Damage Scenario and Its Reduction for Nishi-Chiba Chiba University due to Tokai, Tonankai, Nankai Earthquake and The Capital, Tokyo Inland Earthquake

Xiang Wen, & Takahashi Toru
Chiba University, Chiba City, Japan

Katada Masaki
Kyoto University, Kyoto, Japan

SUMMARY:
The occurrence possibility of the capital, Tokyo inland earthquake and Tokai, Tonankai, Nankai coupled earthquake has been discussed widely, especially since Pacific coastal Tohoku Earthquake took place in 2011. The location of Chiba University Nishi-Chiba campus would get a huge impact when the earthquake occurs. The campus stands on gathering area with great number of people, and as the wide-area evacuation space nearby, is facing heavy responsibilities for disaster prevention and mitigation. In this paper, the authors used 'scenario planning' research method, and analyzed the damage of institutions in Chiba University respectively. The authors evaluated the probability of buildings' damage states using their built year function. Casualties were estimated based on population in the campus. Life-line damage and its restore were also considered. As a result of these projects, some measures for the disaster prevention were suggested.

Keywords: earthquake, scenario, reduction

1. INTRODUCTION

This paper focuses on earthquake disaster scenario about Chiba University Nishi-Chiba campus, in order to find out the problems and dangerous point in campus when earthquake occurred, hope that this result of scenario could be taken as the effective reference to disaster prevention. Since the occurrence possibility of Tokyo inland earthquake and Tokai, Tonankai, Nankai coupled earthquake is very high, this paper selected those two types of earthquake as sample earthquake, estimating and calculating the damages of building, people, Life-line and so on.

2. THE METHOD OF EARTHQUAKE FORECAST

2.1. Tools and parameter

In this paper the authors selected scenario method to analyze seismic damage and casualties, Figure 2.1 shows a flow chart of the scenario based damage evaluation.

