



How can we communicate with people about variety of hazard simulation outputs? shaking and tsunami of Nankai trough earthquake

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Abstract

Researchers update theory and techniques for a hazard simulation continuously. Each researcher publishes his or her unique and original output of hazard simulation result. For scientific research, it is good. However, it is an issue in the practice of disaster reduction. Variety of hazard simulation output annoys practitioners about which scenario we should use for a base of disaster reduction planning? The risk management framework of ISO(ISO 31000) defined that the first step of risk management is "Establishing the Context". It means the goal of risk assessment should be selected before conducting risk assessment, or hazard simulation. Hazard simulation for the evacuation planning, designing sea wall, and pre-disaster recovery plan should be different. For evacuation planning, the worst-case scenario should be selected, and the high possibility scenario would be for the sea wall design.

This paper summarizes the things to be considered for hazard simulation from the category of disaster reduction countermeasure goals, such as saving human life, protecting property, and societal activities. Interviews to engineers, scientists, and disaster management practitioners are used for the base of discussion. And the hazard scenario setting method for a pre-disaster recovery planning, which is new trial in disaster management, would be introduced from the case study at the high tsunami risk area in Japan. The innovative way of hazard simulation mapping which simultaneously shows variety of hazard simulation output is used for the democratic hazard setting. In the new mapping system, almost 1,500 tsunami inundation simulation results, government hazard simulation, and historical tsunami inundation can be shown. People can use all the hazard simulation results for planning, and it works to realize the real meaning of hazard simulation. Same trials about earthquake shaking and damage are also introduced.

Keywords: Hazard Simulation, Risk Communication, Nankai Trough Earthquake, Land-use Planning



1. Introduction

Researchers continuously update theories and techniques for a hazard simulation. Each researcher publishes his or her unique and original output of hazard simulation result. For scientific research, it is good. However, it makes trouble in the practice of disaster reduction. Variety of hazard simulation output annoys practitioners. Which scenario should we use for a base of disaster reduction practices? Risk Assessment is the essential component of risk management. However, ISO risk management framework (ISO 31000) defines “Establishing the Context” as the first step of risk management. It means the goal of risk assessment should be decided before conducting risk assessment, or hazard simulation. Hazard simulation for the evacuation planning, the designing sea wall, the pre-disaster recovery plan should be different, because the goal or the things to be protected is different. For evacuation planning, the worst-case scenario should be selected, and the high possibility scenario for the sea wall design.

There exist many researches about risk assessment, hazard simulation and risk communication. There are many researches on risk communication by psychological perspective (Johnsna et.al., 2017). Uncertainty of natural phenomena, and how to accommodate those uncertainty is the research topic of natural science and engineering (Stein et.al., 2012, Goda et.al., 2016) There also exists research on the mapping of hazard simulation results (Dransch et.al., 2010). However, the research about planning or how to use that hazard simulation results very limited (Mualchin L, 1996), and there is no article dealing with hazard simulation for pre-disaster recovery planning.

This paper proposes the hazard setting method for the pre-disaster recovery planning. The things to be considered for a hazard simulation from the category of disaster reduction countermeasure goals, such as saving human life, protecting property, and societal activities are also summarized as a base of discussion. The innovative way of hazard simulation mapping which simultaneously shows variety of hazard simulation output is introduced. The new mapping system is used for pre-disaster recovery planning at the high-risk community of Nankai trough earthquake.

2. How should the simulation results be used?

2.1 Risk Management Framework

ISO3100 define the risk management framework (Fig.1). The process of risk management starts from “Establishing the Context”, then the risk assessment will be conducted. So that the goal or “how will the risk assessment results be used?” will be pre-fixed as the condition of risk assessment. The way of risk assessment will be different from that for tsunami evacuation for protecting human life, and the sea wall design for saving property. For tsunami evacuation, the worst-case scenario will be used, and the high safety rate of vulnerability setting should be selected. However, for the sea wall design, the high probability scenario will be selected. It means that the risk assessment and hazard simulation should be done reflecting the set “context” or the goal.

