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APPLICATION OF DEAGGREGATION OF SPATIAL PROBABILISTIC SEISMIC HAZARD FOR DISASTER PREPAREDNESS

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ABSTRACT: For regional disaster prevention, it is important to understand the area of occurrence of strong ground motion and its occurrence probability. The spatial probabilistic seismic hazard analysis (SPSHA) proposed by the authors can provide this information. In SPSHA, the results are expressed as a relation between the area where a given seismic intensity is generated and the exceedance probability. Results obtained from such a probabilistic approach include the effects of various seismic sources. Therefore, to efficiently describe an earthquake scenario for regional earthquake countermeasures, it is necessary to understand the impact of each earthquake source. In this study, we propose a seismic hazard deaggregation for SPSHA, and present a method for quantitatively understanding the earthquakes that affect the target region. As a practical application, SPSHA is conducted for Kanagawa prefecture in Japan. We conducted seismic hazard deaggregation for whole and sub-area, and discussed the differences in dominant earthquakes among areas and the use of such information in disaster prevention.

Keywords: PSHA, Seismic hazard deaggregation, Spatial Correlation, Disaster prevention plan

1. INTRODUCTION

In recent years, there have been several highly damaging earthquakes in Japan. There are concerns about the occurrence of megathrust earthquakes around areas such as the Nankai Trough and inland Tokyo. Hence, earthquake countermeasures are urgently needed. Local governments are considering advance measures such as emergency plans, emergency restorations at the time of disasters, and reconstruction plans for regional disaster prevention. To establish a regional disaster prevention plan, an earthquake damage assessment is conducted. This involves selecting earthquake scenarios that occurred in the area, and quantifying building damage, casualty, economic damage, and other factors. This is essential to make proposed preventive measures effective and specific.

In earthquake damage assessment, some target earthquakes are often selected after discussions by expert committees considering large earthquakes that occurred previously and seismically active areas around the target region. The outcome of the earthquake selection may depend on the knowledge and experience of the experts, or the situations considered by them. There are several considerations in selecting target earthquakes by local governments across the country, and there is no unified approach for the selection. Several authors have proposed that criteria for earthquake and earthquake scenario selection require an objective process base. [1,2]

Several studies have been conducted on the selection of target earthquakes in regional earthquake damage assessment. Okada et al. [3] explained that the uncertainty of target earthquake scenario setting affects the estimation of damages. Tomatsu et al. [4] proposed a method to select target earthquakes using analytic hierarchy process (AHP) based on estimated damages. These are based on a deterministic approach, and the earthquake scenario represented by the epicenter location and magnitude is easy to understand. Because few scenarios are targeted, unexpected earthquakes occur. Furthermore, if considering a whole area, appropriate target earthquakes are selected for the entire region. However, a high impact scenario for a specified sub-area may not be selected.

Alternatively, a probabilistic approach covers all earthquakes affecting a region comprehensively and is superior because it can consider the probability of occurrence of earthquakes and earthquake hazards simultaneously. Such Probabilistic Seismic Hazard Analysis (PSHA) have been studied for specific sites. We propose a method that extends PSHA to an entire area. Spatial Probabilistic Seismic Hazard Analysis (SPSHA) discussed in [5] is a method of calculating the relationship between the occurrence area of given ground motion intensity and its exceedance probability in the target area considering the correlation of spatial ground motions. In this method, the earthquake motion prediction equation is corrected following the earthquake observation records from the target area. However, because the result is given by the area of the seismic ground

motion and the occurrence probability, the image of earthquake scenario that generates the seismic hazard is difficult to identify.

In this study, to record results by SPSHA, we propose a method of deaggregation of seismic hazard by SPSHA and a method of selection of suitable target earthquake scenario for earthquake damage assessment in a region. Furthermore, we apply this method to Kanagawa Prefecture and discuss the application for regional disaster prevention.