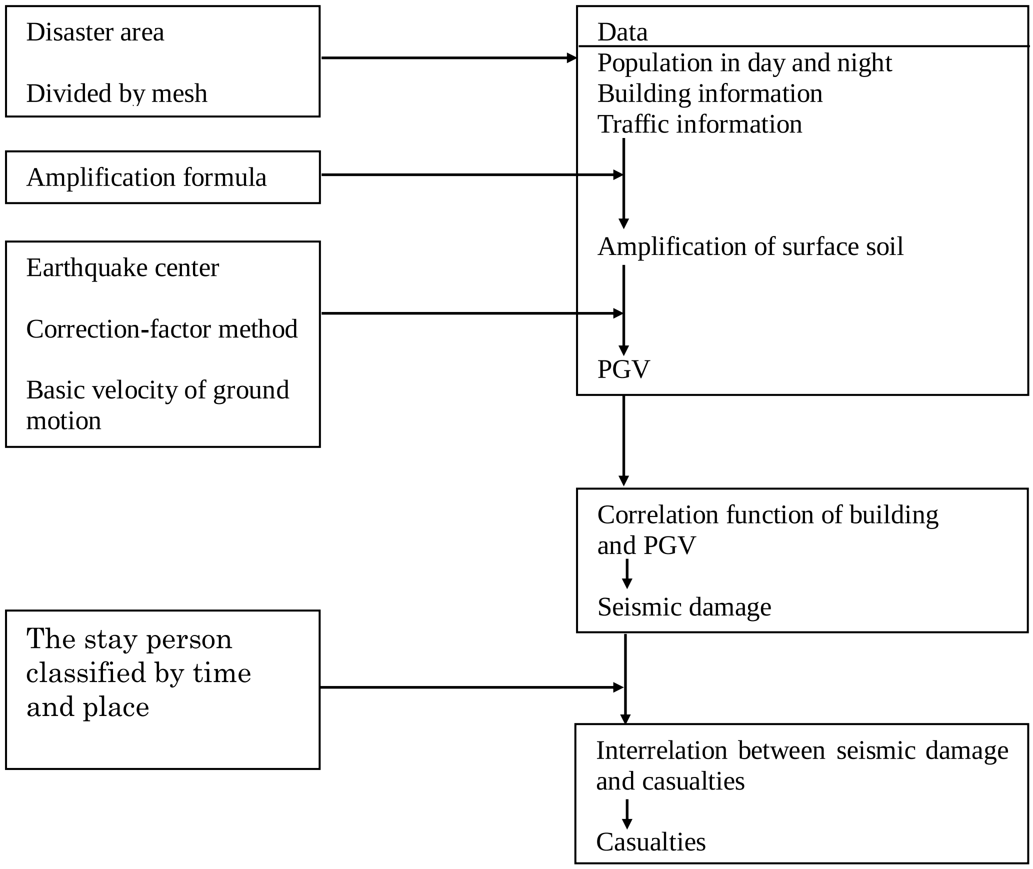


Fig. 2.1 The flow chart of scenario based damage evaluation

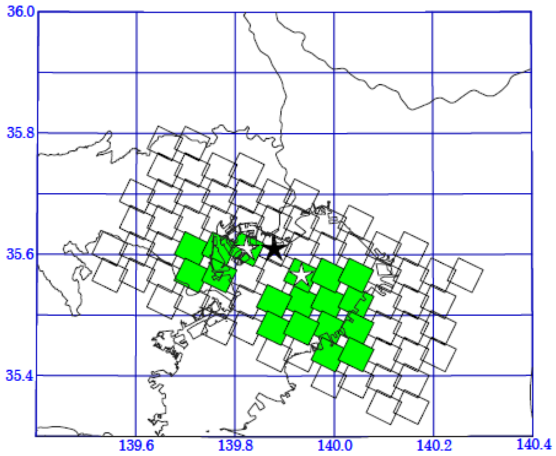
2.2. The hypothesis earthquake

2.2.2. Tokyo inland earthquake

About the Northern Tokyo bay earthquake, we selected the one of earthquake source fault model which be discussed by Cabinet Office Central Disaster Prevention Council (2004) that is the case where the east side of two asperity is large. Figure 2.2.2 shows the earthquake source fault model and its parameter.

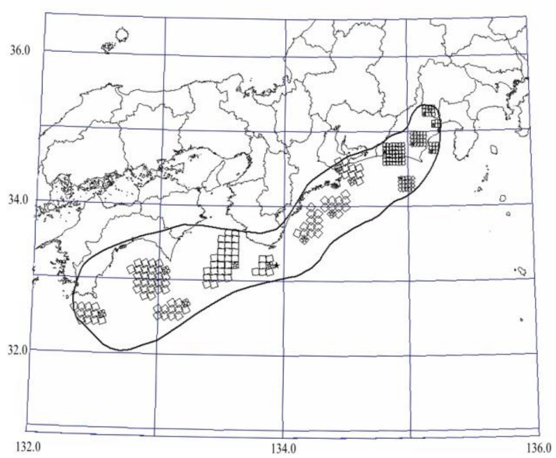
2.2.3. Tokai, Tonankai, Nankai coupled earthquake

About the Tokai, Tonankai, Nankai coupled earthquake, the authors selected the severe earthquake on the basis of Matsumura model that discussed by Cabinet Office Central Disaster Prevention Council the expert examination committee about the Tokai earthquake (1997). Figure 2.2.3 shows the earthquake source fault and its parameters.