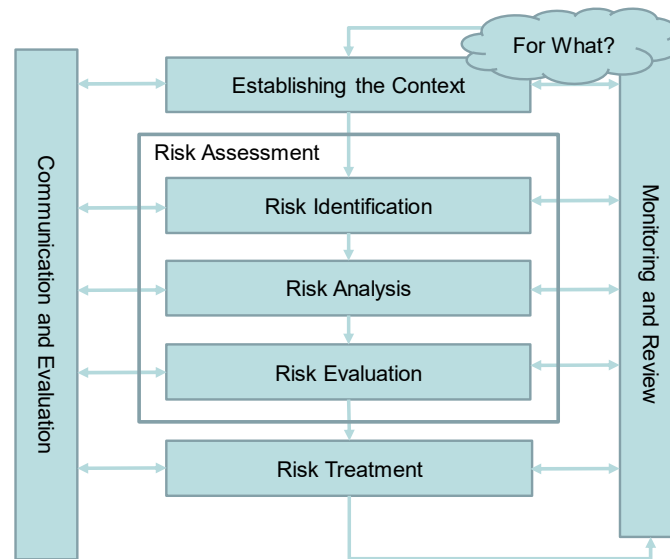


Fig. 1 – Risk management framework (ISO31000)

2.2 Criteria of tsunami hazard simulation

The relation between goals and hazard simulation criteria will be discussed targeting tsunami. Criteria of tsunami hazard simulation for “Risk Management” (Table 1) was summarized through discussions among specialists in academia, and interviews to the stakeholders, such as government engineers, engineering consultants, and risk management consultants.

There exist three goals in disaster management such as saving human life, protecting property, and sustainability of business and community. Criteria is summarized reflecting three goals. Then tools or countermeasures to accomplish each goal are listed. For example, evacuation drill, hazard map can work to save human life, and sea wall can protect properties such as housing and factories. Though sea wall can also work to protect human lives, the uniqueness of each tools is highlighted in the criteria (1. What shall we protect?).

Then the condition and output of hazard simulation for selected tools are clarified. To design evacuation tower, the condition of hazard simulation is the worst-case scenario with scientific proof, and the information about tsunami inundation area, depth, and arrival time is necessary (2. Possible damage and impact).

We can usually get several simulation results in the design process. So that the risk scenario for the design should be SELECTED. Risk management or design of tools for disaster management is the societal process, and the stakeholder should decide the expecting hazard scenario by themselves using scientific simulation results. Interviews to experts proves this selection process exists in all the disaster management activities. For the sea wall design, the stakeholder should decide the hazard scenario for sea wall considering the possibility and capability of acceptance (3. Risk scenario selection). And those countermeasures will be implemented, and used by stakeholders. Output of hazard simulation should be decided reflecting the audience of those information (3. Disaster Reduction). Table1 shows the criteria of tsunami hazard simulation.



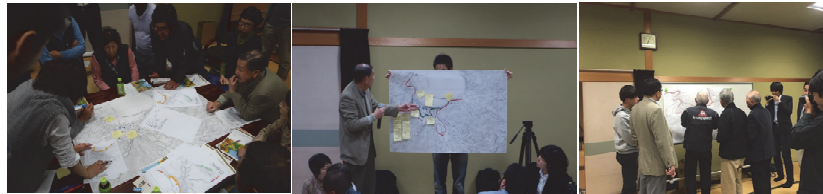
Table 1 –Criteria of Tsunami Hazard Simulation (Norio Maki, et.al., 2018)

1. What shall we protect?		2. Possible damage or impact		3. Risk Scenario selection		4. Disaster Reduction
goal	tools	Type of simulation	information	stakeholders	scenario	implementation
Human life	Evacuation, Evacuation site, Drill	Worst case scenario with scientific proof	Inundation area, arrival time	Government, and residents	—	Residents
	Evacuation tower		Inundation area, depth, arrival time	Government, and residents	—	Government, and residents
Properties (Human Life) (Business)	Sea wall	Hi possibility	Depth	Sea wall installing body	Possible scenario with consensus capability	Sea wall installing body
Business (Properties) (Human Life)	Insurance	All	Inundation area and depth with probability density	Insurance company	Probability density	Insurance company
	Land use, Pre-disaster Recovery	All	Inundation area, and building damage	Residents and business	Scenario with reaching consensus	Residents, business, and government

