Liquefaction and its Influence to House Damage in the Niigataken Chuetsu-Oki Earthquake in 2007

S. Ohtsuka, K. Isobe, T. Hirade, K. Hayashi
Dept. of Civil Engineering, Nagaoka University of Technology
Nagaoka, Niigata, Japan

ABSTRACT

Many houses were damaged and ground failure such as liquefaction was observed in Kashiwazaki city and Kariwa village in the Niigataken Chuetsu-Oki Earthquake. This was the second severe earthquake damage in this area in a span of three years. The relationship between ground condition and damage to houses were investigated using the field investigation of surface wave exploration, Swedish sounding test and boring investigation. In addition, interview to the local people on type of foundation structure of damaged houses, foundation improvement such as piling or soil improvement work and measurement survey on unequal settling of these houses were conducted. The influence of liquefaction countermeasure and geological formation on damage to houses is discussed.

KEY WORDS: liquefaction; earthquake damage; Swedish sounding test; surface wave search; liquefaction countermeasure; differential settlement.

INTRODUCTION

Niigataken Chuetsu-Oki Earthquake occurred in Japan on July 16th in 2007, killing 11 people and damaging more than 1,000 houses. The quake registered 6.8 on JMA Magnitude and the accelerograph of K-net measured at a maximum of 680 gal. Many houses were damaged and ground failure such as liquefaction was observed in Kashiwazaki city and Kariwa village as shown in Fig.1. In Hashiba in Kashiwazaki city and in Kariwa village, foundation damage of wooden houses and ground failure were extensive. In these areas, damage to houses and ground failure caused by liquefaction occurred just like it happened during the Niigataken Chuetsu Earthquake in 2004. This was the second severe earthquake damage in this region in a span of three years. In this paper, results of the investigation work of earthquake damage in Hashiba, Matsunami and Kariwa are reported. The relationship between ground condition and the characteristics of damage to houses was investigated using surface wave exploration, Swedish sounding test (SWS) and boring investigation (SPT). Besides, interview to the local people on type of foundation structure of damaged houses, foundation improvement such as piling or soil improvement work and measurement survey on unequal settling of these houses was conducted. The influence of liquefaction countermeasure and geological formation on damage to houses is discussed.

On damage to houses is discussed as follows.

EARTHQUAKE DAMAGE IN KARIWA VILLAGE

Outline of earthquake damage in Kariwa village

Damage to houses caused by liquefaction and slope failure occurred in Kariwa, which is located between Arahama dune and Kashiwazaki alluvial clay. Inaba was the worst-hit area in Kariwa, located on the eastern border of Arahama dune as shown in Fig.2. The residential site was developed by cut and fill of sand hill. Those houses were severely damaged due to liquefaction during the Niigataken Chuetsu Earthquake in 2004. Some houses were newly built and the others were rebuilt using liquefaction countermeasure such as piling, underpinning, columnar ground improvement, under drainage and so on. Interviewing the local community, investigation works on the surrounding property and unequal settlement of the damaged houses were conducted. Outline of earthquake damage at Inaba district in Kariwa village are schematically shown in Fig.3. The result from the emergent housing risk investigation is indicated in the figure in which yellow marks show