A REVIEW OF EARTHQUAKE DISASTER PREVENTIVE MEASURES FOR LIFELINES

Presenting Author: Eiichi Kuribayashi*
Shunroku Nakamura*
Naojiro Aoshima*
Makoto Kawamura*

ABSTRACT

The Miyagiken-oki, Japan Earthquake of 1978 brought many disasters to one of the most modernized cities of Sendai and the adjacent areas.

The Nihonkai-Chyubu, Japan Earthquake of 1983 brought much damage in lifelines in Akita prefecture and slightly in Aomori, both located in the northern part of Honshyu island. The damage in Noshiro city was typically caused by liquefaction of saturated sandy subgrounds.

The El Asnam, Algeria Earthquake of 1980 brought severe damage in lifelines. Consequently the event showed three types of recoveries of the function i.e., i)INDISPENSABLE in transportations, ii)ALTERNATIVE in water and gas supply, iii)SUSPENSIVE in telecommunication, power supply and sewage disposal.

The southern Italy Earthquake of 1980 affected suspension of functions to lifelines in relatively wide areas, for example, Napoli located about 100km from the epicenter suffered the suspension.

Concludingly, three of these earthquake disasters with individual characteristics tell us lessons for earthquake disaster preventive measures.

INTRODUCTION

This paper presents lessons on preventive measures for lifelines from experiences of recent earthquake disasters in Japan and the Mediterranean seismic zone.

The Miyagiken-oki (off shore), Japan Earthquake of June 12th, 1978 with 7.4 of magnitude on Richter scale, brought many disasters to one of the most modernized cities of Sendai and the adjacent areas. The disaster is supposed as one of the biggest earthquake disasters since the Kanto Earthquake of September 1st, 1923 with 7.9 of magnitude. After then such earthquake disasters in modernized cities with headquarters of prefectural government have been experienced in the Fukui Earthquake of June 28th, 1948 with 7.3 of magnitude and the Niigata Earthquake of June 16th, 1964 with 7.5 of magnitude. However Sendai city was more greatly urbanized than both of Fukui and Niigata cities suffered from these two earthquakes in those days. Substantial damage of lifelines deeply dealt with functional damage during and immediately after earthquakes in this experience.

The Nihonkai-Chyubu, Japan Earthquake of May 26th, 1983 with 7.7 of magnitude, brought much damage in lifelines in Akita prefecture and slightly in Aomori, both located in the northern part of Honshyu island. The substan-

* Department of Civil Engineering/Regional Planning, Toyohashi University of Technology, Tempaku-cho, Toyohashi 440 Japan

tial damage to lifelines in Noshiro city in Akita is typically caused by liquefaction of saturated sandy subgrounds behind sand dunes as well the damage of residential homes. Consequently it took a long time, more than one month or more to resume the functions in two lifelines, water supply and city gas. More detailed analyses will be presented at the Conference Hall. It is limited to introduce only facts of the earthquake in this paper.

The El Asnam, Algeria Earthquake of October 10th, 1980 with 7.3 of magnitude, brought damage in lifelines. Consequently the event showed three types of recoveries of the function i.e., i)INDISPENSABLE in transportations, ii)ALTERNATIVE in water and gas supply, iii)SUSPENSIVE in telecommunication, power supply and sewage disposal. The suspendable in use of utilities will be released after reconstructions of the facilities in El Asnam city.

The Southern Italy Earthquake of November 23th, 1980 with 6.5 to 6.9 of magnitude affected suspension of functions to lifelines in relatively wide areas, for example, Napoli located about 100 km from the epicenter suffered the suspension and also many homelesses. Damage severely occurred in mountaineous areas where towns are located on tops of them, and suspension of functions of water and power supply brought much difficulty in rescue and rehabilitation.

1. Behavior of Lifelines in the Miyagiken-oki Earthquake of 1978

1.1. General Description

This earthquake is characterized by the great damage to lifeline facilities and their functions in Sendai, a large city of 629,000 at population, and its adjacent areas.

After the earthquake, Sendai city and the adjacent areas experienced suspension of electric power, water and gas supply, suspension of railway operation, traffic confusion by the interruption of traffic signals, down of telephone lines, etc. The various damage brought a great inconvenience in urban activities.

Lifeline systems can fulfil their function so far as they are composed as a network. The experience through the earthquake shows us a possibility of the functional paralysis in the whole systems by partial damage to lifeline facilities and the seriousness of the influence of their functional damage on urban activities.

1.2. Transportation Lifelines

Roads: After the occurrence of the main shock at 5:14 p.m. of June 12, the automatic traffic control system at the Traffic Control Center of Sendai Central Police Station did not work by electricity failure and 260 traffic signals in Sendai city did not operate. That was just at rush hours in the evening, and in such situation, the traffic in Sendai city became confused. After the recovery of electricity at the Traffic Control Center at 8 p.m. and the disposition of policemen for traffic cotrol and emergency vehicles for electric-power supply to traffic signals, traffic congestion was gradually dissolved.

