Vibration	Countermeasures against Traffic Vibration of Bridge	Other Equipment
Resonance		

Object Machine

The elevated bridge of expressway of continuous simple steel composite girder bridge with an interval of 25.5m (Fig.1). Four main girders-bridge with a road width of about 15m on both the up and down lines. A simple girder bridge is provided with one girder between each bridge pier. In case of a continuous girder bridge, on the other hand, one long girder is supported by a plurality of trestles (Fig.2). Consequently, the rigidity of a bridge increases as a whole, and at the same time, traffic vibrations are small due to the absence of joints between girders.

Observed Phenomena

Vibrations on ground generated exceeding bodily sensed threshold (55dB) in several private houses about 20m apart from the road boundary.

Cause Estimation

Since this bridge is located in a heavy traffic interval, its vibrations increase according to the growing amount of traffic of large vehicles after opening of the road, and the vibrations propagate to the ground through trestles.

Analysis and Data Processing

As Fig.3 shows, the ground vibrations on the side of private houses are big at the frequency of about 3.7Hz. Major frequency of vibrations of each girder of the bridge have the same frequency, and vibrations show elementary mode with deflection of each girder. Vibrations of the elevated bridge propagate to the surrounding private houses as ground vibrations. There is a high correlation with the girder vibrations of three intervals between P1 to P4.

Countermeasures and Results

Continuous connection of several girders is a common measure against vibrations of elevated simple girder bridge. However, this bridge has a structural difficulty for girder connection, together with a problem of traffic jam due to a long-term construction work. As a result, the keel damper construction method was employed wherein the construction involves only the bottom part of girders without traffic control. Fig.4 shows a schematic diagram of a keel damper. Plate members are extended from the bottom flange of the girder, and damping materials are inserted between two plate members that are extruded from the bridge abutment and the girder so as to tuck these members. As illustrated in Fig.5, the plate members extended from the girder bottom amplify and convert the rotational deformation of the girder edge parts upon vibration of the bridge, so as to effectively absorb the deformation energy.

As a measure against wind-induced vibrations, keel dampers are adopted for two main girders-bridge with an interval of 60m opened in March 2004. As for this bridge, vibrations were measured when general vehicles were traveling, and investigated the effect for vehicle traveling vibrations. As is shown in Fig.6, a comparison was made with girder vibrations at the time of vehicle traveling on a bridge of the same construction having an interval of 50m that is located adjacent to the bridge provided with a damping device, thus the efficacy of keel damper was verified, with the results given in Figs.7 to 9. It can also be confirmed that these dampers act effectively for traffic vibrations with a relatively small displacement for wind-induced vibrations including vortex induced vibrations.

In the target bridge, keel dampers were installed between P2 and P3 (up and down lines). Fig.10 confirms that vibrations in the 3 to 4Hz band are reduced compared to the adjacent intervals without dampers. It is also found in Fig.11 that, from the relationship between the vibration level alongside ethe houses and the number of times of occurrence, the number of occurrence of vibrations exceeding the bodily sensed vibration limit (55dB) is significantly reduced. The same contents in above obtained in the hearing report obtained from nearby residents.

Lesson

Many bridges face ground vibrations and low-frequency vibration problems, but only a few examples of countermeasures are reported. In some instances, measures are taken by means of dynamic vibration absorbers, but problems remain in terms of operation performance and tuning for minute traffic vibrations. It has been made clear that keel dampers offer one method as a countermeasure against traffic vibrations.