2. OUTLINE OF SPSHA

In Spatial Probabilistic Seismic Hazard Analysis (SPSHA) proposed in [5], the probability $P(A > a; t, y)$ that area A (or area ratio) of the area exceeding the strong ground motion intensity y exceeds a in t years owing to earthquakes in a certain area is calculated by

$$\boldsymbol{P(A > a; t, y) = 1 - \prod_k \{1 - P_k(A > a; t, y)\}} \quad (1)$$

where, $\boldsymbol{P_k(A > a; t, y)}$ denotes the probability that area A (or area ratio) of the area exceeding the strong ground motion intensity $\boldsymbol{y}$ exceeds $\boldsymbol{a}$ in next $\boldsymbol{t}$ years owing to the $\boldsymbol{k}$-th earthquake. $\boldsymbol{P_k(A > a; t, y)}$ is given by Eq. (2) if the updating process is adopted for the $\boldsymbol{k}$-th earthquake occurrence probability, and Eq. (3) if the Poisson process is adopted.

$$\boldsymbol{P_k(A > a; t, y) = P(E_k; t) P(A > a; y | E_k)} \quad (2)$$

$$\boldsymbol{P_k(A > a; t, y) = 1 - exp\{-\nu(E_k) P(A > a: y | E_k) \cdot t\}} \quad (3)$$

where, $\boldsymbol{P(E_k; t)}$ is the occurrence probability of the $\boldsymbol{k}$-th earthquake in next $\boldsymbol{t}$ years, and $\boldsymbol{P(A > a; y | E_k)}$ is a conditional probability that the area $\boldsymbol{A}$ (or area ratio) of the area where the strong ground motion that exceeds the ground motion intensity $\boldsymbol{y}$ occurs exceeds $\boldsymbol{a}$, if the $\boldsymbol{k}$-th earthquake occurs.

We calculate the seismic ground motion distribution samples for the target area by Monte-Carlo simulation (MCS) using the Ground Motion Prediction Equation (GMPE) corrected by the earthquake observation records obtained in the target area and the spatial correlation model regressed from these data. The ground motion intensity at each site is treated probabilistically by the following equation considering the spatial correlation of the seismic intensity between sites.

$$\log(x_{ij}) = \hat{x}_j + \beta_i + \varepsilon_{ej}(0, \sigma_e) + \varepsilon_{cj}(0, \sigma_c) \quad (4)$$

The subscripts i and j represents a site and a sample number respectively. x is a ground motion intensity sample, $\hat{x}$ is a log median value of ground motion intensity calculated by the GMPE, and β_i is a site correction coefficient of the GMPE obtained from data analysis of earthquake observation records. $\varepsilon_{ej}(0, \sigma_e)$ and $\varepsilon_{cj}(0, \sigma_c)$ are random variables with an average 0 and a standard deviation of σ_e and σ_c, respectively.

σ_c represents inter-event variation and assumes common and perfect correlation at all sites. σ_c indicates intra-event variation and gives spatial correlation by the equation

$$\rho = exp(-\gamma \cdot z^{\delta}) \quad (5)$$

z is a separation distance (km) between two sites, ρ is a correlation coefficient, and γ and δ are regression constants obtained from data analysis of earthquake observation records.

β_i in Eq. (4) is calculated only at earthquake observation sites. Therefore, after sampling ground motion intensity at sites by Eq. (5), the ground motion intensity at the center points of the meshes obtained by spatially discretizing the target area are calculated by spatial interpolation using the simple kriging method.

The relationship between the area and the exceedance probability exceeding the given ground motion intensity y calculated from the above is hereinafter referred to as a seismic area hazard curve

3. EARTHQUAKE SCENARIO SELECTION BY SEISMIC HAZARD DEAGGREGATION

3.1 Deaggregation of the Seismic Area Hazard

Seismic hazard deaggregation in PSHA is a method to measure the contribution of each seismic source on the seismic hazard for a given exceedance probability. The deaggregation of seismic hazard at a specific site is shown by Kameda et al. [1] and McGuire [6]. The magnitude of the influence of each seismic source on the seismic hazard with a certain exceedance probability is expressed as the contribution index. Expected values of magnitude and source distance are derived from the results of hazard deaggregation to get the image of seismic source corresponding to the probabilistic seismic hazard. This is the expected target scenario for various damage assessment based on PSHA. In SPSHA, the target is the area, thus the source distance cannot be determined identically. Therefore, the degree of contribution is calculated as follows, and the earthquakes that affect the earthquake hazard are identified from the source model of PSHA.

STEP1: SPSHA for the target region

Conduct SPSHA for the target region to be evaluated and calculate the seismic area hazard curve. At the risk level $R(a; yt)$ where the area of the region exceeding the earthquake ground motion intensity y exceeds a for next t years, the exceedance probability $P\ (a; yt)$ is obtained.

