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The Situation Regarding Damage to Interlocking Pavement Caused by Major Earthquakes

Comparison of Tohoku Region Pacific Coast Earthquake and Hyogoken-Nanbu Earthquake

Shigeki Saeki Tokyo University of Agriculture Graduate School
Tsuneo Maki Professor, Tokyo University of Agriculture
Masashi Koyanagawa Professor, Tokyo University of Agriculture
1-1-1 Sakuragaoka Setagaya-ku, Tokyo, 156-8502, Japan
Tel: +81 03-5477-2343, Fax : +81 03-5477-2620, 65110004@nodai.ac.jp

Summary
Many lives were lost in Tohoku Region Pacific Coast Earthquake in March 2011. This earthquake did not have its hypocenter directly below an urban area such as the Hyogoken-Nanbu Earthquake, which occurred in January 1995 and directly struck the large city of Kobe, but the area affected by Tohoku Region Pacific Coast Earthquake was large and there was damage resulting from a massive tsunami. In the area damaged by this earthquake, IL blocks had been constructed into sidewalk, square and other pavements. At these locations, collapse, local subsidence, ground sink, destruction of edges of IL block pavements and other such damage occurred, which was caused by the earthquake tsunami, liquefaction and other factors. In this report, we detail what the differences in the damage circumstances regarding IL blocks on the basis of damage situations which developed in the earthquakes in 1995 and 2011.

1. Introduction

Tohoku Region Pacific Coast Earthquake happened on March 11, 2011. This earthquake was magnitude9.0 in scale and massive trench type earthquake, ranging about 500km north-south, 200km east-west in this region. It covered hypocentral region of the Pacific coast in Tohoku, with massive tsunami attacked the place, and caused big damage including land liquefaction. Even the place, 300km from the epicenter suffered serious damage of the houses and roads.
Japan experienced another big earthquake in Hyogoken-Nanbu Earthquake in 1995.
In Kobe city, collapse of buildings, big fire and land subsidence occurred. No Tsunami happened.

2. Overview of earthquake

2-1 Tohoku Region Pacific Coast Earthquake

Tohoku Region Pacific Coast Earthquake was the fourth largest earthquake in the world since 1900, approximately 130km east-southeast from the northeast coast of Japan, with magnitude of 9.0 and the epicenter the point of 24km depth. This earthquake was caused by the action that Pacific Ocean fell into the Japan Trench, and big Tsunami causing strain to the North American Plate, by this strain big Tsunami and landslide happened. This Tsunami has been recorded maximum high 40.1m with flooded 6km from the coast. After shock has occurred in a wide range of 200km width, 500km length, some of them were of magnitude 7.3.

–Features of this earthquake –

① Strong shake in wide coverage of area
② Shaking time was long-lasting
③ Extensive grand movement

Regarding the earthquake was caused by the movement No.③.
In Onagawa-cho 5.85m to the direction of east-southeast horizontally, Rikuzentakata city 4.473m ground subsidence was seen.
Finally, as serious damage by big tsunami, about 19,000 people are dead including missing ones. Also impact of the earthquake as liquefaction phenomenon in the coastal and inland marshes of Tohoku, This liquefaction phenomenon brought very serious damage in 300km away from the earthquake.

2-2 Hyogoken-Nanbu Earthquake

Hyogo-ken Nanbu earthquake happened in Kobe on January 17, 1995, with magnitude 7.3.This earthquake occurred in a shallow urban 16km epicentral earthquake focal depth, in the myriad of active faults running in Kobe. It was caused by the displacement of the fault. The biggest after shock was 5.4magnitude. In this earthquake no Tsunami occurred. The characteristics of this earthquake are that the wooden houses were damaged by waveform generated for a second, affected by the earthquake was partial one, but some serious damage on highway or on railway were seen only in the urban area by local earthquake. It has been said liquefaction may not have happened in this area because a decomposed granite soil protects it from sink. Actually it occurred and dead and missing people reached to 6,400.

