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Archiving Disaster Remains: The Case of “Sasanao Factory” in Yuriage Village, Natori City, Miyagi Prefecture

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Abstract. In the areas affected by the 2011 Great East Japan tsunami, some damaged buildings were proposed to be preserved as “Disaster Remain” to share this experience and educating future generations. However, many these potential buildings were eventually demolished. This study aims to provide an alternative and eventually a consensus among communities that faced conflicts over the preservation or destruction of such disaster buildings. The methodology consists of 3D building modelling, tsunami numerical simulation and recording tsunami evacuation behaviour with interview survey. In sum, this practical study of “Sasanao Factory” demonstrates that the archiving of disaster remain can offer a compromise between those who wish to preserve disaster ruins, here the owner of the building, and those who want or need their destruction, here local government.

1. Introduction

In the areas affected by the 2011 Great East Japan tsunami, some damaged buildings were proposed to be preserved as “Disaster Remain” to share this experience and educating future generations [1]. However, many these potential buildings were eventually demolished because of the budget provided by the Japanese government for the reconstruction of the coastal areas covers only the preservation of one building per one municipality [2] after receiving the agreement of local residents [3]. For those buildings that must be demolished, an original solution is to archive them as “Disaster Remain.”

This study first aims to introduce a whole new process of archiving disaster remain using digital technology. Secondly, it investigates the effectiveness and problems of implementing this approach in the short term/technically speaking. We expected that this approach will provide an alternative and eventually a consensus among communities that faced conflicts over the preservation or destruction of such disaster buildings.

2. Methods

During this study, we digitally archived the “Sasanao Factory” building which used to manufacture boiled fish pastes in Yuriage area, Natori City in Miyagi prefecture. This operation was realized after the demolition of the building as ordered by the local government of Natori City. The method consists of making a 3D building model of the building using UAV scanning, tsunami numerical simulation and recording experience of the stakeholder using interview survey.



2.1. 3D building model of the building

Vertical direction (Nadir) images of the building and oblique images of its surroundings and circumferential position surrounding the building were taken in total of 671 images using UAV (DJI Inspire1) and autopilot software DJI Ground Station and Litch for DJI drones (Figure 1). In addition, 1,127 pictures of the surroundings and the interior of the building were taken by digital single lens reflex (Nikon D 700). In order to create a 3D model by combining successive images with Context Capture using SfM (Surface from Motion) software, it is desirable to take a series of images from a distant view position to a position close to the photographing field angle by a digital single lens reflex camera when photographing with UAV. Finally, laser measurement using a handheld laser scanner ZEB - REVO and movie shooting with a set of ZEB – CAM were also conducted (Figure 2).



Figure 1. Images shooting using UAV



Figure 2. Laser measurement using ZEB-REVO

2.2. Tsunami numerical simulation

An important parameter for tsunami simulation is the initial seafloor deformation that is computed from the fault parameters. This study estimated the initial water level based on a rectangular fault model and assumed that the change in the sea surface is the same as the seafloor deformation. The rectangular faults are assumed to have a fast movement toward the sea surface that is only a vertical displacement [4]. The fault parameter of the 2011 earthquake based on the Tohoku University model is used [5]. To obtain the tsunami inundations, a numerical tsunami simulation was conducted with the TUNAMI-N2 model [6]. The TUNAMI-N2 model uses the nonlinear theory of the shallow water equation, which is solved using a leap-frog staggered-grid finite difference scheme with the bottom friction represented by Manning's roughness coefficient. The simulation was run on six computational domains using a nesting grid system, from the largest region (1,215 m resolution) to the smallest region (5 m resolution) along the coastline of Yuriage village using the fixed ratio of the two domains as one-third (Figure 3 left). Initial water level calculated using the fault parameters are shown in Fig. xx1 right. This study also considered tsunami mitigation effect from the reconstruction (elevated land, elevated road and new seawall) as shown in Figure 4.

