

## Experimental Study on Mechanical Characteristics of CRTSIII Slab Ballastless Track under Train Load

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**Keywords:** CRTSIII slab ballastless track; self-compacting concrete thickness; fatigue experiment; mechanical characteristics

**Abstract.** This paper studied on the fatigue experiment of two CRTSIII slab ballastless tracks on subgrade under high-speed train load, one was the track structure with self-compacting concrete thickness of 70 mm (the 70 mm's), the other was 90 mm (the 90 mm's). The two tracks were made of 1:1 full-scale test models and were carried out 3million times fatigue load test respectively. The experimental results show that the self-compacting concrete thickness has little effect on the change of fastener stiffness and isolation layer stiffness, while greatly affects the acceleration of track panel and the base and the strain of the self-compacting concrete and the base concrete. With the same experiment times, the maximum of the acceleration of track panel and the base of the 70 mm's is 1.2-1.4 times that of the 90 mm's. With the same experiment times and the same position, the maximum of the strain of the self-compacting concrete and the base concrete of the 70 mm's is 1.2-1.5 times that of the 90 mm's.

### Introduction

Currently, the ballastless track types used by high-speed railway and passenger dedicated line are mainly CRTSI slab, CRTSII slab, double-block, sleeper buried ballastless track and so on. As a new type of ballastless track, CRTSIII slab structure was developed based on optimization and innovation of CRTSI and CRTSII, and China owns its intellectual property rights. The mechanical characteristics of CRTSIII slab ballastless track have brought widespread concern of scholars. Hanmin WANG[1] analyzed the change of mechanical characteristics of track panel and base panel in response to the structure parameters by establishing finite element model of CRTSIII slab ballastless track on subgrade. Lu SUN[2] et al. analyzed static characteristics of the structure by using high-speed railway CRTSIII slab ballastless track. China Academy of Railway Sciences[3] et al. systemly studied on the key parameters and static and dynamic characteristics of the reasonable scale of many parts, fasteners reasonable stiffness, reasonable Stiffness isolation layer, function positioning of CRTSIII slab ballastless track , by establishing static structural finite element model and vehicle-track-basic coupled dynamic model. Self-compacting concrete thickness is one of the key mechanical parameters of CRTSIII slab ballastless track, this paper studied on the influence regular pattern of track mechanical characteristics in response to the self-compacting concrete thickness, and the fatigue characteristics of ballastless track on subgrade under train load.

### Experimental Program

Experiments of 1:1 full-scale test models of two ballastless tracks with different self-compacting concrete thickness (90 mm and 70 mm) were carried out, and 3 million times fatigue test was carried out respectively.

**CRTSIII Slab Track Test Model Imitating on Subgrade.** Subgrade supporting role was played by rubber pad, with the size of 6060mm×3330mm×76mm. In addition to the track panels, the base panels, self-compacting concrete etc. were made strictly according to the relevant design drawings, using materials and construction technology consistent with the construction site and by the professional team in the laboratory, as is shown in Fig. 1.



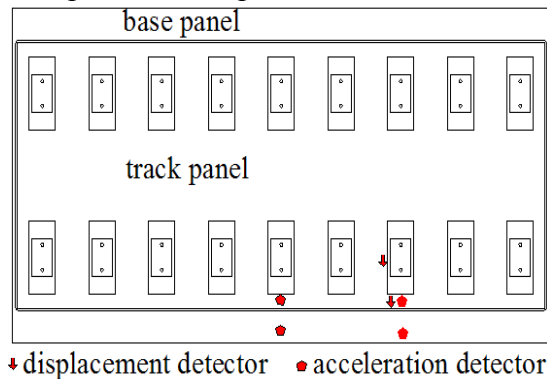
(a) Construction of steel mesh inside base



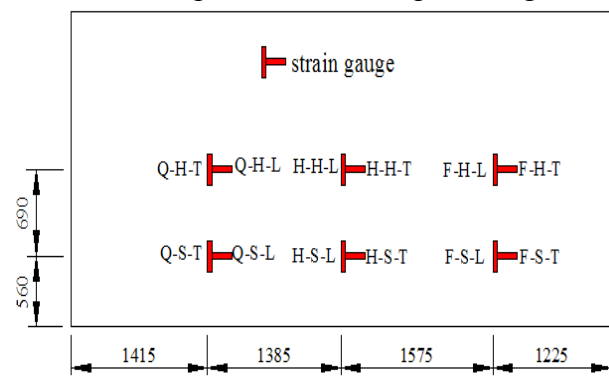
(b) Test loading device

Fig. 1 The test model of CRTSIII slab ballastless track structure on simulated subgrade

