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Development of the knowledge-based disaster management system "BOSS" for Japanese standard system

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Abstract

This research developed the disaster response simulation system "BOSS" (BOSai System, Bosai means the disaster management in Japanese). To build the system, the standard response process for the local governments is defined. BOSS is developed based on the standard disaster response process. BOSS can show the total disaster process with database of historical disaster knowledge. About 500 processes are defined by the interview for staffs in Ishinomaki city in Miyagi prefecture where was heavily damaged by the 2011 Tohoku disaster. And the database of people, houses, industry, law, land etc. are defined the relationship to the disaster responses. In post disaster phase, BOSS can be used the simulation of disaster responses to show the critical path and bottle neck response according to different cases of input conditions. Then stakeholders can understand all disaster processes with priority, difficulty or level for the effective human resources management. For the verification of this system, the staffs of Ishinomaki city have used this system. The results show that the analyzed responses can clearly explain the role of each stakeholder in the emergency and recovery phase.

Keywords: disaster process, disaster standard process, information system, support municipalities, Ishinomaki city

1. Introduction

It is important to take effective and efficient responses for the national and local government during the emergency phase for the gigantic disaster such as the 2011 Great East Japan earthquake disaster in Japan. However both the national and local governments could not take effective responses and manage appropriate operations of the organizations for the unexpected scale of the disaster. One big reason is that the standard disaster management system had not developed in Japan. It means that as standard disaster response processes are not defined, stakeholders cannot understand their own roles during disasters.

Two main causes can be considered for no-existing Japanese standard disaster management system. First, although Japan has taken many kinds of disaster experiences for many years historically, the standard disaster process is not defined in Japan. Because there are a few research to define the total framework of disaster processes. Generally most research topics focus on the particular research field, the approaches to design the disaster framework is a few challenges. Second, all municipalities have prepared the disaster management plan/ manual, but this plan could not be used well for real disasters. Since this plan is constituted by huge documents, it is difficult to search the response process and roles of each member of municipalities during disasters. The role of each staffs is not stated clearly.

Over the whole Japan, as most local governments are small population (53% of local governments have less than 30,000 population), this small local governments have no enough budget and knowledge to define the disaster response processes in details, and to develop/ manage their original ICT system for supporting disaster responses.

Our research aims to develop a process based sustainable disaster/ emergency management system to accomplish the total disaster response cycle. A total disaster response cycle featuring measures as follows: pre-disaster damage prevention, damage reduction, disaster prediction, early warning and alert system, damage assessment, emergency response according to damage assessment, and smooth recovery/reconstruction. Current efforts by regions and organizations should be reviewed in terms of hard/software and disaster response, while different kinds of hazard and its levels (in terms of intensity, extension and frequency) should also be taken into consideration. Weak points in a region are analyzed after a regional survey. Extracted problems are improved under the limitations of time and budget. This process is the most effective and efficient way to solve the problems what they need to be in the future.

By following this system, problems will be solved accurately, improvements of extracted problems in regions made at ordinary times, alert will be heightened before urgent situation, damage precisely assessed after disaster, and damage response conducted appropriately according to the assessments. It realizes "seamless transfer from ordinary times to emergency situations".

This research defined the standard response process for the local governments and estimated the relationship between damage level and workload of necessary response. These model is developed as for IT disaster management system named BOSS (BOSai System, Bosai means the disaster management in Japanese, Business Operation Support System).

BOSS includes the 500 disaster response processes defined by the interview for staffs in Yabuki town of Fukushima prefecture and in Ishinomaki city of Miyagi prefecture where was heavily damaged by the 2011 Tohoku disaster. Their experiences can be applied to design the BOSS development. And the database of people, houses, industry, law, land etc. are defined the relationship to the disaster responses. In post disaster phase, BOSS can be used the simulation of disaster responses to show the critical path and bottle neck response according to different cases of input conditions. Then stakeholders can understand all disaster processes with priority, difficulty or level for the effective human resources management.

Therefore, BOSS has huge potential to apply small local governments with the past knowledge in Japan. Japan has suffered from many different kinds of natural disasters. And now the country has entered a seismically active period, damage mitigation is addressed as the major national issue.

