ABSTRACT

There had been public complaints of “excessive” vibration felt on our highway bridges which was reported in the local newspapers recently. The concerns were targeted at the MRR II viaducts at Ampang (in front of Flamingo Hotel hereinafter known as the Ampang Bridge) and at Kepong (near Desa Jaya Shopping complex known hereinafter as the Kepong Bridge). JKR had viewed the public complaints of bridge vibration seriously and is desirous in carrying out a comprehensive study to address this public concern with respect to the safety and serviceability of the bridges[*].

Bridge vibration may sometimes indicate a loss in structural integrity of the bridge due to presence of damage or defects in the bridge. The opposite is also true whereby excessive vibration may sometimes result in damage to the bridge components. In either case, a comprehensive inspection of the bridge is necessary to ensure safety. It is also important to note that although the bridge integrity is intact, the level of vibration may still be sufficiently high as to cause discomfort or annoyance to the motorists. Thus, the level of vibration caused by the traffic must be measured and compared with the acceptable threshold value provided by established codes or standards. Should the vibrations exceed this value then some mitigation measures or control may be necessary to improve the level of service.

This is the approach to the vibration study as outlined in the JKR TOR. Local consulting firm Evenfit Consult Sdn. Bhd. (the Consultant) was commissioned by JKR to carry out this study. The study commenced on 1st October, 2012 and was completed on 31st March, 2013.

Access to the bridge for inspection was made using the skylift, ladder and scaffolding depending on the site conditions. Inspection was carried out visually, following the

[*] JKR had since decided that the Kepong Bridge be removed from the study in view of the fact that repair and strengthening work is now in progress and any assessment of the bridge could only be in the interim.

procedures outlined in the REAM (Road Engineering Association of Malaysia) guide on bridge inspection. Each bridge component of the 24-span bridge was checked visually for any sign of damage or defect. The severity and extent of the damage or defects found were further assessed and reported.

For bridge vibration monitoring, vibration caused by the ambient traffic was measured using an *accelerometer* installed under the bridge deck. The vibration measurement was carried out by a team of researchers from Universiti Teknologi Petronas Sdn. Bhd. (UTP). The data collected was analysed by the UTP team to obtain the statistical distributions of the data for comparisons with the acceptable value and to determine the dynamic characteristics of the bridge. The dynamic characteristics of the bridge in the forms of *natural frequencies*, *mode shapes* and *damping ratios* represent the inherent property of the bridge in vibration.

An analytical model based on the 3D Finite Element (FE) Method was also developed to assess the dynamic response of the bridge on a theoretical basis. Due to inevitable deviation in the structure's construction details from the design, and uncertainties associated with time-dependent material properties, support conditions etc., it is difficult to establish an FE model to represent the actual structure. Besides, it is well accepted that computer modelling alone could not determine completely the dynamic behaviour of the structures because certain properties such as damping and nonlinearity do not conform to traditional modelling treatment. As a standard engineering practice, the analytical model was "tuned" and calibrated against the modal data from field measurements. The analytical model thus calibrated could then be used to compute the vibration that would be caused by legal loads permitted under the Weight Restriction Order (WRO) 2003. These computed vibrations were then compared with the acceptable threshold value to determine whether the bridge needs to be strengthened or modified.

To ensure safety of the bridge during the study, deflections of two of the bridge spans and pier cross beams were monitored continuously for a period of 5 months. A

total station was employed to take measurements of the deflections. Should the deflection readings suggest a progressive increase in these deflections then an alert would be triggered to initiate a closer surveillance of the bridge.

From the study, it was concluded that the vibration levels did not exceed the acceptable “High vibration” limit as to require any mitigation measure, although they were at the level that could be perceived by road users. No major damage or defects were detected in the bridge inspection. The few minor defects observed were considered not severe or extensive as to reduce the strength of the bridge or to contribute to the vibration of the bridge. They are indeed defects that were commonly found in concrete bridges in the country. As a good maintenance practice these minor defects may be repaired.