STEP2: Contribution index for each seismic source

At the risk level $R(a; yt)$, the contribution index of each earthquake in the source model is calculated. The contribution index c_k of earthquake k to $R(a; yt)$ is defined by Eq. (6). c_k denotes the conditional probability that the event is earthquake k if the area of the region exceeding the seismic intensity y in the area exceeds a.

$$c_k\left(R_{a;yt}\right) = P_k(A > a; t, y)/\sum_k P_k(A > a; t, y) \quad (6)$$

3.2 Earthquake Scenario Selection by Seismic Area Hazard Deaggregation

Earthquakes in a source model used in SPSHA are partitioned into several groups relative to activity, area, and type. The contribution to the risk level $R(a; yt)$ is determined up by groups. From the group with the highest contribution value, the earthquake with the highest contribution rate is the representative scenario of the risk level $R(a; yt)$. If contribution indexes are similar among multiple groups, it is necessary to adopt representative scenarios from multiple groups. Thus, earthquakes that affect a region is selected by a probabilistic approach. Target earthquake scenarios for regional disaster prevention is then selected objectively for an optional probability.

4. APPLICATION

4.1 Conducting SPSHA

SPSHA conducted for Kanagawa Prefecture is shown in Fig. 3. There are six subareas in Kanagawa Prefecture based on administrative divisions. From Table 1, approximately 57% of the total population in the prefecture live in Yokohama City (A1) and Kawasaki City (A2).

From the proposed method, correction term of GMPE and spatial correlation model of ground motion intensity are set based on the earthquake observation records of K-NET/KiK-net in Kanagawa Prefecture and ground motion intensity is sampled at observation station sites. We perform surface interpolation of the ground motion intensity distribution of the target area by Simple Kriging method using ground motion intensity samples at observation sites. The target area is discretized into a mesh of about 1 km^2 and Peak ground velocity (PGV) on engineering bedrock at the center point of the mesh is estimated. Ground motion intensity distribution is calculated on a mesh of about 250 m^2. The earthquake source model, earthquake ground motion prediction equation on engineering bedrock, and shallow soil amplification factor are obtained from Japanese National Seismic Hazard Map by HERP [7,8]. Probability characteristics of ground motion intensity is sampled by MCS, considering perfect correlation for inter-event error and the spatial correlation for intra-event error for GMPE based on [5]. Standard deviation of inter-event variation and intra-event variation are 0.192, and 0.160, respectively. The number of earthquake ground motion distribution samples of each earthquake by MCS is 1,000 times. The area of a given ground motion intensity is summed up as seismic area hazard curve.

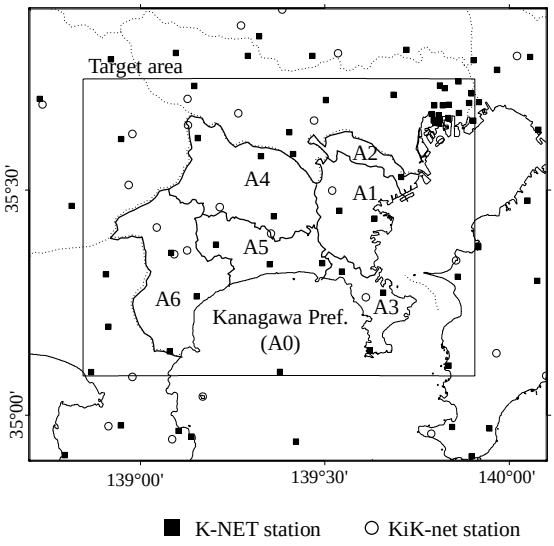

Fig.1 Target area for this study

Table 1 Areas and the populations (As of March 2019.)

Area	Cities	Area(km^2)	Population
A1	Yokohama	437	3.74 mil.
A2	Kawasaki	143	1.52 mil.
A3	Yokosuka, Kamakura, Zushi, Miura, Hayama	207	0.70 mil.
A4	Sagamihara, Atsugi, Kiyokawa, Yamato,Zama, Ebina, Ayase, Aikawa,	621	1.57 mil.
A5	Hiratsuka, Fujisawa, Oiso, Chigasaki, Hatano, Isehara, Aikawa, Ninomiya	372	1.31 mil.
A6	Odawara, Nakai, Oi, Hakone, Minami-Ashigara, Matsuda, Yamakita, Kaisei, Manazuru, Yugawara	635	0.34 mil.
Total	Kanagawa prefecture	2,416	9.18 mil.

