STUDY ON OPERATION TEST OF REMOTE BUILDING DAMAGE ASSESSMENT SYSTEM DURING LARGE SCALE EARTHQUAKE DISASTER

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ABSTRACT: This paper proposed the new system for building damage assessment using photos of damaged house taken by residents or volunteer fire corps in damaged area. Specialists outside the damaged confirm these photos on the website and assess their damage levels. All the data used for building damage assessment is managed with GIS database on the management server located outside the damaged area under cloud condition. This kind of digital management system can contribute to enhance the accuracy and efficiency of the procedures for issuing the Victim Certificates for residents. In this paper, the remote system for specialists to assess the damage level was developed as web service for supporting building damage assessment. Furthermore, authors conducted operation test for some local government staffs to evaluate the effectiveness of developed systems. As a result of this operation test, it became clear that developed system can assess their damage levels using uploaded photos of damaged house taken by residents or volunteer fire corps in damaged area.

Key Words: building damage assessment, large scale earthquake disaster, Android application, remote system, IT system

INTRODUCTION

In Japan, several big earthquakes are expected to occur in the near future. A lot of structural damages due to these earthquakes will cause enormous needs for building damage assessment. Building damage assessment is necessary for governments to issue the Victim Certificates for residents who suffered housing damages. However, current number of human recourses who are trained with the procedure of building damage assessment is not enough. It is necessary to develop the new system which can correspond to next large-scale earthquake disaster. The guidelines of general procedure for inspecting building damage and evaluating loss due to disasters were published by the Cabinet Office in 1968, 2001 and 2009. However, in past disasters, various problems of building damage assessment have been pointed out such as inaccurate inspection, difficulty in quick inspection and lack of human recourses with sufficient skill of assessment.

New remote system for building damage assessment using IT system was proposed and prototype system was developed. These systems have some features that can solve some problems pointed out by past building damage assessments and execute building damage assessment quickly after a large scale earthquake disaster. This proposed system has two sub-systems. First one is photo uploading system used in damaged area. Second one is assessment system for supporting experts such as

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registered architects and experienced workers outside the damaged area. But authors only develop the prototype system, and do not evaluate the effectiveness of developed system. In this research, authors conducted operation test for some local government staffs to evaluate the effectiveness of developed systems.

CONCEPT OF NEW REMOTE SYSTEM FOR BUILDING DAMAGE ASSESSMENT

As a new system for achieving all the solutions for the problems reported at the past building damage assessments, we proposed a new remote system for supporting building damage assessments during large-scale earthquake disaster. The concept of the system is illustrated in figure 1.
The total system consists of two sub-systems. The first one is photo upload system in damaged area. Photos of a damaged house are taken by residents or volunteer fire corps in damaged area and those data is uploaded to the server. The second one is remote assessment system for specialists. Specialists located outside the damaged area confirm these photos through the website, and assess their damage levels and area.
All the data used for building damage assessment is managed with GIS database on the management server located outside the damaged area under cloud condition. This kind of digital management system can contribute to enhance the accuracy and efficiency of the procedures for issuing the Victim Certificates for residents.