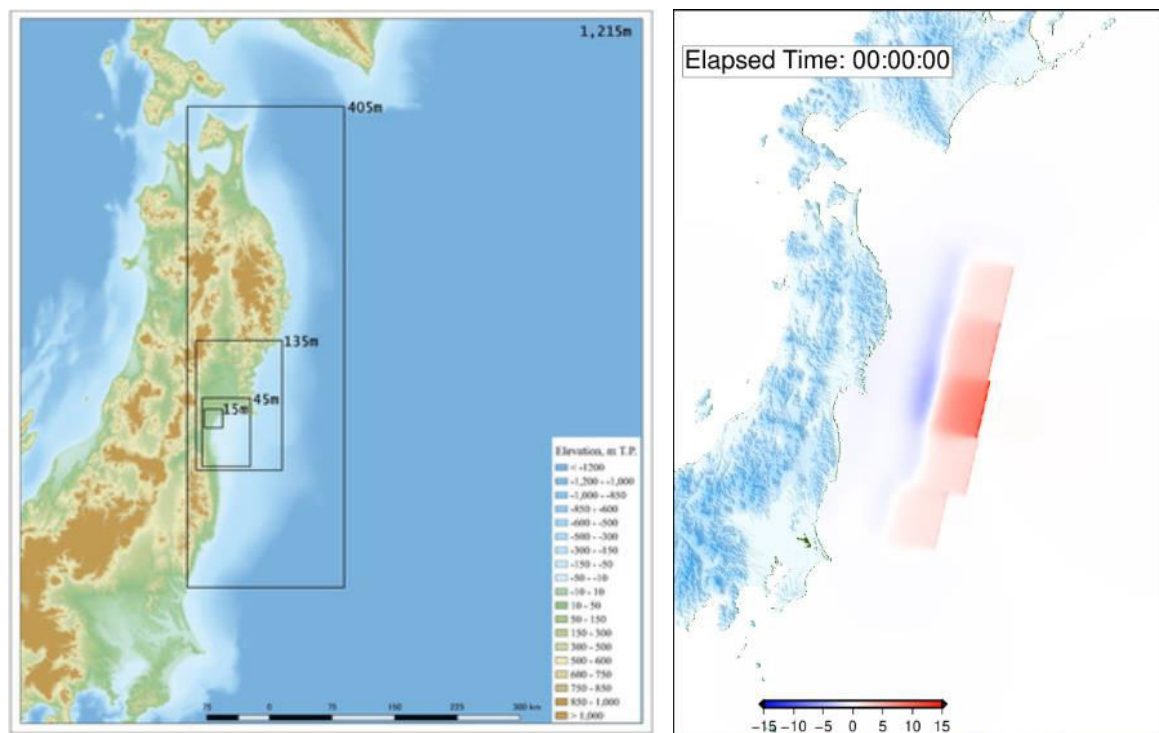


Figure 3. Left: Bathymetry and topography data in nesting grid system and Right: Initial water level computed using the proposed fault parameters

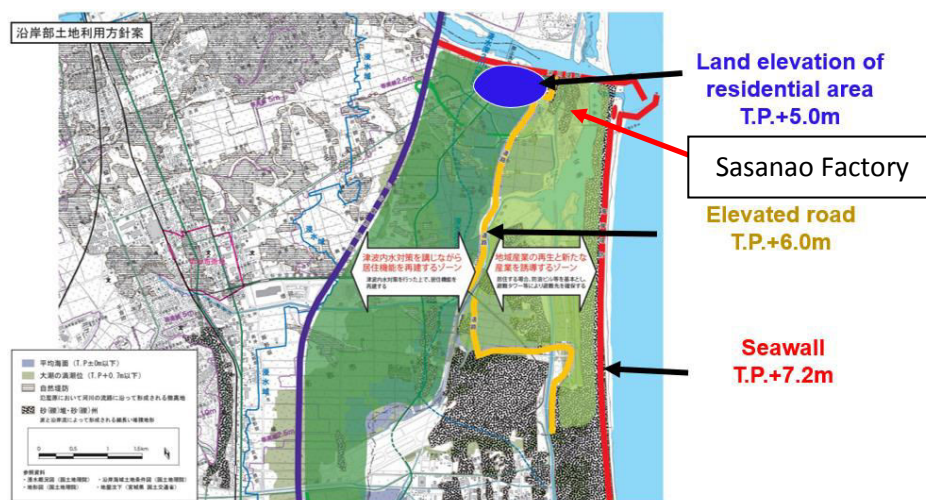


Figure 4. Location of Sasanao factory and reconstruction plan of Yuriage village

2.3. Interview survey

In order to record and to describe the tsunami evacuation and the other first response of the building owner (The company's CEO), we conducted detailed interviews, spending a total of 2 hours to obtain information on just before the earthquake and the company recovery process for about one year after the disaster, starting from immediately after the quake. The interviews were conducted in a semi-structured approach based on the development of talks by interviewee so that the process of the talks would not be hindered and the interviewees would be urged to speak further. Special consideration was given so that detailed information on experiences of individual interviewees could be obtained in addition to common premise-based questions by the interviewer. The data were made to a transcript.