The earthquake environment of Kanagawa Prefecture differs from the subareas. The Philippine Sea plate subducts toward the northern part of Tokyo Bay, and inter-plate and intra-plate earthquakes have occurred in this area. Furthermore, from the eastern part, the Pacific plate subducts to a

deeper place than the Philippine Sea plate, and this area is an active seismic source area. Additionally, in A3, A4, A5, and A6, there are active shallow crustal faults such as the Miura Peninsula fault zone with a relatively high probability of occurrence among active faults around Japan.

Table 2 lists the results of SPSHA for 50 cm/s or more and 100 cm/s or more of PGVs for the whole region and sub-regions in the prefecture. EP30 means the exceedance probability in the next 30 years.

Table 2 Area ratio corresponding to EP30 by SPSHA

PGV (cm/s)	Area	Area ratio				
		EP30 1%	EP30 3%	EP30 6%	EP30 14%	EP30 26%
50 or more	A0	0.76	0.65	0.57	0.45	0.34
	A1	0.93	0.83	0.73	0.57	0.42
	A2	0.94	0.90	0.78	0.67	0.57
	A3	0.92	0.80	0.66	0.44	0.27
	A4	0.81	0.62	0.52	0.38	0.27
	A5	0.94	0.88	0.82	0.72	0.59
	A6	0.82	0.68	0.59	0.46	0.30
100 or more	A0	0.35	0.25	0.18	0.11	0.06
	A1	0.53	0.36	0.27	0.17	0.09
	A2	0.64	0.54	0.50	0.38	0.21
	A3	0.41	0.23	0.14	0.05	0.02
	A4	0.34	0.23	0.16	0.09	0.05
	A5	0.66	0.52	0.41	0.25	0.13
	A6	0.33	0.20	0.13	0.06	0.02

EP30: Exceedance Probability in next 30 years

The area ratio indicates the ratio of the area where each ground motion occurs to the area of each region. Furthermore, Fig. 2 shows the seismic area hazard curve. The larger seismic hazard curves indicates that the region is prone to hazards and ground motion will be widespread. From recent earthquakes in Japan, it noted that a significant damages occurs when PGV exceeds 100 cm/s. So, we compare the seismic area hazard curves of PGV:100 cm/s or more. The seismic area hazard curves show that the whole region (A0) and A4 are equivalent. A1, A2, and A4 in the west of the prefecture have a high hazard of PGV 100 cm/s or more in a wide area compared to A0. Table 2 shows that strong ground motion occur more than twice when the PGV exceeds 50 cm/s, compared to the case of 100 cm/s or more. Table 2 shows that in any region, an area with a PGV of 50 cm/s or more is more than twice as large as an area of 100 cm/s or more, with the same EP30. If EP30 is 6% that is equivalent to about 1/475 of the annual occurrence frequency, the A2 area has the highest hazard, resulting in strong motions in excess of 100 cm/s in half of the A2 area.

In the case where EP30 is 1%, A5 area has the highest hazard. Seismic area hazard has different results depending on EP30. These are caused by differences in earthquake environments in each region.

3.3 Conducting Hazard Deaggregation

Seismic hazard deaggregation for the results of SPSHA in the previous section are conducted to record quantitatively the contribution of each seismic source for the seismic area hazard. If we deaggregate the seismic area hazard, it is necessary to set earthquake groups referring to the seismic source data of SPSHA. Earthquakes are first classified into two categories: the identified earthquakes and the unidentified earthquakes. The former is called the characteristic earthquakes and the latter is called the background earthquakes in PSHA. Next, they are classified into earthquakes associated with the plate subduction earthquake of Pacific plate, Philippine sea plate and inland crustal earthquakes. Characteristic earthquakes of the Philippine sea plate are further classified into M8 class earthquake around Sagami Trough (hereinafter called “Sagami Trough earthquake”) and M8 class Nankai Trough earthquakes (hereinafter called “Nankai Trough earthquake”). Characteristic earthquakes of the crustal inland faults are classified into major active faults and other active faults. Subclassification of background earthquakes includes inter-plate earthquakes, intra-plate earthquakes around the Pacific and Philippine sea plate, and crustal faults. However, from the long-term evaluation for the earthquakes around Sagami Trough [9] by HERP, the M7 class earthquakes owing to Philippine sea plate subduction (hereinafter called “Tokyo inland earthquake”) have about 70% chance for next 30 years. It has a huge impact on the target region, thus classified as an independent group. Tokyo inland earthquake is modeled as a background earthquake (area No.6/7) of the Philippine Sea plate in the Japanese National Seismic Hazard Map. Magnitude of these earthquake is M6.7 or higher.