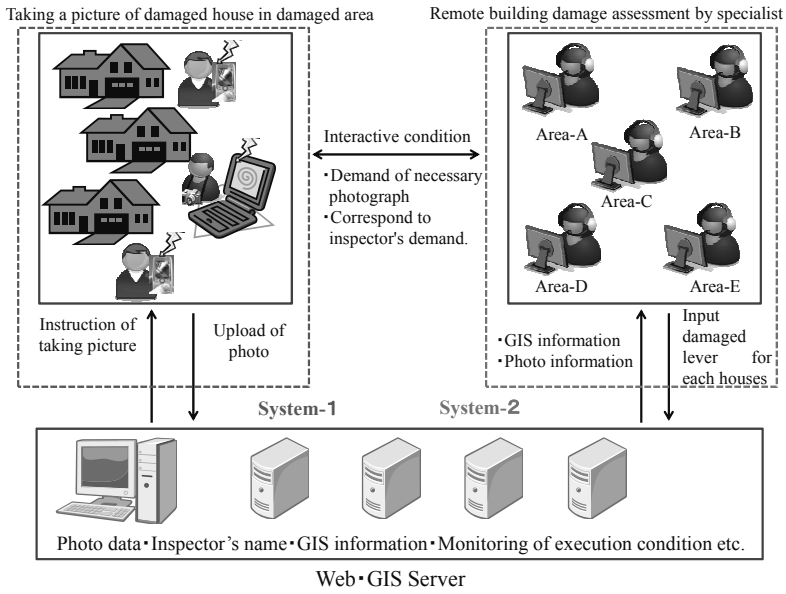

Figure 1. Concept of remote system for building damage assessment

DEVELOPMENT OF REMOTE BUILDING DAMAGE ASSESSMENT SYSTEM

Development of photo upload system in damaged area
Here, prototype of "Photo upload system in damaged area" was developed. Photos of a damaged house are taken by residents or volunteer fire corps in damaged area and those data is uploaded to the server. This system was developed by Android as the mobile phone operating system which is installed in almost all the smart phones except iPhone. Photo upload application is installed to each Android

smart phone by inspectors who are residents or volunteer fire corps in damaged area.
Flow of photo upload system is as follows. Firstly, residents or volunteer fire corps as inspectors input the basic information such as GPS information, address and owner name. Secondary, they upload some photos such as overview of damaged house, incline of damaged house and damaged point of roofs, walls and fundamentals. Finally, they confirm the input data and some photos.
Method of completing for photo upload in damaged area using upload application is as follows. Inspectors take some damaged house photos which are full views of a damaged house (north side, east side, south side and west side) and closeup views of damaged points. They select some photos for upload in each factors page, and fill in the comments about damage level and location of a house etc. Inspectors should take pictures of damaged house concerning three factors: externals, inclination and building element (roof, exterior wall and foundation). Furthermore, they have to relate closeup views of damaged points to full views using touch screen functions. The prototype system of photo upload system was developed based on the data of totally damaged houses due to the 2011 off the Pacific coast of Tohoku Earthquake.
After taking some pictures, inspectors need to upload them to an exclusive server in cloud condition using upload application. Using this application makes it easier to select and upload photos which are taken by inspector in damaged area. The reason is that smart phone has touch screen functions which are tap, drag, flick and pinch out/in operations.

Development of remote assessment system for specialists

Here, prototype of "remote assessment system of photos of damaged houses was developed as shown in figure 2. Specialists outside the damaged area confirm these photos on the website and assess their damage levels. All the data used for building damage assessment is managed with GIS database on the management server located outside the damaged area under cloud condition.
Flow of remote assessment system is as follows. Firstly, specialists who are registered architects and