Latitude (°)	35.32
Longitude (°)	140.14
Depth(km)	17
Length(km)	63.64
Width(km)	31.82
Strike(km)	296
Angle of inclination (°)	23
Magnitude	7.3

Figure 2.2.2. Tokyo inlande earthquake fault model and parameters (after Cabinet Office, 2004)



Latitude (°)	34.93
Longitude (°)	138.63
Depth(km)	10
Length(km)	88.2
Width(km)	47.2
Strike(km)	230
Angle of inclination (°)	12
Magnitude	8

Figure 2.2.3. Tokai, Tonankai, Nankai coupled earthquake fault model and parameters (after Cabinet Office, 2001)

3. THE RESULT OF SCENARIO

3.1. Earthquake motion

We calculated the Peak Ground Velocity (PGV) based on Effects of Distance Measures by Si and Midorikawa (Equation 3.1), and drawed the PGV figure by disaster damage assesment tool. The figure 3.1 shows the distributions of PGV based on the Tokyo inland earthquake and Tokai, Tonankai, Nankai coupled earthquake.

$$\log PGV = 0.58M_W + 0.0038D - 1.29 - \log(X + 0.0028 \times 10^{0.50M_W}) \qquad (3.1)$$

In this equation, PGV is Peak Ground Velocity, M_W is moment magnitude, D is depth of earthquake source, and X is Fault shortest distance.

Therefore we can understood the Seismic Intensity (JMA) of Nishi-Chiba campus regions is 6-upper in Tokyo inland earthquake and 5-upper in Tokai, Tonankai, Nankai coupled earthquake basically. And calculate the PGV of Nishi-Chiba campus regions. Table 3.1 shows the PGV in two types of earthquake.

Table 3.1. Data for Seismic Intensity (JMA) and PGV

	Tokyo inland earthquake	Tokai, Tonankai, Nankai coupled earthquake
Seismic Intensity (JMA)	6	5
PGV (m/s)	0.565	0.172

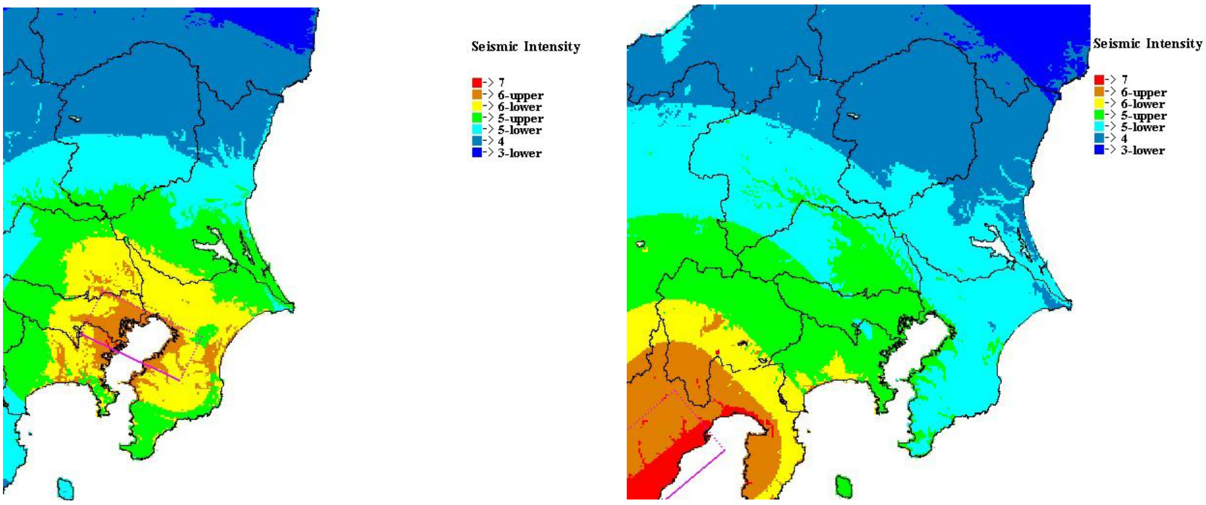


Fig 3.1. Distributions of PGV (left: Tokyo inland earthquake, right: Tokai, Tonankai, Nankai coupled earthquake, drawn by disaster damage assesment tool)

3.2. Seismic building damage

The seismic buiding damage is because of quake, Liquefaction and Steep slope collapse mainlly, but the loction of Chiba university is not the area of Liquefaction and Steep slop collapse spot in Hazard map that announced by Chiba city office. So this paper just discussed the damage because of quake.