Figure 3 shows the results of hazard deaggregation for seismic area hazard of 50 cm/s or more and 100 cm/s or more in area A0. The vertical and the horizontal axis represents the contribution of each earthquake group and the area ratio of Area A0 respectively. Figure 3 shows quantitatively the earthquake groups with greatest effect on the extent of strong ground motion. The lower part of the thick solid line indicates the contribution of the characteristic earthquakes and the upper part indicates the that of the background area earthquakes. Overall, the contribution of the characteristic earthquakes is larger than that of the background earthquakes, as the strong ground motion becomes wider. Therefore, if considering earthquake disaster prevention in a region, an earthquake scenario with strong ground motion

occurring in a narrow area is set as a hypothetical seismic source, and earthquakes scenario that generate strong ground motion in a wide area is selected from characteristic earthquakes.

Table 3 shows the result of deaggregation of seismic area hazard of EP30:6% for the entire area(A0) and sub-area (A1-6). The Nankai Trough earthquake (C11) with a contribution of 0.36 has the greatest impact on the risk of strong ground motion exceeding 100 cm/s in an area of 18% of A0 once every 475 years. The background earthquakes corresponding to the Tokyo inland earthquake are the intra-plate earthquake (B25) and the inter-plate earthquake (B26) with contributions are 0.16 and 0.35, respectively. The summed contribution is 0.51. This has greater impact on A0 than the Nankai Trough earthquake. Therefore, if selecting an earthquake scenario for A0, it is important to select the inter-plate and intra-plate type earthquakes of the Tokyo inland earthquake, and the Nankai Trough earthquake.

Figure 4 shows the relationship between the contribution of seismic sources and the extent of strong ground motion for each area shown in Fig. 3. From Fig. 4 and Table 3, the tendency of contributions varies with regions. From A1 to A5, the intra-plate earthquake (B26) of the Philippine sea plate has a large impact, from small to large area ratios. Because these are classified as background earthquakes where the epicenter cannot be identified, the earthquake damage scenario by placing the epicenter directly under the region must be considered in regional earthquake risk assessment for these areas. In A3, earthquakes owing to major active faults (C13) have major impacts. This area covers the Miura Peninsula Fault Zone considered to have a high probability of occurrence of earthquakes among active faults in Japan. Because the influence of this fault zone is significant for A3, it is important to understand the damage scenario caused by this fault. A4, A5 and A6 are located west of Kanagawa Prefecture and close to the Nankai Trough, thus are affected by the Nankai Trough Earthquake (C11). Especially in A6, the Nankai Trough earthquake has remarkable influence from a small area to a wide area. In risk assessment, it is expected to examine seismic hazards that considers the spread of such strong ground motion distributions caused by the Nankai Trough earthquake. In any area, as the area of strong ground motion becomes wider, the contribution of the Sagami Trough earthquake (C10) increases. In particular, A4 is most affected by the Sagami Trough earthquake. It is necessary to adopt it as a risk scenario for A4 and A0.

