Comprehehensive Urban Studies No.61 1996

Economic Impact of an Earthquake :
Estimation of the Amount of Direct Damage

Hitoshi Taniguchi*, Ayako Kanto**, Toshio Mochizuki*** and Yujiro Ogawa*

Abstract

The type and intensity of the effects of an earthquake disaster is influenced by the social and economic development patterns prevailing in the region. Thus, it becomes of particular relevance to evaluate the damage caused by such disasters from social and economic perspectives, that is, as part of the development process. Namely, it is important to collect and to analyze the amount of direct and indirect of socioeconomic damages caused by earthquakes for the enhancement of the seismic safety environment in the course of regional development. This study, first of all, develops an experimental equation for estimation of the total amount of direct damage caused by an earthquake in Japan. The evaluation of direct economic loss by the experimental equation is carried out through the use of statistical data " MINRYOKU" which is a database of an accumulated social and economical information in each prefectures and/or cities.

1. Introduction

The total amount of direct damage incurred on Hyogo Prefecture by the Great Hanshin-Awaji earthquake was approximately 10 trillion yen (100 billion US$). This resulted in a big economic crisis as far as reconstruction was concerned. Because of this, the problem of economic management after a disaster again came to focus in regional disaster prevention planning. However, the approach from an economic point of view, was omitted in the initial draft of the regional disaster plan.

*United Nations Centre for Regional Development
**Graduate Student, Tokyo Metropolitan University
***Center for Urban Studies, Tokyo Metropolitan University

This study is based on the background mentioned above and tries to develop an estimation method of direct and indirect economic loss. This first paper focuses on the development of a method for estimating the economic direct loss based on the statistical data of previous earthquake in Japan.

2. Fundamental policy of economic damage estimation

If we define the total amount of economic damage as Yi,k,t, the amount of direct damage as $Y_C i,k,t$ and that of indirect damage as $Y_D i,k,t$, then we can write the formula below.

$$Yi,k,t=\sum_{i=1}^{l}\sum_{k=1}^{m}\sum_{t=1}^{n}\left(Y_C i,k,t+Y_D i,k,t\right) \qquad (1)$$

Here, i shows the administrative unit of the city, towns and villages, and k is the damaged components such as buildings, commercial and industrial damages, and t is a time until the spread out of earthquake damage. Although, for, t, which is the time for the occurrence of direct damage, three days would be enough even considering earthquake fire damage, the time period for the occurrence of indirect damage, t, should be considered for several years depending on the intensity of direct amount of damage. Most of the previous damage statistics were collected only considering direct damage as Y_C.

The direct damage, Y_C, can be expressed as the product of seismic hazard and vulnerability. The total amount of direct damage, $Y_C i,k,t$, is shown in the following formula.

$$Y_C i,k,t=\sum_{i=1}^{l}\sum_{K=1}^{m}\left(N_E i\times S_E i,k\right) \qquad (2)$$

Here, $N_E i$ shows the seismic hazard as seismic intensity and the natural environmental condition (topography/geological feature), $S_E i,k$ is the social vulnerability in the damaged region, i. In the same way, if the amount of indirect damage, $Y_D i,k,t$, is expressed as a function of the direct damage, $Y_C i,k,t$, socioeconomic structure of damaged region, $E_E i,k$, and time taken for reconstruction of physical damages, Ti,k, then we arrive in the following formula.

$$Y_D i,k,t=\int\left(Y_C i,k,t,\ E_E i,k,\ Ti,k\right) \qquad (3)$$

Here socioeconomic structure refers to the economic structure thought from the social characteristics of a region such as the ratio of 1st. to 3rd. industries, households, population and other indicators of the region. Time taken for reconstruction is the variable factor by the direct damage loss, damage items, and revival cost.

By keeping the above-mentioned fundamental general idea in mind and analyzing the previous earthquake damages after the 1964 Niigata Earthquake, an experimental equation of economic loss was proposed relating to the direct damage. This analysis was done by the unit of a prefecture or the damaged region where the seismic intensity is over 5.

3. Statistical analysis of previous earthquake damage

The amount of the direct damage caused by earthquakes after 1960 was collected as an object of statistical analysis. We have selected several earthquakes of which damages were of various kinds of damage occurrence under the natural environment and with different types of damages. The typical damage characteristics from previous earthquakes is listed in Table 1. Eleven earthquakes were analyzed to get the important damage items after the Niigata Earthquake in 1964 in areas where the maximum seismic intensity was more than 5 in the Japan Meteorological Agency (JMA) Scale. The damage characteristics may be divided into three types on the basis of the detailed earthquake disaster such as ***"Urban Seismic Disaster"***, ***"Local City Disaster"*** *and* ***"Hilly and Waterfront District Disaster"*** .

Table 1 Summarized earthquake disaster aspects and characteristics of the damage

No.	Earthquake	Seismic Intensity	Geography Geology	Damaged region	Damage item and Characteristics
1	1964 Niigata	5	Plain (sandy layer)	Local city	Liquefaction, Collapsed bridge, houses. Ground destruction
2	1968 Tokachi-Oki	5	Plain (volcanic ash)	Local city	Reclaimed ground
3	1974 Izu-Hanto	5	Mountain	Village	Destruction of steep slope, fill-up ground. Hilly region disaster
4	1978 Izu-Ohsima	6	Mountain	Village	Steep lope, land slide Transportation Hilly region disaster
5	1978 Miyagi-KenOki	5	Plain (alluvium)	Urban city	Lifeline, reclaim ground Information panic, Urban disaster
6	1982 Urakawa-Oki	6	Hilly, Slope	Local city	Bridge, Steep slope, Transportation Local city disaster
7	1983 Nihonkai-Chub	5	Plain (sandy layer) Waterfront	Local city Fishing Village	Tsunami, Liquefaction, Local city disaster
8	1984 Nagano-Seibu	5	Mountain (volcanic rock and ash)	Village in mountain	Transportation, land slide, steep slope Mt.Village disaster
9	1993 Kusiro-Oki	6	Hilly, Slope	Local city	Collapsed building, Ligeline, Transportation. Local city disaster
10	1993 Hokkaido-Nans	6	Hilly, Waterfront	Fishing Village	Tsunami, Fire, Strong motion, Tsunami Dis
11	1995 Hyogo-Nanbu	7	Plain, Waterfront	Megalopolis	Strong motion, Lifeline, Collapsed building, Fire Transportation, Loss of lives