On the other hand, the traffic through major roads was obliged to be suspended or restricted by structural damage to national and prefectural highways, and Tohoku Expressway.

Railways: After the shock, all railways under the control of Sendai Railway Control Bureau were suspended. Therefore many commuters and travelers were deprived of means of transit. As a result of inspection and temporary restoration, Tohoku Main Line in south of Sendai and Joban Line reopened on June 14, and Tohoku Main Line in north of Sendai on June 15. As for local lines in and around Sendai, their reopening was completed on July 8.

Harbors: Ishinomaki Industrial Harbor, Sendai Harbor, etc. were suffered such damage as cracks in aprons, breakdown of loading machines, etc. But by emergency measures, the function of the harbor was secured.

Airports: Sendai Airport suffered slight damage of small cracks in runways, and taking-off and landing of planes were suspended for a while. But normal operation was soon resumed.

1.3. Water Supply Lifelines

Water supply facilities were damaged in 54 cities, towns and villages in Miyagi prefecture.

In Sendai city, water supply services were suspended at about 7,000 houses located mainly in newly developed areas after the main shock. Water supply suspended at the number decreased to 2,000 on June 14, 700 on June 15. As for other small cities, by the severance of water pipes, the services were suspended at all houses (16,000 houses) in Shiogama city and at 10,500 houses in Izumi city. So far as a view point of the functional recovery, water supply services were resumed in almost all cities and the others in June 16.

1.4. Sewerage Lifelines

In Miyagi prefecture, sewerage facilities had been constructed in 16 cities and towns before the earthquake.

After the main shock, sewerage treatment and pump yards in Sendai city and some other cities around Sendai did not work because of electricity failures and structural damage. Under such situations, sewage water was obliged to be discharged into rivers without full treatment.

As a result of temporary restoration, the function of these damaged facilities was recovered within a few days except for Kooriyama Pump Yard which was recovered in June 23 in Sendai city.

1.5. Medical Lifelines

Medical activities after the main shock were for a while impeded because of electricity failures and the damage to equipments and fittings at hospitals and clinics in Sendai city and the adjacent areas.

However, accidents of inpatients were prevented by emergency measures, and serious confusion of medical activities did not come about by means of the cooperation extended from non or slightly damaged facilities.

1.6. Energy Supply Lifelines

Electric Power Facilities: A total demand of electric power in Tohoku District was 4,900 MW immediately before the main shock. After the shock, the loading electric power reduced 1,500 MW, and the electric power for supply reduced 1,000 MW. The reduction of electric power generation, transmission

and transformation was not serious except distributers for individual homes.

A number of electricity-failed houses reached 681,600 (419,100 houses in Miyagi prefecture, 103,000 houses in Fukushima prefecture, 95,800 houses in Yamagata prefecture, 58,600 houses in Iwate prefecture). With the advance of temporary restoration, the number of electricity-failed houses decreased to 280,000 on June 12 and to 12,000 on June 13. The function of electric power faciliries was completely recovered on the early morning of June 14.

Gas Supply Facilities: The damage to gas supply facilities was brought by the main shock in four cities of Sendai, (including Izumi city and Tagajo city) Shiogama, Furukawa and Ishinomaki . There was slight damage in these cities except for Sendai city, and after inspection and restoration, the function of gas supply facilities was completely recovered on June 13 in Ishinomaki city, on June 16 in Shiogama city and on June 18 in Furukawa city.

However, in Sendai city, gas production facilities at Minato Plant and Haramachi Plant suffered severe damage, and what is worse, underground gas pipes severed at many places. Gas supply in Sendai city was wholly suspended by such serious damage. With the advance of temporary restoration, gas supply was resumed at some places in Sendai city on June 16. After the accomplishment of inspection and restoration of all the gas pipes, from main pipe lines to twig pipes inside of every house, gas was supplied block by block. It was on July 9 that gas supply was resumed to every house in Sendai city.

Propane-gas supply through gas pipes was also suspended at 7,861 houses among 16,266 in Miyagi prefecture after the main shock. Propane-gas supply to 4,444 houses was resumed on June 14, and the supply to the rest 3,417 houses was completed within few days.

1.7. Telecommunication Lifelines

3,845 telephones of 1,738,000 subscription telephones in four prefectures of Miyagi, Fukushima, Iwate, Aomori were damaged by snapping of wires, the damage to telephone sets, etc, They were entirely restored on June 20. As for long-distance transmission lines, 24,000 circuits of 70,000 circuits into, out of and through Sendai city were down by the damage to coaxial cables, inclination of micro antennas, etc, All the circuits were restored on June 14. Short-distance transmission lines were also damaged, but all the circuits were soon restored on June 13. Further more, as telephone calls for inquiries poured into Sendai city after the main shock, extraordinary congestion of calls arose untill June 14.