Then, the transcript was compiled the reading material to learn the tsunami behaviour, his tsunami evacuation and the building damaging process.

3. Results

3.1. 3D building model of the building

As benefit of using SfM software, it became possible to produce 3D models from continuous images (Figure 5, Figure 6). Context Capture, one of SfM software was used to photograph the Sasanao factory using UAV and digital single lens reflex camera and combined the images. 1,762 images were combined from a total of 1,818 images, and a 3D model was produced from the point cloud (set of points having coordinates) data.

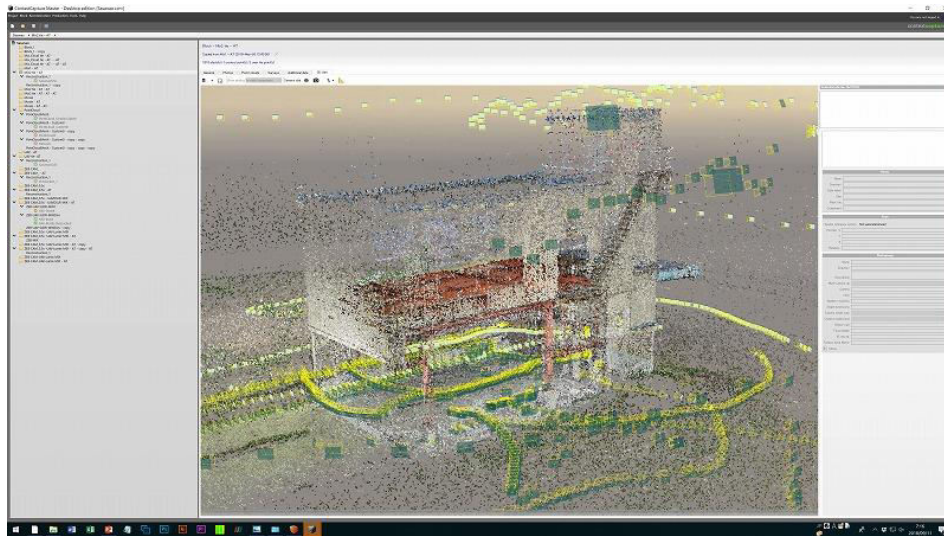


Figure 5. Construction of 3D building model by SfM Software



Figure 6. 3D building model of Sasanao Factory

By using free viewing software Actute 3D Viewer and embedding it in a web site, 3D model can be browsed easily while rotating, zooming in and out. Wireframe and texture can be also switched on and off (Figure 7, Figure 8).