On the other hand, seven earthquakes in Table 1 were selected for the statistical analysis of an amount of direct damage, and epicenters and influenced areas caused by these earthquakes were shown in Figure 1. In Figure 1, symbol ★ shows a location of epicenter and symbol ○ shows a damaged area which seismic intensity is more than 5. The numbers in the figure corresponded to the earthquake number in Table 1. Figures 2 to 7 shows a proportion of the total amount of direct damage to various kinds of damage items such as Agriculture, Fisheries, Forestry and Public facilities and so on. As shown in Figures 2 to 7, the proportion of amount of each damage items to the total amount of damage is clearly understood with the varying proportions of damages among the three earthquakes, namely, the 1964 Niigata eq, the 1978 Miyagi-ken Oki eq, the 1983 Nihonkai-Chubu eq, the 1984 Nagano-ken Seibu eq, the 1993 Kusiro-Oki eq, the 1993 Hokkaido-Nansei Oki eq and the 1995 Hyogo-ken Nanbu (Hanshin-Awaji) earthquake.

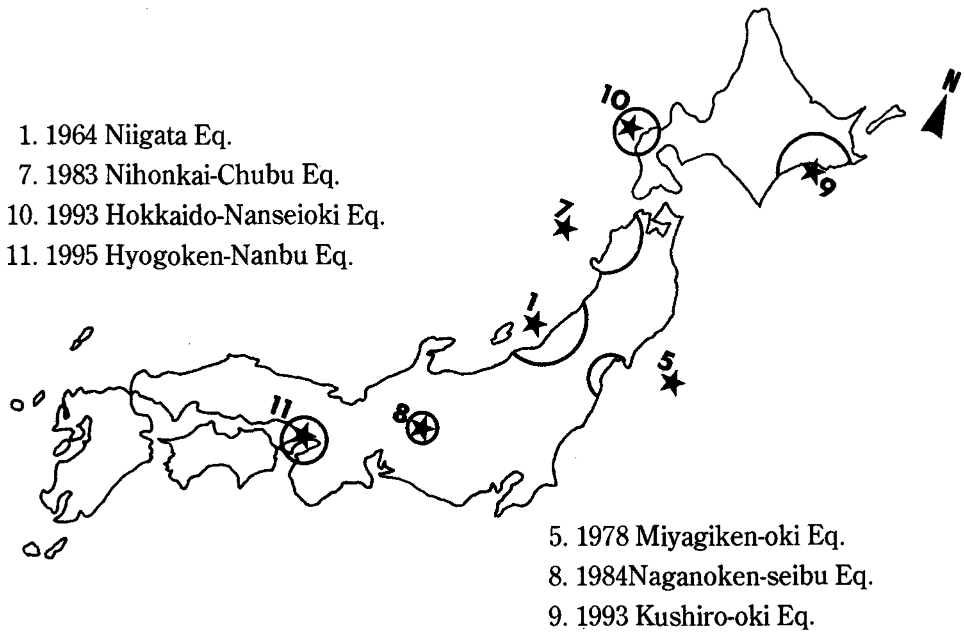

Figure 1 Epicenters and influenced areas caused by selected earthquakes

The characteristics of the total losses are reflected in the type of the socioeconomic activity and the natural environmental condition in the damaged regions. For example in the case of a local city in Niigata, as shown in Figure 2, which is one of most biggest city and a commercial town in the Hokuriku district , the highest ratio of amount of damage is the commercial and industrial losses with 27% to the total amount, secondary damaged item is transport and telecommunication systems with 23% and civil engineering facilities (infra-structures) with 22%.

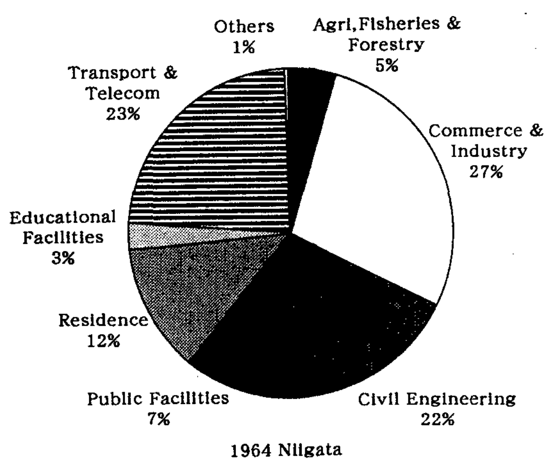

Figure 2 Proportion of amount of direct damage caused by the 1964 Niigata earthquake

These losses re-present about 75% of the total losses, and are not only caused by the ground liquefaction in the damaged areas but was also dependent on the characteristics of the socioeconomic structure of Niigata city.