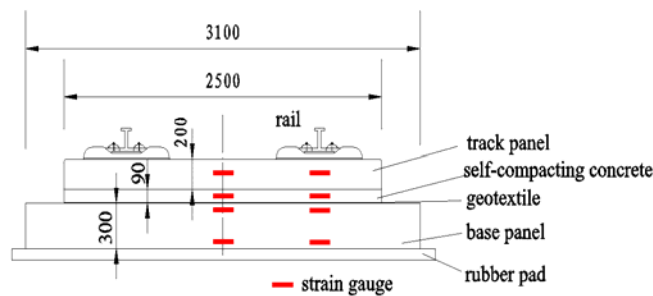
**Test content and component arranging.** The specific test contents include: the displacement of the rail with respect to track panel, the displacement of the track panel with respect to the base, the acceleration of track panel and the base panel and the strain of self-compacting concrete and base concrete. The Components include strain gauge, motion detector and acceleration detector, as is shown in Fig. 2. As is shown in Fig. 2(b), Q, F, H, S, L, T represents portrait quarter, longitudinal load point, longitudinal middle of the panel, lateral middle of the panel and lateral panel edge, for example, H-S-L represents the strain of longitudinal middle of the panel and lateral panel edge.



(a) Displacement and accelerator detector



(b) Strain gauge of the track structure



(c) Cross section of the track structure

Fig. 2 The layout of test element

**Load program.** The experiments were carried out by PMW-1200 pulsating electro-hydraulic fatigue testing machine with loading frequency of 2~8Hz in National Engineering Laboratory for High Speed Railway. The wheel was simulated by distribution beam, when the load acts, that was equivalent to the wheel acting, as is shown in Fig. 3. Simplified calculation method was used in dynamic load test simulation, high-speed train's maximum axle load is 17t, considering the power factor 2.5 times, the maximum fatigue load was 850KN, its minimum was 85KN. In order to study the effects of fatigue track structure, static load test was carried out during the whole process, respectively, before the dynamic load test, after 250000, 500000, 1000000, 1500000, 2000000, 2500, 000 and 3000000 times the static load rating load test was carried out. The static load rating load was carried out by 0, 50, 100, 150, 200, 300, 350 and 400KN, respectively measure the displacement and strain of every level. Figure 4 shows the load curve .

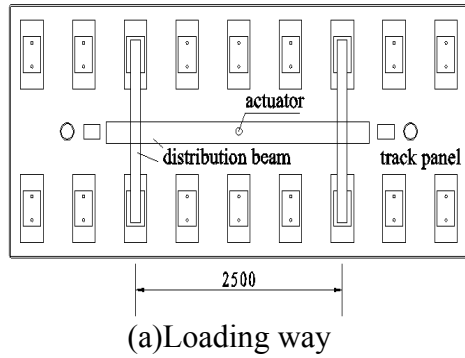


Fig. 3 Ballastless track model test system

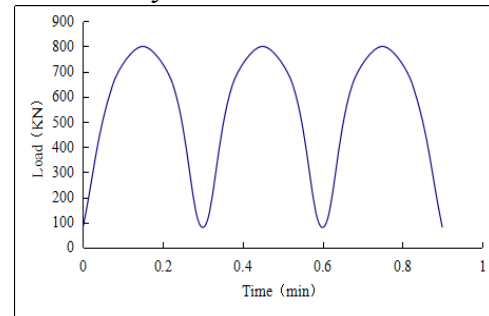
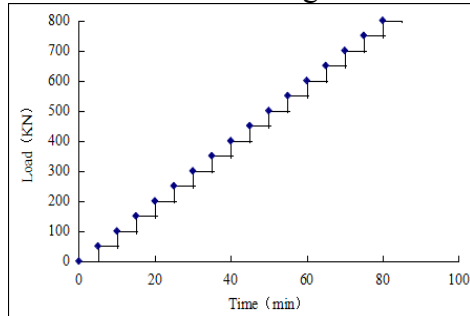


Fig. 4 Test load curve

### Analysis of the Results

3million fatigue load test was respectively carried out on the two CRTSIII slab ballastless tracks with different self-compacting concrete thickness (90 mm and 70 mm). According to the results, the maximum of displacement, acceleration and strain were drawn for comparative analysis, as are shown in Figs. 5-10.

