Tsukuba, Japan

International Institute of Seismology and Earthquake Engineering

Building Research Institute

STUDY TRIP TO ITAKO CITY

A Technical Report

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Introduction

With the objective of to observe the damage caused due to earthquake occurred on March 11th, the E-Course went to Itako city,

Itako city is located in Ibaraki prefecture, Japan (Figure 1), 85 Km to North-East from Tokyo, approximately, and 315 Km to South-West from the epicenter of the Tohoku Earthquake (March 11th, 2011).

We visited specifically Hinode-district (Figure 1) (Housing area), located 3 Km to South-West, approximately, from the center of the city.

In this place the major of the damage was caused because the liquefaction phenomenon, been this the principal objective of our visit.

This study trip was organized by the BRI/IISEE staff and JICA-Tsukuba, as part of the Master program of the Training course of Seismology, Earthquake Engineering and Disaster Management Policy.

**The objective was to visit Itako city, however on the way we took advantages for see several damages at Inashiki city*

Damage observed and comments

INASHIKI CITY

1. - Road

Photo 1. Crack at the middle of the road. Many time this kind of damage is presented when earthquake occur due to change of level of the ground (down or uplift of the ground). The localization of the crack, at the middle of the road, can be due to separate construction of each way, different level of compaction

Photo 2. Crack at the border of the road. This kind of damage can be occasioned due lateral displacement not uniform of the ground, because the shaking from the earthquake.

Photo 3. Settlement of the sidewalk. Difference of level, due to liquefaction phenomenon. In this case the settlement of the sidewalk was around 16 cm. This kind of damage is common in area with soil condition susceptible to liquefaction. At this site was possible to observe the liquefaction phenomenon, so, is sure about the cause of this kind of damage.

Photo 4. Uplift of the drainage structure. Due to liquefaction phenomenon the structure of the concrete utilized for drainage system was uplifted around 15cm from the original level.

Photo 5. Inclination and collapse of electric post. Due to liquefaction phenomenon the loss of the shear strength of the soil, the electric post is impossible to keep straight. In this photo we can see also, the water from the ground that indicates that liquefaction was occurred.

2. - Fence and Wall, and ground condition

Photo 6a) and 6b). Crack and displacement (vertical and horizontal) in the fence retaining wall (concrete block). Damage due to liquefaction phenomenon, the dash line show the direction of the crack on the ground, the fine sand is evidence of liquefaction, the lateral and vertical displacement on the retaining wall is showed (orange dash circle).

Photo 7a) and 7b). Crack and displacement (vertical and horizontal) in the fence wall. The left photo (7a) show of the continuation of the crack (black dash line) and the damage in the fence wall (red dash ellipse). Horizontal and vertical displacement, due to liquefaction phenomenon. Also, the right photo (7b) show the effect of liquefaction, lateral and vertical displacement, tilted wall, crack on the bottom of the wall and separation between the road and the fence wall (yellow dash ellipse).

3. - Damage at Building (directly)

Photo 8a) and 8b). Settlement of the building. Due to liquefaction phenomenon, several building suffered severe settlement like this building of two stories at Inashiki city. The settlement was around 1.8m, this is enough for become useless the building, the message in front side (8b) indicate that the building is “UNSAFE”. This message was collocated after the earthquake by the inspector from the local government.

8b

ITAKO CITY

The Figure 1, show the localization of the affected area visited, Hinode District in Itako city, in Japan map, is showed the localization of the epicenter of the earthquake occurred on March 11th, 2011(orange arrow line).

The site is located in near to the Tone River and Kasumigara Lake in Ibaraki (in the past this area was cover with water from the lake), so the soil is susceptible to suffer liquefaction when is excited by shaking from the earthquake in this case, so the major of the damage at this site was due to liquefaction. Also, before that built house in this area, was used for cultivate rice, that means that this land during long time was saturated with water (the level of the water ground varies between 1 to 2 meter).

Figure 1. Geographic localization of the affected area visited (Hinode district) and epicenter of the Tohoku earthquake.
Source: Google Earth, commercial version.

Damage observed and comments

1. – Road

Photo 9. Distortion of the ground surface. The sidewalk went up and the road went down, crack at the road, this is clear evidence of the occurrence of liquefaction phenomenon.