3.2.1. The method of calculate building damage

The building damage is calculated by Damage Rate Curve, which describe the relationship between Peak Ground Velocity and Complete-Collapse Rate, Partial-Collapse Rate by Miyakoshi et al. (1998).

$$\mathrm{P(x)} = \Phi\{(\ln(\mathrm{x} - V_0) - \lambda)/\zeta\} \tag{3.2.1}$$

In this equation, P is damage rate, x is peak ground velocity, λ, ζ is Average value and Standard deviation of $\ln(\mathrm{x})$, V_0 is ground velocity that in the time of earthquake occurred. Table 3.2.1 shows the parameter of damage rate curve. Figure 3.2.1.1 shows the curve based vaule of these parameters .

Table 3.2.1. The parameter of damage rate curve (after Miyakoshi et al.(1998))

Structure	Built year	complete-collapse rate			partial-collapse rate		
		λ	ζ	R	λ	ζ	R
RC	-1971	5.16	0.849	0.961	4.58	1.015	0.935
	1972-1981	5.4	0.71	0.98	4.93	1.12	0.978
	1982-	5.58	0.551	0.983	5.36	0.897	0.924

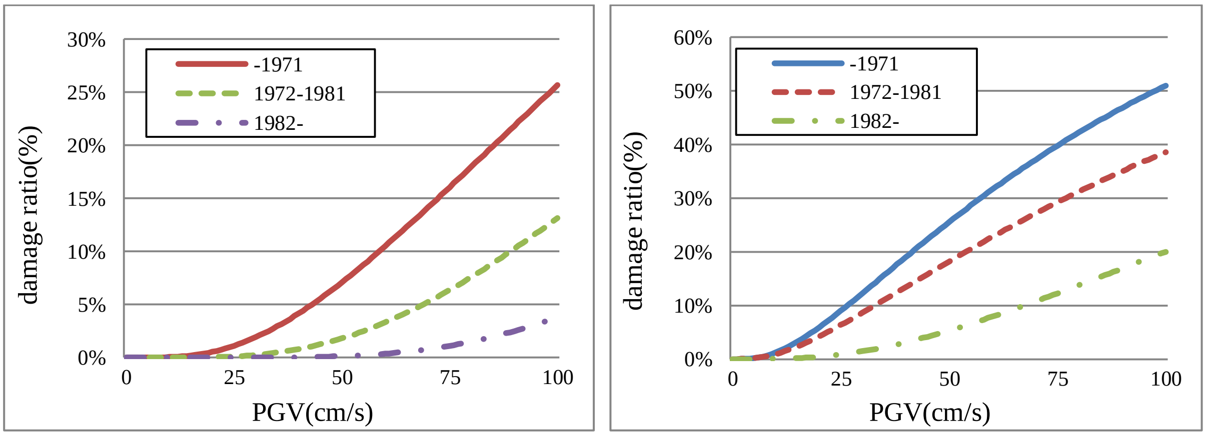


Figure 2.2.1.1. Damage rate curve (RC, Left: complete-collapse rate, Right: partial-collapse rate, after Miyakoshi et al. (1998))

Figure 3.2.1.2 shows the flow of discussion by using damage rate curve to evaluate building damage.