3. Democratic way of tsunami hazard setting for Pre-Disaster Recovery Planning

There is the standardized procedure of tsunami hazard setting for a hazard map and a sea wall design. However, the trial of pre-disaster recovery is new, and the process or criteria of tsunami simulation has not been established. The process of setting tsunami hazard for pre-disaster recovery planning is developed through the case study at the community which has the high tsunami risk, Ena community in Yura town, Wakayama Prefecture. The possibility of tsunami risk of the Nankai trough earthquake is 80% within 30 years, and the community will be hit by maximum 3-5 m height tsunami.

In the recovery planning, the most important thing to be considered is the consensus among stakeholders. Three step tsunami hazard setting process considering consensus building was tested (Fig.2). The first step of the trial is tsunami hazard selection through group discussion. Community member are divided into four groups consisting of 5-7 people, and each group select their own tsunami hazard scenario for pre-disaster recovery planning or land use planning. In addition to the tsunami inundation line for the pre-disaster recovery planning, we also asked them to write the tsunami inundation line of the hazard map for saving human life. The difference between line for saving human life, and recovery was recognized. As the tools for discussion, all the available information about tsunami hazards simulation such as the historical tsunami, the worst-case scenario for evacuation which is used for the hazard map, and the 1506 possible tsunami inundation (Fig.3). The map showing frequency of 2 m high tsunami which destroy buildings among the 1506 scenario was also provided.



Step 1 group discussion
Each group will set their own tsunami scenario using all the available data about tsunami

Step 2 Sharing Information
They explain why they selected their scenario.

Step 3 Voting
Community members vote to preferable tsunami scenario

Fig. 2 – Democratic tsunami hazard setting process for pre-disaster recovery planning

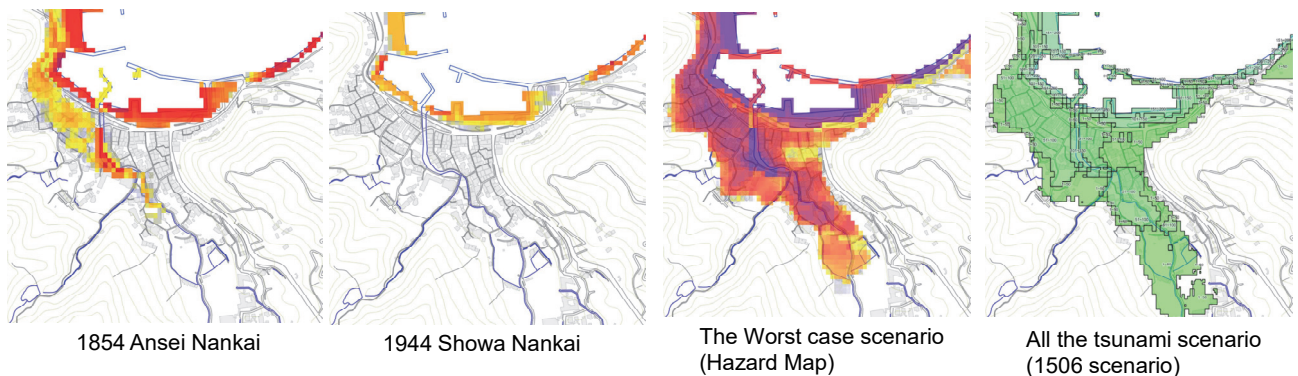


Fig. 3 – All the available tsunami simulation results

Second step of tsunami hazard setting is information sharing. Each group explains their selecting tsunami scenario, and why they selected their scenario. One group (Group 3) select the scenario same with the 1946 tsunami inundation, which also correspond to the inundation area of high storm surge. Two group (Group 1, 2) select the area of 50-100 frequency tsunami inundation, and Group 1 added the inundation from the river. One group (Group 4) did not select their scenario. They say that it is too difficult to set the scenario by community members.