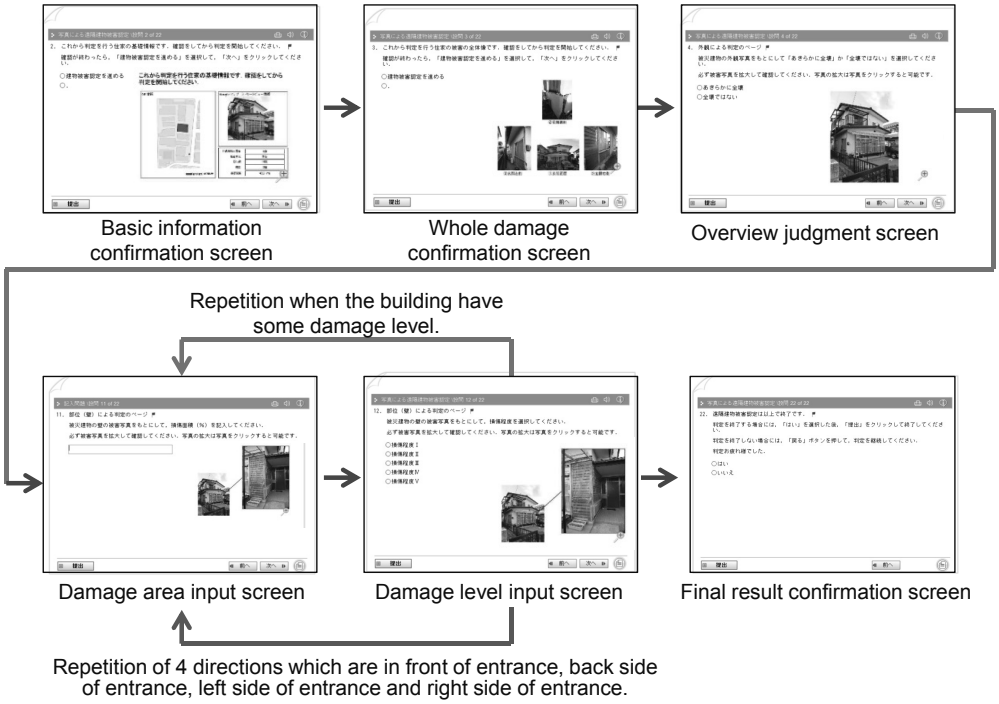

Figure 2. Remote building damage assessment system

experienced workers outside the damaged area confirm the basic information such as shape of damaged house, location and seismic level on the web system and overview all the photos of a damaged house. Secondary, they assess the damage level and area using some photos such as overview of damaged house, incline of damaged house and damaged point of roofs, walls and fundamentals. Finally, specialists confirm the input data and some photos. Then result of first assessment is passed to the next specialist to carry out double check.

EVALUATION OF EFFECT OF REMOTE BUILDING DAMAGE ASSESSMENT SYSTEM

Condition of operation test

Authors conducted operation test for twenty local government staffs which experienced building damage assessment due to the 2011 off the Pacific coast of Tohoku Earthquake, and they belong to Yokohama city and Sendai city as shown in figure 3.
The date of operation test is 26 and 27 April in Yokohama city, and 15th May in Sendai city. Duration of operation time is about two hours. Contents of operation test are explanation of building damage assessment, developed system and questionnaire survey for developed system. After the explanation of that, operation test was started by author using developed system. When the operation test finished, test staffs answer the questionnaire survey regarding usability and feasibility of developed system.
Table 1 shows condition of operation test. Operation test has four damage patterns and two cases respectively (except major-moderate damage). Totally seven scenarios of operation test are examined by operation test staffs. Damage patters of operation test are major damage, major-moderate damage, moderate damage and minor damage, and two scenarios are easy to assess and difficult to assess for experienced person. Operation test adopt local government staffs which have experienced to carry out the building damage assessment during the 2011 off the Pacific coast of Tohoku Earthquake. Figure 4 shows example of damage photo for remote assessment system due to the 2011 off the Pacific coast of Tohoku Earthquake which are moderate damaged houses. Scenario 4 is moderate damaged house which is easy to assess for all test persons, and scenario 5 is also moderate damaged house which is difficult to assess for experienced person.

Figure 3. Operation test in Yokohama city

Table 2. Condition of operation test

Scenario	Damage Level	Test Conditions
1	Major damage	Easy to assess for all test persons
2	Major damage	Easy to assess for all test persons
3	Major–moderate damage	Difficult to assess for experienced person
4	Moderate damage	Easy to assess for all test persons
5	Moderate damage	Difficult to assess for experienced person
6	Minor damage	Easy to assess for all test persons
7	Minor damage	Difficult to assess for experienced person

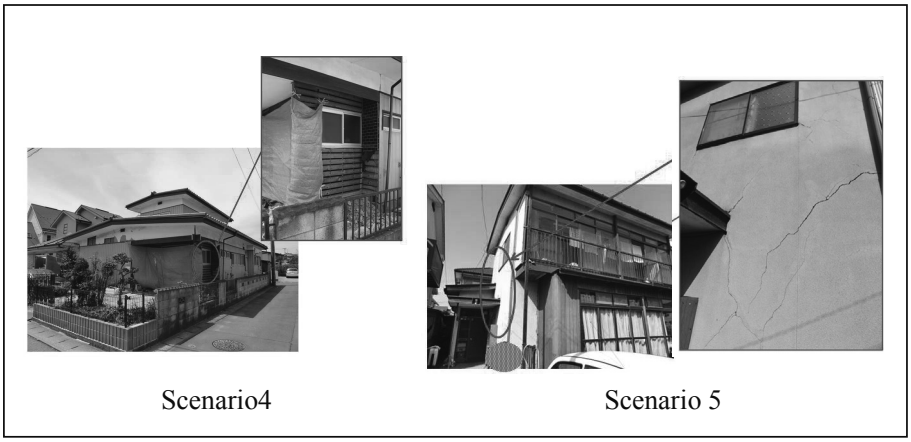

Figure 4. Example of damage photo for remote assessment system

Result of operation test

Figure 5 shows result of final damage level using developed remote building damage assessment. As a result of operation test, scenario 1 and 2 are all operation staffs assess correct damage level. On the other hand, scenario 3,4,5,6 and 7 does not assess completely. East to assess for all test persons cases are high correct answer ratio which is about 80%. But, correct ratio of difficult to assess for experienced person cases is lower than another case.

