A Report on The Temporary Rehabilitation of the Sea-side Truss Bridge of Gunung Sitoli damaged by the M8.7 Nias Earthquake of 2005

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1 INTRODUCTION

A very large earthquake with a magnitude of 8.7 occurred nearby Nias Island of Indonesia on March 28, 2005. Very strong ground motions were observed, which resulted in heavy damage in coastal cities and towns along the eastern shore of Nias Island. The strong ground motions also induced widespread ground liquefaction along the eastern shore of the island, which severely damaged buildings, bridges and roadways.

There are two bridges on the river passing through Gunung Sitoli City (Figure 1). The seaside bridge is a Truss type bridge designed as a single span simple structure. The total width of bridge is about 550cm and it is approximately 25m long. The ground nearby the bridge was liquefied and spread laterally. Although the earthquake did not damage the superstructure of the bridge, there are some damage to foundations due to the liquefaction of ground induced by the earthquake and corrosion resulting from seawater. The piles of the NW abutment pier were ruptured together with some corrosion of steel reinforcing bars. Although the piles of the SE abutment pier are not visible, the abutment pier was settled and moved towards the sea. The settlement of this abutment is not even. As a result, there is a gap between the super structure and abutment, which results in some torsion vibration of the bridge due to passing vehicles.

The authors did some in-situ measurements on the vibration characteristics of the superstructure and investigated the foundations of the bridge. This report briefly describes the observations, measurements and recommends a temporary rehabilitation procedure for the bridge abutments.

Figure 1. Location of the seaside Truss bridge in Gunung Sitoli

2 GEOTECHNICAL CONDITIONS

Although the exact geological condition is not known at the site, the foundation rock is expected to consist of sedimentary rocks of intercalated mudstone and sandstone. The depth of the bedrock is unknown to the authors. Nevertheless, two geotechnical explorations are carried out nearby the site. The exploration indicates the ground is sandy silt for a depth of 6m from the ground surface.

3 DAMAGE OBSERVATIONS

The wing-walls of the abutments of the bridge were ruptured and partly collapsed due to ground shaking as well as lateral spreading of ground. Furthermore, the fillings of abutments were settled by more than 250mm. There is no visible damage to the superstructure of the bridge. The piles of the NW abutment pier were ruptured. Furthermore, the steel reinforcing bars are corroded and the corrosion resulted in a considerable amount of area reduction of the bars (Figure 2a,c,d).

Although the piles of the SE abutment pier are not visible, the abutment pier was settled and moved towards the sea. The settlement of the SE abutment is not even and the settlement of the seaside of the pier is greater than that of the mountain side (Figure 2b,e) Because of uneven settlement, there is a gap between the shoe of the superstructure and the seating of the SE pier. When trucks pass over the bridge, the bridge shakes and the torsion vibration of the superstructure is induced.

(a) NW abutment with visible piles

(b) SE abutment

(c) Broken cast-in pile head (NW-Ab.)

(d) Corroded steel bars of a pile (NW-Ab.)

(e) Uneven settlement of the SE abutment. The settlement at the seaside of the pier is greater than that at the mountainside

Figure 2. Views of damage of the piers and piles of the bridge

4 MEASUREMENTS

The authors made some measurements using a portable vibration measurement device produced by IMV Corporation and an accelerometer produced by SRIC. The vibration device can measure only one component and is able to store the both acceleration wave data and its FFT analysis. The accelerometer can measure three components of accelerations. Figure 3 shows some views of the measurements on the Truss bridge. In addition, some measurements were carried out on the corrosion state and possible breakage of reinforcing bars embedded in piles of the NW abutment (Figure 4).

Figure 3. Acceleration measurements of the bridge by a 3-component accelerometer

Figure 4. Measurement on the breakage and corrosion state of reinforcing bars

Figure 5 shows FFT spectra of the vertical vibration of the bridge. As noted from the figure, the superstructure seems to be behaving elastically. Figure 6 shows the acceleration response of the bridge for vertical component during the passage of a 6-7 tonf truck. The axial and traverse components of the acceleration response of the bridge are small while the vertical component indicates a non-symmetric very high acceleration response, which implies a torsion type vibration of the superstructure of the bridge.