References

(1) Yoshimura, Fujinami, Okada: Japan Society of Civil Engineers, the 60th annual academic lectures, 1-539, 2005
(2) Kishi, Fukumoto: EXTEC, Expressway Technology Center, No.82, pp29-32, 2007.9

Keywords

Girder bridge, traffic vibration, ground vibration, damping device

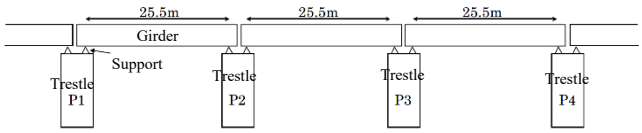


Fig.1 Target bridge (simple girder bridge)

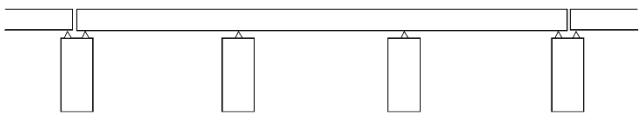


Fig.2 Continuous girder bridge

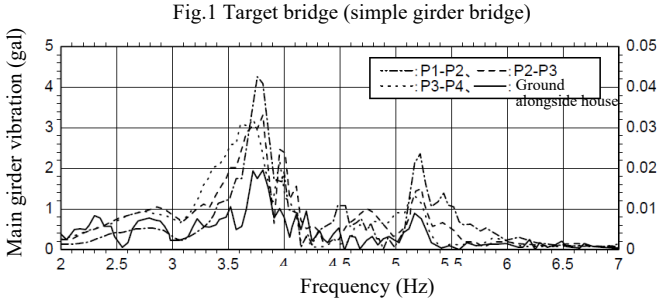


Fig.3 Characteristics of main girder vibration and house vibration

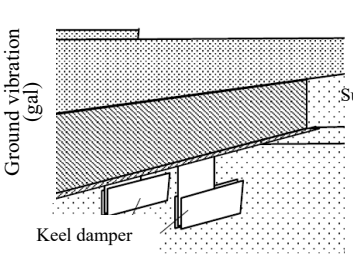


Fig.4 Overview of keel damper

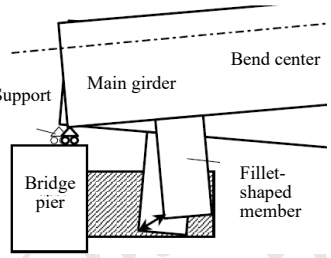
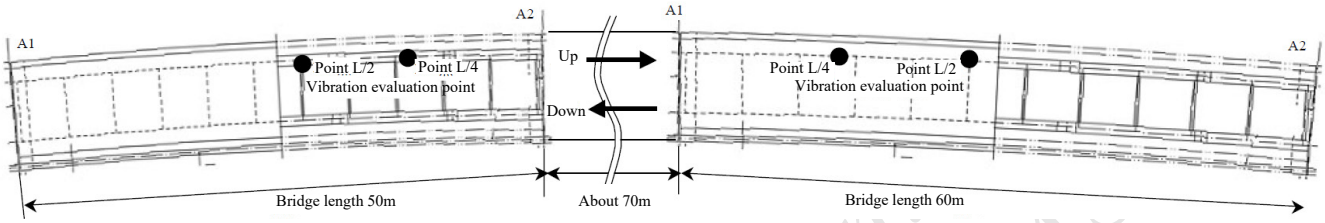


Fig.5 Principle of operation



(a) Bridge without installation of keel damper (b) Bridge with installation of keel damper

Fig.6 Measurement & evaluation points of two main girders-bridge (not the target bridge)

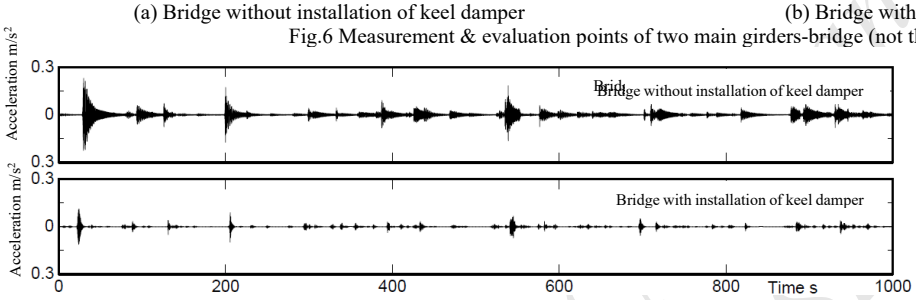


Fig.7 Time history waveforms of girder vibrations of two main girders- bridge (evaluation point: point L/2)