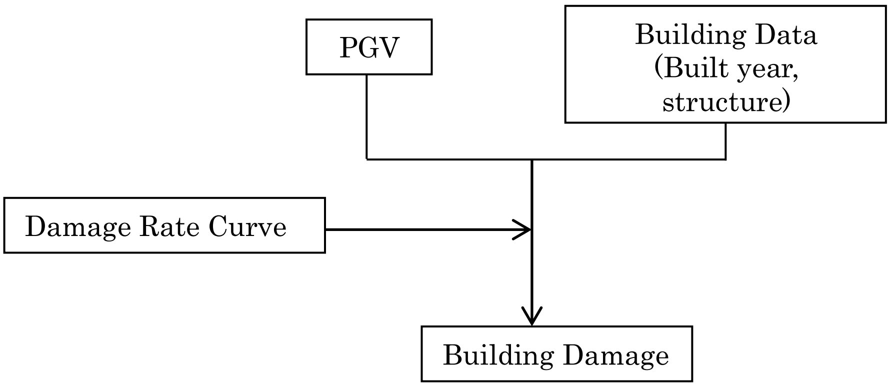


Figure 3.2.1.2. The flow of building damage discussion

3.2.2. Building data

The building data was got from Chiba University Campus Master Plan 2012, figure 3.2.2 shows built year distribution, and table 3.2.2 shows the building number based on parameter of damage rate curve.

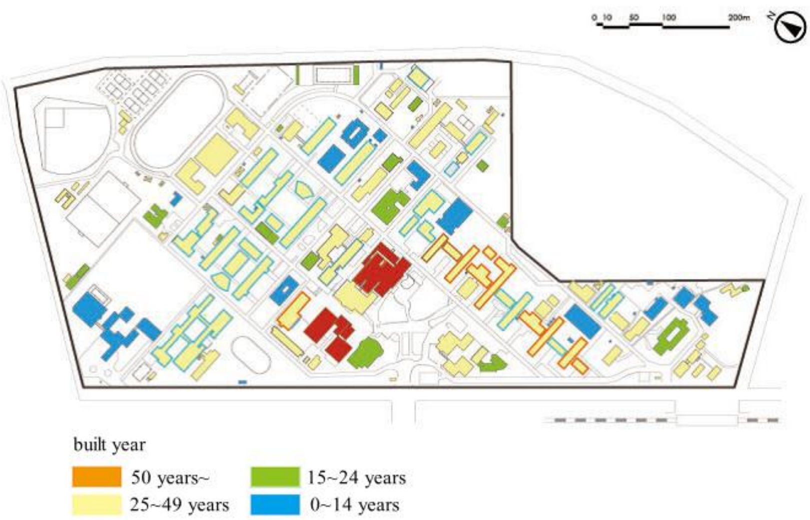


Figure 3.2.2. Campus built year map (after Chiba University Campus Master Plan 2012)

Table 3.2.2. Building number

	total	1972-1981	1982-
Building number	130	93	37

3.2.3 The result of building damage

Table 3.2.3 shows the building damage rate and number based on two tpyes of earthquake.

Table 3.2.3. Building damage

	PGV	Seismic Intensity(JMA)	complete-collapse rate (amount)		partial-collapse rate (amount)	
			1972-1981	1982-	1972-1981	1982-
Tokyo inland earthquake	56.54	6	3% (3)	0% (0)	21% (20)	7% (3)
Tokai, Tonankai, Nankai coupled earthquake	17.19	5	0% (0)	0% (0)	3% (3)	0% (0)

3.3. Seismic casualty

The casualty is calculated based on result of buiding damage. The population data of campus is got from Chiba University Campus Master Plan 2012, number of student staying in classroom is calculated by Percentage of attendance that based on questionnaire. The population of stuff and teacher is assumed that all the members are in their room.

3.3.1. The method of calculate casualty

The casualty that because of building damage is calculated by regression of casualty y about building damage x that presented by Saeki. Table 3.3.1 shows the regression.

Table 3.3.1. regression of casualty about building damage (after Saeki)

casualty y / building damage y	Death rate	Death + Hospitalization rate	Death + Serious injury	Death + Slight injure
Earthquake disaster Special Committees Low layer building complete-collapse rate	y=0.0233x (R=0.939)	y=0.0305x (R=0.946)	y=0.0495x (R=0.918)	y=0.0950x (R=0.304)

3.3.2. Population calculation

Table 3.3.2 shows the population of Chiba University Nishi-Chiba campus by affiliation and classification respectively.

