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# Earthquake disaster mitigation program for urban industries in Japan

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ABSTRACT: This paper deals with the development of earthquake disaster mitigation programs mainly from the viewpoint of Japanese industries. The discussion firstly focuses on survey of the historical development of earthquake countermeasures in this area over the past three decades in Japan. It covers representative technological innovations and works such as construction of huge aseismic design test facilities, seismic base isolation techniques and application of active vibration control methodology. Counterplanning in nonproductive industries such as utility companies and hotels are also investigated. Disaster mitigation system in this program is devided into two parts; hardware system of disaster prevention facilities and software or manpower system that functions as information network. After surveying some actual examples of the systems, a new key-strategy and seismic disaster mitigation concept are proposed. The report finally suggests demanding urgent attention which could lead to the establishment of integrated countermeasures for urban industries.

## 1 INTRODUCTION

Japan is always exposing to high risk seismicity and historically it has experienced major destructive earthquakes. The Great Kanto Earthquake 1923, as a typical example, attacked Tokyo metropolitan area and almostly destroyed major structures and facilities and burned majority of residential area which consequently led to about 100,000 died, 100,000 injured and 40,000 lost. Although, since then, Japan has not been exposed to such a destructive earthquake as Kanto Earthquake, it has been frequently subjected to strong earthquakes which inflicted severe damage on major structures, facilities and sometimes on residential zone.

As is generally known, Japan has fostered technological and industrial activity over 3 decades and it is now keeping the highest level of industrial development. That is why it is maintaining a variety of up-to-date facilities and systems which have high risk potential to seismic damage and secondary disaster. Almost of all these facilities and systems are internally charged and controlled by an individual industry. As well as other industrial countries, in Japan, remarkable technological innovation has achieved in industries during past some 3 decades. Therefore, this development inevitably facilitated the technological and socio-political advancement of the anti-earthquake design concept and the seismic disaster mitigation program.

From this viewpoint, this particular report deals with a brief survey of historical development of industrial counterplanning for earthquake disaster mitigation. It also provides some key issues demanding urgent attention which could lead to the establishment of countermeasures for urban industries includin productive and nonproductive industries.

## 2. EARTHQUAKE DAMAGES IN INDUSTRIES AND PROGRESS OF COUNTERMEASURE

The Niigata Earthquake of M = 7.7 caused a new type of damages to the Niigata city on June 16, 1964 when Japan had just started a great step to the industrial expansion in the 1970's. Niigata is the biggest city among the coast of the Japan Sea and has several great petroleum facilities. Immediately after the earthquake, at the Showa Petroleum Industry, fire occurred and attacked severe damages to oil tanks and other structures. 144 tanks containing about 32 million liters amount of liquids are totally lost. Sloshing was observed at about ten tanks and considerable amour of oil overflew.

4 years after, another great quake of the Tokachi-oki Earthquake arose in northern part of Japan Islsnds on May 16, 1968. Many industrial structures such as cranes, iron mill facilities and harbor structures are damaged. Through both of the earthquakes, damages caused by liquefaction were also remarkable.

Taking these damage experiences into consideratin, several technological investigation and testing were carried out under the joint

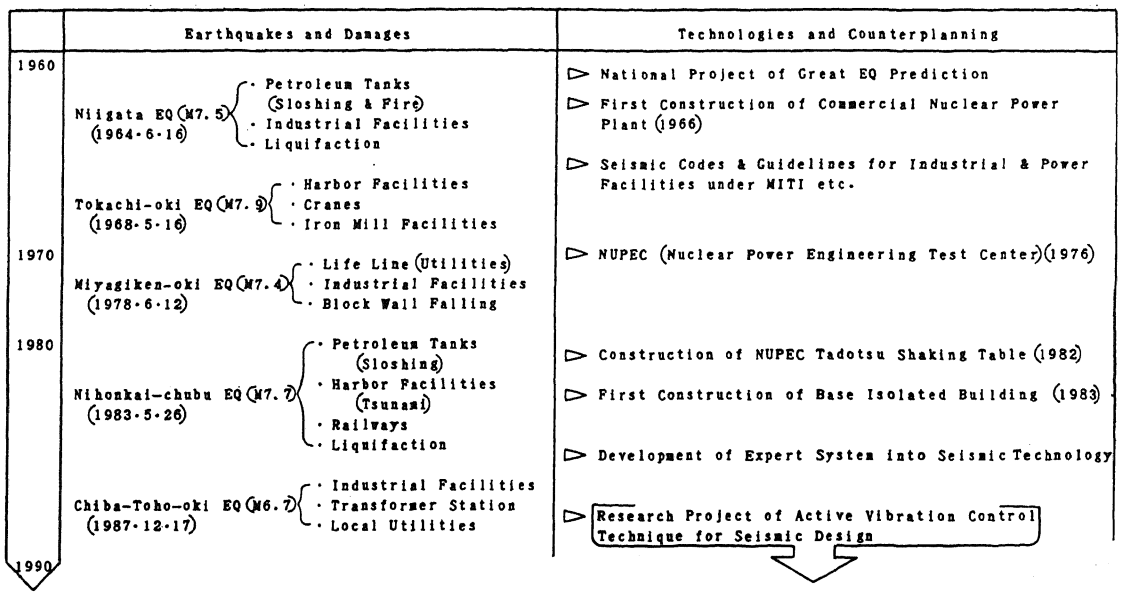


Figure 1. Earthquake damages and technological development of countermeasures during past 3 decades in Japan