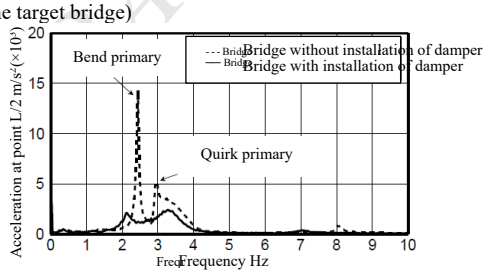
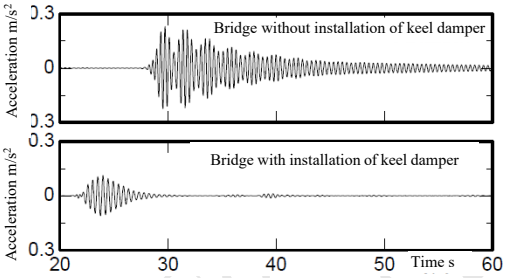
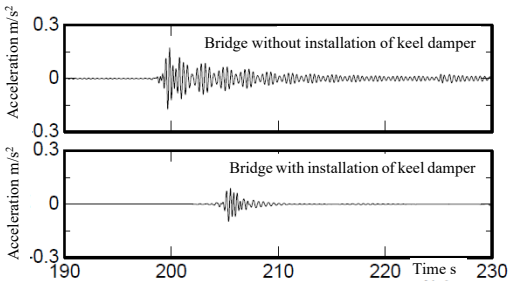


Fig.8 Frequency characteristics of girder vibration (averaged)



(a) When vehicles traveling on down line



(b) When vehicles traveling on up line

Fig.9 Comparison of acceleration responses when large vehicles are traveling on two main girders-bridge (evaluation point: point L/2)

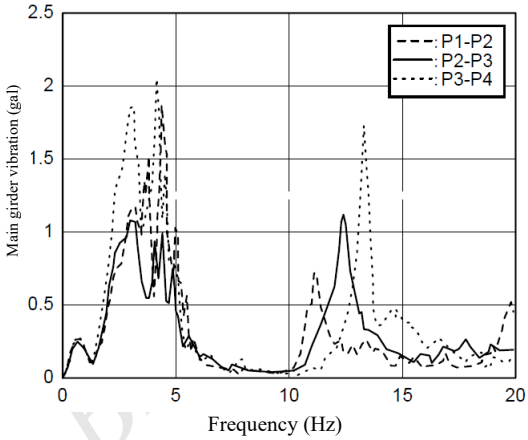


Fig.10 Characteristics of main girder vibration after installation of damper on the target bridge (when large vehicles passing)

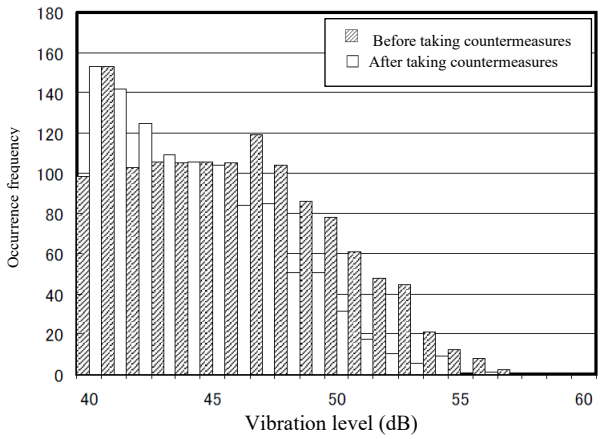


Fig.11 Characteristics of ground vibration alongside houses before and after taking countermeasures on the target bridge