2. Research flow

This research compose three steps: (1) Definition of the disaster response processes, (2) Evaluation of workload for each disaster responses, (3) Simulation of disaster responses.

(1) Definition of the disaster response processes
Necessary disaster response processes are defined based on the disaster management plan in this research for the initial conditions. All municipalities in Japan publish their own local disaster management plan even for the small size of local town or villages.

Disaster management plan states the overall items for disaster responses considering the local conditions. However, as all items are just abstracts and not including concrete contents, disaster responses processes are not concrete and difficult to understand the responses for each different stakeholder. It is also necessary to make a relationship among all responses such as dependent with the previous response or independent.

This research defined the relationship among disaster responses by flowchart and extracted 500 responses for the 45 categories such as evacuation, medical treatment, rescue operation, providing goods, processing of body, stability of life, temporary housing, vulnerable people, education, and so on. Next the order of responses is defined. For example, response B can start after completing of response A. In this case, response A is parent of response B (Fig. 1). All 500 responses are assigned those order and their parents. The starting time is controlled by the end of previous response. Namely after completing previous responses, next response can start. The effect of duration of disaster response is controlled by the response which needs long period or high workload as for the maximum period of responses. The potential critical responses are defined for controlling critical path. Fig.2 shows the 500 processes describing stakeholders in vertical axis and time phase in horizontal axis.

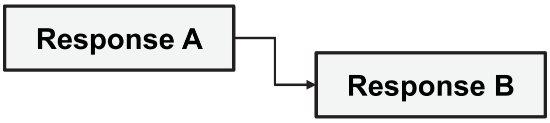


Fig.1 Response flow

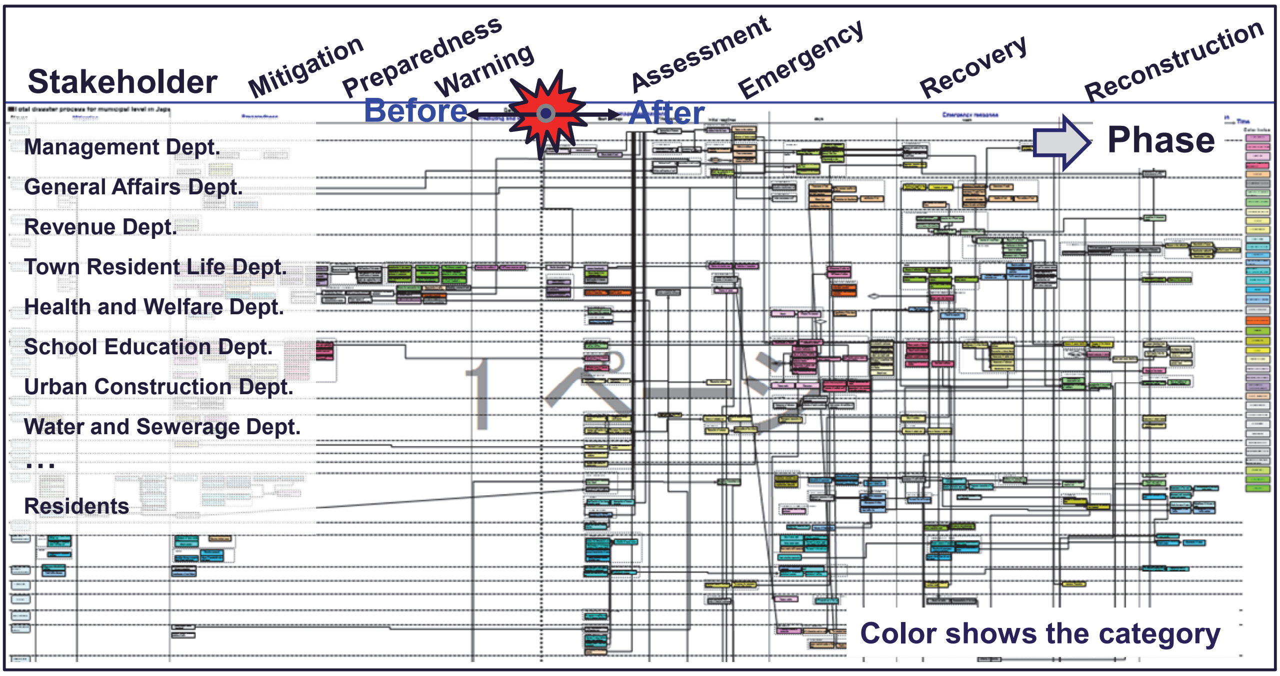


Fig.2 Response process map

(2) Evaluation of workload for each disaster responses

To develop the simulation model of the disaster response processes, the equations to evaluate the relationship between workload and disaster level is developed. To create this equation, the actual workload is calculated in the case of the 2011 Great East Japan Earthquake disaster in Ishinomaki city of Miyagi prefecture.

