Advanced Science and Technology Letters
Vol.120 (GST 2015), pp.377-381
http://dx.doi.org/10.14257/astl.2015.120.71

A Study on Variation of Response according to Longitudinal Track-Bridge Interaction Analysis Methods

Kyungmin Yun[1], Beomho Park[1], Hyunung Bae[1],
Shinhyung Choi[1], Namhyoung Lim[1*]

[1] 99, Daehak-ro(St), Yuseong-gu, Daejeon, 305-764, KOREA
{ Kyungmin Yun, Beomho Park, Hyunung Bae,
Shinhyung Choi, Namhyoung Lim} nhrim@cnu.ac.kr

Abstract. When constructing a track on a bridge, the track-bridge interaction analysis is performed in order to examine the influence of the interaction. Two analysis methods are proposed according to whether the loading history is considered or not in analyzing the track-bridge interaction. In this study, track-bridge interaction analysis was performed on various types of bridges in order to examine the variation of response according to each analysis method. The additional axial stress of the rail was found to have decreased by the maximum 21.7% with an average decrease of 11.4% in the longitudinal track-bridge interaction analysis performed by complete analysis method which considering the loading history in comparison with the separate analysis method.

Keywords: track-bridge interaction, additional axial stress, loading history, F.E. analysis

1 Introduction

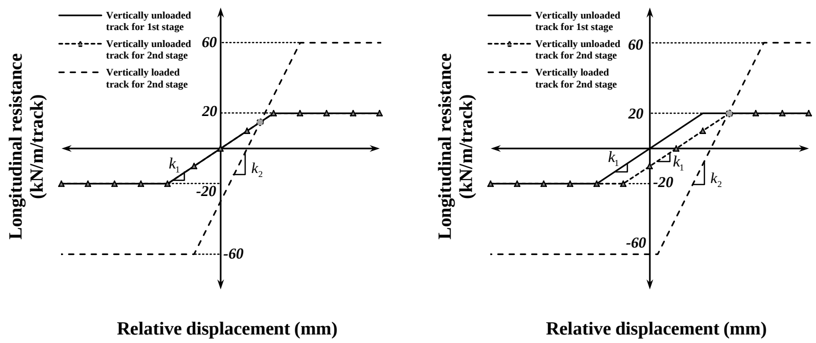
The continuous welded rail track constructed on a bridge is influenced by the actual performance of the bridge and thus suffers the occurrence of very complex additional axial stress and displacement, in comparison to the continuous welded rail on an embankment. During the process of designing a bridge for a track to be laid on, its safety is examined by performing a track-bridge interaction analysis. For the purpose of examining its safety, Eurocodes[1], UIC 774-3R[2], and KR C-08080[3] propose modeling methods, loading sizes and loading methods. UIC 774-3R[2] also proposes simple(separate) and complete analyses according to whether the loading history is considered or not.

In this study, the track-bridge interaction analysis was performed on various types of bridges. Additional axial stress and displacements were comparatively examined according to two different analysis methods: A separate analysis which considers the longitudinal track-bridge interaction-inducing load independently and the complete analysis which considers the long-term and short-term load histories.

ISSN: 2287-1233 ASTL

2 Analysis Methods

UIC 774-3R provides two analysis methods according to the structural design of a bridge and its significance. It suggests both the separate analysis method and the complete analysis method in order to select one of the two analysis methods for the purpose of performing analysis. In this study, the analysis was performed using a two-stage analysis method, as shown in Fig. 1.[4]



(a) Elastic state after 1st stage (b) Plastic state after 1st stage

Fig. 1. Modification of longitudinal resistance of ballast in complete analysis

3 Interaction responses according to the analysis methods

Target bridges. 20 designed bridges were modeled. The target bridges have various spans and cross sectional shapes. They are bridges that are designed as simple supports for ballast tracks. The selected types of bridges have been summarized as shown in Table 1.

Table 1. Types of seven in twenty bridges

Bridge	Type of girder and length
Br-1	29.95m(PSC-e)*16= 479.2m
Br-2	24.945m(PSC)+39.9m(WPC)*5= 224.445m
Br-3	39.9m(WPC)*8+34.94m(IPC)+39.9m(PRECOM)= 394.04m
Br-4	40.05m(WPC)*2+40m(WPC)*5+45m(IT)*2+10m(Rahmen)= 380.1m
Br-5	35.03m(PSC-e)+30m(PSC-e)+50.05m(SB composite girder) +14.9m(Rahmen)*4+55.1m(STB) +50.1m(SB composite girder)*5+9.9m(Rahmen)*2 +14.95m(Rahmen)+35.06(PSC-e)= 555.09m
Br-6	*25.025m(PSC)*2+35m(PSC-e)*6= 260.05m*
Br-7	*35.08m(PSC-e)+35.05m(PSC-e)*12+30.05m(PSC-e)*2 +35m(PSC-e)*4+45m(PRECOM)*3+40m(WPC)*4 +55m(STB)*2+15m(Rahmen)*2+35.03m(PSC-e)= 1125.81m*

