Evaluation of Additional Rail Stress for Partial Application of Sliding Slab Track

Dong-ki Jung* and Kyoung Chan Lee†

Abstract

CWR(continuous welded rail) on railway bridges should be carefully examined and installed due to additional rail stress caused by track-structure interaction. The additional rail stresses are caused by longitudinal displacement of bridge due to temperature change and train vertical load and traction/braking force. Design codes limit the additional rail stress less than or equal to 92 MPa. Previous researches showed that the additional rail stress generated through track-bridge interaction can be reduced significantly up to 80% by applying sliding slab track system. This study evaluates the effectiveness of partial application of the sliding slab track system, in which the sliding slab track is applied only at bridge roller support region rather than applying it to the entire bridge span. The proposed system has been verified here through track-bridge interaction analysis for 60 m or 70 m long simple span bridges and suggested proper application length of the partial sliding slab track.

Keywords: Track-Bridge Interaction, Partial Sliding, Sliding Slab Track, CWR

1. Introduction

The railway bridge applying CWR is more advantageous than jointed rail that is 20 to 25 m long, because CWR provides higher running stability with less vibration for the train and it is easier to be maintained due to the absence of rail joint. Influencing factors of track-bridge interaction include temperature load, vertical load of the train, as well as train traction and braking load.

Korean and other international design codes(Korea Rail Network Authority, 2014; International Union of Railways, 2001; The European Standard EN 1991-1-2, 2003) limits the additional rail stress of CWR on bridge up to 72 MPa in compression and 92 MPa in tension for the ballast track. In case of the slab track, both tension and compression apply 92 MPa. In some cases, special types of fasteners such as zero longitudinal restraint fastener (ZLR) or reduced longitudinal restraint fastener (RLR) are applied to relieve longitudinal track-bridge interaction for longer span bridges.

Yang et al. (2000) developed a program to analyze CWR’s axial force for analytic evaluation. Choi & Lee et al. (2015) proposed a design chart to consider CWR’s additional axial force and displacement for both high speed and normal railways. Lee et al. (2015) suggested a method to reduce additional axial stress significantly by inserting a low frictional sliding layer between the bridge deck and slab track that preventing longitudinal displacement generated on the bridge from being delivered to the track system.

The purpose of this study is to evaluate additional rail stresses caused by using partial application of the sliding slab track at the movable support region. The partial application can be a more economically feasible method than the previous sliding slab track system that should have been installed on entire bridge span with large amount of anchors. This study will provide a proper length of the application of sliding layer and presents additional rail stresses and anchor forces accordingly.

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2. EVALUATION STUDY

Fig. 1(a) shows a typical sliding slab track system. The low frictional sliding layer is installed between top of the bridge deck and the bottom of the slab track for entire bridge length. The slab track for the sliding slab track should be continuously reinforced concrete tracks (CRCT) and rigidly anchored at the fixed supporting point and abutments.

Fig. 1(b) shows an example of the partial application, in which the sliding system is only applied at the roller support region of the bridge. Anchors are only installed at this region and the slab does not have to be continuous all over the bridge span but does only at the sliding region.

Fig. 2 shows an analysis model for evaluation. Longitudinal restraints provided by rail fastener and low frictional sliding layer are modeled with nonlinear springs. For the part of conventional track without sliding layer, slab and bridge are rigidly connected with rigid link element.

The target bridges for the analysis are simple span bridges of which span lengths are 60 m or 70 m. The analyses were carried out according to procedures given in the design codes (Korea Rail Network Authority, 2014; International Union of Railways, 2001; The European Standard EN 1991-1-2, 2003). The results of analyzing the cases of partial sliding track system are presented in Table 1 and Table 2 for each span length. The conventional track are used for comparison, in which slab tracks are rigidly connected to the bridge structure and large amount of additional rail stresses are occurred due to track-structure interaction. The sliding slab track case shows the case that the sliding layers are installed for the entire span length such as shown in Fig. 1(a). The sliding slab track system suggested in Lee et al. (2015) indicates additional rail stress 80 to 86 % less than that of the conventional slab track without sliding layer. The results from this study also shows that 83 % and 87 % of rail stresses are reduced for each span length cases.

In Figs. 3 and 4, rail stresses are shown with respect to bridge length for applying the fixed conventional track, full sliding slab track and 10 m long partial sliding slab track at the roller support region. The full sliding slab track can reduce the rail stress significantly same as previous study. The partial sliding slab track can reduce the peak stress at the applied region which can be effective to satisfy the rail stress limit of 92 MPa for long simple span bridge such as 70 m or 80 m long.

The partial sliding track system that is 10 m, 15 m, and 20 m installed at the roller support region indicates 25 to 33 % reduction of additional axial stress. For 70 m long bridge cases, the rail stress with conventional track gives 102.17 MPa that is larger than 92 MPa. With partial appli-
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For sliding slab track, anchors in the end of the bridge plays a key role to resist the slab track not to move relatively to bridge structure. The anchors should resist large amount of shear forces as shown in Table 3 due to longitudinal restraint for temperature change. However, the anchors for the partial sliding slab track resists only traction/braking force of the train. Therefore, shear forces of the anchors are 4 to 10% of that generated from the full sliding slab track. This shows that the partial application can be an economical solution for long simple span bridge rather than using a full package of sliding slab track.

### Table 3. Maximum shear force at anchor

<table>
<thead>
<tr>
<th>Track type</th>
<th>60 m long bridge</th>
<th>70 m long bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sliding slab track</td>
<td>22,338 kN</td>
<td>22,522 kN</td>
</tr>
<tr>
<td>Partial sliding at 10 m</td>
<td>1,107 kN</td>
<td>1,210 kN</td>
</tr>
<tr>
<td>Partial sliding at 15 m</td>
<td>1,544 kN</td>
<td>1,760 kN</td>
</tr>
<tr>
<td>Partial sliding at 20 m</td>
<td>1,859 kN</td>
<td>2,138 kN</td>
</tr>
</tbody>
</table>

3. Conclusion

The sliding slab track system with a low frictional sliding layer can reduce track-bridge interaction by separating the longitudinal behavior of the bridge and the track. This study evaluated track-bridge interaction generated by applying the sliding slab track partially at the region of bridge roller support and compared rail additional axial stress resulted from the conventional fixed slab track and the previous full sliding slab track system that is applied on entire bridge span. Followings conclusions are derived:

- According to the results of evaluating track-bridge interaction for the partially applied sliding track compared to the fixed slab track indicates additional rail stress 25 to 33% lower. It will be possible to reduce additional axial
stress further by increasing the application length of the sliding track partially applied.

The partial application can reduce the anchor forces significantly, which is only 4 to 10% compared to the anchor forces of the full sliding slab track. This can significantly reduce the number of required anchors for the track system.

In conclusion, when additional rail stress is slightly exceeded the reference stress 92 MPa, for example 70 m long simple span bridge, the partial application of sliding slab track can be a suitable option rather than using a full sliding slab track.

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References