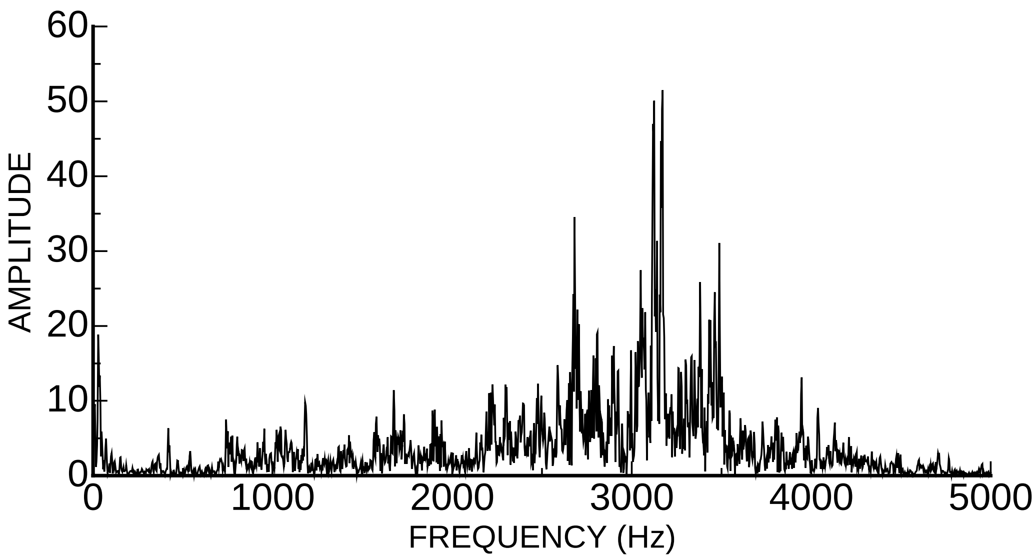

Figure 5. FFT spectra of vertical acceleration response of the bridge

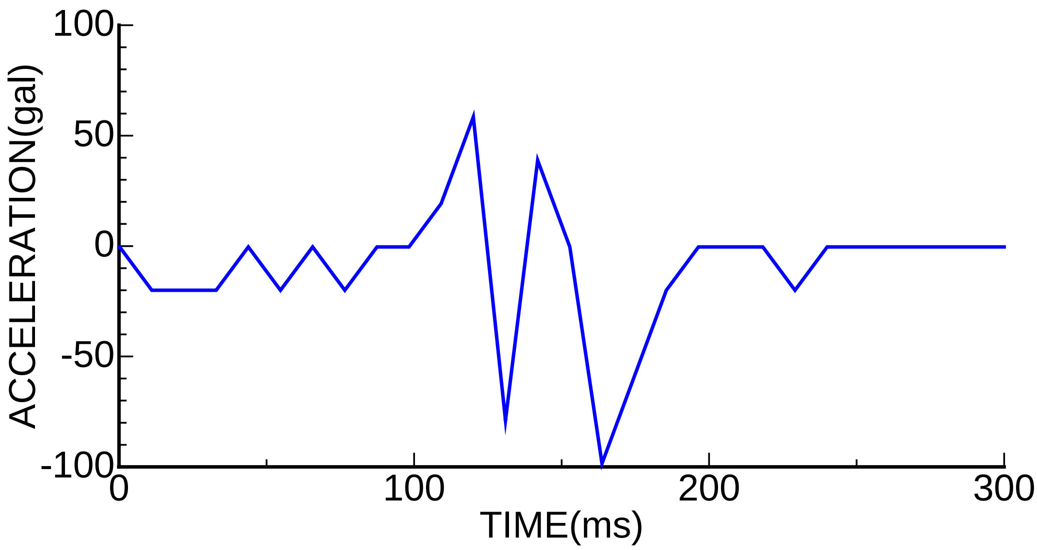

Figure 6. Vertical acceleration response of the bridge

5 RECOMMENDATIONS

The motion of the bridge during the passage of vehicles may cause some damage to superstructure if much heavier vehicles are allowed to pass over the bridge. The main cause of this vibration is thought to be the gap between the shoe(upper bearing plate) of the superstructure and the seating(lower bearing plate) of the pier at the seaside of the SE abutment. Therefore, inserting a steel platen wedge (jacks would probabely be needed), which fits the gap geometry seen in Figure 2e, must be used to eliminate the gap between the superstructure and pier.

The piles heads are damaged and their steel bars have been corroded. If no pre-cautions are taken, the pier heads may further settle and cause some uneven settlements. It is recommended to cast a reinforced slab of concrete around the perimeter of the both abutments and to fill the gap between the ground and pier slab as illustrated in Figure 7.

Figure 7. An illustration of casting a reinforced concrete slab around the pile heads of the piers of the abutments.