2-3 Difference of two earthquakes

Comparing Tohoku Region Pacific Coast Earthquake and Hyogoken-Nanbu Earthquake the former one caused huge damage by Tsunami more seriously than by earthquake. The latter one, more collapse of buildings and houses than in Tohoku, as the reasons of the buildings in Tohoku. First the short waveform, next quake‐proof polity has been well prepared.

3. Survey methods

In Japan 90% of IL block use has been on the sidewalk, a park and square, as these places are used by humans not for vehicles. In both earthquake, the provisional restoration was arrived out quickly, and there was no hindrance on people passing, except for the serious damaged places.

In this survey, we investigated the cause of damage in advance based on filed survey by the other team, by delivered images on the internet, and by the materials offered by medias.

The prospective points are as follows.

① Tsunami
② seismic motion
③ liquefaction
④ Multiple factor

Regarding survey location, the coastal area of Miyagi Prefecture on Tsunami damage, sendai city on earthquake damage. The survey was carried out in January and May in 2012, when most of the debris have been taken away and it enabled the venires to pass through. The place where the base were totally destroyed and replayed to new pavement material, means that there were serious damage and the cause of the damage is possible to find.

As for liquefaction we carried out the survey in the coastal area of Miyagi where no repairing was done. In the landfill of the coastal area in Chiba, the survey was based on photos on the website, because right after the earthquake, the place was strictly banned to enter.

In Hyogo earthquake the photos taken by Professor Maki, and JIPEA delegates greatly contribute to the survey.