Photo 10. Inclination of the electric post and tree.

Whe liquefaction occurre, the manly effect on the ground is the loss of the of the capacity shear strength, so the slender structure, like electric post, can not keep straigth, and sometimes fail down (including tree)

Photo 11a) and 11b). Distortion of the ground surface under the sidewalk. The Photo 11b) shows the sidewalk after the earthquake, before the seismic event this sidewalk was like Photo 11a). This photo was took in the middle on two segment of sidewalk, so this indicate different effect of the ground motion over the structure, this can be due to different soil condition in each side or different construction method or different quality of the construction or the combination between these and another factors.

Photo 12. Distortion of the ground surface on the road. This point is between two segment of sidewalk showed on the Photo 11a) and 11b). The underground went up, around 10cm, and the lateral inclination is 7.6 degre. (In the photo, Rusli-san, take the inclination measure)

Photo 13. Down of ground level. In this case the manhole went down due to liquefaction phenomenon.

Photo 14. The pipe water went up. After the earthquake the water service remained out of service, this kind of damage is due to liquefaction also.

Photo 15a) and 15b). Fall down of the small structure for "road signs". In the case of the slender structure is very easy fall down when occur the liquefaction phenomenon, like the electric post, tower structure, but in case of small structure, like as the shown on the photo 15b, is not common, and also is very difficult fall down due to the large (height) is relative small, so the momentum force necessary for become fall down is big, however is necessary to take account, also, the foundation condition of the structure. In this case, we can see a weak foundation, combined with the liquefaction phenomenon, the soil behavior, like water, without shear strength, all these factors combined can be the cause of several damages.

2. - Surrounding area of building

Photo 16a) and 15b). Distortion of the ground in the surrounding area of building. Down of ground level causing severe damage (crack on the sidewalk) and differential settlement on the structure around of the building.

Photo 17. Settlement around of the building. Some case differential settlement can cause the total collapse of the building, however when the settlement is uniform, the building can keep straight, in this case the photo shown good behavior of the building against differential settlement, due that the structure around the building suffered settlement with different magnitude, maybe due to kind of foundation .

3. - Fence and Wall

Photo 18. Settlement of retaining wall. The engineer indicates the original level of the retaining wall before of the earthquake; in this case the settlement was around 50 cm.

Photo 19. Crack and difference level at the retaining wall. In this case was difficult see, if this wall has steel reinforce, because the crack is not perpendicular to the longitudinal section. On the top of the wall the wide of the crack is around 1.5 cm.