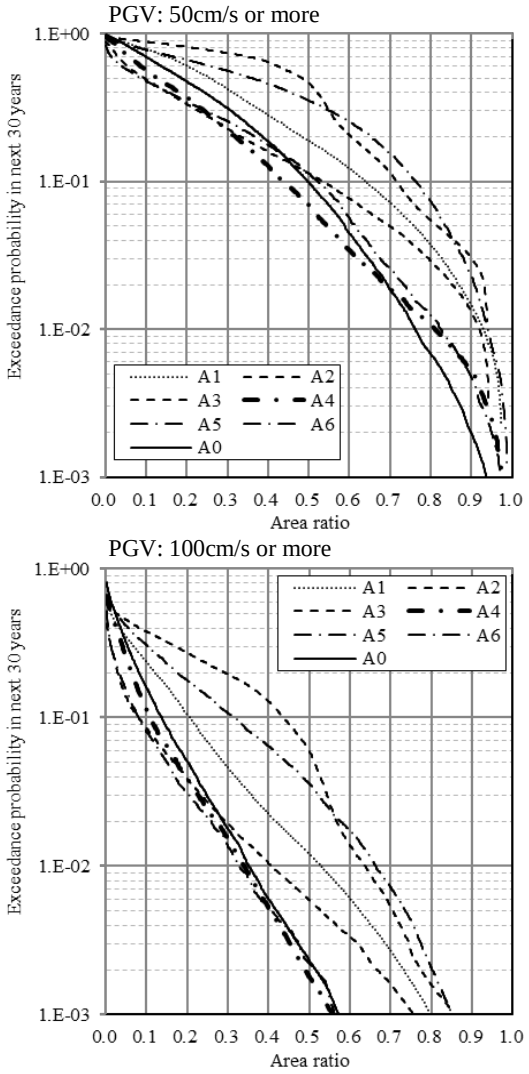

Fig.2 Seismic area hazard curves of each area

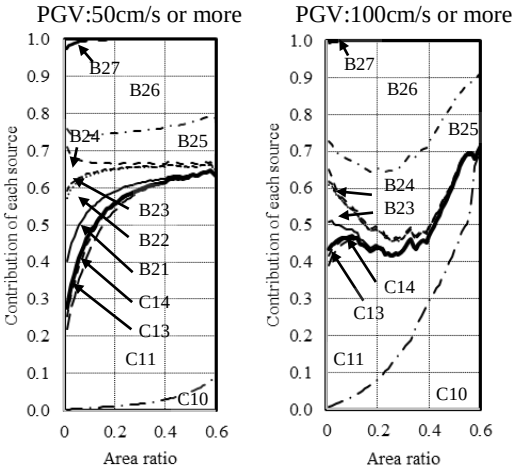

Fig.3 Results of hazard deaggregation of area A0

Table 3 Seismic area hazard deaggregation PGV:100cm/s, Exceedance Probability in next 30 years : 6%

Category	Class	Earthquake group	Group ID	Contribution for each source area						
				A0	A1	A2	A3	A4	A5	A6
Characteristic earthquakes	Philippine sea plate	Sagami Trough Earthquakes	C10	0.07	0.02	0.01	0.02	0.02	0.01	0.02
		Nankai Trough Earthquakes	C11	0.36	0.25	0.21	0.27	0.50	0.54	0.76
	Pacific plate	Specified Earthquakes	C12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Crustal faults	Major faults	C13	0.00	0.02	0.01	0.11	0.00	0.01	0.00
	Crustal faults	Other faults	C14	0.00	0.00	0.00	0.02	0.01	0.03	0.01
Background earthquakes	Pacific plate	Inter-plate earthquakes	B21	0.01	0.09	0.13	0.05	0.02	0.02	0.00
	Pacific plate	Intra-plate earthquakes	B22	0.04	0.14	0.18	0.09	0.05	0.04	0.00
	Philippine sea plate	Inter-plate earthquakes (Except area No.6/7)	B23	0.00	0.00	0.01	0.01	0.01	0.01	0.00
		Intra-plate earthquakes (Except area No.6/7)	B24	0.01	0.02	0.04	0.02	0.02	0.02	0.01
		Inter-plate earthquakes (Area No.6/7)	B25	0.16	0.11	0.09	0.10	0.09	0.08	0.05
		Intra-plate earthquakes (Area No.6/7)	B26	0.35	0.34	0.31	0.31	0.27	0.24	0.12
	Crustal faults	Unknown faults	B27	0.00	0.00	0.01	0.00	0.00	0.01	0.01

