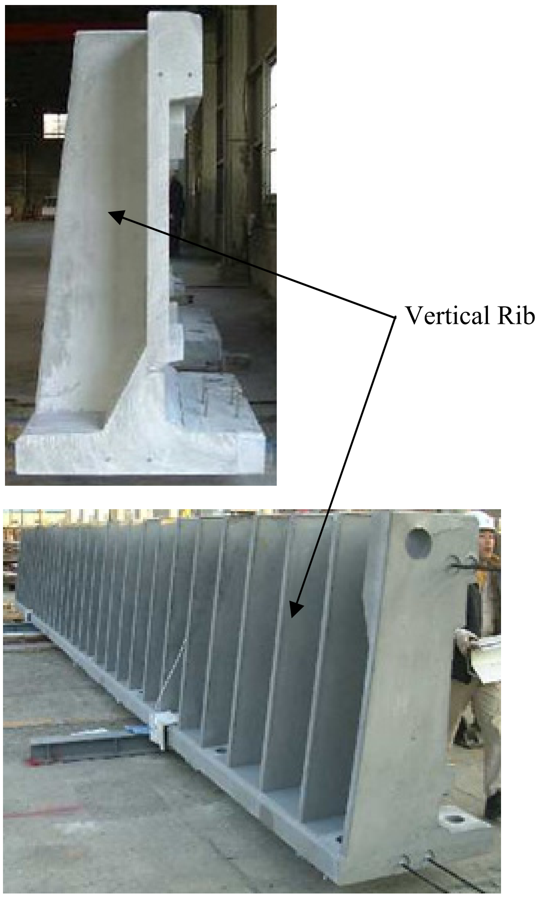

Figure 2: Cross-Section and Back Side of Newly Developed Guideway Sidewall

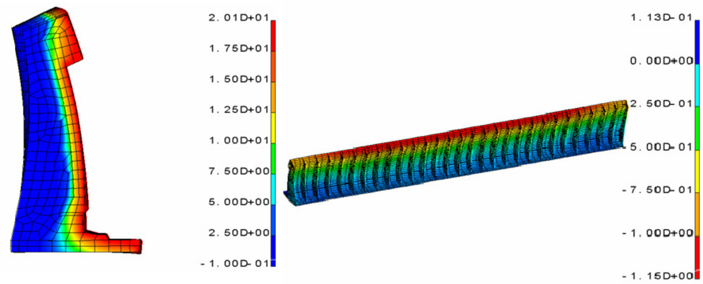

Figure 3: Deformation Caused by Change of Temperature

3 STRUCTURAL VERIFICATION OF GUIDEWAY SIDEWALL

3.1 Bench tests

Various tests have been carried out to verify the performance of the newly developed guideway sidewall. The structural safety at the ultimate limit state such as unlikely case of failure of the magnetic levitation or guidance was confirmed through the loading tests. Figure 4 shows the deformation curve obtained by the loading tests. It is demonatrated that the displacement due to the design load is within the allowable displacement and the ultimate resistance load is about 1.8 times of the design capacity. The fatigue test for the new guideway sidewall was also conducted to verify that the UFC could indicate the fatigue performance. Fatigue 5 demonstrates the fatigue S-N curve. Though the numbers of the test results are not good enough, it can be noted that the new guideway sidewall has enough fatigue resistance against the cyclic loads equivalent to that for one hundred years service time. The dynamic characteristics of guideway sidewall was also studied through the FEM analyses.