In the Sendai city, as shown in Figure 3, an urban area which is the economic and political center of the Tohoku district, the highest ratio of losses to total amount is the commercial and industrial losses with 37%, secondary damaged component is a residential houses and buildings with 29%. Civil engineering facilities (infrastructures), however, with 10% losses was very low even if that city has been developed and infrastructures are completely established in urban ward. The commercial and industrial losses and the residential houses and buildings losses reached about 65% of the total losses, and was mainly caused by the destruction of reclaimed ground for residential damage and the characteristics of socioeconomic structure for commercial and industrial losses.

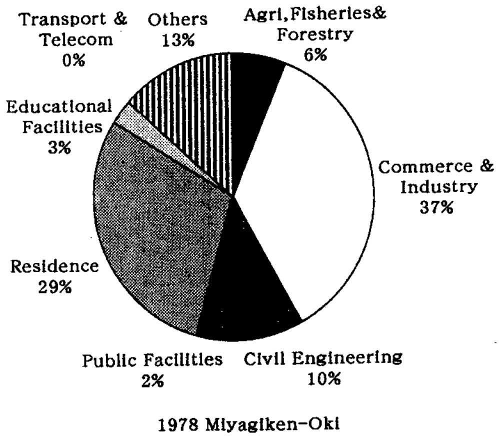

Figure 3 Proportion of amount of direct damage caused by the 1978 Miyagiken-oki earthquake

In the case of the Nihonkai-Chubu earthquake, as shown in Figure 4, Nosiro and Akita cities were affected by tsunami and liquefaction, the agricultural, fisheries and forestry losses with 27% would be caused by tsunami. Of the civil engineering facilities losses with 39%, almost all of the losses were caused by liquefaction. Nosiro and Akita which are local cities have been developed as the fisheries towns. The chief industries in these cities are mainly the primary industries, so the agricultural, fisheries and forestry losses relatively increased to the other losses. This phenomena would explain the correspondence to the industrial structures in the damaged areas. The proportion of direct losses caused by this earthquake is quite different with other cases mentioned-above.

1984 Naganoken-Seibu earthquake attacked at Ohtaki village which was located at the foot of Mt. Ontake with 3,063 meters above sea level in central Japan. The Ohtaki village is a typical type of town in the mountain area, and has been developed based on the forestry and tourist industry. As shown in Figure 5, the highest ratio of amount of damage is the agricultural and forestry losses with 48% to the total amount, secondary damaged item is civil engineering facilities (infrastructures) with 47%. These losses represent

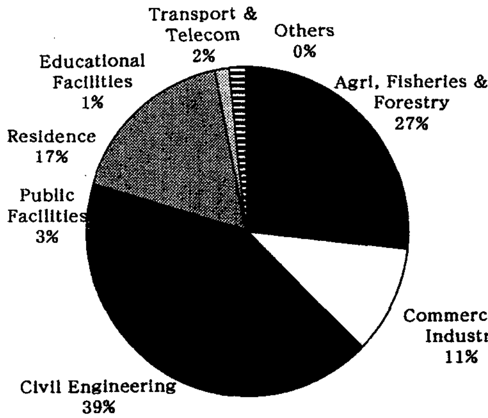

Figure 4 Proportion of amount of direct damage caused by the1983 Nihonkai-chubu earthquake

about 95% of the total losses, and are not only caused by the land slide in the damaged areas but was also dependent on the characteristics of the socioeconomic structure of Ohtaki village.

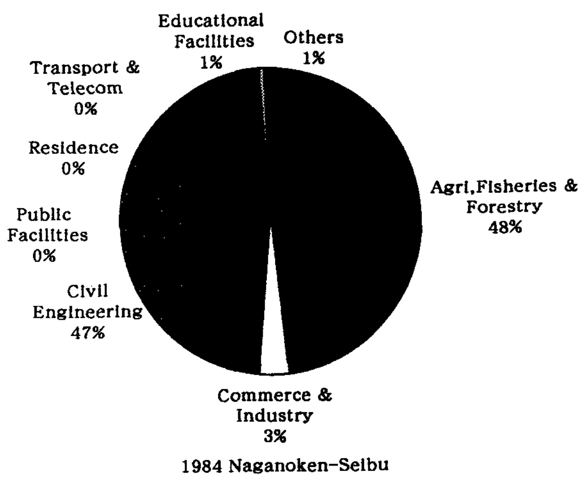

Figure 5 Proportion of amount of direct damage caused by the1984 Naganoken-seibu earthquake (the damage to residential losses is not included in this statistic data)

In the case of the Kushiro-oki earthquake, as shown in Figure 6, Kushiro city was affected by very strong ground motion, a local city in Kushiro which is one of most biggest city and a commercial town in the eastern part of Hokkaido district , the highest ratio of amount of damage is the commercial & industrial losses with 32% and civil engineering facilities (infrastructures) with 40% to the total amount, secondary damaged item is the agricultural, fisheries and forestry losses with 13%. The losses represent about 72% of the total losses, and are not only caused by the ground motion but was also dependent on the characteristics of the socioeconomic structure of Kushiro city.

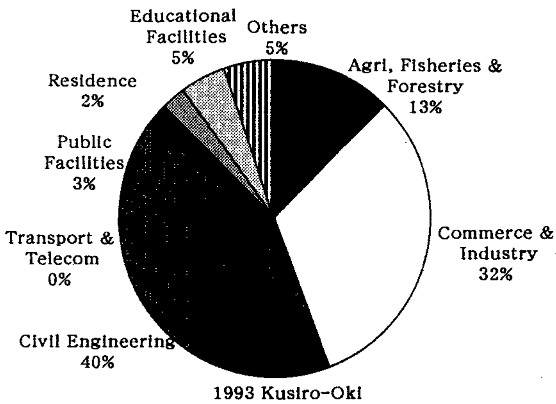

Figure 6 Proportion of amount of direct damage caused by the 1993 Kushiro-oki earthquake

In 1993, the big earthquake occurred just under the Okushiri island which was located on the western part of Hokkaido. The Okushiri town was affected by strong ground motion and tsunami, as shown in Figure 7, the agricultural, fisheries and forestry losses with 39% would be caused by tsunami. And also, the civil engineering facilities losses with 37%, almost all of the losses were caused by tsunami. Okushiri and the other small towns which are small village in Okushiri island have been developed as the fisheries towns. The chief industries in these towns are mainly the primary industries, so the fisheries losses relatively increased to the other losses. This phenomena would explain the correspondence to the industrial structures in the damaged areas. The proportion of direct losses caused by this and Naganoken-seibu earthquakes quite different with other cases mentioned-above.

