Structural monitoring of the Iris railway viaduct in Belgium

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Summary

In order to expand the existing end station for railway connections to the Brussels Airport in Belgium, the Diabolo project was created. One of the largest structures built in this project was the “Iris” railway viaduct. The viaduct has a total length of approximately 800 m and the piers consist of a high vertical shaft supporting a system of six curved branches. Because of its rather unusual design, load tests were carried out with two freight trains. During these tests, strains and acceleration measurements were performed. This not only indicated that the theoretical calculations are conservative, but also reflected the complex structural behaviour. The piers seems to be very stiff but still have the capacity to distribute the braking and acceleration forces across the bridge. Finally, the long-term behaviour is observed indicating the importance of the daily temperature variations in the bridge design.

Keywords: railway viaduct; strain gauge; accelerometer; monitoring; structural assessment.

Fig. 1: Double track pier PA8 of the Iris railway viaduct

1. Introduction

Assessment of structural elements in civil structures through monitoring techniques is often necessary to verify certain design hypotheses or to evaluate the condition of existing structures. Therefore, both short- and long-term behaviour monitoring of structural parameters often imposes itself. Possible structural parameters to be verified are strains, temperatures, accelerations, frequencies, etc. The Iris railway viaduct in Belgium is such an example where a short- and a long-term monitoring for strains and accelerations was set up. This viaduct has a total length of approximately 800 m and contains 35 spans carrying two railway tracks. Because of its rather unusual design, several structural assessments were needed. The structural assessment set out in this paper reflects also the possible monitoring techniques for other civil structures, newly built as well as existing.

2. The monitoring programme

A one day load test with two freight trains was set up for a short-term monitoring. Therefore, 54 strain gauge measuring points were installed on a double track pier (PA8) and 38 on a single track pier. The measuring points were mainly located on the branches of the piers. In addition, six strain gauge measuring points were attached to the rail tracks itself. Therefore, dynamic strain measurements could be registered to evaluate the distribution of the braking and

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acceleration forces. Also several acceleration measurements were carried out using uniaxial high-precision accelerometers.

When studying the long-term behaviour of the structure, it is necessary to monitor certain structural parameters. In the case of the Iris viaduct, the installed strain gauges of piers PA8 en PC10 were monitored during one year using an autonomous measurement system.

3. Results

During the one day testing programme, it can be noticed that the asymmetric train positions are the dominant ones for the resulting strains and therefore the stresses. Especially position 1 where both trains are positioned left of the middle of pier PA8. When the measured to calculated stress ratios are compared, it is visible that the stress ratios are rather small and therefore indicate that the theoretical models are a safe prediction of the reality.

After the static measurements, dynamic strain measurements were performed through several braking operations with one or two freight trains. These measurements points the effect of the distribution of the braking forces over the total length of the bridge and therefore proves the effect of ballast layers.

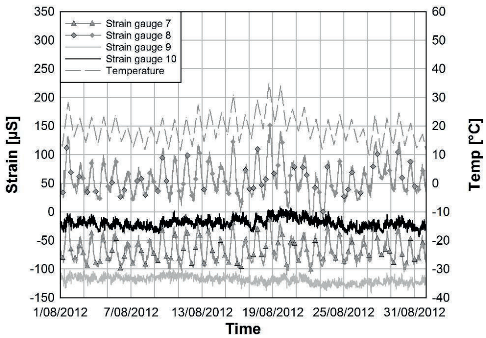

Fig. 2: Daily temperature variations and the corresponding strains

If a frequency analysis is done on the acceleration measurements, it seems that the bridge was already vibrating in several Eigen frequencies because of ambient factors. The influence of the trains not really imposes new Eigen frequencies which implies that a forced vibration because of freight trains does not really change the behaviour of the bridge.

Apart from the short-term measurements, the long-term behaviour of the structure was also monitored. It must be remarked that the strain variations are often much larger than those detected during the static loading tests. Therefore, temperature effects cannot be neglected in design calculations.

4. Conclusions

In order to verify the structural assessment and the durability of a civil structure, a monitoring programme imposes itself. Depending on the structural parameters to be investigated a short- or long-term testing programme is needed. As for the short-term behaviour of a structure, a lot of data could be achieved using strain gauges and accelerometers. In the case of the Iris railway viaduct, it becomes clear that the testing programme worked properly, resulting in a better understanding of the complex structure. As often the case for design rules, calculations are rather conservative and therefore result in a safe prediction. This was also noticed when comparing the measured strains with the theoretical ones. When looking at the long-term behaviour of a structure, both temperature changes and strains are important values to register. It seems as if the daily variations of the temperature have an important influence on the structure, even more so than the strain variations measured during static load tests. A possible conclusion could be that daily temperature variations cannot be neglected in the design although often regarded as a minor load. Although this paper reflects the structural assessment of one bridge in particularly, these techniques are applicable for several other structures and therefore contribute to an improved understanding of both existing structures as well as future design possibilities.