The relationship between the actual workload for each disaster responses and the damage level (number of collapsed building, number of evacuation people, number of dead body etc.) are analyzed by linear function (Fig.4). R describes workload and D shows the damage level, D is input for the calculation of workload.

The relationship between the actual response period *t* and damage level *d* is surveyed by questionnaire for the 222 municipalities where are damaged by the 2011 Great East Japan Earthquake disaster. The survey is conducted from 22th December 2014 to 15th January 2015 by FAX and e-mail. 45 municipalities answered to the survey. Table 1 shows the relationship between damage level and workload.

The survey asked the duration of each disaster categories for all municipalities not to ask workload for each disaster categories. Because all most all municipalities don't record the workload of each staffs during the disasters. Therefore, the workload cannot be obtained directory by the survey. To evaluate the workload q, the actual number of staffs who engaged in disaster responses is needed. For the 2011 Great East Japan Earthquake disaster, since it is difficult to record the number of staffs who responded to each disaster responses, this research surveyed the interview to around 60 staffs who engaged in the disaster to obtain the number of staffs for each disaster responses in Ishinomaki city (from 24th December, 2014 to 26th January 2015). To simulate the schedule of disaster response, as for input data, the number of staffs is needed besides Ishinomaki city. But it is difficult to obtain the number of staffs engaged in disaster responses for the 2011 Great East Japan Earthquake disaster in all related municipalities.

The number of staffs for all over municipalities in Japan is opened by the database of MIC (Ministry of Internal Affairs and Communications). This research applied the assumption that same rate of assigned number of staffs as the case in Ishinomaki city. The staff number can be evaluated according to the rate of Ishinomaki city case.

Fig.4 shows the relationship between damage level and workload for 4 categories as for samples out of all 34 categories. All 34 kind categories set these linear functions.

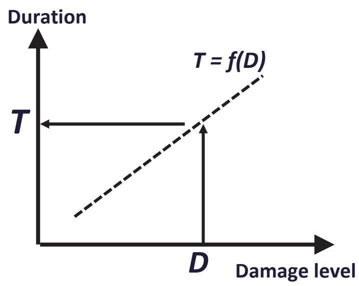


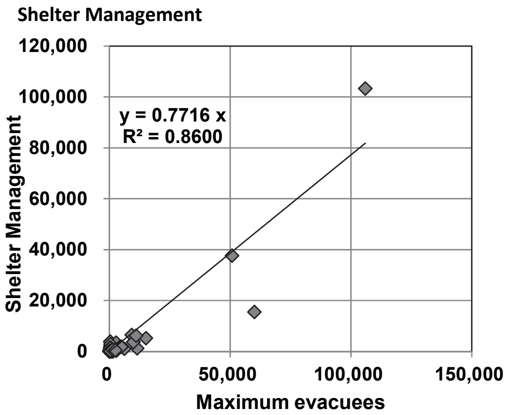
Fig.3 Response flow

The workload q for each disaster responses can be obtained by equation (1). *T* shows the duration of each disaster response. The *n* is the number of assigned staffs for each disaster responses.

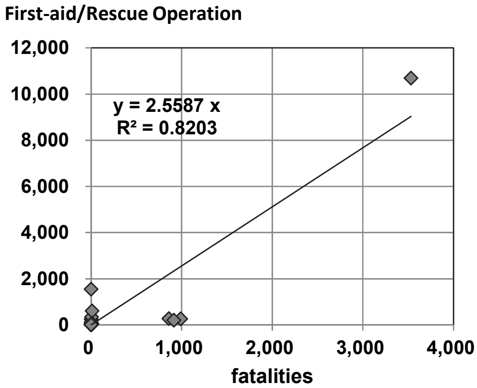
$$q = T \times n \quad (1)$$

Also, the workload q is obtained from the damage level d by the single regression analysis. The equation (2) shows the q as A of coefficient for workload for unit damage level.