As is shown in Fig. 5, with the increase of test times the maximum of displacement of rail with respect to track panel declines. Substantially the maximum of displacement reduces linearly, after 50 thousand times, the maximum reduces 0.02mm-0.03mm. After 3million times, the maximum displacement of rail of the 90 mm's reduces 10.9%, from 1.1 mm to 0.98 mm, while that of 70 mm's reduces 14.7%, from 1.16mm to 0.99mm. We can see, self-compacting concrete thickness has little effects on the displacement of rail.

As is shown in Fig. 6, with the increase of test times the maximum of displacement of track panel with respect to the base panel declines. After same test times, the maximum of the displacement of track panel of the 70 mm's is 1.3-1.4 times that of the 90 mm's. After 3million times, the maximum of the displacement of track panel of the 70 mm's and 90 mm's reduces 26.7% and 27.3% respectively, from 0.15mm and 0.11mm to 0.11mm and 0.08mm respectively. We can see that self-compacting concrete thickness has little effects on the displacement of track panel.

As is shown in Fig. 7, with the increase of test times the maximum of acceleration of the track panel declines. After same test times, the maximum of acceleration of the 70 mm's is 1.3-1.4 times that of 90 mm's. After 3million times, the maximum of acceleration of the track panel of the 70 mm's and 90 mm's reduces 22.1% and 21.9% respectively, from 66.1mg and 55.1mg to 51.6mg and 42.9mg respectively. We can see, self-compacting concrete thickness has little effects on the acceleration of track panel.

As is shown in Fig. 8, with the increase of test times the maximum of acceleration of the base panel increases. During 500 thousand and 2million times, the acceleration of base panel grows rapidly, the acceleration of base panel of the 70 mm's grows faster than that of 90 mm's. After same test times, the maximum of acceleration of the base panel of the 70 mm's is 1.2-1.4 times that of the 90 mm's. After 3million times, the maximum of acceleration of the base panel of the 70 mm's and the 90 mm's increases 34.6% and 30.5% respectively, from 29.8mg and 22.3mg to 40.1mg and 29.1mg respectively. We can see, the maximum of acceleration of the base panel of the 70 mm's grows faster with respect to test times.

As is shown in Fig. 9, with the increase of test times the maximum of strain of self-compacting concrete declines. Before 500 thousand times, the maximum of self-compacting concrete strain stays unchanged (H-S-L of the 90 mm's and the 70 mm's was  $14\mu\epsilon$  and  $12\mu\epsilon$  respectively). After same test times and same position, the maximum of self-compacting concrete strain of the 70 mm's is 1.2-1.5 times that of the 90 mm's. After 3million times, the maximum of H-S-T strain of the 70 mm's and the 90 mm's declines 8.3% and 20.0% respectively, from  $12\mu\epsilon$  and  $10\mu\epsilon$  to  $11\mu\epsilon$  and  $8\mu\epsilon$  respectively; the maximum of H-S-L strain of the 70 mm's and the 90 mm's declines 11.8% and 14.3% respectively, from  $17\mu\epsilon$  and  $14\mu\epsilon$  to  $15\mu\epsilon$  and  $12\mu\epsilon$  respectively.

The upper H-H-T strain of the base is compressive strain, figure 10 was drawn with its absolute value. As is shown in Fig. 10, with the increase of test times, the maximum of the strain of the base concrete increases. After same test times and same position, the maximum of base concrete strain of the 70 mm's is 1.2-1.4 times that of the 90 mm's. Before 1.5million times, the maximum of upper H-H-T strain stays unchanged (that of the 90 mm's and the 70 mm's was  $10\mu\epsilon$  and  $8\mu\epsilon$  respectively). After 3million times, the maximum of upper H-H-T strain of the base of the 70 mm's and the 90 mm's increases 20.0% and 12.5% respectively, from  $10\mu\epsilon$  and  $8\mu\epsilon$  to  $12\mu\epsilon$  and  $9\mu\epsilon$  respectively; the maximum of lower H-S-L strain of the base of the 70 mm's and the 90 mm's increases 50.0% and 66.7% respectively, from  $4\mu\epsilon$  and  $3\mu\epsilon$  to  $6\mu\epsilon$  and  $5\mu\epsilon$  respectively.