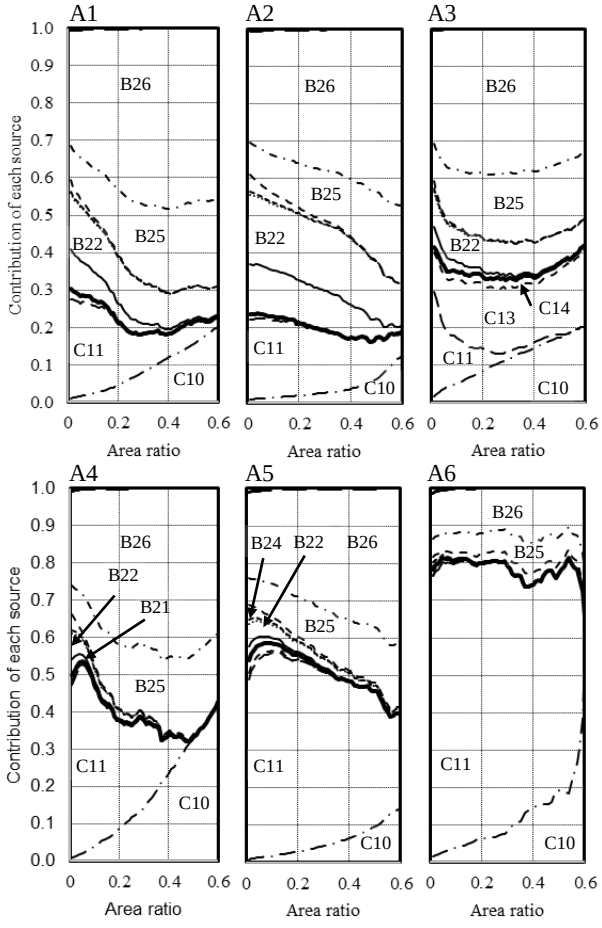

Fig.4 Results of hazard deaggregation of each area (Case of PGV 100 cm/s or more)

In the report of earthquake damage assessment of Kanagawa prefecture [10], the targets of characteristic earthquakes are follows: the Sagami Trough Earthquake, the Nankai Trough Earthquake, the Miura Peninsula Fault Zone Earthquake, and the Tokai Earthquake. Furthermore, it is assumed that there are M7 class earthquakes in the south of central Tokyo and in western Kanagawa prefecture, as earthquake scenarios of background earthquakes. From this study, although the target earthquakes selected by Kanagawa Prefecture are appropriate, it is noted that there are not enough earthquake scenarios that occur under these areas relative to damage scenarios for A1 and A2. Thus, this method is effective in the review of earthquake scenario selection in the target area.

5. CONCLUSIONS

In this study, a method of seismic area hazard deaggregation of SPSHA is proposed. Furthermore, from application to the region of Kanagawa Prefecture, utilization of the method in regional disaster prevention is discussed.

6. REFERENCES

[1] Kameda, H., Ishikawa, Y., Okumura, T., Nakajima, M.: Probabilistic Scenario Earthquakes. Definition and Engineering Applications, Transactions of the Japan Society of Civil Engineers. 1997, Vol.577 / I-41, 1997, pp. 75-87 (in Japanese)

[2] Ishikawa, Y., Okumura T.: Risk-based Determination of Scenario Earthquakes for Regional Disaster Mitigation, Journal of Social Safety Science, Vol.3, pp. 199-206, 2001. 11 (in Japanese)

[3] Okada, S., Tomatsu, M.: Regional Disaster Prevention Planning Guide Based on Seismic Risk Assessment for Earthquakes Occurring near Urban Districts, Journal of Structural and Construction Engineering (Transactions of AIJ), No.530, 2000., pp. 37-44 (in Japanese)

[4] Tomatsu, M., Okada., S.: Study on the Priority of Measuring against Scenario Earthquakes Based on Seismic Risk Estimation, Journal of Japan Association for Earthquake Engineering. 2011, Vol.11, No.2, 2011, pp. 1-19 (in Japanese)
[5] Hayashi, T., Yashiro, H.: Proposal of Spatial Probabilistic Seismic Hazard Analysis and the Application to the Disaster Prevention, Journal of Structural and Construction Engineering (Transactions of AIJ), 2019. (in Japanese)
[6] McGuire, R. K.: Probabilistic Seismic Hazard Analysis and Design Earthquake. Closing the Loop, Bulletin of the Seismological Society of America, Vol.85, No.5, 1995, pp. 1275-1284.
[7] The Headquarters for Earthquake Research Promotion: National Seismic Hazard Maps for Japan (2018 Edition), 2018. (in Japanese)
[8] National Research Institute for Earth Science and Disaster Resilience: Improved Seismic Hazard Assessment after the 2011. Great East Japan Earthquake, Technical Note of the National Research Institute for Earth Science and Disaster Resilience, No.399, 2015. (in Japanese)
[9] Hadquarters for Earthquake Research Promotion: Long Term Evaluation for the Earthquakes Around Sagami Trough (2nd Edition), 2014. (in Japanese)
[10] Kanagawa Prefecture: Report of Earthquake Damage Assessment in Kanagawa Prefecture, 2015. (in Japanese)