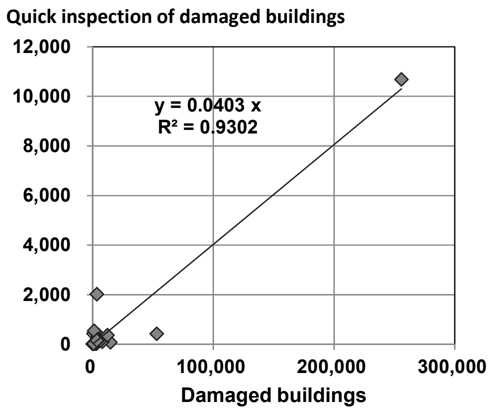
$$q = A \times d \quad (2)$$



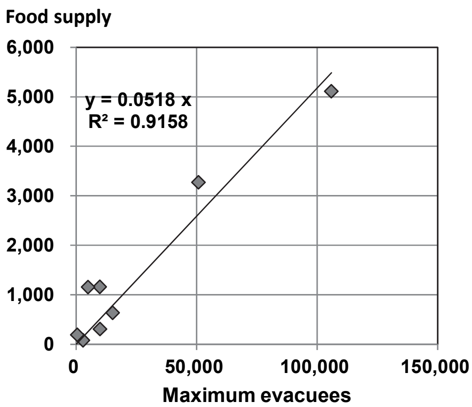
(a) Evacuation place



(b)Emergency rescue



(d) Building damage assessment



(c) Goods

Fig.4 Relationship between damage level and workload

Table 1 Relationship between damage level d and workload q

No	Workloads q_i	Amount of damages	Samples	A_i	R	P value
1	Shelter Management	Maximum evacuees	13	0.7739	0.9345	P <.01
2	First-aid/Rescue Operation	fatalities	19	2.559	0.915	P <.01
3	Medical/Relief activities	fatalities	17	2.403	0.5418	P <.05
4	Food supply/security	Maximum evacuees	8	0.05178	0.9762	P <.01
5	Searching missing person/Corpse treatment	Damaged buildings	8	1.165	0.727	P <.05
6	Postearthquake quick inspection of damaged buildings	Damaged buildings	22	0.0403	0.9682	P <.01
7	Damaged land and properties servey	Damaged buildings	24	1.808	0.323	P <.05
8	Building temporary houses	Damaged buildings	10	0.03941	0.7708	P <.01
9	Providing lease houses	Damaged buildings	7	0.7194	0.6305	0.0937
10	Setting /oparating welfare shelters	People in need of care	7	0.04391	0.6902	0.0582
11	School recover/restart	Damaged school facilities	28	18.12	0.5713	P <.01
12	Setting /oparating inquiry counter for after disaster	Damaged buildings	16	0.09235	0.5088	P <.05
13	Roads restoration	Damaged roads	20	29.39	0.7765	P <.01
14	Providing emergency transportations	Damaged roads	5	0.1028	0.4307	0.3939
15	Policing/trafic control	Damaged roads	11	2.804	0.4515	P <.05
16	Agricultural properties and facilities restoration	Damaged farm land and facilities	11	10.3	0.9133	P <.01
17	Waterworks restoration	Waterworks	18	1.026	0.7777	P <.01
18	Sewers restoration	Sewers	12	3.776	0.162	0.5975
19	Revers and costs restoration	Restoration of revers and costs protection	4	522.8	0.3464	0.5679
20	Public Facilities temporary repair	Public Facilities	19	28.38	0.5378	P <.05
21	First treatment for dangerous facilities	Dangerous goods storage facilities	3	0.4131	0.859	0.141
22	Disposal of disaster wastes	Disposal of disaster wastes	7	0.00495	0.159	0.7069
23	Removing obstacles	Disaster waste	13	0.0189	0.7951	P <.01
24	Disaster relief fund operation/breake down	Damaged buildings	3	0.1204	0.8082	0.1918
25	Managent of revenue, expenditures, and payment	Damaged buildings	7	0.01742	0.1949	0.6437
26	Reciving contribution	Damaged buildings	18	0.6599	0.5328	P <.05
27	Issuing Disaster public information magazine	Damaged buildings	17	0.05712	0.592	P <.01
28	Operation of Emergency Management Headquarters	Maximum evacuees	36	0.2242	0.6126	P <.01
29	Staff disposition	Maximum evacuees	25	0.6908	0.5292	P <.01
30	Receiving volunteers procedual	Volunteers	32	0.0418	0.6373	P <.01
31	Coordinate with voluntary organization for disaster prevention	voluntary organization for disaster prevention	12	5.171	0.832	P <.01
32	Opening Temporaly support staff window/ entrance procedure	Temporaly support staff	12	0.305	0.861	P <.01
33	Setting window for self - Defense Forces disaster relief mission	Accepted Self-Defense personnels	5	0.6207	0.969	P <.01
34	Process of confirmation and application Disaster Relief Law	Damaged buildings	15	0.1733	0.7621	P <.01

