LIFELINE EARTHQUAKE ENGINEERING

～Lessens from 1995 Kobe earthquake and 2011 East Japan earthquake～

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PREFACE

Life is lined with lifelines in current civilizations all over the world. Nowadays, one may think of an earthquake as a “life-quake” since it has great impacts on the lifespan of structures and infrastructures. Severe ground motions and Tsunami waves attacked east Japan areas on March 11, 2011; explosions with vast energy caused by unexpected crust failure followed nuclear power plant failures. Emotional unrest and anxiety about the future of life are now spreading all over Japan. The number of killed and unknown persons has exceeded 20,000 and flow-out collapsed houses have been estimated to be 130,000. The earthquake caused direct and indirect economic losses of about 2,000 million USD, including infrastructure damage in wide areas. The restoration and reconstruction projects have only just begun.

On the other hand, the 1995 Kobe earthquake caused enormous damage and over 6,400 casualties, mostly concentrated in densely populated urban areas in Japan. This earthquake attacked residential houses, lifelines, transportation systems and all others facilities causing total economic loss of 100 billion USD, leaving Kobe City in need of reconstruction. Eighteen years later, restoration and complete reconstruction of activities in the damaged cities and towns have occurred. However, reconstruction of individual daily life is difficult and emotional effects have not been cured completely. The biggest disaster would be forgetting how families have suffered.

An earthquakes is, a natural phenomena which can cause a big disaster to human society. A lot of research has been done so far on the prevention of earthquake disasters, based on severe earthquakes in the past. Those studies are divided into several categories based on their academic fields, purposes, and methodology, namely as Seismology, Seismological Engineering, or Earthquake Engineering. The first group, seismologists, studies the inner geotechnical structure of the earth and their goals are to find the mechanism of the earthquakes and to predict future earthquake occurrences. The second group, seismological engineers, studies the motion of the ground surface during earthquakes and its effects and measures on the human life, structures, and society. The main purpose of Earthquake Engineering is to increase the seismic safety of structures against earthquakes.

The Earthquake Engineering field has been developing in Japan mainly after the great earthquake in Kanto area (Tokyo and vicinity) since 1923. In this earthquake, more than 250,000 buildings and the urban facilities suffered severe damage with more than 100,000 casualties. After this disaster, there was a large and rapid advancement in this field. However, compared to the other fields of science and technology, there is not as much historical background in the field of Earthquake Engineering.
Concerning the changes in the structures and lifestyles of the cities in recent years, it seems that there should be also some changes in the field of Earthquake Engineering. For example, we can consider the seismic design and construction of bridges, subways, and other long-period structures, which requires a more deep knowledge of earthquake waves.

Therefore it is necessary to have a lot of data knowledge, information, and data to extend research in this field. Since infrastructure has important roles and functions in the cities, it is quite necessary to make each of them anti-earthquake in order to have more safe cities. In the safety factor of a city system, both the seismic and rehabilitation plans of the city are necessary.

Considering the problems such as emergency response and socio-economic after-earthquake conditions, earthquake research has branched out to other fields of science such as psychology, sociology, and economic.

In 1978, the Miyagi-Ken Oki Earthquake clearly demonstrated such effects on a big city on a large scale. Besides the buildings and city facilities, other lifeline structures, e.g. power, gas, water, waste water and telecommunication systems (especially buried lines), were severely damaged, and everyday life in the city was suspended as a consequence. The huge damage to the lifelines during this earthquake made Lifeline Earthquake Engineering a topic considered and investigated principally in Japan.

The 1971 San Fernando earthquake is often considered to be the starting point of serious research in the field of Lifeline Earthquake Engineering in USA, since huge lifeline damages occurred during the earthquake.

Among the different parts of lifelines, the seismic behavior of the buried lines for common transmission is different from the other structures; their behavior is mainly affected by the behavior of surrounding soil as opposed to earthquake forces. Consequently, a new branch of Earthquake Engineering has emerged: Lifeline Earthquake Engineering. This branch is different from Building Earthquake Engineering in seismic force evaluation, response analysis, safety evaluation, design, and experiment. Of course, it was built the advancement of the Earthquake Engineering, but from an academic standpoint it is developing.

Most of this book has been established before the 1995 Kobe earthquake; however Japanese seismic design codes in the field of lifeline structures have been revised, introducing lessons of the Kobe earthquake. Also, the 2011 east Japan earthquake is the first experience in Japan under Mw=9.0 with earthquakes following nuclear power plant accidents. This book incorporates various data in the Kobe and the east Japan earthquakes in the field of Lifeline Earthquake Engineering.

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