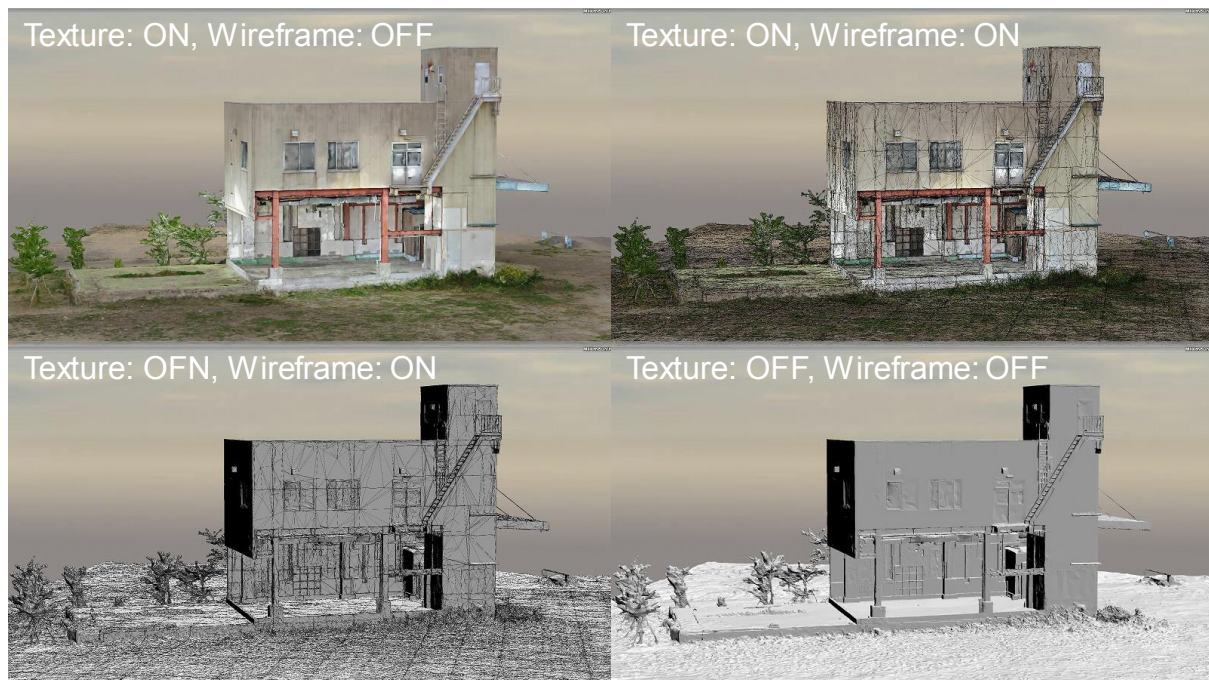


Figure 7. 3D building model (facade)



Figure 8. 3D building model (inside)

In addition, moving images taken by the handy laser scanner ZEB-REVO and the set ZEB-CAM is cut out by cutting 1,376 consecutive still images every 0.5 seconds. Based on the point cloud shape data obtained from the laser scanner, 3D model was created by combining images taken with three cameras of UAV, digital single lens reflex camera, and ZEB - CAM. Although it was expected that the 3D model with the laser survey shape data was expected to have high building details but some data loss in the shadow of the laser such as rooftops, detail reproduction of the internal image etc (Figure 9, Figure 10). This work gave example in preserving and digitalizing the disaster remains using UAV and digital single lens reflex images that can be transferred to future generations.

