STUDY ON FOLLOW-UP PROCESSING OF CROSSING-FAULT HUALIEN BRIDGE DAMAGED BY THE 0206-HUALIEN-EARTHQUAKE 2018

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Abstract

In 2018, the 0206-Hualien-Earthquake (ML=6.26) created a fault rupture yielding a significant ground displacement and damaged several bridges. As one of those damaged, the Hualien Bridge has a superstructure comprising multiple simply supported beams. Its span between pier no. 9 and 10 crosses the Lingding fault at a nearly right angle. Between the bridge's pier foundations, the ground rupture created a relative permanent displacement, twisting the deck, causing span collisions at the expansion joints. Thus the deck surface became bumpy and were unable to keep its original profile for traffic use.

For the follow-up processing of this bridge, a three-dimensional numerical model of structural analysis is established to find out the failure mode caused by the ground rupture under this earthquake. The structural model is supposed to be reliable and available for engineering possibility analysis or economy evaluation of various succeeding retrofit works or further reconstruction.

Keywords: 0206 Hualien earthquake; active fault; numerical model

1. Introduction

On February 2, 2018, a seismic event named Hualien earthquake with M_L-6.26 occurred in the offshore nearby Hualien City in the eastern Taiwan. Hualien earthquake caused several implicit surface rupture deformations and severe damages of bridges, including Hualien Bridge, Qixingtan Bridge, Hualien City NO.3 Bridge and Shangzhi Bridge. Hualien Bridge (See Fig. 1), located at Provincial Highway No. 11 between Jian and Shoufeng Township, was damaged due to the ground movement induced by the rupture of Lingding Fault that is believed to run across the bridge. To simulate the responses of Hualien Bridge under this event, this study employs a 3-span PCI bridge model as an illustrative example. Dynamic time history analysis (DTHA) and static forced displacement analysis (SFDA) are then adopted to find out the seismic capacity of the bridge. The analytical results and data obtained by this survey may serve as useful references for seismic evaluation and retrofit design of bridges in the future.

Fig. 1 The lateral deformation of Hualien Bridge[1]

2. Description of Bridge

The bridge is located in Shoufeng Township of Hualien County. It has 3 continuous spans and is supported by 4 piers (P9~P12) with M-H-H-M supporting conditions as shown in Fig. 2. Each span is 40m long, so the total length of the bridge is 120m. The deck is carried by 6 I-shaped prestressed concrete girders; its total width is 11.0 m. The concrete compressive strength of deck, diaphragm, and girder are 245 kgf/cm^2, 245 kgf/cm^2, and 320 kgf/cm^2. The diameter and concrete strength of single-type circular cross section piers are 2.6m and 210 kgf/cm^2. All piers have the same geometry with a height approximating to 8m. Besides, the bottoms of all foundations are fixed, considering no soil-structure interaction.

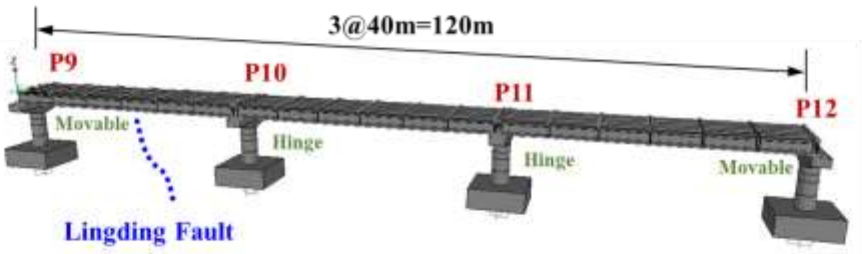

Fig. 2 Longitudinal elevation of the bridge

3. Analytical Methods

According to what Central Weather Bureau (CWB) announced [2], Hualien earthquake induced the explicit left-lateral permanent displacements along the two sides of Lingding Fault. Hence, Hualien earthquake's recorded data including permanent displacements is used to analyze the behaviors of the bridge that is modeled to cross Lingding fault's rupture zone. There are two analysis cases:

(1) Case A: a DTHA is used to simulate the bridge's seismic response. The analysis uses Hualien earthquake's ground accelerations collected at YENL station in three directions (See Fig. 3). The PGAs in three directions are 280.769 gal,-462.548 gal, and -477.898 gal.

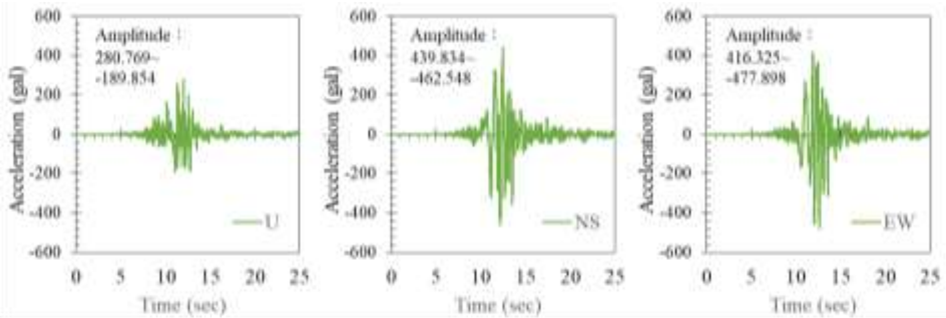

Fig. 3 Ground accelerations collected at YENL station

(2) Case B: a SFDA is performed here. The analysis uses Hualien earthquake's surface ruptures that CWB released were measured by campaign-mode GPS stations. Along the left side of Lingding Fault (where P9 located), the permanent displacements in EW, NS, and U directions are -315.8 mm, -232.3 mm, and 163.6 mm. To the right side (P10~P12), the permanent displacements in three directions are -7.2 mm, 337.2 mm, and -52.0 mm.

4. Results and Discussions

Fig. 4 shows the results of the two analysis cases. In comparison of the transverse bending moments at the bottoms of piers between cases A and B, it can be found that case B (using SFDA) has larger moments than A (using DTHA) does because of suffering surface permanent displacements. For case B, though no dynamic responses can be added on, the first and second largest moments are induced. In the near future, a more precise simulation will be performed, which considers the inelastic properties of members, precise modeling of bearings, and multiple-support excitations using displacement histories.

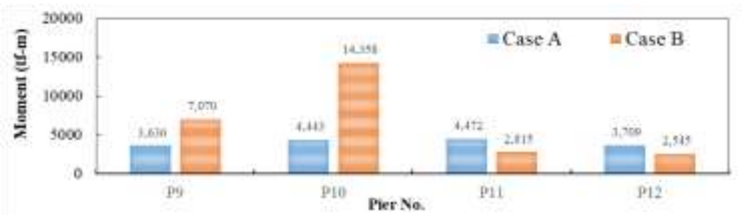

Fig. 4 Two cases' bending moments at all pier bottoms.

5. References

[1] Central Geological Survey (2018): Geological survey report of 20180206 Hualien earthquake. Ministry of Economic Affairs, Taiwan.

[2] Central Weather Bureau (2018) Website News: http://www.cwb.gov.tw/V7/earthquake/rtd_eq.htm. Ministry of Transportation and Communications, Taiwan.