Seismic Performance of Bridges with Rubber Bearing Systems under the 2011 Off the Pacific Coast of Tohoku Earthquake Ground Motions

Tongxiang AN
Associate Professor
Waseda University
Tokyo, Japan
antongxiang@aoni.waseda.jp

Tongxiang An, born 1965, received his civil engineering degree from Lanzhow Jiaotong University, China

Osamu KIYOMIYA
Professor
Waseda University
Tokyo, Japan
K9036@waseda.jp

Osamu Kiyomiya, born 1948, received her civil engineering degree from Tokyo Institute of Technology, Japan

Summary

In this study, the characteristics of ground motion and the damage to bridges with a rubber bearing system were investigated and the seismic performance of a typical bridge with a rubber bearing system was verified by dynamic analysis method. As a result, the ground motions caused by this earthquake affected the seismic performance of bridges with rubber bearing systems.

Keywords: seismic performance; vibration behavior; bridge; rubber bearing system; 2011 off the Pacific Coast of Tohoku Earthquake.

1. Introduction

A large scale earthquake with a magnitude of 9.0 (M_w) severely struck the north-eastern region of Japan on 11th March, 2011. The maximum peak ground acceleration (PGA) recorded from this earthquake reached 2700 gal (NS component) and the ground motion lasted around 300 seconds. This earthquake caused a dramatic tsunami and brought about massive damage to the infrastructure of the region, including road and railway traffic networks. According to the JSCE investigation report on the earthquake damages [1], the damage to bridges has some features as following: 1) The damage to the bridges designed and constructed in alignment with the design specifications which were revised after 1990 were not serious; 2) Rubber bearing systems were adopted in most of the recently constructed bridges that were designed according to the verification of lateral strength and ductility capacity. There was some damage to the side stopper, pin and so on, but little damage to the body of the rubber bearing system.

Triggered by the damages of the 1995 Hyogo Nanbu Earthquake, the rubber bearing system has been widely used for bridge engineering in Japan. Elongating the period of the bridges by providing flexibility to keep the fundamental period of the bridges away from the periodic region of the main ground motion, and dispersing the inertial forces of the superstructure, and absorbing the earthquake energy with its hysteretic damping, the rubber bearing system takes an important role in the bridge structure. The characteristics of the ground motions caused by the 2011 Off the Pacific Coast of Tohoku Earthquake (hereinafter referred to as 2011 Tohoku Earthquake) were significantly different from those specified in the current design specifications. Furthermore, there were some reports of damage to the body of the rubber bearing system of bridges in the regions affected by the force of the 2011 Tohoku Earthquake. It became apparent that there was significant reason to investigate the vibration behavior, and to verify the seismic performance of bridges with rubber bearing systems under the 2011 Tohoku Earthquake ground motions. In this study, the characteristics of the ground motion and the damage to bridges with rubber bearing systems were investigated, and the seismic performance of typical highway bridges with rubber bearing systems was verified by dynamic analysis method.

2. Ground motions

The 2011 Tohoku Earthquake occurred at a distance of approximately 130 km east-southeast of the Oshika Peninsula of Tohoku, caused by the rupture of part of the boundary of the Pacific Plate and North America Plate where the Pacific Plate is subducting under the North America Plate beneath northern Honshu. The fault was broken with a length of 510 km, and a width of 210 km [2], and a

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