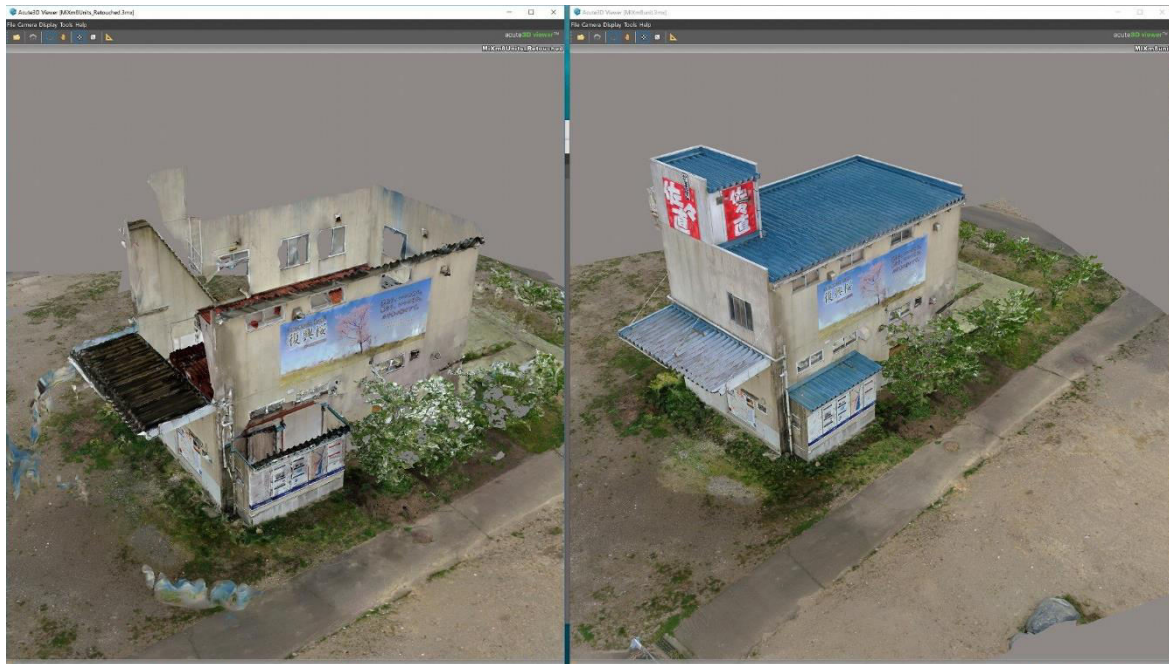


Figure 9. Comparison of 3D model (Left: with Scanner Data, Right: without Scanner Data)

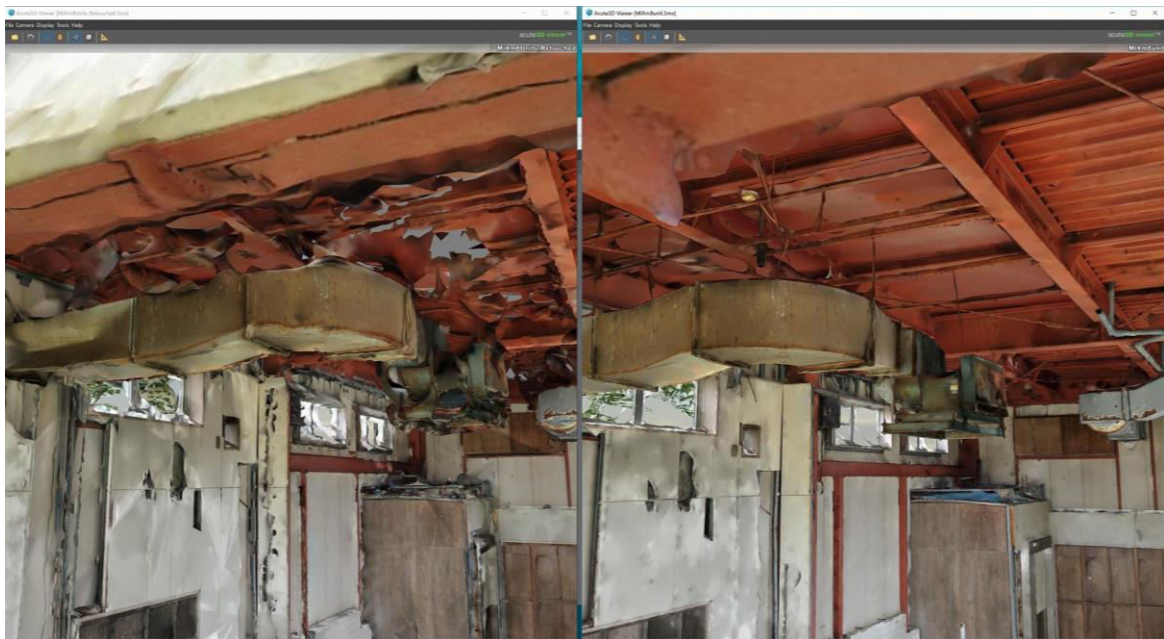


Figure 10. Comparison of 3D model (Left: with Scanner Data, Right: without Scanner Data)

3.2. Tsunami numerical simulation

The 2011 tsunami inundation heights and depths were collected by the 2011 Tohoku Earthquake Tsunami Joint Survey Group [7]. The numerical tsunami model results were verified using a geometric mean (K) and geometric standard deviation (κ) proposed by Aida [8]. These values refer to the deviations or variances from the proportion of observed and computed data. The simulation results give value of $K = 1.03$ and $\kappa = 1.31$ which can be classified as “good agreement” based on a guideline proposed by Japan Society of Civil Engineers (JSCE). Figure 11 shows snapshots of tsunami inundating Yuriage village at 65, 69 and 82 min after the earthquake. Figure 12 shows comparison of

simulated tsunami flow depth between before and after reconstruction. This simulation result illustrated that tsunami arrived Yuriage village around 67 min. It can be seen that residential area was not inundated after the reconstruction with the same 2011 tsunami-like event and inundation area was much decreased.