Table 3.3.2. The population of campus (after Chiba University Campus Master Plan 2012)

The population by affiliation			The population by classification	
Letters, Law & Economics	3255		Undergraduate students	8476
Education	2648		Graduate students	2504
Science and Technology	1503		Post-graduate students	483
Engineering	5011		International students	825
Advanced Integration Science	521		Faculty	1034
Others	1934		Others	1450

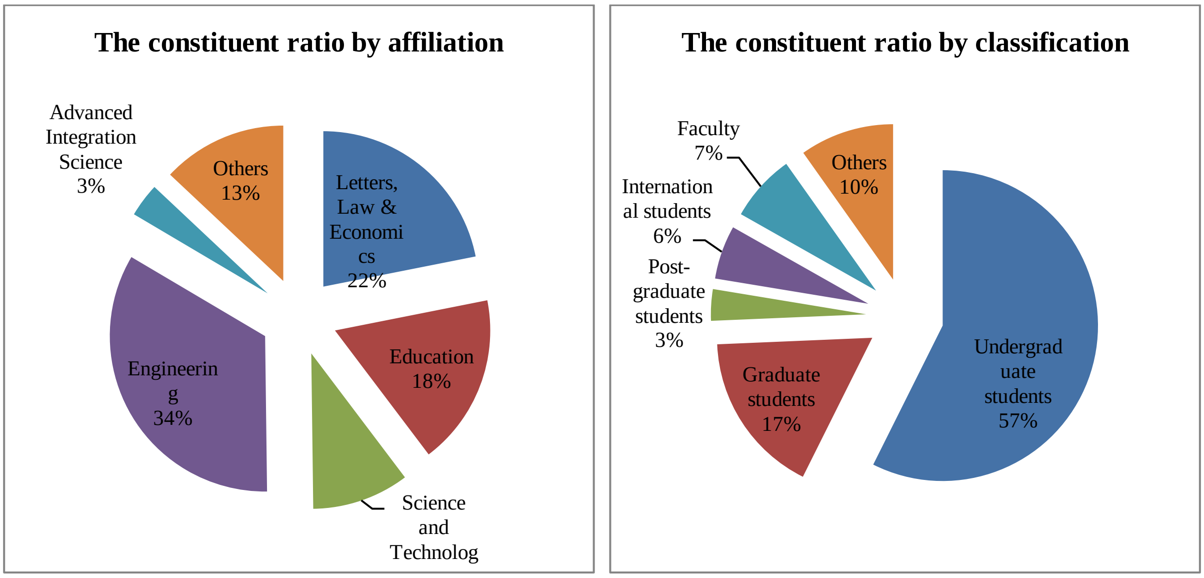


Figure 3.3.2. Population of Nishi-Chiba campus (after Chiba University Campus Master Plan 2012)

Figure 3.3.2 shows the constituent ratio of Chiba University Nishi-Chiba campus. While we understood that Tuesday morning (10:30) is regarded as the time period of maximum population in campus by investigation of courses, while midnight is regarded as the time period of minimum population in campus. So we discussed the casualty in these two time period. Table 3.3.2 shows the population of campus.

Table 3.3.2. Campus Population

	Total	Staying in the room(rate of staying in the room)
student number	11805	9845(83.4%)
faculty number	1134	1134(80%)

3.3.3. The result of casualty

Table 3.3.3 shows the result of casualty. at the moment of midnight, there is no people except guard, so we assumed that the casualty is 0 at midnight, in this paper we discussed the situation in Tuesday moring.