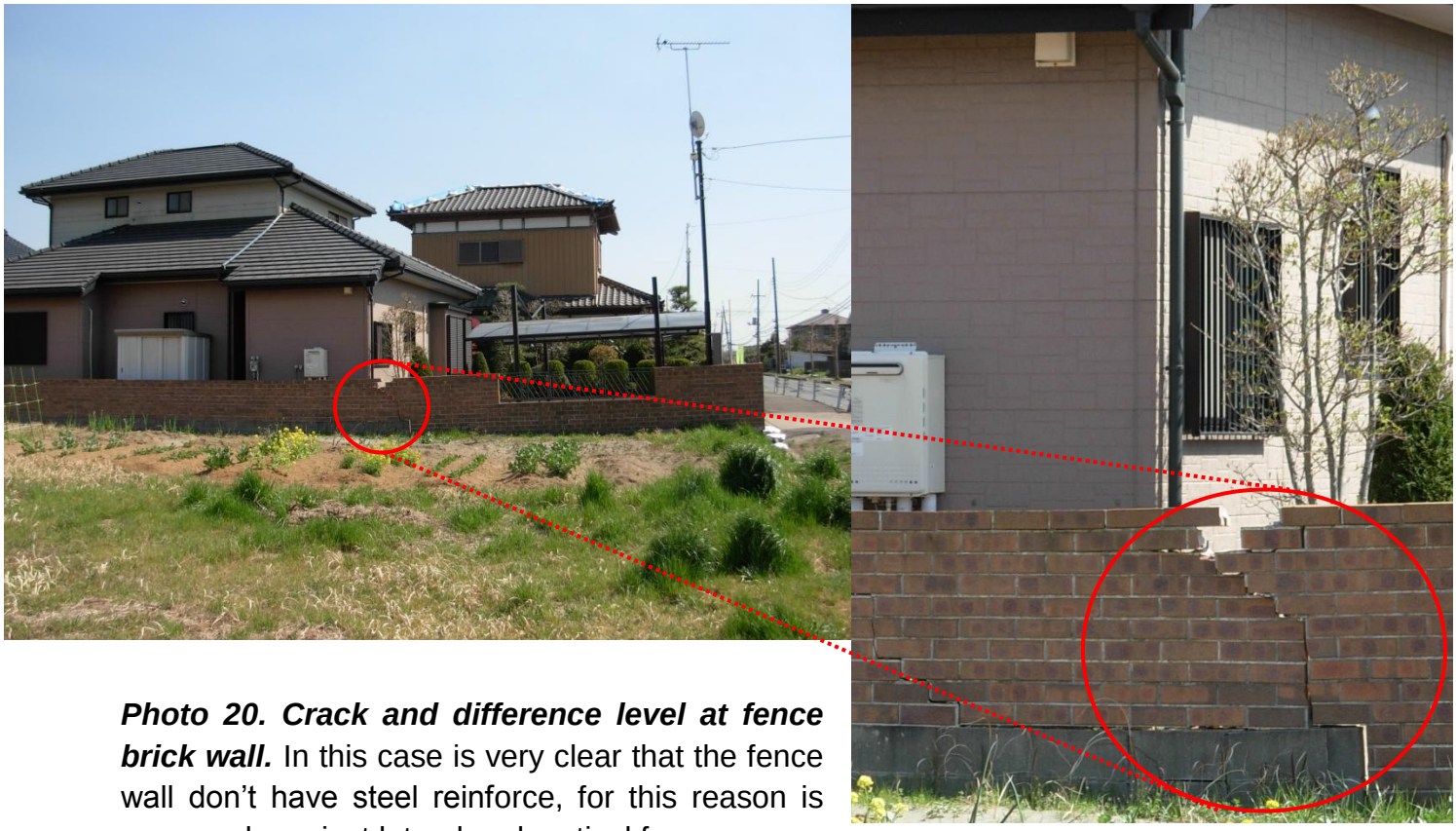

Photo 20. Crack and difference level at fence brick wall. In this case is very clear that the fence wall don't have steel reinforce, for this reason is very weak against lateral and vertical force.