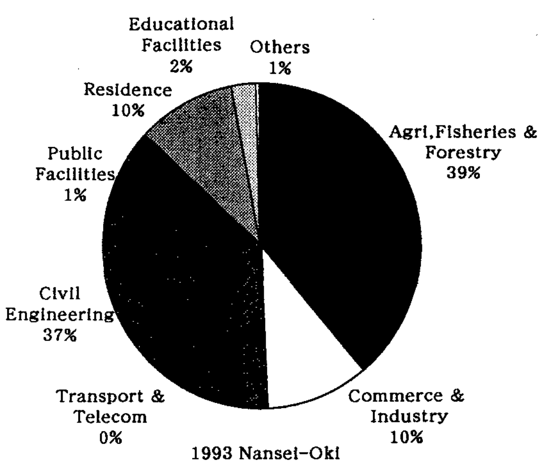

Figure 7 Proportion of amount of direct damage caused by the 1993 Hokkaido-nansei-oki earthquake

The Great Hanshin-Awaji earthquake abruptly occurred breaking the silence of the early morning of 17 January 1995. The epicenter of the earthquake was located about 15 kilometers to the southwest of Kobe City. The total amount of direct damage incurred on Hyogo Prefecture by the earthquake was approximately 10 trillion yen (100 billion US$). Kobe which is the biggest city in Hyogo prefecture developed along with the opening of the international trading port of Hyogo in 1868 and it has a long history, being one of the thirty-one cites where a municipal administrative system was introduced in 1889. With a population of approximately 1.52 million, Kobe is currently the sixth largest city in Japan. The Hanshin industrial area, which centers on Kobe, is the west-central base of the Pacific industrial belt area. Kobe City totals US$ 45 billion in domestic industrial shipments, ranking seventh nationally. About 70% of total losses would occurred in Kobe city.

Figure 8 shows a transition of gross domestic product (GDP) based on the Primary, Secondary and Tertiary industries from 1975 to 1991. Primary industries include agriculture and fisheries which account for 11.6 billion yen (116 million US$). Secondary industries was composed of two industries as the manufacturing of 1.527 trillion yen (15.3 billion US$) and construction of 500 billion yen (5 billion US$). The Tertiary industries mainly consisted of three industries as the transport and communications of 674 trillion yen (6.7 billion US%$), domestic trade and services of 1.06 trillion yen (10.6 billion US$), and wholesale and retail trade of 1.18 trillion yen (11.8 billion US$). As shown in Figure 8, the amount produced from Tertiary industries in Kobe comprise the highest part of the domestic product with its output reaching about 4.5 trillion yen (45 billion US$), which 68.8% of the total domestic product for fiscal year 1991 in Kobe. The amount produced by Secondary and Primary industries were 2.03 trillion yen (20.3 billion US$) and 11.6 billion yen (116 million US$), respectively. Kobe Port handles approximately 170 million tons of cargo each year, out of which 4,000 tons are in-ternational containers, 30% of Japan's foreign. As indicated by the above statistics, Kobe is literally the biggest urban with international port in Japan.

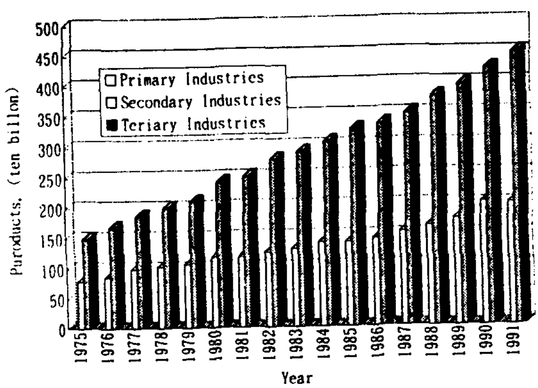

Figure 8 Transition of the gross domestic product from 1975 to 1991 in Kobe city

Figure 9 shows a proportion of an amount of direct damage losses, waterfront and central part of Kobe city and northern part of Awaji island were affected by very strong ground motion which almost reached 1g , the highest ratio of amount of damage is the residence losses with 59%, secondary damaged item is the transport & telecommunications losses with 20% in whole Hyogo prefecture. The proportion of direct losses caused by this earthquake is quite different with other cases mentioned-above, especially, direct damage losses of residence which is reached 5.8 trillion yen (58 billion US$) is quite different with other cases. This phenomena would explain the correspondence to the natural environmental and industrial structures in the damaged areas.