Table 3.3.3. The result of casualty based on built year (above: Tokyo inland earthquake, below: Tokai, Tonankai, Nankai coupled earthquake)

Built year / casualty	1972-1981	1982-
Death rate (Death number)	0.059% (6)	0.005% (1)
Death+Hospitalization rate (Death+Hospitalization number)	0.081% (9)	0.007% (1)
Death+Serious injury rate (Death+Serious injury number)	0.132% (14)	0.012% (1)
Death+Slight injure rate(Death+Slight injure number)	0.253% (27)	0.023% (2)

Built year / casualty	1972-1981	1982-
Death rate (Death number)	0% (0)	0% (0)
Death+Hospitalization rate (Death+Hospitalization number)	0% (0)	0% (0)
Death+Serious injury rate (Death+Serious injury number)	0% (0)	0% (0)
Death+Slight injure rate(Death+Slight injure number)	0% (0)	0% (0)

3.4. Life-line damage

3.4.1. Electric power damage

It is assumed that a power failure arises from telegraph pole damage, that telegragh pole damage is because of ground motion and building collapse. Telegraph pole damage rate use the preset vaule by Central Disaster Prevention Council.

Table 3.4.1. Relationship between Seismic Intensity and Telegraph pole damage rate (after Central Disaster Prevention Council)

Seismic Intensity (JMA)	Telegraph pole damage rate
7	0.800%
6-upper	0.056%
5-upper	0.00005%

So the power failure arises rate is 0.056% in Tokyo inland earthquake and 0.00005% in Tokai, Tonankai, Nankai coupled earthquake.

The restore days after the power failure arises are 6 days that is preseted by Central Disaster Prevention Council.

3.4.2. Gas service damage

Tokyo gas provides Nishi-Chiba campus' service, from its hompage we understanded that the service is stopped when Seismic Intensity is greater than 5, so the service is be stopped after earthquake whatever it is Tokyo inland earthquake or Tokai, Tonankai, Nankai coupled earthquake.

The restore days after gas service stopped is based on damage numbers, restore velocity and restore members.

3.4.3. Water service damage

Water pipe damage use the method that based on analysis of Hanshin, Awaji earthquake's water pipe damage data by Japan Water Works Association (1998).

$$R_s = \begin{cases} 0 & (V_{max} < 15cm/s) \\ 3.11 \times 10^{-3}(V_{max} - 15)^{1.30} & (V_{max} \geq 15cm/s) \end{cases} \qquad (3.4.3.1)$$

In this equation, R_s is standard damage rate, V_{max} is max ground velocity.
Water service stop rate by Kawakami's method.

$$R = \begin{cases} \frac{1}{1+0.0473\times X^{-1.61}} & \text{(immediately after)} \\ \frac{1}{1+0.3070\times X^{-1.17}} & \text{(1 day after)} \\ \frac{1}{1+0.3190\times X^{-1.18}} & \text{(2 days after)} \end{cases} \qquad (3.4.3.2)$$

By that method, we drawn the curve to describe the relationship btween peak ground velocity, water pipe damage and water service stop rate intuitively. Figure 3.4.3.1 and figure 3.4.3.2 show the water pipe damage and water service stop rate.