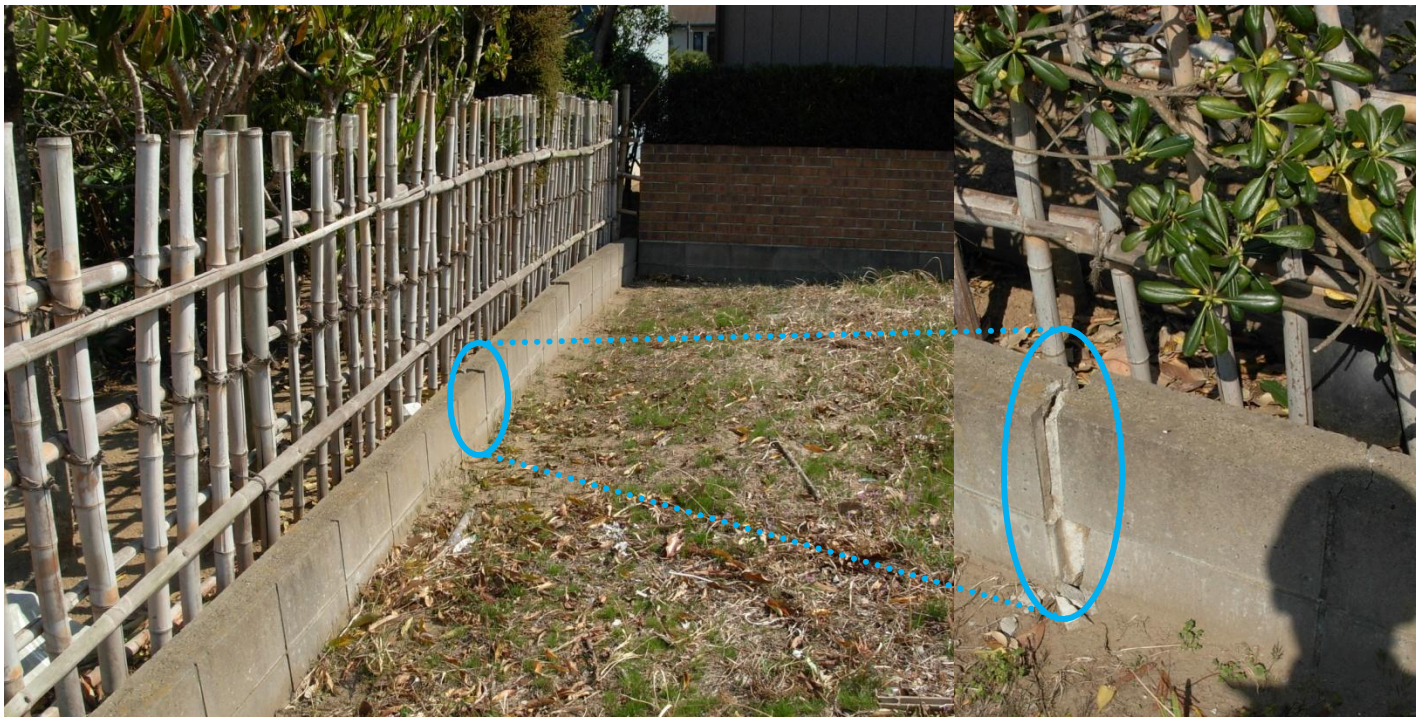

Photo 21. Crack and horizontal displacement on the fence concrete block wall. Without steel reinforce.

Photo 22a), 22b), 22c) and 22d). Differential settlement: crack and different level on fence brick wall and retaining wall. Due to liquefaction phenomenon, this wall suffered higher differential settlement, causing lateral-vertical displacement and crack. The photo 22d) show that the wall don't have steel reinforce, so is very weak in horizontal direction. The horizontal displacement of the wall (crack) in the superior side was around 15cm, and in the inferior side was around 5 cm (photo 22d)

4. - Damage Building itself

Photo 23. Crack at the house's corner. Due to lateral displacement and settlement in the front side, this house suffered damage in the back side, specifically crack at the both mainly corner.

Photo 24. Differential settlement of the two stories building. This kind of damage was observed in several houses around the area visited, this is due to liquefaction phenomenon and foundation condition.

5. - Ground Condition

Photo 25a), 25b), 25c) and 25d). Alteration of surface soil characteristics. Before the earthquake this kind of soil (fine sand) there was not on the surface, due to liquefaction phenomenon, the uplift of the underground occurred. The kind of sand is fine sand silty (photo 25d), even on the paving stone the sand came up (photo 25c)

Photo 26. Sand boils was observed. Sand boils are diagnostic evidence of elevated poor water pressure at depth and an indication that liquefaction has occurred.

Photo 27. Deformation of the surface ground. Difference of level of the ground, due to settlement occurred.

Conclusion and final comments

Always that occur the earthquake several damages are presented, on the ground by itself and on the civil structure (building, road, basic facilities), this damages depend of the condition of the affected area (soil condition, characteristic of the structures, underground structures).

In this study trip we had the opportunity of observe several damages at Inode district in Itako city, specifically the liquefaction was presented due to soil condition. Was already estimated (according with information obtained from researches and engineer that are working in recover of the city) the depth of the sand, around 4m.

In general much kind of damages is associated with liquefaction phenomenon, including rise of poor water pressure, sand boils, and various types of deformation. Such deformation of the ground is called ground failure and may be manifested in several forms or types.

This was a good experience for us, due that we could see the damage directly on the field, and how solve the problems when the liquefaction phenomenon affects a specific area, also how is directly related the site condition with the damage occurred.

The liquefaction phenomenon is a complex problem to solve, and now the idea is, how we can reduce the effect on the structure, when these are located over ground susceptible to suffer liquefaction.

We can think in specific kind of foundation, like piles, or another special foundation, however, always we need considerer the monetary cost, so the goal is get structure with high performance and good behavior when the earthquake occur, without increase considerably the cost of the structure.