Figure 6 shows result of judgment of damage level which is scenario 7. Scenario 7 is difficult to assess for experienced person case. Scenario 7 has three walls which locate left side of entrance and back side of entrance. Red circle in the graph indicate correct judgment. As a result of operation test, about 70% of test staffs can assess correct damage level of wall. But, about 30% of test staffs do not assess the damage level correctly because of small cracks cannot find.

Figure 7 shows result of judgment of damage area which is scenario 7. Scenario 7 is difficult to assess for experienced person case. Scenario 7 has three walls which locate left side of entrance and back side of entrance. Red circle in the graph indicate correct judgment. As a result of operation test, wall 1 and wall 2 is assessed larger damaged area than correct damaged area, but wall 3 is assessed smaller than correct damaged area. The reason of that result as follows. Test staffs cannot evaluate correct damaged area because of small cracks. Damaged area is difficult to assess using photos for test persons. As a result of two reasons, it is necessary to install the easy calculation system using area mesh, and procedures which can assess the damage level using example of damage.

Figure 8 shows result of questionnaire survey regarding usability and feasibility. This system has many advantages than present procedures. Especially, “reducing inspection time” and “Result of inspection is managed by digital data.” is high evaluated point by test staffs thorough the questionnaire survey. As a result of discussion as test staffs, developed system is very useful to carry out the primary inspection.

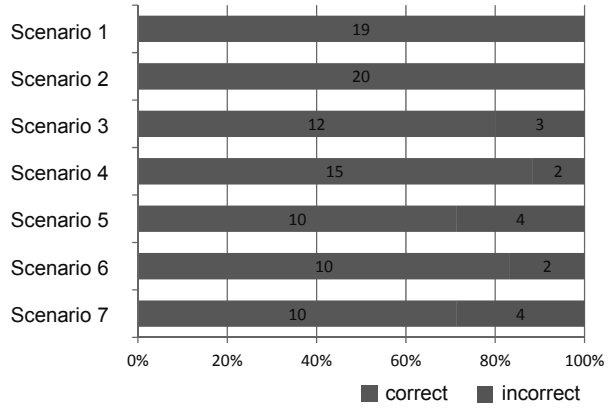

Figure 5. Result of final damage level

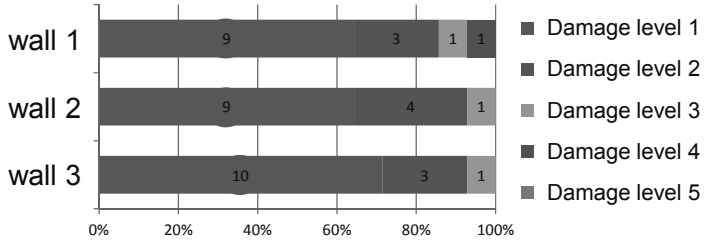

Figure 6. Result of assessment of damage level (wall inspection)

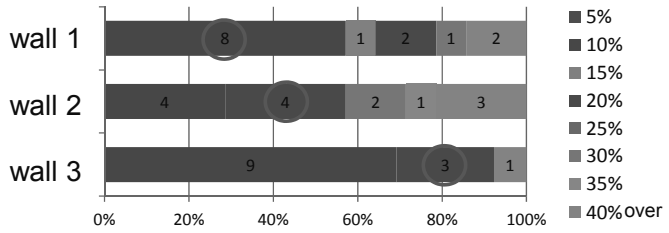

Figure 7. Result of assessment of damaged area (wall inspection)