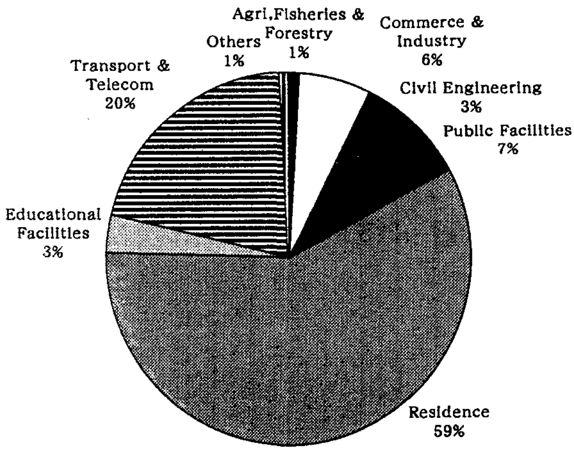

Figure 9 Proportion of amount of direct damage caused by the 1995 Hanshin-Awaji earthquake

Table 2 shows the amount of the direct losses for the 15 affected areas caused by ten earthquakes including Tokai and Minami-Kanto earthquake of which occurrence will be indicated by

Table 2 Statistics data of direct damage losses caused by previous earthquakes

No.	Earthquake	Damage Area	Direct Damage (JPY/trillion)
1	1964 Niigata	The whole area of Niigata Pref	2.003
2	1964 Niigata	Niigata City	1.614
3	1978 Izu-Oshima Kinkai	Izu•Atami•Shunto area	0.068
4	1978 Miyagi-Oki	The whole area of Miyagi Pref.	0.591
5	1978 Miyagi-Oki	Sendai•Sennan•Ishimaki area	0.591
6	1983 Nihonkai-Chubu	Tsugaru area ①	0.083
7	1983 Nihonkai-Chubu	Noshiro•Akita City•Honjo ②	0.236
8	1983 Nihonkai-Chubu	The Areas ① and ②	0.319
9	1984 Nagano-Seibu	Kiso Area (Otaki Village)	0.038
10	1993 Kushiro-Oki	Kushiro•Nemuro Area(Kushiro City)	0.046
11	1993 Hokkaido-Nanseioki	Donan-ken (Okushiri Island)	0.124
12	1995 Hyogo-Nanbu	The whole area of Hyogo Pref.	9.916
13	1995 Hyogo-Nanbu	Kobe City	6.915
14	? ? Tokai (estimate)	The whole area of Shizuoka Pref.	12.238
15	? ? Minami-Kanto(estimate).	Tokyo and the neighbourhood 3 Pref.	166.000

The Tokai earthquake is modeled on the 1854 Ansei-Tokai Earthquake

The Minami-Kanto earthquake is modeled on the 1923 Kanto Earthquake

Meteorological Agency in near future. In the Table 2, the amount was adjusted for inflation in 1994 though the use of GDP from 1964 to 1995. The amount of direct damage in Shizuoka

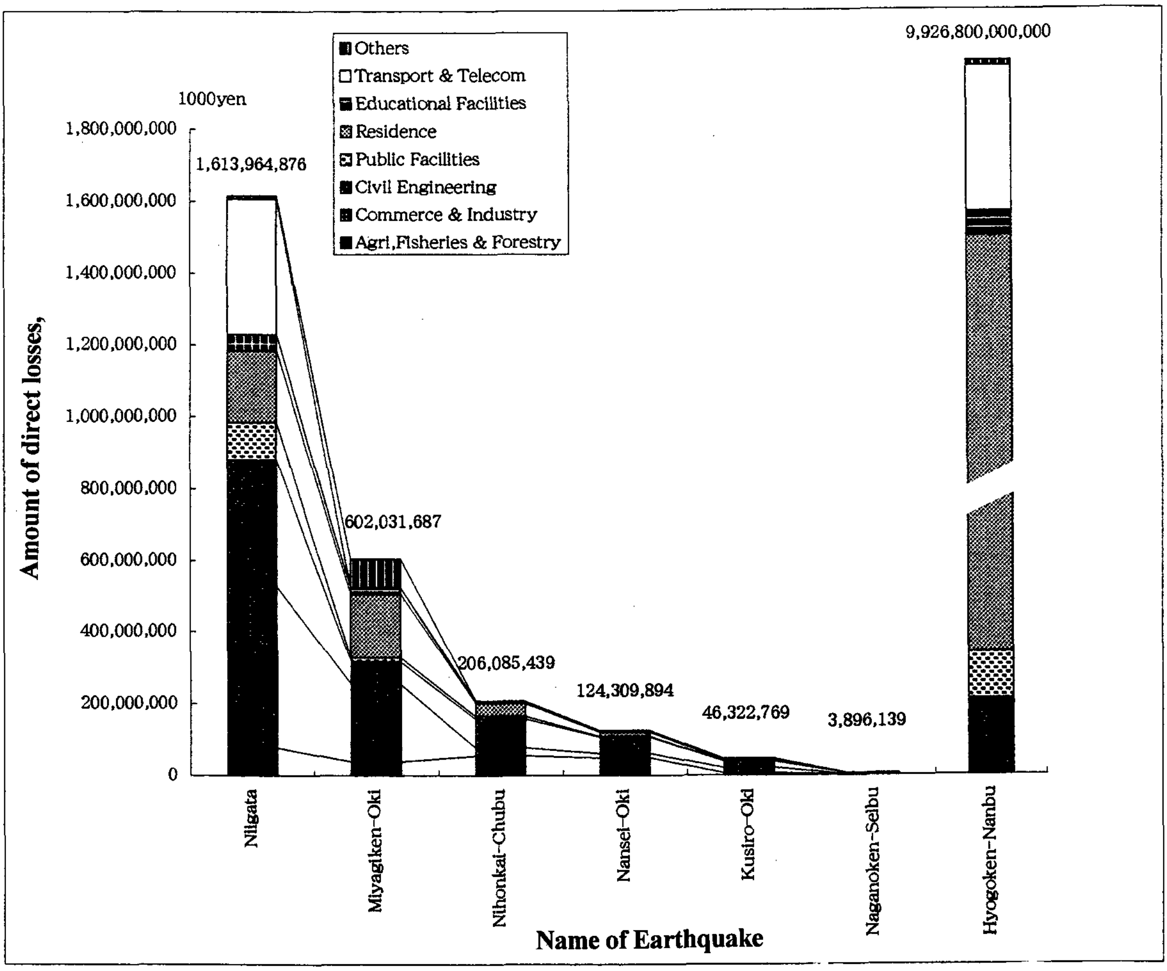

Figure 10 Comparison with direct damage losses and its proportional ratio of each damage component among seven previous earthquakes

Prefecture and Tokyo due to the Tokai and Minami-kanto Earthquakes is estimated by the Government of Shizuoka Prefecture and by Haresh Shah of Stanford University, respectively.