Third step is voting. Community member individually selected their own scenario from the tsunami inundation are of group work. The voting is not for selecting one scenario, it is for understanding the trend of community members. Medium tsunami hazard scenario (Group 2) got seven votes, but the light (Group 3) and the large scenario (Group 1) also have some voting. So that one tsunami scenario for the pre-disaster recovery planning has not been fixed.

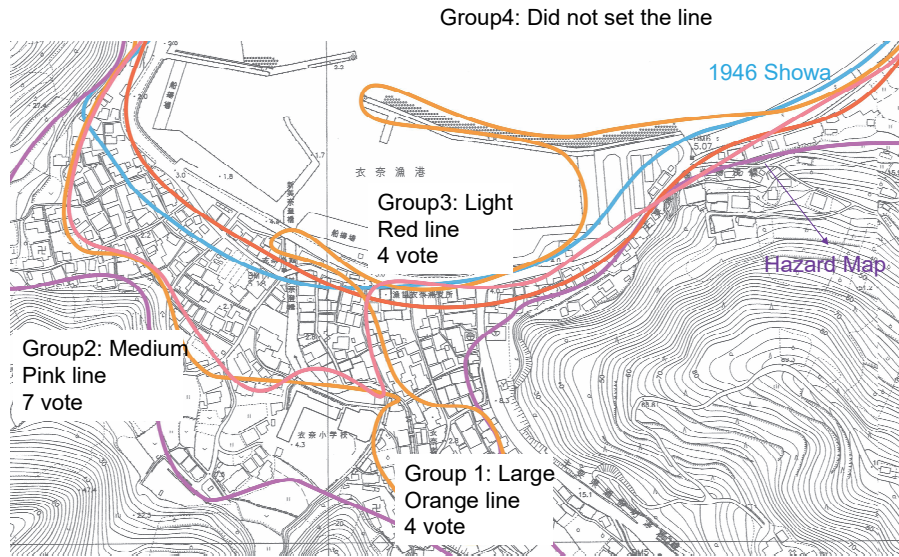


Fig. 4 – Output from group work and voting

4. Tools to support community hazard setting

Table 1 shows the criteria of tsunami hazard simulation. For insurance rating, the map showing the probability of tsunami hazard will be used, and for a hazard map, the worst-case scenario will be used. For the pre-disaster recovery planning, all the available tsunami simulation results should be shown on the map. Viewer for multi-tsunami simulation results were developed (Fig.5). This viewer can show all the possible tsunami inundation such as the historical tsunami (1707 Hoei, 1854 Ansei, 1946 Showa), 11 government simulation, and the 1506 simulation results, which conducted for the early tsunami warning in Wakayama prefecture. The 1506 simulation can sort by magnitude, depth of epicentre, and slip. And the frequency of tsunami inundation of 0.5 cm (evacuation), 2m (building damage) can also be shown.

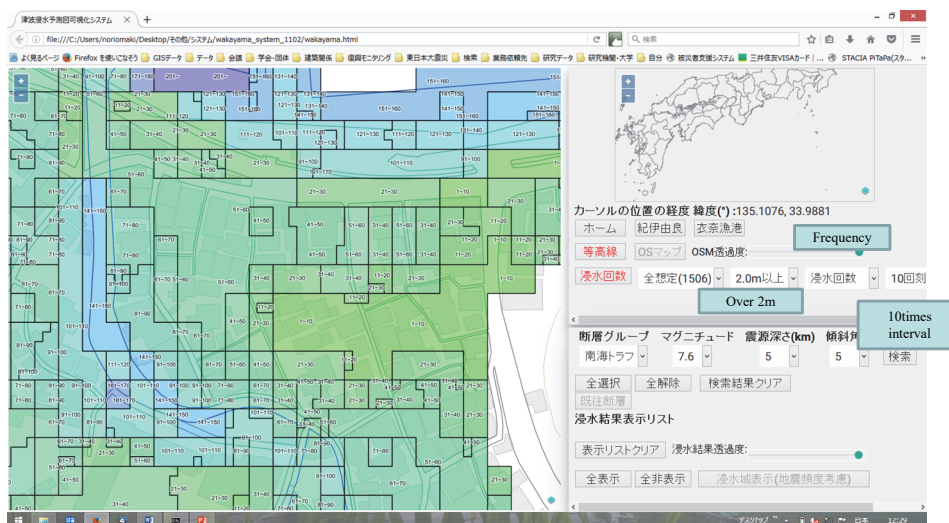


Fig. 5 – Multi-tsunami hazard simulation viewer



Same trials about earthquake shaking is also conducted. By combination of 6 earthquake source model with rating by experts, 5 GMEPs model, and three variances of amplification for probabilistic shallow surface amplification equation, the distribution of shaking intensity of each 250m mesh was calculated (Fig. 6)