Besides, public telephones were unusable for several hours by electricity failures, and telegraph services were not able to be given at Sendai Central Telegraph Office by the damage to transmission lines. Their functions were soon recovered. In three days after the main shock by June 15, 64,000 telegrams reached Sendai city, that is 20 times than usual.

On the other hand, wireless facilities for emergencies connecting between the prefectural and municipal governments were slightly damaged in Miyagi prefecture. There was only one town that could not communicate by wireless.

As for broadcasting, 94 of TV stations and 7 of radio srations including one international could not broadcast for a while after the main shock by electricity failures and the damage to micro wave circuits. Their functions were soon recoverd within 32 minutes.

2. Behavior of Lifelines in the Nihonkai-chubu Earthquake of 1983

2.1. Substantial Damage to Lifelines

Noshiro city with a population of sixty thousand or more in Akita prefecture, one of the severest districts had been equipped with all lifelines except key stations of broadcasting before the earthquake. Heavier damage was observed in the followings than the other,

i Railroads
ii Water Supply Lifeline, and
iii Gas Supply Lifeline.

Damage was observed in houses and the other ground structures caused by liquefaction of sandy grounds but also in off-shore structures and fishing boats by tsunami (upheaval of sea levels), along the coast lines, one thousand km or more in total, faced to Japan Sea.

2.2. Functional Damage and Rehabilitation to Lifeline Systems

Functions of all lifelines except the above three were recovered within a half day after the main shock.

Resumption of Railroad, water and gas lifelines was entirely accomplished in June, 16, 20, and 25, respectively.

3. Behavior of Lifelines in the El Asnam Earthquake of 1980

3.1. Substantial Damage to Lifelines

El Asnam city had been equipped with all sort of lifelines except navigation channels before the earthquake. Heavier damage was observed in the followings than the other,

i Telephone Lifelines
ii Sewerage Lifelines, and
iii Gas Supply Lifelines.

The severest damage was induced in the telephone lifelines, especially in the telephone operating station. The sewerage and gas supply lifelines were heavily damaged.

3.2. Functional Damage and Rehabilitation to Lifeline Systems

Functions of roads were rapidly recovered as it took only tow hours or less after the the main shock to reopen national highways by means of repair or temporary viaducts in El Asnam prefecture. Railway took ten days to reopen. Immediately after the main shock, roads and airways had heavy duties to transport articles of medical care, food, drinking water and construction machinery, and materials.

Within the day of the main shock, temporary telephone systems were installed among government offices in El Asnam prefecture and emergency local wireless communication systems were operated immediately after the main shock.

Resumption of water supply started in ten days after the main shock.

Sewerage systems and gas supply systems were not reopened for a long time, because damage sites and degrees of damage were not clear.

Electricity had been gradually reopened after the next day to the main shock and Diesel generators temporarily installed began working at midnight on the day of the main shock.

City gas supply was replaced by portable propane gas.

4. Behavior of Lifelines in the Southern Italy Earthquake of 1980

4.1. General Discription

Traffic jam occurred on expressways near Napoli immediately after the main shock. This seems to be one of the reasons why systematic rescue activities were delayed by rushing volunteers and relatives to the refugee in the disaster districts. This should be a phenomenon in developed countries in which there is a high standard of levels in communication and transportation measures. Traffic disturbances caused by collapsed houses on roads were remarkable in the mountaineous areas. Severe damage of individual house was brought suspension in functions of lifelines, even as their terminal facilities and distributers survived from the disasters.

On the other hand relatively severe damage occurred in water supply and telephone systems.

4.2. Individual Lifelines

Traffics on roads: Local roads near the epicenter were slightly damaged but national roads (including expressways) and provincial roads. Streets were blocked traffics with rubbish of collapsed houses on both sides near the epicenter. Traffic control was conducted to prevent secondary disaster caused by vulnerable buildings along streets, especially historical heritages in Napoli. Traffic jam occurred at a part of national roads immediately after the main shock. Pre-registeration systems were applied to heavy vehicles entering the disaster areas to control the traffics between Nora and Salerno near Napoli.

Railways: Bridges, tunnels, stations were slightly damaged in Napoli, and trains were obliged to stop near Napoli only immediately after the main shock. There is no railway near the epicenter.

Telephone: Telephone wires did not suffer any damage, but they could not use telephone for a while in wide area in Southern Italy. The telephone services were restored by almost one day after the main shock. Temporary public telephones were installed in some areas.

Water supply: Villages near the epicenter were located mountaineous areas near tops of the mountains, and water supply systems were indispensable for the areas. Drinking water was supplied by tank lorries after the damage of the systems. Buried water pipes were slightly damaged, and muddy water with yellow color was found in Napoli. The authority advised the public that drinking water should be boiled. In Avellino, which is located about 40 km from the epicenter, water was polluted by damage of burried pipes, and stopped at many sites.

Electric power: No damage was observed with high voltage transmission lines but damage of intermediate and low voltage lines. Supply of electric power was stopped near the epicenter. In some parts of Napoli, supply of electric power was stopped for preservation.