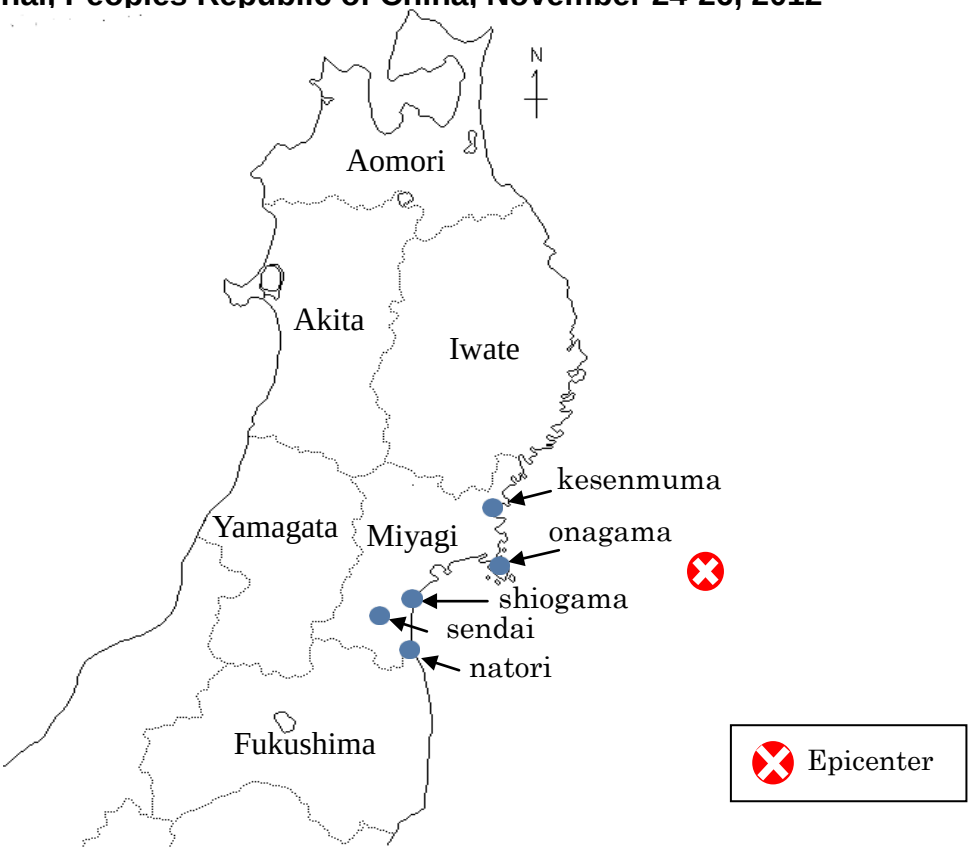

Figure-1 Tohoku Region Pacific Coast Earthquake

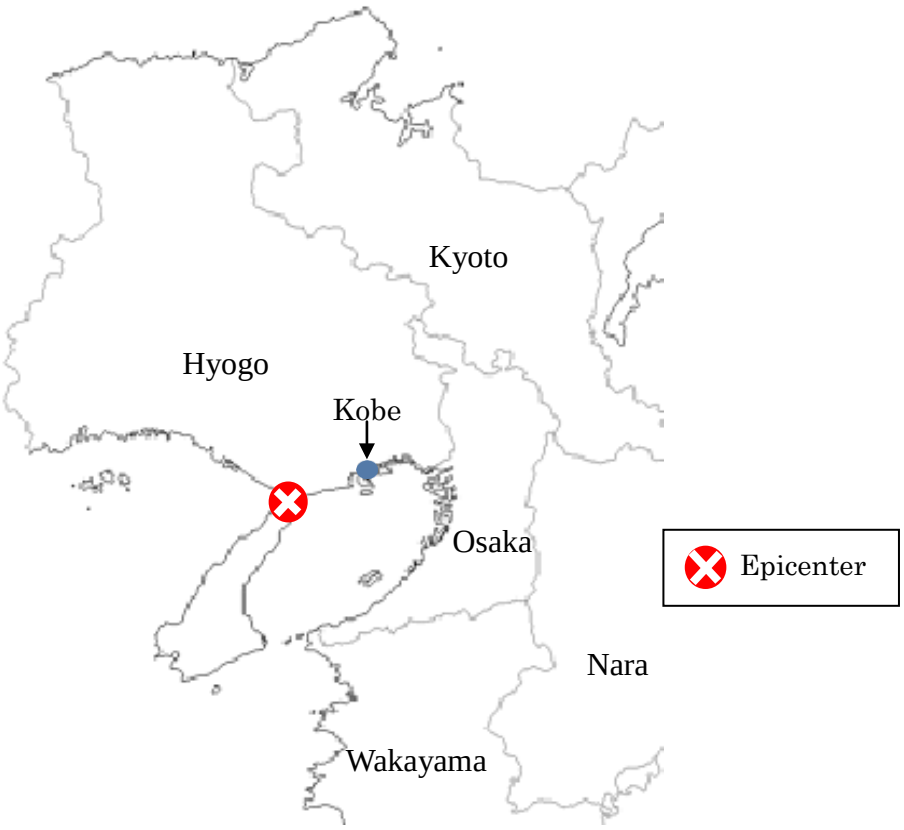

Figure-2 Hyogoken-Nanbu Earthquake

4. State of damage to IL block by earthquake

4-1 Tohoku Region Pacific Coast Earthquake

Figure 3 was taken in the Kesennuma bay of Kesenmuma city. The block pavement curb was destroyed by tsunami, and block in the damaged part of the curb were missing. Figure 4 was for the place about a few hundred meters inland from Kesennnuma port. Almost all the houses in the area were destroyed, and only building foundation were remained, with IL block pavements fixed to the curb. Figure-5 shows that the ship flown remained the surface of the pavement.



Figure-3



Figure-4



Figure-5

Figure-6 was taken in the revetment asphalt in Natori port. There, the edge of the asphalt pavement were totally destroyed and washed out the base.