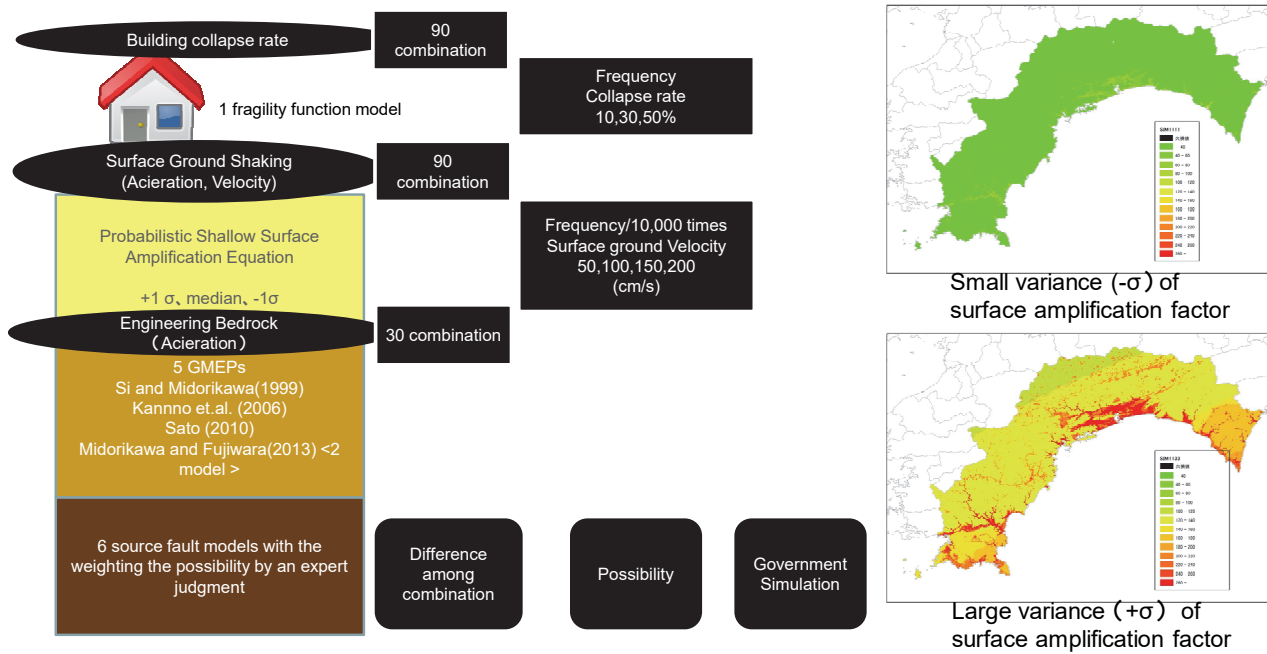


Fig. 6 – Concept of multi earthquake shaking simulation viewer

5. Discussion

Criteria of tsunami hazard simulation reflecting the goals of disaster reduction was summarized through the interviews to experts. The tsunami hazard setting method for pre-disaster recovery planning, which has not developed, was developed from the case study at the high tsunami risk community. Trial to set their own tsunami inundation scenario was conducted. People could select their original tsunami scenario to make their pre-disaster recovery planning. Through the setting process, people could understand the reality of tsunami simulation, and the meaning variety of simulation results. It is proved that the democratic way of hazard setting, people selecting their tsunami scenario by themselves, could work. However, this is just for the scenario for pre-disaster recovery planning targeting sustainability of community. The scenario relating to human life shall not be selected by community. It should be set by the experts and government. Based on the set goal or context of disaster reduction, the way of selecting hazard would be selected.

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