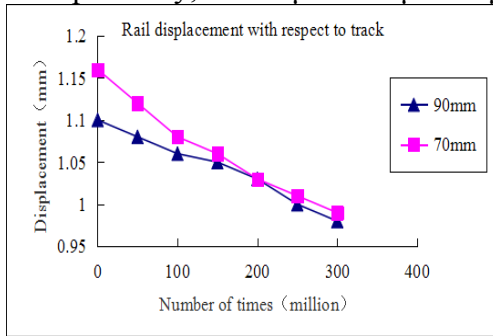


Fig. 5 Variation chart of rail displacement

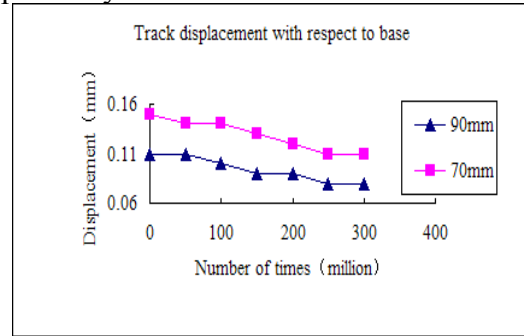


Fig. 6 Variation chart of track panel displacement

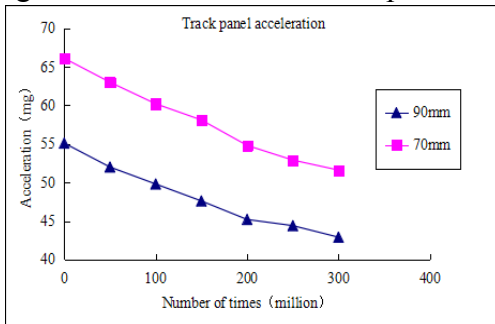


Fig. 7 Variation chart of track panel acceleration

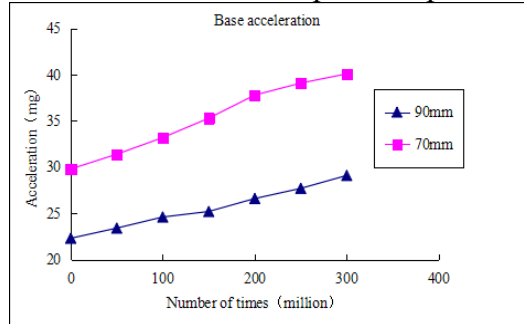


Fig. 8 Variation chart of base acceleration

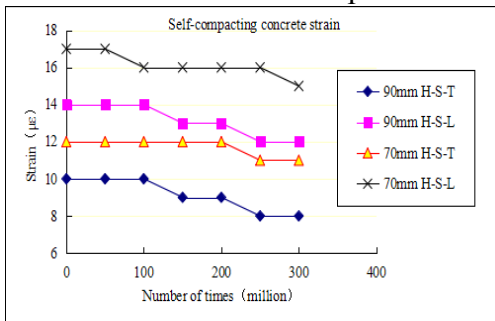


Fig. 9 Variation chart of self-compacting strain

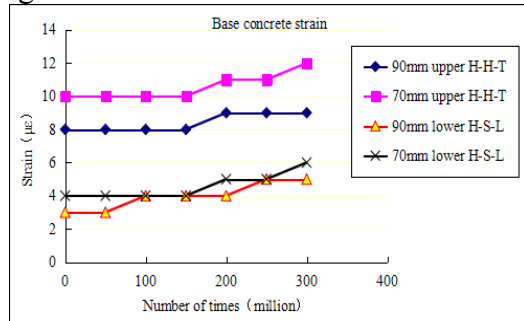


Fig. 10 Variation chart of base concrete strain

## Conclusions

1. With the increase of test times the fastener stiffness and stiffness of the isolation layer of the two tracks with different self-compacting concrete thickness (70 mm and 90 mm) increase.

Self-compacting concrete thickness has little effect on the fastener stiffness while has great effect on the stiffness of the isolation layer.

2. With the increase of test times the maximum of acceleration of track panel of the two tracks with different self-compacting concrete thickness (70 mm and 90 mm) decline. After same test times, the maximum of acceleration of track panel and base of the 70 mm's is 1.2-1.4 times that of the 90 mm's.

3. With the increase of test times, the maximum of self-compacting concrete strain of the two tracks with different self-compacting concrete thickness (70 mm and 90 mm) decline, while the base concrete strain increase. After same test times and same position, the maximum of self-compacting concrete strain and base concrete strain of the 70 mm's is 1.2-1.5 times that of the 90 mm's.

## Acknowledgements

The research described in this paper was financially supported by the Joint Funds of the National Natural Science Foundation of China (Grant Nos. U1434204 and U1361204), the Program for Changjiang Scholars and Innovative Research Team in University (Grant No. IRT1296) and the Project of Innovation-driven Plan in Central South University.

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