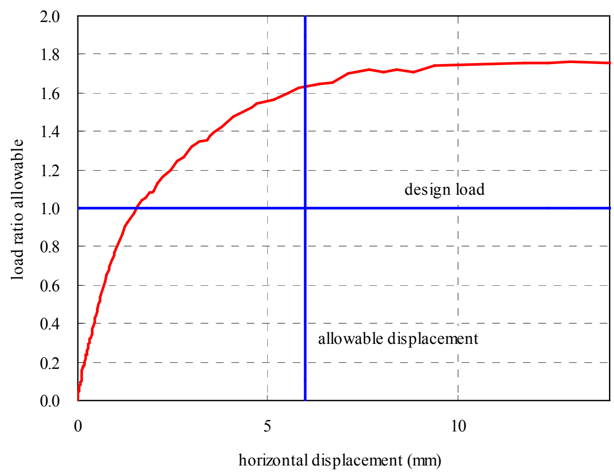

Figure 4: Load-Displacement Curve

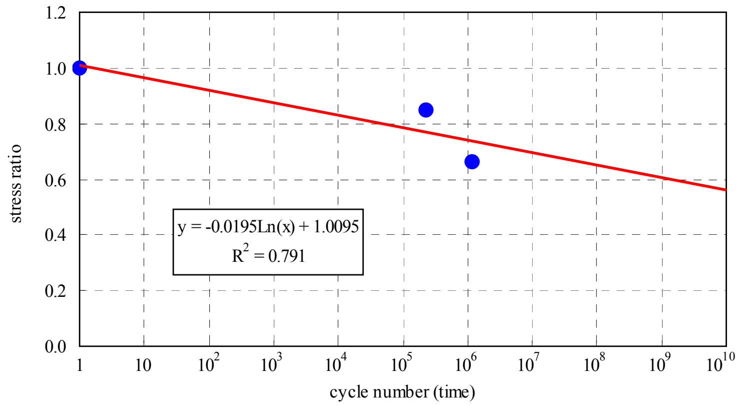

Figure 5: Fatigue S-N Curve

3.2 Running tests

The conventional guideway sidewalls were partly replaced to the new ones to investigate the various dynamic responses due to the running of maglev vehicles at the speed over 500 km/h. The horizontal displacement response in the 500km/h running test is shown in Figure 6, 7. The horizontal displacement was calculated from the vibrating acceleration of the guideway sidewall. It is indicated that significant differences among the types of guideway and train speed is not observed. The concrete stress are compared in Figure 8, 9. The concrete stress of the newly guideway sidewall became a little larger compared with those of the conventional ones. There were any significant differences in stress depending on the train speed. From these results, we confirmed that the newly developed guideway had good and safe performance that was almost equivalent to the conventional types of guideway.

