The Third Joint Seminar of Japan and Indonesia Environmental Sustainability and Disaster Prevention (3rd ESDP-2015)
Institut Teknologi Bandung, Indonesia – November 25th, 2015

IMPORTANCE OF PAST DISASTER RECORDS -A CASE STUDY OF ITS APPLICATION AFTER THE NOUBI EARTHQUAKE IN GIFU-

[a]Takahiro Shimizu[*,†],
[a]Department of Architecture, National Institute of Technology, Gifu College, Japan
Email: t-shimizu@gifu-nct.ac.jp
*Presenter; † Corresponding author.

Abstract: The damage from natural disasters, such as earthquake, typhoon, volcano eruption, and so on, to constructions and cities has happened repeatedly in Japan. It cannot be said the sustainable society, if we just wait for the next disaster with doing nothing and rebuild the infrastructures and buildings each time. As a matter of course, we have learnt many from a lot of disasters and its damage. It is important to record, reconsider and exploit the tragedy as a valuable opportunity what we can learn from. In this study, the simple devices which was based on the remaining records of the Noubi Earthquake, individual measures with technique of trial-and-error by the general people, given to a certain residence is analyzed. To figure out achievements of our predecessors implemented promptly after damage, and to know application of traditional architectural technique to countermeasures against disaster, those are very curious and meaningful experiences. The importance of the approach that considered not only a new approach that used the latest technology but also the traditional approach that had been piled using the experience and wisdom in a word that was rooted in history and culture, through the records, it became clear in this study.

Keywords: Past Disaster Records; Countermeasures Against Disaster; The Noubi Earthquake; Traditional Architecture

INTRODUCTION

The damage from natural disasters, such as earthquake, typhoon, volcano eruption, and so on, to constructions and cities has happened repeatedly in Japan. The Noubi Earthquake, an 8.0 magnitude earthquake, occurred in Gifu on October 28th, 1891. It was a devastating earthquake killed more than 7,000 people and injured more than 17,000 people. And it was also reported about 140,000 buildings totally collapsed and about 80,000 buildings half-collapsed. Table 1 shows the fundamental data of the Noubi Earthquake. It cannot be said the sustainable society, if we just wait for the next disaster with doing nothing and rebuild the infrastructures and buildings each time. As a matter of course, we have learnt many from a lot of disasters and its damage. It is important to record, reconsider and exploit the tragedy as a valuable opportunity what we can learn from. In this study, the simple devices which was based on the remaining records of the Noubi Earthquake, not big countermeasures against disaster by the country and specialists but individual measures with technique of trial-and-error by the general people, given to a certain residence is analyzed.

Table 1. Data of the Noubi Earthquake

Date	28 October, 1891
Magnitude	8.0Ms
Epicenter	Nishi-Neo Town (present Motosu City), Gifu Prefecture
Casualties	More than 7,000 dead
	More than 17,000 injured
Building damage	approx. 140,000 total collapsed
	approx. 80,000 half-collapsed

MATERIALS AND METHODS

First of all, we overviewed of the disaster records about not only the Noubi Earthquake but also various disasters around Gifu City. Obviously a lot of detailed information and the situation afterwards can be confirmed from the newspaper and the architectural magazine about the damage of the Noubi Earthquake. On the other hand, the records about other disasters, for example typhoon and flood that more frequently hit the region for research than earthquake, show only Public Record of the simple numerical data. In such records, the detailed information of individual constructions and the situation afterwards until restoring all things are scarce. Thus, not only objective information but also more important records by the person concerned are collected and analyzed. For instance, Figure 1 shows the description from diary of chief priest at Shinryu-ji Temple in Gifu.

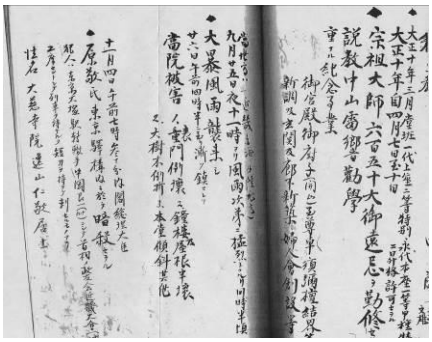

Figure 1. Diary of Chief Priest at Shinryu-ji Temple

"Wind and rain gradually became severe from 11pm on September 25th, 1921. At half past 11pm a big rain storm had come. And then it had calmed down at half past 4am on September 26th. The damage of our temple are as follows: 1. Main gate collapsed. 2. Bell tower and roof are half-collapsed. 2[sic]. Giant tree collapsed. 3. Main hall is leaning."

That is a kind of record a person concerned only knows. As an individual damage case, it is also important to know which building collapsed or what building survived.