Figure 10 shows a difference of the direct damage losses and its proportional ratio of each damage component among seven previous earthquakes listed in Table 2. Compare the direct damage losses caused by earthquakes, the highest direct damage losses was 10 trillion yen which appeared by the Hanshin-Awaji earthquake, secondary case was the Niigata earthquake with 1.6 trillion yen in Niigata city. In a case of 1978 Miyagiken-oki earthquake, which was well known as the first urban earthquake disaster in Japan, the direct damage losses was only 602 billion yen. And also, although the 1983 Nihonkai-chubu earthquake of which damaged area was widely spread caused by tsunami and liquefaction, the direct damage losses with 206 billion yen was carried.

4. Estimation of direct damage losses

As shown in equation (2), the direct losses can be expressed as the product of seismic hazard and vulnerability. The hazard can be replaced with seismic intensity, liquefaction, steep slop disaster and tsunami that are dependent on the natural environmental conditions. On the other hand, in order to evaluate the social vulnerability, the possibility of direct damages should be quantitatively estimated under the socioeconomic stocks.

In this study, " MINRYOKU" which is a database of an accumulated social information is used for the evaluation of social vulnerability. The database of the MINRYOKU is composed of 24 indexes as 6 basic indexes, 6 industrial indexes and 12 consumer price indexes. Figure 11 shows the content of a detailed index of the MINRYOKU database.

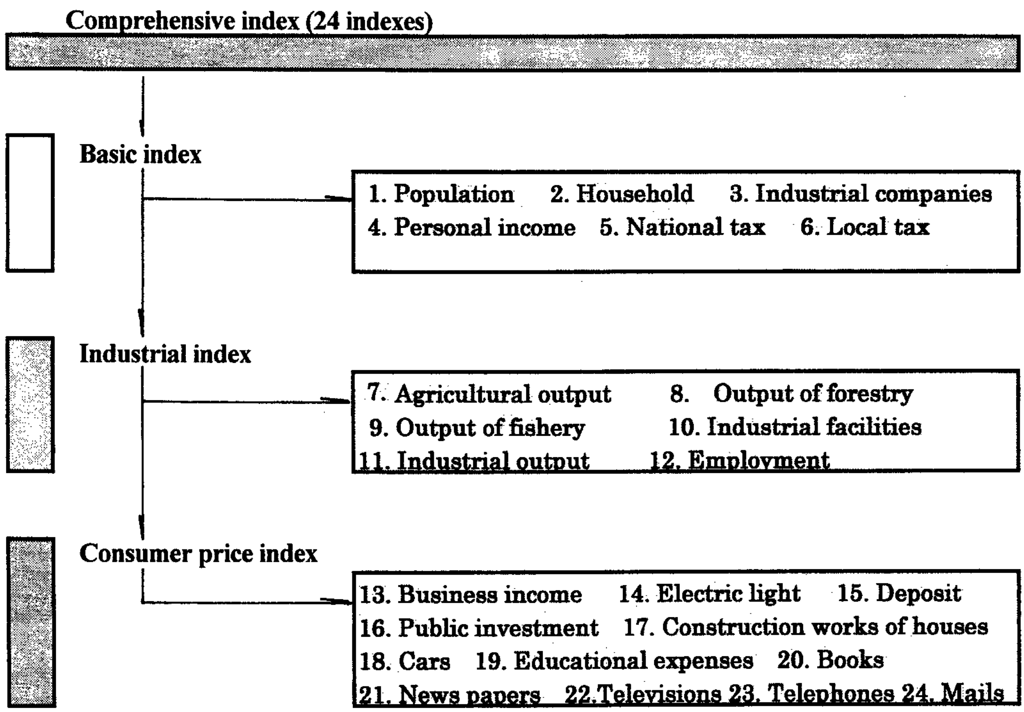

Figure 11 Contents of detailed indexes of the MINROKU database

As shown in Figure 11, the comprehensive index consists of a basic index, industrial index and consumer price index, and considering the whole country as having a value of 1,000 in each index, which are referred to as sum and average individual indices.

Figure 12 shows the relationship between the amount of direct damage as shown in Table 2 and the comprehensive index of MINRYOKU database. The amount of losses include the earthquakes after the Niigata earthquake in 1964 and the results of the amount of direct damage losses in the whole of Shizuoka prefecture was estimated by the government of Shizuoka Prefecture in case the Tokai earthquake occurrs in the area. Also the Tokyo metropolitan area estimates the Minami-