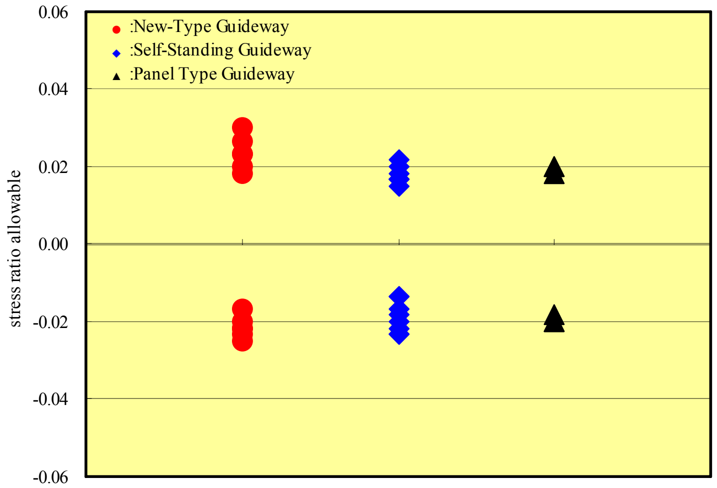

Figure 6: Horizontal Displacement

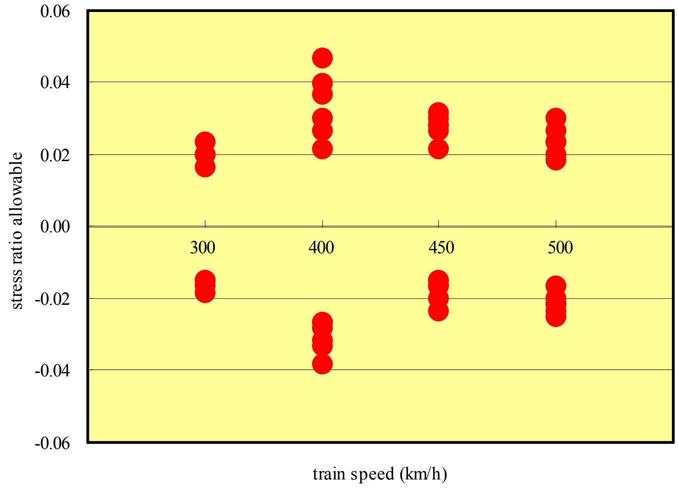

Figure 7: Horizontal Displacement

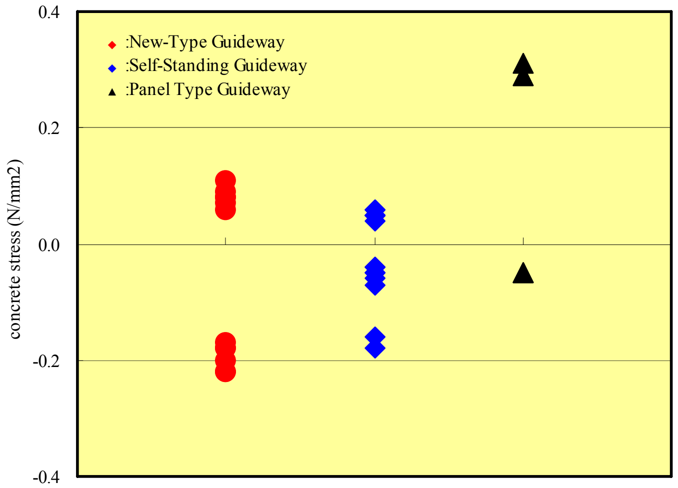

Figure 8: Concrete Stress

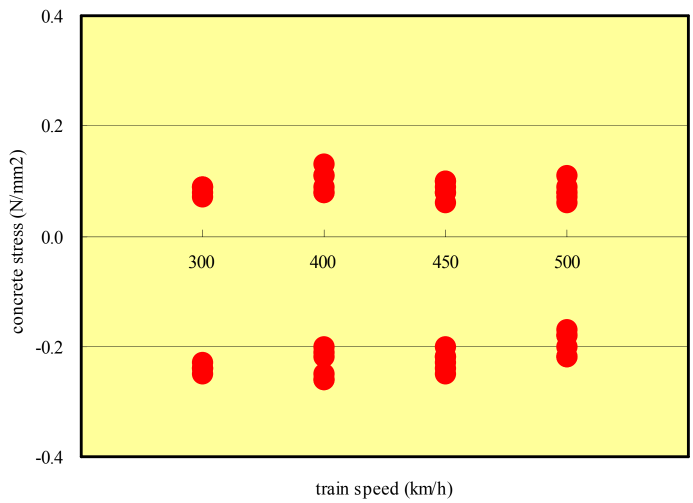

Figure 9: Concrete Stress

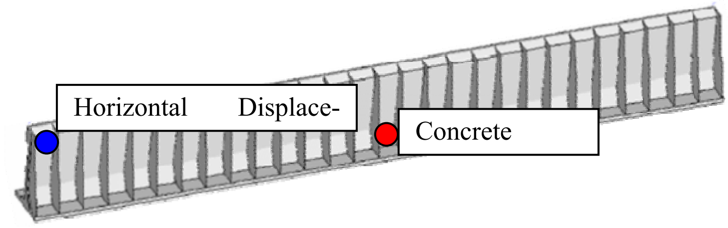

Figure 10: Measuring Point

4 CONCLUSION

The guideway sidewall using ultra high strength fiber reinforced concrete was compared with that of ordinary concrete. Through the implementation of no reinforcing rbars and the extremely thin cross section, the self dead weight resulted to be reduced by 42 % compared to that of the self-standing guideway sidewall. Moreover, various bench tests and running tests on the Yamanashi Maglev Test Line were carried out, and it was clarified that it had the performance equal to conventional guideway sidewalls. We are now making ongoing efforts to verify the long term durability of the new sidewall on the Test Line.

5 REFERENCES

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