REVIEW

There are many previous research about the Noubi Earthquake (e.g. [1]-[3]). Most of them are a research on the mechanism and the active fault of the earthquake, and a document

that chiefly recorded casualty toll and damage situation. The early studies referred in detail about disaster record of construction, and countermeasures afterwards are known (e.g. [4][5]). After long periods of time, for example Nishizawa revaluates the records and facts (e.g. [3][6][7]). These are all important studies, but all of them are based on records by third party such as government agency and general architects. Meanwhile, in this study records by the person concerned are also analyzed.

PUBLIC DISASTER RECORDS

Recently, information on the disaster is immediately transmitted around the world through TV, the newspaper, the Internet, SNS, etc. with texts, photos, or videos. On the other hand, things were recorded by texts, pictures, and word of mouth until early modern period. Therefore it was not widely shared.The Noubi Earthquake is located in transition period. That was the first big earthquake which modern Japanese society faced. It was also the first disaster to investigate by specialist and record the damage by photograph. Moreover through the newspaper, the damage information was reported to all over Japan comparatively in a short term.After the Noubi Earthquake it is known well that a lot of leading specialists and researchers of that time proceeded to the stricken area from Tokyo and surveyed and analyzed. And then the results were published in an academic journal and used for architectural designs, and it contributed to the control of the expansion of the Great Kanto Earthquake(1923) damage. Concretely, because of wide spread of information about fall of Nagara-gawa River Iron Bridge (Figure 2, [8]) and damage of Nagoya Postal Telegraph Office which was a two-story brick building (Figure 3, [8]), the earthquake engineering of iron bridge and especially brick construction had developed.

Figure 2. Fall of Nagara-gawa River Iron Bridge
(Source: *Photo book of the Noubi Earthquake* [8])

Figure 3. Damage of Nagoya Postal Telegraph Office
(Source: *Photo book of the Noubi Earthquake* [8])

On the other hand, naturally a lot of wooden buildings were struck by the earthquake. A public record and the news report do not necessarily show a complete and correct realities because it is sometimes likely to be given priority to a grasp of various circumstances and overall trend, and priority to the interest in sensational phenomenon. The large majority of wooden buildings where they had lived collapsed much more than the brick construction. Countermeasures for the wooden buildings (not for the brick construction, however it was impulsively destroyed) were more serious problem for victims. That is to say, it was more important for them to improve earthquake resistance of wooden buildings rather than brick construction.

Therefore, it became clear that a true situation of victims on the site cannot be understood and connect with appropriate countermeasures if only public disaster records are used. In a word, the record by the person concerned is extremely important in the disaster records.

PRIVATE DISASTER RECORDS - COUNTERMEASURES AND THE RESULT-

The Hayakawa Residence is located on approximately 9,000 square meters site beside the approach way to a famous shrine, Chiyobo-inari Shrine, at Kaizu city in Gifu. This region is placed between two big rivers, so it is influenced by a lot of natural disasters such as flood damage and the typhoon that occurs one after another, and also earthquake. The epicenter of the Noubi Earthquake is only 40km away. Shuzo Hayakawa was born as the first son of a wealthy farmer, the Hayakawa family, in August, 1863. He became a prefectural assembly member in 1890, concurrently worked for a local bank as an executive, and was elected to a member of the House of Peers in 1897. He played an active role in politics and industry.

The members of Kawata laboratory, Nagoya Institute of Technology and Shimizu laboratory, National Institute of Technology, Gifu College investigated the buildings, the records and materials at the Hayakawa Residence in July and September, 2012. Figure 4 shows a current floor plan drawn by using the measured data.