Analysis models. LUSAS Ver.15.0, a finite element analysis (FEA) program, was used for the longitudinal track-bridge interaction analysis. The rails and the bridge decks were modeled using Timoshenko beam elements. The ballasts were modeled using elasto-plastically behaving nonlinear joint elements (elasto-plastic joints). Rigid beam elements expressing a distance from the neutral axis of the bridge deck to the bridge pier were added. Constraint equations were applied so that in the event of any flexural displacement in the bridge deck, its influence on the actual height of the upper structure of the bridge could be taken into consideration.(Fig. 2)[5]

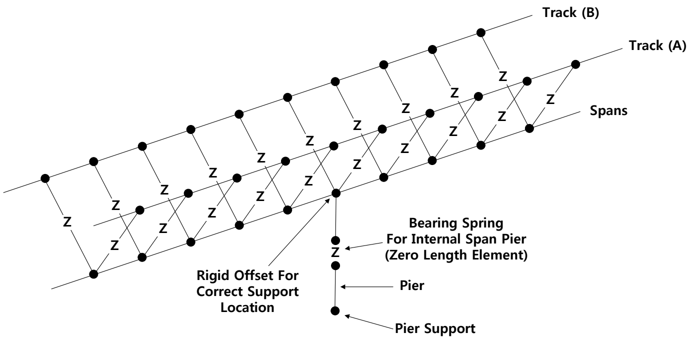


Fig. 2. Schematic diagram of Track-Deck(Span)-Pier

The loads taken into consideration were the temperature load, the acceleration/braking load, and the vertical load of the train as shown in Table 2. Various positions were also considered in order for the most unfavourable results to be obtained.

Table 2. Temperature and vehicle loads[3]

Load		Magnitude (Loading length)
Temperature load		±25℃
Vehicle load	Acceleration	33 kN/m/Track (33 m)
	Braking	20 kN/m/Track (400 m)
	Vertical	80 kN/m/Track (400 m)

Analysis results. As for each bridge, separate and complete analyses were used to deduce the maximum tensile stress and a vehicle load case where the maximum additional tensile stress could occur. The analysis results for the 20 bridges were compared. The maximum stresses and the variation ratios (Complete analysis/Separate analysis) according to the analysis methods are as shown in Fig. 4. The additional axial stress from the rail was found to have decreased by the maximum 21.7% with an average decrease of 11.4% in the longitudinal track-bridge interaction analysis performed by complete analysis method when considering the loading history in comparison with the separate analysis method.

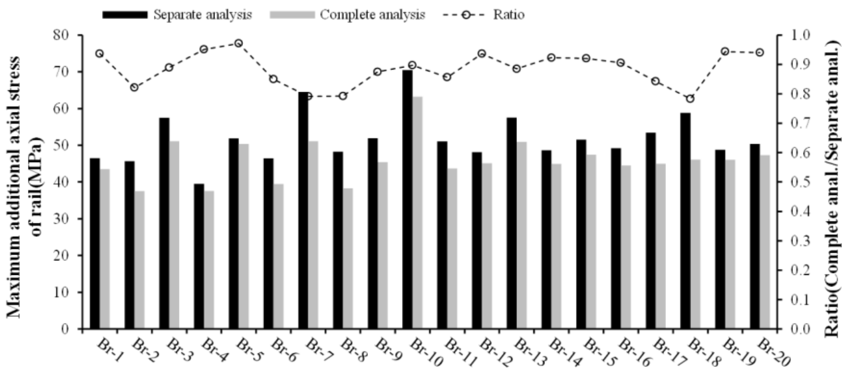


Fig. 3. Maximum additional tensile stress of rail according to analysis methods

4 Conclusion

A track-bridge interaction analysis was performed on various types of bridges, and the additional axial stresses from the rail according to the analysis methods were compared and analyzed. An analysis which considers the loading history is an analysis method which also takes the actual in-situ conditions into consideration. It is concluded that this analysis method will more or less resolve the constraints caused by the axial stress of the rail.

Acknowledgments. This research was supported by a grant (15RTRP-B067919-03) from Railroad Technology Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

References

1. CEN, EN9: EN1991-2, Eurocode 1-Actions on structures-part2 Traffic loads on bridges (2003)
2. UIC, Code 774-3R, Track/bridge Interaction Recommendations for calculations (2001)
3. KR(Korea Rail Network Authority), Korea Railway Design Guideline (2011)
4. Yun,K.M., Choi,J.Y., Lee, J.O., Lim,N.H., Modification of the conventional method for the track-bridge Interaction, Vols. 204-208, pp. 1988-1991 (2012)
5. LUSAS Inc.,LUSAS User's manual, Surrey, KT1 1HN, UK(2006)