(3) Simulation of disaster responses

The equation of R and D is applied to the case of Ishinomaki city during the 2011 Great East Japan Earthquake disaster. Firstly, the workload is calculated and assigning staffs for each disaster responses, then the Gantt chart (Time-chart) is created to show the schedule. Fig. 5 shows the workload of each disaster category comparison with real and model calculations for Ishinomaki city. Developed model in this research can show the high accurate results to describe real behaviors. The workload of evacuation facility is highest due to the needs of human resources to manage the facilities. Fig. 6 shows the time-chart of each responses. The case of considering a workload to assign staffs is shorter than that of no consideration of workload to assign staffs. As staffs are assigned to the responses that need a lot of human resources, responses with many workload can be reduced the period of the responses.

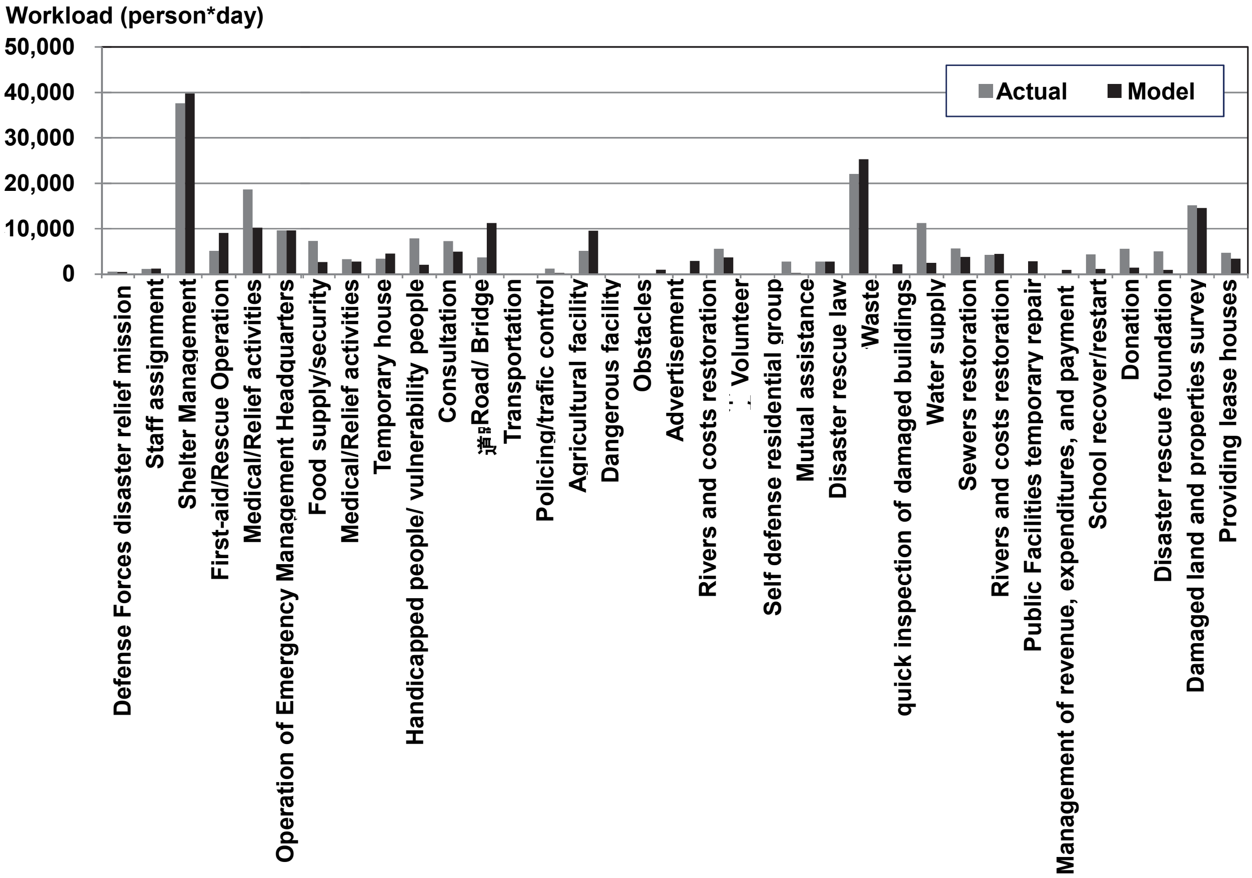
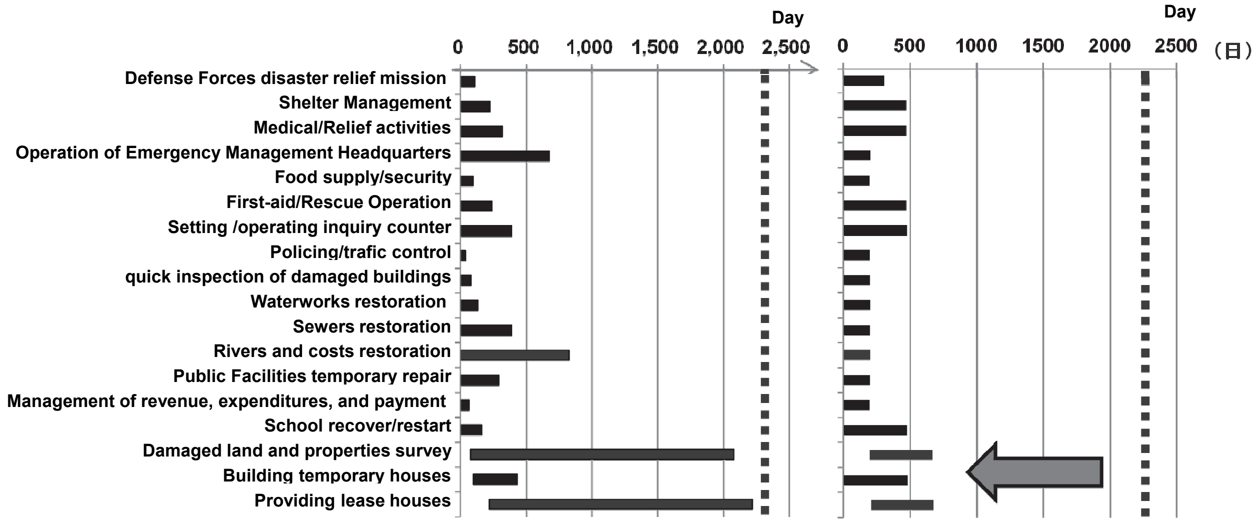


Fig. 5 Comparison actual workload and model



No-Considering workload to assign staffs Considering workload to assign staffs

Fig 6. Time-chart for effect with considering the workload

3. BOSS on WEB system

Developed model in this research is compiled on the web database as name of "BOSS (Bosai System)" (Fig. 7). Tsunami simulation, seismic motions and other monitoring data can be used as an input data for BOSS. Then, damage level is evaluated based on input hazard data. To evaluate hazard level, fragility functions are used. The researches for evaluating fragility function/ curve are historically approached (for example [1, 2]). Web-BOSS is used current fragility functions to evaluate damage level. Then, the workload can be evaluated based on the model relationship between damage level and workload. After assigning staffs for each response, the time line can be scheduled.