Figure-6

Figure-7 was taken in inland Miyagi Prefecture. In this area there was no Tsunami sufferings but IL block pavement moved simultaneously. In the place the edges of the pavement were fixed to the building and the drainage ditch, the width is narrowed, IL block in the center and the end of sidewalk were swollen. Figure-8, the end constraint blocks were moved and there joints become loose, making wider, as a result the road were to replace for use.



Figure-7



Figure-8

Figure-9 was the one for after replacement. Figure -10,-11 was taken of the interior slab pavement. This place has no serious damage and tentative repair by asphalt pavement was done.



Figure-9



Figure-10



Figure-11

Figure-12 was the artificial reclaimed land in Urayasu, where the jets of sand from the joints and the sink of the ground by the sink caused by liquefaction were observed. Also the rise of the manhole was seen. This place was replaced for selling manhole before the earthquake. Figure-13 shows the sink of the pavement and the subsidence in the contact part with the building.



Figure-12



Figure-13

Figure-14,-15 were taken at Shiogama port. In this place the jets of sand was also seen in the landfill area as shown. The liquefaction may have caused. Figure- 16 shows the opposite side of figure-14,-15. There, no effects by liquefaction observed because no manhole and underground utilities.



Figure-14



Figure-15



Figure-16

Figure-17 was taken at Kesennuma port. There the lift of manhole was observed. The serious Tsunami damage of blocks flowing into the sea and handrail's curbing was seen in figure-18.



Figure-17



Figure-18

4-2 Hyogo-ken Nanbu earthquake

Figure-19 was taken in Kobe city, 16 year after. The sidewalk blocks swollen were like the case in Tohoku. Figure-20 shows that the curb fell down to the roadway and blocks in the sidewalk scattered. Figure-21 shows the joints expedition. In the place was made that the joints were wide apart, the replacement by asphalt had been made.



Figure-19



Figure-20



Figure-21

The figure-22 shows the asphalt pavement in the sidewalk. The destruction caused by the longitudinal cracks were so remarkable that it were to be mended, compared with figure-23.



Figure-22



Figure-23

The figure-24 was in the portside in Kobe city. The liquefaction caused the wall destruction in the coast, with base and IL blocks flowing into the sea. The figure-25 shows the situation of sand jets like Tohoku, causing difficulty in passing through for the pedestrians.



Figure-24



Figure-25

In the figure-26, in spite of the sink of the pavement, the buildings themselves had no sufferings because of the strong base. Only the collapse of the blocks was observed.
In Hyogo earthquake, we verified various types of damages to the pavements; however the blocks themselves had little damage in any cases. In the place where the bump between the buildings and the pavements existed, the measures of setting the staircase by using IL blocks was taken.



Figure-26

5. CONSIDERATION

The survey was practiced in the place people use dairy, like sidewalks, squares and so on.
The damage of earthquake

1) IL block pavement makes less breaking apart by its joint structure.
2) The 60mm or more thickness of the block enabled to reuse them.
3) In the place, where base flowing into the sea, ground sink, because of the collapse, base function was lost.
4) In the landfill area, the burst of water and sand between the blocks was observed. As a result, some areas where the measures had not been taken had serious damages as the flow of the subgrades.
5) The earthquake caused the crack of asphalt pavements, while IL block and concrete plate pavement had little damage of destruction.

6. CONCLUSIONS

In comparison with two earthquakes, no specific differences could be observed although the scale and seismic vibration time are different. In both cases, the damage by liquefaction is so serious that the measures should be inevitably taken.
Wrapping up the damage of IL block pavement, curb were missing, the center and the end of sidewalk were swollen, subsidence in the contact part with the building, base and IL blocks flowing into the sea were observed. In some areas, the function of IL block pavement became less or no effective in case end constraint. It may not be specified whether there symptoms are caused by seismic motion, tsunami, or liquefaction, because of the complex and integral motion.
Considering this situation, we should focus on checking, curb, end constraint, joint sand, subgrade and judging the condition, for the purpose of lessening the damage by the earthquake.

7. REFERENCES

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