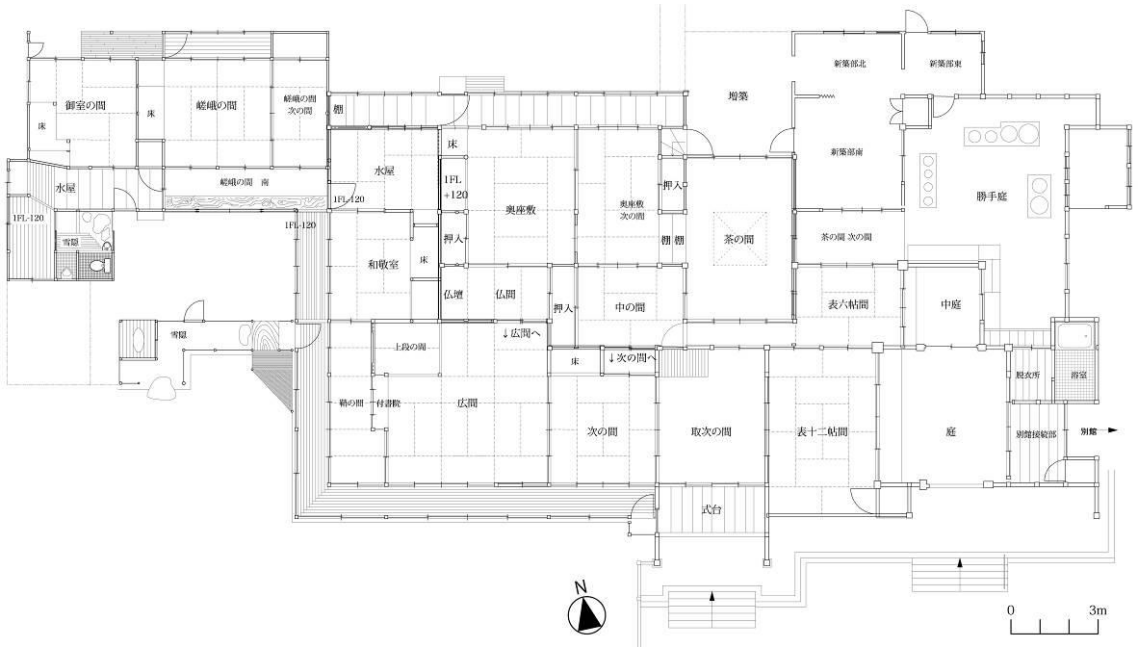

Figure 4. Current floor plan of the Hayakawa Residence

Table 2 shows a list of records confirmed by the investigation which includes eight historical drawings and four text records. Material A-D are arrangement plan of the buildings in the site before and after the Noubi Earthquake (1891). Material E-G are drawings for floor planning of a main house of the Hayakawa Residence (Figure 5) started constructing in March, 1892. It shows the transition of various buildings of the Hayakawa Residence, in particular number and shape of buildings faced the earthquake and revival situation. Material H-K are text records concerning the buildings constructed after Noubi Earthquake, and especially Material H, "Kiroku-cho -Record Note-", is the research object of this study.

Table 2. List of the records at Hayakawa Residence

code	Title	estimated year of compilation
A	site plan	1860
B-1	site plan with house physiognomy	1854
B-2		1878
C	survey drawing of site plan	1891
D	drawing of buildings and garden	1891
E	floor plan of new main house (1)	1892
F	floor plan of new main house (2)	1892
G	new main house plan with house physiognomy	1895
H	"Kiroku-cho" (Record Note)	1892.12-
I	"HontakuMinamiNiwa Syokeihi Tsukekomi-cho" (Aaccount Book for construction of Garden)	1894.10-
J	"Saganoya Koshitsutsuki Furo Benjyo" (Aaccount Book for construction of Saganoya)	1895.10-
K	"Saganoya Omuro Shintiku Keihi" (Aaccount Book for construction of Omuro room)	1899.5-

Figure 5. Hayakawa Residence

Figure 6. Secondhand Wooden Material

"Kiroku-cho -record note-"

"Kiroku-cho" is a detailed Record Note about the damage of the Noubi Earthquake that Shuzo Hayakawa recorded. In the Record Note, the struck buildings are classified into three groups, collapsed, half-collapsed and undamaged. Moreover it shows the probable reason of each situation. For instance, “Because of lack of walls, braces, and beams”, “By the reason why wooden shingle roofing is light”, these descriptions are valuable information which only the person concerned is possible to record. The judgments of the struck buildings, such as repair, relocate and reconstruct, or demolish, are decided according to the analyzed situation. It is common in Japan to repair (disassembling a frame of building, replace a faulty member, and restructuring) or relocate and reconstruct the old traditional wooden buildings. It is also usual that even the dismantlement materials from the demolishing building are recycled as materials of new construction. There are numerous traditional architecture cases of using the secondhand wooden materials. For example, Figure 6 shows a member of roof truss of the Main Hall at Shinryu-ji Temple in Gifu. The beam located in dark and out-of-sight attic is strangely decorated. Those devices for forestry preservation and effective utilization of wood are one aspect of sustainability in Japanese culture.

COUNTERMEASURES

A main house of the Hayakawa Residence began to reconstruct within half a year after the Noubi Earthquake, "Kiroku-cho -Record Note-" showed some countermeasures created by Shuzo Hayakawa and master carpenter Ichiroji Ito. Those are as follows: I. raised ground level. II. pine pile. III. concrete on ground surface. IV. bolt. V. earthquake-beam. The construction ground was raised by approximately 750mm. [I.] It was used a lot of pine piles of 150mm in diameter and 3m in length for ground improvement. [II.] The ground was dug up to the depth of 2.4m and piling 9-10 pine piles to each of 40 holes, and poured concrete. [III.] The wooden columns, standing on the foundation stone especially supplied from the Mikawa region, were reinforced with iron materials and bolted on in the upper part of the column. [IV.] The member of roof truss that was called “Jishin-bari (earthquake-beam, two

log beams were crossed)" was installed in the back of the ceiling. [V.] Only a few similar examples are known but it is not general technology.