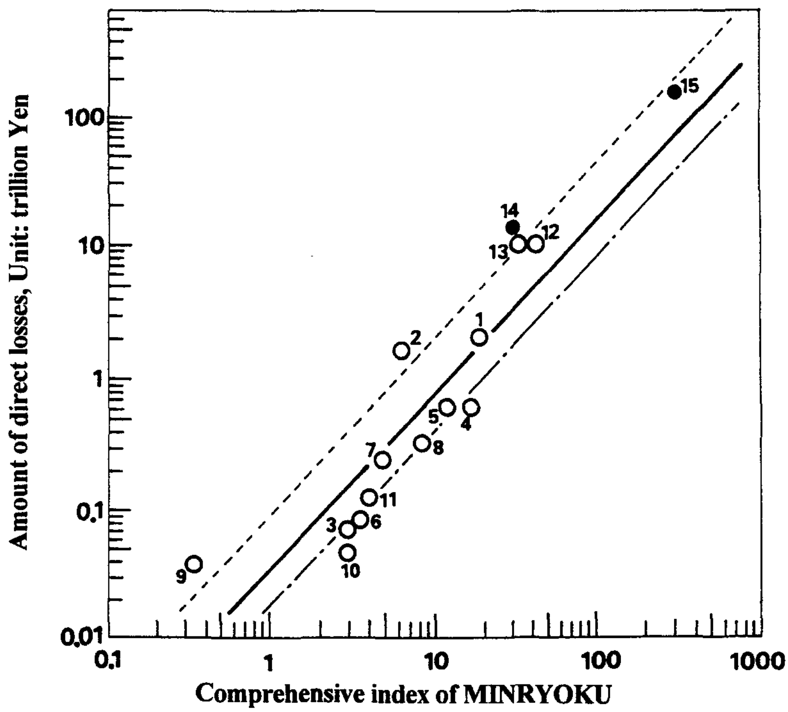

Figure 12 Relationship between the amount of direct damage and comprehensive index of MINRYOKU
(The numbers in the figure correspond to the earthquake number in Table 2.)

kanto earthquake which assumed to have the same characteristics as the Kanto earthquake in 1923. The amount of the previous damage is inflated considering 1994 as a standard year.

As shown in Figure 12, on the basis of the relation of both about 11 damaged areas except for black points in the figure which are estimated value in Tokyo and Shizuoka, we can get an experimental equation of direct damage loses as in (4).

$$Y_C i,k,t = 0.0347 \times S_E^{\ 1.3119} \qquad (4)$$

The decision coefficient of equation (4) is 0.90 which gives a strong correlation. Considering equation (4) as the average relation between the social vulnerability and the damage potential, the damaged regions situated on the upper part of this formula will have more damage than potentially social vulnerability. For this reason, the increase in the natural environmental condition, the seismic intensity and the damage influenced by the socio-economic structure are considered.

On the other hand, the regions located on the lower part may have been damaged locally or may have had relatively small seismic intensity. When an approximate formula on these spots is calculated by making the gradient of equation (4) equal, it becomes similar to equation (5) in the upper regions, and similar to equation (6) in the lower regions.

$$Y_C i,k,t = 0.0858 \times S_E^{\ 1.3119} \quad (5)$$

$$Y_C i,k,t = 0.0177 \times S_E^{\ 1.3119} \quad (6)$$

If the constant (0.0347) in equation (4) is assumed to be 1.000, equation (4) considering the change of constant number of three experiences formula as the difference of the earthquake ground motion, the ratio of the constants in each equation, i.e. (0.0858/0.0347=2.47 and 0.0177/0.0347=0.51) are considered as the correct coefficients corresponding to the seismic intensity. The constants 2.47 and 0.51 correspond to the seismic intensity of more than 6.5, but less than 5.5.

With same consideration as mentioned-above, the correct coefficient depending on the natural condition such as steep slop damage, liquefaction damage is simply estimated based on the damage of liquefaction caused by the Niigata earthquake, and the correction coefficient of steep slope damage is estimated from Naganoken-seibu earthquake. The former coefficient is 2.47, and the latter is 4.51.

From these correct coefficients, equations (4) to (6) are arrived in the following formula.

Seismic intensity index **Characteristics of damage**

$$Y_C i,k,t = 0.0347 \times S_E^{\ 1.3119} \times \begin{bmatrix} 2.47 & (I \geq 6.5) \\ 1.00 & (5.5 \leq I < 6.5) \\ 0.51 & (I < 5.5) \end{bmatrix} \times \begin{bmatrix} 1.00 (\mathit{strong\ motion}) \\ 2.47\ (\mathit{liquefaction}) \\ 4.51\ (\mathit{steep\ slope}) \end{bmatrix} \quad (7)$$

5. Conclusions and remarks

In the present study, the previous damage of earthquake is analyzed from an economic point of view and the method for estimating the amount of direct damage is developed relating to the potential of socioeconomic power based on the analysis of previous earthquake damage. The characteristics of the total losses have been clarified on the bases of analyzing the economic damage due to seven earthquakes which occurred from 1964 to 1995.

The characteristics of total amount of direct damage and of the proportion of the total amount of direct damage to damage components are shown in Figures 2 to 10. Comparison of the direct damage losses caused by previous seven earthquakes, the highest direct damage losses was 10 trillion yen which appeared by the Hanshin-Awaji earthquake, secondary case was the Niigata earthquake with 1.6 trillion yen in Niigata city. In a case of 1978 Miyagiken-oki earthquake, which was well known as the first urban earthquake disaster in Japan, the direct damage losses was only 602 billion yen. Based on the results, it was clarified that the degree of total amount caused by direct damage and proportional ratio of damage losses are not only reflected in the seismic intensity, the natural hazard as ground liquefaction, tsunami but also the type of the socioeconomic activity in the damaged regions.

On the other hand, regarding to the direct damage losses estimation method is proposed as shown in formula (7). In the future, it will be necessary that the relation between the amount of direct damage and that of indirect damage is developed concerning the characteristic of the economical and industrial area classified.