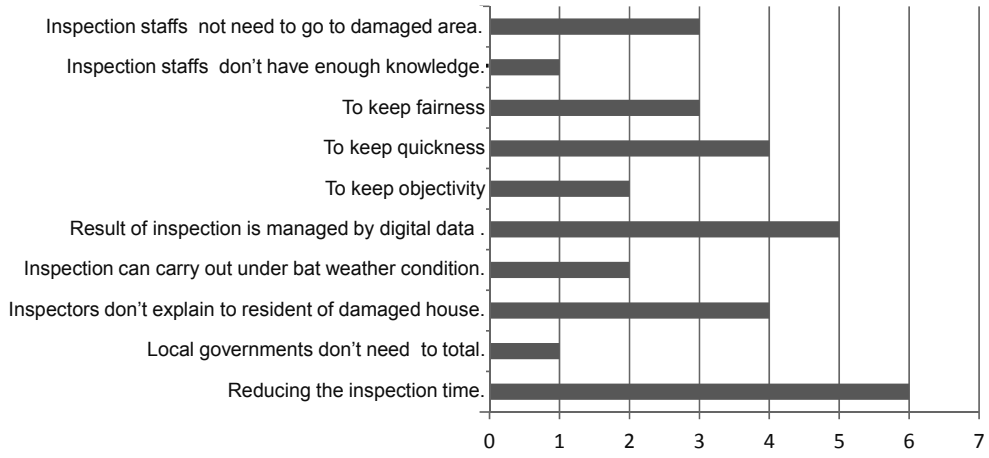

Figure 8. Result of questionnaire survey regarding usability and feasibility

CONCLUSIONS

In Japan, several big earthquakes are expected to occur in the near future. It is necessary to develop the new system which can be corresponds to next large-scale earthquake disaster. In this research, new remote assessment system for building damage assessment was developed and conducted operation test.

The prototype system of remote building damage assessment system was developed based on the data of damaged houses due to the 2011 off the Pacific coast of Tohoku Earthquake, and conducted operation test for local government staffs which experienced building damage assessment. As a result of operation test and questionnaire survey, it become clear that building damage suffered from earthquake can assess using developed system and this system has many advantage point than present procedures.

In the future, we plan to conduct the operation simulation using developed system for Tokyo metropolitan inland earthquake, and examine its effectiveness and quickness.

REFERENCES

Murao, O., Yamazaki, F., 1999, Comparison of Building Damage Evaluation by Local Governments after the 1995 hyogoken-nanbu earthquake, Journal of Architecture Planning and Environmental Engineering, No.515, pp.187-194

Shigekawa, K., Tanaka, S., Horie, K., Hayashi, H., 2005, Some Regulational Issues on Building Damage Assessment –A Case Study of Niigata-ken Chuetsu Earthquake- , Journal of social Safety Science No.7, pp.133-140

Horie, K., Shigekawa, K., Maki, N., Tanaka, S., Hayashi, H., 2005, Application of Damage Assessment Training (DATS) to Ojiya City following 2004 Niigata-ken Chuetsu Earthquake –Through a Disaster Response Support Activity for Issuing Victim Certificate- , Journal of social Safety Science No.7, pp.123-132

Yoshitomi, N., Hayashi, H., Urakawa, G., Shigekawa, K., Tanaka, S., Horie, K., Matsuoka, K., 2005, The Development of a Damage Certificate Issuing Support System –A new disaster response database schema created for the Niigata Chuetsu Earthquake- , Journal of social Safety Science No.7, pp.141-150

Tanaka, S., 2008, A Study on the Building Damage Assessment Processes for the 2007 Niigata Chuetsu Oki Earthquake Disaster : Kashiwazaki Case Study , Proceedings of social Safety Science No.22, pp.35-38

Fujiu, M., Ohara, M., Meguro, K., 2011, Development of remote system for supporting building damage assessment during large-scale earthquake disaster, Proceedings of the Eighth International Symposium on New Technologies for Urban Safety of Mega Cities in Asia, Chiang Mai, Thailand, CD-ROM

Fujiu, M., Ohara, M., Meguro, K., 2012, Development of remote system for supporting building damage assessment during large-scale earthquake disaster, Proceedings of 9th International Conference on Urban Earthquake Engineering, CD-ROM

Fujiu, M., Ohara, M., Meguro, K., 2012, Development of remote building damage assessment system during large-scale earthquake disaster, Proceedings of the 15th World Conference on Earthquake Engineering, CD-ROM, Lisbon, Portugal