All of the above-mentioned countermeasures are the simple applications of the traditional techniques (, not using new technology) that two people (the client and the carpenter) devise. In some cases, it might be criticized as the hasty response. After a certain period, the effect is verified and the useless one is dumped into the dustbin.

They did not wait for the development of the theory or the enactment of the system by the government. It shows an importance of doing something, thinking what they could do at once, and making an effort individually even a little. It only repairs if there is a great difference between the countermeasures already done and the statement from government agency and researchers after a long while. Actually, the government agency for seismic disaster launched after one year from the Noubi Earthquake. After several years, they encouraged the use of bolt and diagonal bracing for wooden buildings in their statement. That was not so different from the countermeasures that had already been given to the Hayakawa Residence.

The improvement of earthquake resistance (though it might be the same for everything) based on the experience has been done for a long time, and that is rule of thumb. It sometimes needs prompt response with traditional and existing technology, without excessive expectations and persistence in new technology. Still the Hayakawa Residence is alive after nearly 120 years in use without big damage by flood and typhoon.

DISCUSSION

It is clear that it is not drastic measures of new structure, material, and construction method for natural disasters based on the public records, but devices created by one client or one carpenter based on the private disaster records is important. In addition, to decrease the disaster damage in the future, unknown private records should be collected, and analyzed. It is also important not only to collect old records but also to record a new disaster if it occurs in the future. The countermeasure is not considered if there is no record, and then the damage happens over and over again.

On the other hand, as pointed out by Nishizawa ([6]) when the disaster is recorded and analyzed it is necessary to pay attention to not only "What building broke." but also "What building remained.". Figure 7 shows Horyu-ji Temple in Nara, one of the oldest wooden buildings existing in the world that constructed over 1000 years ago. Figure 8 shows the Main Hall at Shinryu-ji Temple in Gifu that constructed about 10 years before the Noubi Earthquake. In the background of survival from various natural disasters, there are technologies and devices that have been cultivated in the history. Although it does not refer in detail in this study, effect of traditional construction method is pointed out as the reason (e.g. [9]).

Figure 7. Horyu-ji Temple

Figure 8. Main Hall at Shinryu-ji Temple

The techniques and lessons concerning construction of traditional architecture have been handed down from generation to generation by carpenters. A part of them were recorded in the Japanese traditional architectural reference books (,which had been already researched enough for many years (e.g. [10])) . The importance of any kind of records is recognized again.

CONCLUSION

To figure out achievements of our predecessors implemented promptly after damage, and to know application of traditional architectural technique to countermeasures against disaster, not to invent a new construction technology with spending much time, those are very curious and meaningful experiences. The importance of the approach that considered not only a new approach that used the latest technology but also the traditional approach that had been piled using the experience and wisdom in a word that was rooted in history and culture, through the records, it became clear in this study.

In this study, one of the different method for improvement of strength against disasters with using records was shown.

ACKNOWLEDGEMENT

The author is grateful to Mr.M.Hayakawa and Mr.T.Nakanishi for providing the records, an opportunity to survey, and many suggestions. The author is also greatly indebted to Professor K.Kawata and his laboratory for joint survey of the Hayakawa Residence.

REFERENCES

[1] Fusakichi Omori, 1893. *Preliminary report of the Noubi Earthquake 1*, The Journal of the Geological Society of Japan: Volume 2, Pages 42-55.

[2] Gifu nichinichi Shimbun, 1 November, 1891. *the Great Earthquake* (newspaper article), extra edition, Japan

[3] Special investigation committee on succession of disaster lessons, 2006. *the 1891 Noubi Earthquake Report*, Central Disaster Management Council, Japan

[4] Chuta Ito, 1891. *Earthquake and Brick Construction*, Journal of Architecture and Building Science: Volume 59, Pages 291-295.

[5] Imperial University, 1891. *The compilation by the Imperial University about the earthquake*, Journal of Architecture and Building Science: Volume 59, Pages 303-304.

[6] Yasuhiko Nishizawa, 2012. *Building damage associated with the 1891 Nobi earthquake and its effect on earthquake engineering*, Active Fault Research: No.37, Pages 45-51.

[7] Masayuki Takemura, 2012. *Characteristics of disaster from the 1891 Nobi earthquake compared with the 1923 great Kanto earthquake*, Active Fault Research: No.37, Pages 39-44.

[8] Research conference of local materials in Gifu, 2009. *Photo book of the Noubi Earthquake*, reprinted edition, Japan

[9] *Preparatory Committee on technology of Japanese traditional wooden architecture for Intangible Cultural Heritage*, http://dentoh-isan.jp/ (10 October, 2015).

[10] Takahiro Shimizu, Katsuhiro Kawata, Akira Naito, 2005. *A study on the design system of tahoto pagodas in Japanese traditional architectural reference books*, Journal of Architecture and Planning: No.591, Pages 155-160.