Translations in bridge bearings due to traffic and temperature loads based on a finite element analysis and measurements

Niels KOSTENSE
Structural Engineer
Ministry of Transport
Utrecht, the Netherlands
Niels.Kostense@rws.nl

Martijn DE BOER
Structural Engineer
Royal HaskoningDHV
Amsterdam, the Netherlands
Martijn.de.Boer@RHDHV.com

Cor P.M. KUILBOER
Senior advisor
Ministry of Transport
Utrecht, the Netherlands
Cor.Kuilboer@rws.nl

Johan S. LEENDERTZ
Senior advisor
Ministry of Transport
Utrecht, the Netherlands
Han.Leendertz@rws.nl

Summary

This study examines translations (or slide paths) of sliding elements in bridge bearings that occur in practice, due to traffic and temperature loads. A finite element model is made of a concrete box girder bridge and results near the supports are analysed. In addition to the finite element model measurements are carried out on the bridge itself. During the period of one year the bridge is monitored with respect to the translations and rotations of the bearings, temperature of the bridge and stresses at midspan.

Keywords: concrete bridge; box girder; finite element analysis; bridge bearings; monitoring; wear; service life; slide path.

1. Introduction

Forces, displacements and rotations transferred by the bearings induce a wear process of the bearing itself. As a consequence, the service life of a bearing is often shorter than the lifetime of the bridge and therefore the bearing has to be replaced during the bridges service life. Materials for bridge bearings are subjected to tests, according to the European Standards NEN-EN 1337 [1]. In these tests sinusoidal or constant forces are applied on a sample which at the same time has to absorb displacements or rotations. Both the sinusoidal force and the sinusoidal movement have a constant amplitude and a constant speed, conditions which does not appear in practice. Since wear phenomena are found, it is necessary to have a critical look at the different parameters which are included in the tests, in particular the slide path. In order to give a judgment, the variable movement history of bridge bearings of one of the bridges across the Dintelharbour (figure 1) is analysed. This is done first with a finite element model [2] and secondly by taking measurements on the bridge. The prestressed concrete bridge has a main span of 184.95m, side spans of 86.5m, pot bearings for support 2 and 3 and spherical bearings near support 1 and 4.

Fig. 1: The bridges across the Dintelharbour

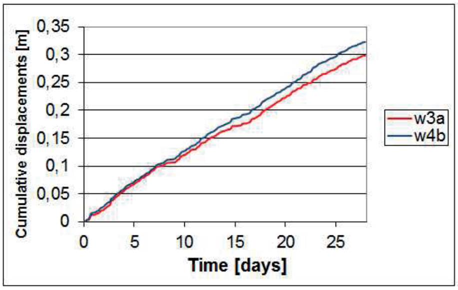
2. Finite element model and measurements

From the bridge across the Dintelharbour a finite element model is made. Two load types are taken into accout, traffic load and temperature load. A traffic model that will be representative for the traffic on a Dutch motorway is used. The influence lines are determined for the reaction forces, displacements and rotations in the bearings caused by the individual types of trucks. After that, the influence of different distances between trucks on the slide path in longitudinal direction is investigated. When two trucks drive at a constant distance of 130m

https://doi.org/10.2749/222137813806501849

from each other a significant reduction (57,5%) of the slide path occurs. When more trucks cross the bridge at the same time the slide path will also reduce. Another important parameter is friction in bearings. It can be expected that when friction in the bearing is taken into account, much of the displacement vanishes. This is demonstrated by static analysis. Thermal loading due to daily temperature changes, based on the European Standards [3] in combination with the national annex [4], is also taken into account. Extreme daily displacements in the bearing and corresponding slide paths are detmined.

After a finite element analysis has been carried out measuring instruments are installed at various locations on the bridge. Measurements are tracked and stored with high and with lower sample frequency (100Hz and 0.0033 Hz) for a period of one year. The several sensors capture the air temperature inside and outside the bridge, structural temperature, solar radiation, displacement of a bearing of support 3 and 4, inclination of the pier and deck and the strains in the top and bottom flange near midspan. After installation, test measurements with an 84-tonne mobile crane were carried out [5]. To give an insight into the displacement behaviour of the bearing the results of 4 weeks are examined. The cumulative displacements (slide path) of the bearing caused by temperature only (low sample frequency) even as the slide path caused by a combination of temperature en traffic load (high sample frequency) are presented in figure 2. In practice very small deformations or velocities between the steel sheet and PTFE layer do not contribute to wear. When subsequent cumulative displacements of 0.1 mm or less are neglected, the slide path of bearing w3a (support 3) reduces by 50%.



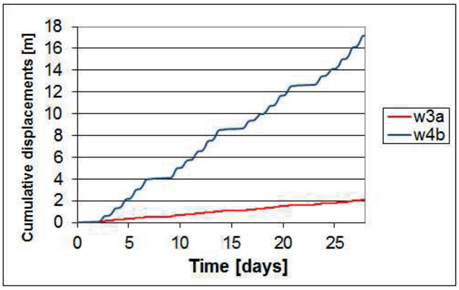


Fig. 2: Low sample (left) and high sample (right) frequency measurement results

3. Conclusion and recommendations

The preliminary calculated values of displacements of the bearing due to temperature correspond very well with the measured values. In the case of traffic load the finite element model will give an upper-bound limit for the slide path of the bearings. Due to friction and real traffic flow (distances between vehicles, number of trucks on the bridge simultaneously and stiffness of the substructure) the slide path of a bearing will be much lower in practice. More study of the minimum displacements and velocities for the wear initiation is needed to determine the reduction of the slide path.

4. References

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