About 500 response processes are databased in BOSS. All processes are divided into four types.(1) the responses by everyone can work immediately after disaster such as such as management of the Volunteer Center etc., (2) the responses by government staff at first stage of disaster but gradually shifting to the other people such as food supply, water supply etc. (3) the responses by every government staff such as residents support, issuance of certificate, etc., (4) the responses by government staff with a special skills such as restoration of infrastructure and lifelines, health issues etc.

It is important to make a category for each disaster response according to these kinds of types in a regional disaster prevention plan. Then we can understand what kinds of disaster responses are necessary by staffs with special skills or without those, and manage the limited resources effectively.

The database of people, houses, industry, law, land etc. are defined the relationship to the disaster responses. In post disaster phase, BOSS can be used as simulation tool of disaster responses to show the critical path and bottle neck response according to different cases of input conditions. BOSS can show (1) Evaluation of amount of work (work load), (2) Effective distribution of human resources with skill level and work load and (3) Management of response schedule.

After the hazard level is estimated, the damage level is calculated by the hazard level. Then, the work load, time schedule of staffs and the flow of responses are shown by BOSS. Then stakeholders can understand all disaster processes with priority, difficulty or level for the effective human resources management.

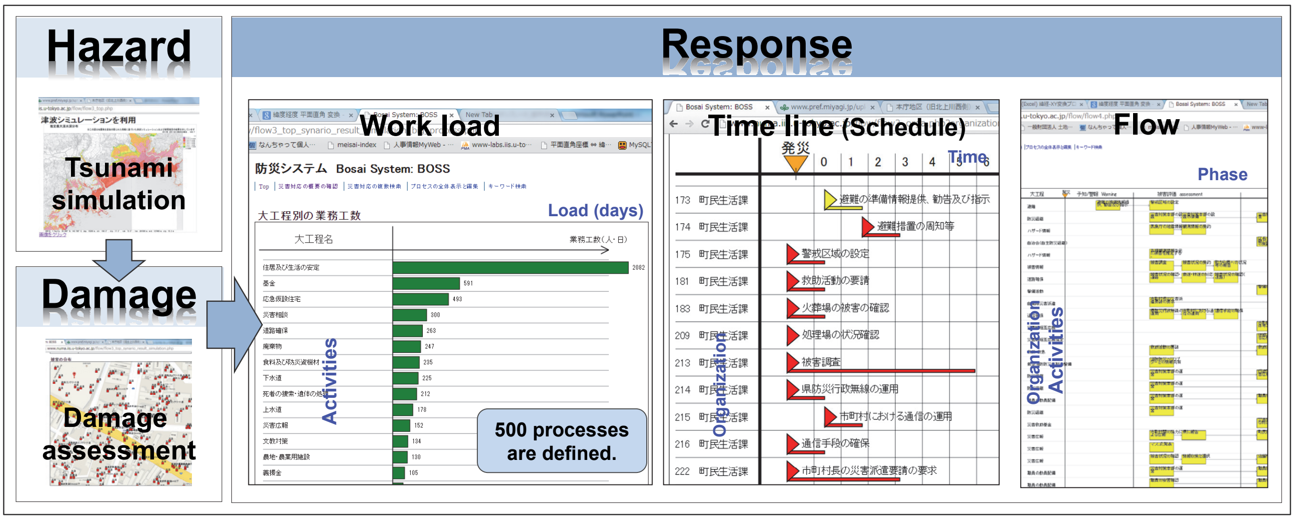


Fig. 7 Web based BOSS system

4. Conclusion

Our research aims to develop a “sustainable disaster/emergency management system” to accomplish the above-mentioned process. By following this system, problems will be sorted out accurately, improvements made at ordinary times, alert will be heightened before urgent danger, damage precisely assessed after disaster, and damage response conducted appropriately according to the assessments. It realizes “seamless transfer from ordinary times to emergency situations”.

This study analyze the patterning the kinds of disaster response, defining its flow and evaluating its amount of volume which are expected in advance to build effective the spatio-temporal disaster responses model. By understanding these operations for each different actors or players, it will be possible to carry out disaster responses4immediately under the condition of confused disaster phase.

Over the whole Japan, as most local governments are small population (53% of local governments have less than 30,000 population), this small local governments don’t have enough budget and knowledge to develop and manage their original IT system. Therefore, BOSS has huge potential to apply small local governments with the past knowledge in Japan.

5. References

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