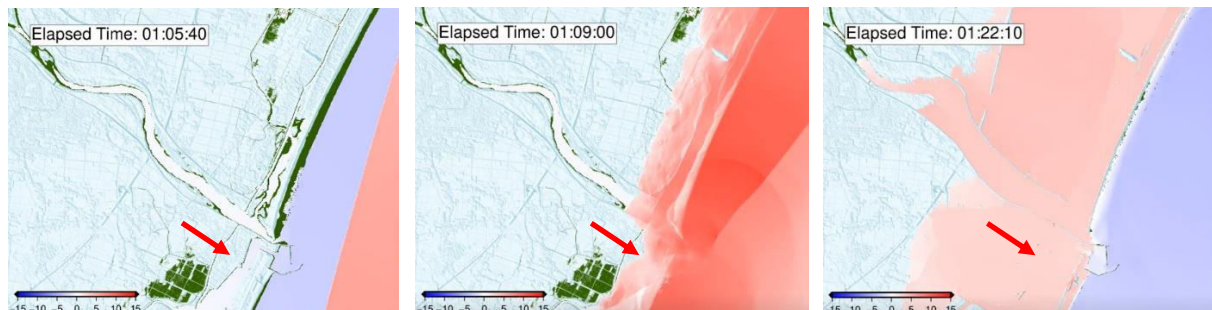


Figure 11. Snapshots of tsunami inundating Yuriage village at 65, 69 and 82 min after the earthquake

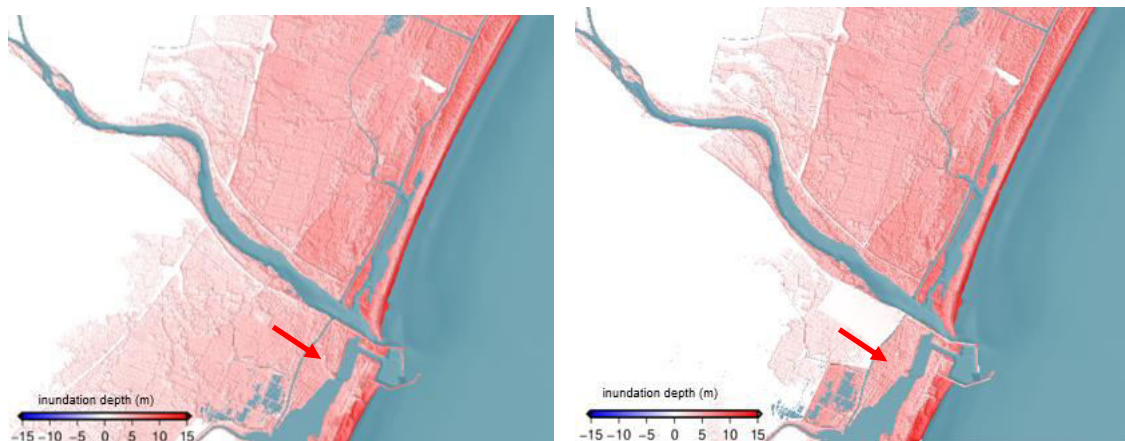


Figure 12. Comparison of the maximum flow depth between before reconstruction (at the time of the 2011 tsunami) and after reconstruction

3.3. Interview survey

The results of interview survey are summarized as follows.

- He took a lunch break at home about 200 m from Sasanao Factory in Yuriage village before the quake.
- After the earthquake, he moved to the factory to inspect the factory building and employees.
- He did not order evacuation to employee immediately because he did not have awareness of tsunami coming after earthquake at the coast.
- In the meantime, water level of “Teizan-bori” moat became lower.
- He was worried about tsunami coming to see the phenomena which is backwash before tsunami.
- His elder sun order evacuation to employees. CEO’s wife, the sun and others moved to Yuriage elementary school building which is three stories to inland by cars. Fortunately, they didn’t run into a traffic jam.
- He stayed the Factory building because he thought that the building is not destroyed by tsunami attack and wanted to see the tsunami behaviour.
- Then, went upstairs and took pictures of tsunami and situation of around the building with his cell phone camera. However,



Figure 13. Situation of interview survey

4. Conclusion

The 3D building model of the Sasanao factory was completed using commercially available UAV (Unmanned Aerial Vehicle). This model was then shown to the owner of the factory, who shared his impressions and thoughts. Unstructured interview survey based on direct interview with the owner was made. The owner was asked to narrate his own experience of the day of 2011 Great East Japan Earthquake and Tsunami including tsunami related information such as the maximum flow depth and arrival time. The recording of the owner's experience was then transcribed. In addition, a tsunami numerical simulation followed by a tsunami CG was created using the eyewitness's information of the owner. Both transcription and tsunami CG were shown to the owner to receive his feedback and carry out further corrections.