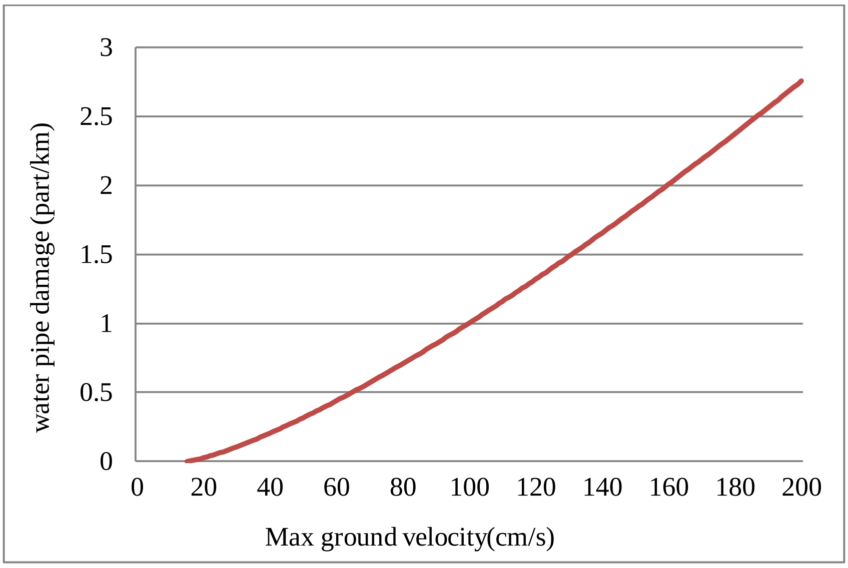


Figure 3.4.3.1. water pipe damage function (after Japan Water Works Association (1998))

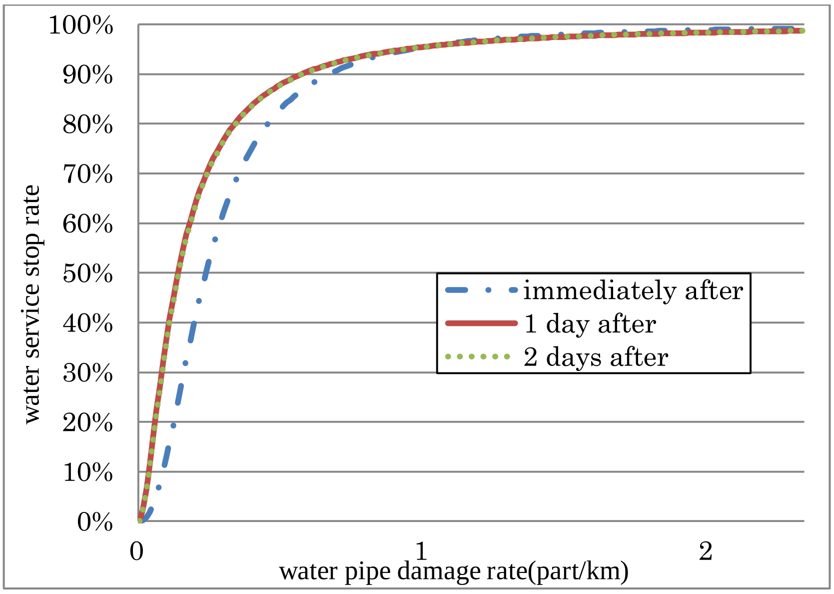


Figure 3.4.3.2. water service stop rate function (after Kawakami)

the water pipe damage and water service stop rate is calculated based on PGV of two types of earthquake, table 3.4.3 shows the result.

Table 3.4.3. The result of Tokyo inland earthquake and Tokai, Tonankai, Nankai coupled earthquake

	V_{max}	water pipe damage (part/km)	water service stop rate		
			immediately after	1 day after	2 days after
Tokyo inland earthquake	56.5	0.392	0.824	0.876	0.775
Tokai, Tonankai, Nankai coupled earthquake	17.1	0.008	0.008	0.067	0.785

4. CONCLUSION

This paper discussed Chiba University Nishi-Chiba campus seismic damage in two scenario earthquake types, Tokyo inland earthquake and Tokai, Tonankai, Nankai coupled earthquake.

Analyzed and discussed building damage, casualties, electric power damage, gas service damage and water service damage. From the results, the damage that because of Tokyo inland earthquake is more grievous than Tokai, Tonankai, Nankai coupled earthquake, therefore, in the future it should focus on the Tokyo inland earthquake, and take measures to prevention. from the figure 3.2.2, we understood the building which built before 1986 year and through more than 25 years is more than 60% of total area, and then the rate of these buildings' damage is higher than others, more serious hazard is exist. Therefore these buildings should be repaired for anti-earthquake.

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