References

1) Asahi Shimbun, *MINRYOKU*, 1976 - 1996 (in Japanese).
2) Haresh Shah, Fouad Bendimerad, Jawhar Bouabid etc, *What if the 1923 Earthquake Strikes Again? -A Five-Prefecture Tokyo Region Scenario-*, Risk Management Solutions, Inc., pp.1-97, 1995.
3) Niigata City Office, *Report of Earthquake Damage due to the 1964 Niigata Earthquake*,Niigata city, pp.1-498,1966 (in Japanese).
4) Sendai City Office, *Report of Earthquake Damage due to the 1978 Miyagiken-Oki Earthquake*, Sendai city, 1979 (in Japanese).
5) Akita City Office, *Report of Earthquake Damage due to the 1983 Nihonkai-Chube Earthquake*, Akita city, pp.1-143,1984 (in Japanese).
6) Ohtaki Village Office, *Report of Earthquake Damage due to the 1984 Naganoken-Seibu Earthquake*, Ohtaki village, pp.1-487,1985 (in Japanese).
7) Kumizi Iida, "Reconnaissance Report on The 1984 Naganoken-Seibu Earthquake" , *Research report on natural disasters*, Supported by the Japanese Ministry of Education, Science and Culture, Group for the study of Natural Disaster, pp.1-296,1985 (in Japanese).
8) Kushiro City Office, *Report of Earthquake Damage due to the 1993 Kushiro-Oki Earthquake*, Kushiro city, pp.1-377,1993 (in Japanese).
9) Hiroshi Kagami, "Reconnaissance Report on The 1993 Kushiro-Oki Earthquake" , *Research report on natural disasters*, Supported by the Japanese Ministry of Education, Science and Culture, Group for the study of Natural Disaster, pp.1-209,1993(in Japanese).
10) Yuji Ishiyama, "Reconnaissance Report on The 1993 Hokkaido-Nansei-Oki earthquake", *Research report on natural disasters*, Supported by the Japanese Ministry of Education, Science and Culture, Group for the study of Natural Disaster, pp.1-196,1994 (in Japanese).
11) Kobe City Office, *The great Hanshin-Awaji Earthqauke*, Kobe city, pp.1-699, 1996 (in Japanese).
12) Hitoshi Taniguchi, "Economic Impact of an Earthquake - Japanese experiences -", *Workshop on the Enhancement of Seismic Safety Environment in the Course of Regional Development in China*, 1996.
13) Hitoshi Taniguchi, Ayako Kanto and Toshio Mochizuki, "Investigation of Earthquake Damage from an Economic view point and its Impact to the socio-economic in Damaged Area" , Proc. Symp. *Natural Disaster*, pp.93-94,1996 (in Japanese).

Key Words (キー・ワード)

Earthquake (地震), Economic Loss (経済的被害), Amount of Direct Damage (直接被害額), MINRYOKU (民力)

地震災害が地域に及ぼす経済的影響

ー直接被害額推定法の提案ー

谷口仁士*
神頭綾子**
望月利男***
小川雄二郎*

総合都市研究　第61号　1996　p.167-181

1964年新潟地震が発生し、新潟市内では液状化による被害が多発した。この「液状化」現象は世界的に有名になり、地盤工学の分野で発生メカニズムの解明・対策などの技術が飛躍的に進歩した。しかし、新潟市で1,048億円（1994年換算で約1.6兆円)、新潟県で1,300億円（1994年換算で約2.0兆円）の直接被害額が発生し、この直接被害総額は1964年新潟市税収入の約40年分に相当する規模であった。しかし、このような経済的視点からの被害の考察や地震防災の必要性を指摘した事実は見当たらない。同様に、1995年阪神・淡路大震災による被害は、高架橋の横転や大規模な地震火災など、物的被害がセンセーショナルに報道された。しかし、兵庫県における直接被害総額約10兆円の被害規模や、この被害額が震災後も被災地域の社会経済活動に大きく圧し掛かっている事実を詳細に調査・研究しているとは言い難い。

今までの地域防災計画は、地震発生直後の救急・消火、被災者への対応など救急・応急対応を主眼として構成されていた。もちろん、こうのような緊急・応急対策は重要な対策であるが、他方、地震発生後から始まる地域の復旧・復興、再建、特に、経済活動の早期立ち直りに関する具体な対策が不十分であったと推察される。地震後の地域再建過程で問題となるのは、地域経済を如何に速やかに再建させるかである。

そのための事前の準備として、経済的被害（直接・間接被害を含む）に関する予測やそれに対する地域経済への影響予測が必要になってくる。しかし、既往の地震災害事例調査を概観すると、そのほとんどが、地震学的観点からの分析・考察、一方、工学分野では物的・人的被害発生の原因究明と対策に限定されていたと言える。物的・人的被害の軽減は地震防災に与えられた究極の課題であるが、同様に、経済的視点からの災害規模の把握・考察さらに経済的対応・対策も必要であると言える。

本研究は既往の地震災害を経済的損失面から整理するとともに、直接被害額推定の開発を試みたものである。本論では、1964年以後の被害地震（7地震：表1､2参照）による直接被害額の情報収集・整理を行い、さらに地域固有の「社会経済力」の評価を民力総合指数を用いて行い、両者を対応させることで経験的な直接被害総額推定式（本論の７式）を開発した。この推定式には震度補正項と被害の直接的起因となる地震動、液状化、津波補正の３項目が考慮されている。しかし、社会経済力評価に用いた民力総合指数はストックとフローを合算した指標を用いており、元来、直接被害額とは資本ストックの被災量（額）であるから、この総合指数の中からストックに関連する指標のみを抽出し適切に評価することが重要である。

今後の課題として、社会経済力評価の改善とさらに間接被害額も直接被害額と同じかあるいはそれを上回る規模になるとの報告や予測が出ており、それらを今後の研究課題とするものである。

*国際連合地域開発センター
**東京都立大学大学院都市科学研究科（修士課程）
***東京都立大学都市研究所