Digital data of such disaster remains can be utilized in various ways, such as publishing in a form that anyone can publicly view, creating a 3D movie in combination with the experience stage of the disaster, and reproducing the 360 degrees' view model. Although methods of digitalizing and preserving such precious disaster remains are still during a trial and error stage that reflected advancement of technology of that period. However, the cost is cheaper than maintenance cost of the real structures. Therefore, this work shows a good example of a modern way in digitalizing and preserving disaster remains to transfer disaster experience to future generations. Such method can be applied to some tsunami disaster remains such as electric generation ship in Banda Aceh and fishing boats and patrol boat in Thailand [9].

Tsunami numerical simulation was also performed to reproduce tsunami characteristics such as flow depth and arrival time at the whole Yuriage village and verified by testimony the eyewitness (owner of Sasanao Factory) such as tsunami trace at his factory and tsunami arrival time at the village. The numerical was also conducted to illustrate effectiveness of the reconstruction plan in the future.

The outcomes of the research were finally compiled and donated to the owner in the form of a written document and a digital model of the building in replacement of the ruin to be demolished. In addition, these archived contents (3D building model, transcription and tsunami CG) will be exhibited at a new disaster museum to be built by the city. In sum, this practical study demonstrates that the archiving of disaster remain can offer a compromise between those who wish to preserve disaster ruins, here the owner of the building, and those who want or need their destruction, here local government. We hope that this small experiment may give way to large project in Japan and beyond.

Reference

- [1] Sato S 2017 The Great East Japan Disaster-Present situation of disaster remains *Shinsai-gaku* **11** Tohoku Gakuin University 146-161
- [2] Reconstruction Agency 2013 Support for the preservation of disaster remains , http://www.reconstruction.go.jp/topics/m13/11/20131115_press_sinsaiikou.pdf
- [3] Sato S, Kawashi S, Imamura F 2018 The Establishing Process of Disaster Remains Affected by the 2011 Great East Japan Earthquake and Tsunami Disaster in Kesennuma City *Proceedings of the annual conference of the Institute of Social Safety Science* **7** 81-86

- [4] Okada, Y 1985 Surface deformation due to shear and tensile faults in a half-space. *Bull. Seismol. Soc. Am.* **75**, 1135–1154.
- [5] Imamura, F, Koshimura S, Murashima Y, Akita Y, Shintani Y 2012 The Tsunami Source Model of the 2011 Tohoku Earthquake (ver.1.2). Available online: http://www.tsunami.civil.tohoku.ac.jp/hokusai3/J/events/tohoku_2011/model/dcrc_ver1.2.pdf (accessed on 25 April 2012).
- [6] Imamura, F 1995 Review of tsunami simulation with a finite difference method. In Long-Wave Runup Models *World Scientific Pub Co Inc.* 25–42.
- [7] The 2011 Tohoku Earthquake Tsunami Joint Survey (TTJS) Group. 2011 Nationwide field survey of the 2011 off the Pacific coast of Tohoku earthquake tsunami. *J. Jpn. Soc. Civ. Eng.* **67**, 63–66.
- [8] Aida, I 1978 Reliability of a tsunami source model derived from fault parameters *J. Phys. Earth* **26**, 57-73.
- [9] Suppasri A, Goto K, Muhari A 2015 Ranasinghe, P., Riyaz, M., Affan, M., Mas, E., Yasuda, M. and Imamura, F A decade after the 2004 Indian Ocean tsunami - *The progress in disaster preparedness and future challenges in Indonesia*, Sri Lanka, Thailand and the Maldives, *Pure and Applied Geophysics*, **172(12)**, 3313-3341

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