project among academic organizations,industries and governments. As well as building and civil structure fields,scientists and engineers from mechanical engineering had joined this activity whereby Professor Shibata was leading this field.The effort is mainly concentrated on the establishment of anti-earthquake design criteria and codes for high pressurized cessels and pipings,petrochemical structures, electrical equipments and those in nuclear power plants.

On June 12,1978, the Miyagi-ken-oki Earthquake hit industrial area around Sendai; the biggest city in Tohoku district.This M = 7.4 earthquake and follwing Nihonkai-chubu earthquake on May 26.1983 (M = 7.7) damaged again heavy oil tanks (inducing sloshing),underground pipings,tower and vessels and furnaces.

Learning these damage failures,systematic investigation was carried out in order to analyze response of underground and widespread systems and dynamic interaction between structures and soil surface.

Under the sponcership of MITI,huge shaking test table was constructed on 1982 at Tadotsu in Shikoku Island. This table was utilized for the seismic proving test of nuclear structures and components having fullsize or large scale model.NUPEC(Nuclear Power Engineering Test Center) is still now leading this task since 1982. Heavy industries and construction companies have given active cooperation for this project.

During the period of the 1980's,Japanese industrial policy rapidly changed from haevy product industy to "light" product industry. such as electronical and information industry.

Chiba-Toho-oki Earthquake on December 17,1988 brought damages on these industries in metropolitan area. Figure 2 demonstrates damage modes in C.R.T. manufacturing process . In order to reduce this new type of damage which induce a great loss of financy,base isolation technique has been highly developed. Isolation floor systems by use of springs,dampers or bearings are proposed and producted by many industies.

Through past about five years,active vibration control technique has been introduced in conjunction with the development of sensitive sensors and efficient actuators. In this field, major industries are now so actively working.

## 3 DEVELOPMENT OF EARTHQUAKE DISASTER MITIGATION PROJECT IN JAPANESE INDUSTRIES

### 3.1 Disaster reduction activities by productive industries

In general,almost of all industries in Japan have developed their private earthquake hazard reduction programs which were undertaken without governmental aid. These programs were established according to the requirement from consumers, inhabitants who are living near the companies and (local) governmental sectors. As Guna pointed out at the last 9 WCEE,a variety of Japanese industries have specifically developed several hazard reduction products such as seismometers,gas valves,oil dampers, kerosine space heaters with automatic shutoff device and emergency alarms.

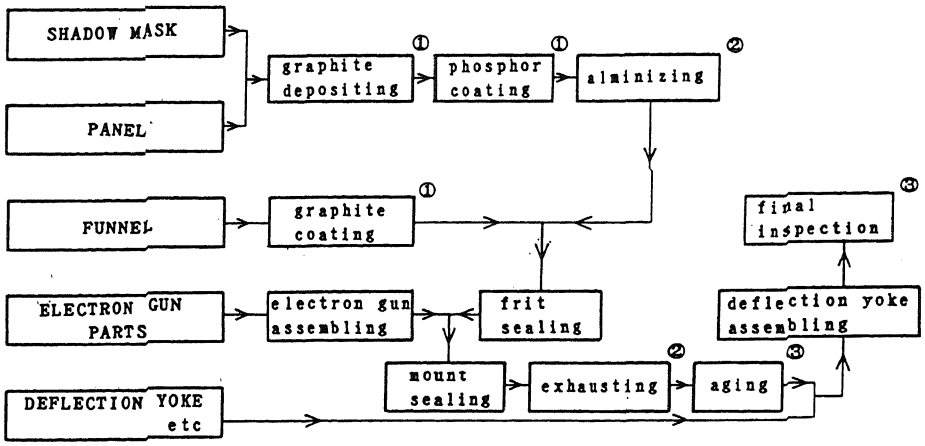


Figure 2. Damages observed in C.R.T. manufacturing process

Particular attention has to be devoted to base isolation facilities against seismic excitation. Through self-examination of serious damage on computer systems during the 1978 Miyagikenoki earthquake, several types of base isolation floor systems were proposed and developed by major building construction companies and heavy industries. The Kajima Construction Co.Ltd. and the authors have also developed a unique base isolation floor system by using bearing motion. Since the 1980's, several industries have investigated and designed active vibration control system against seismic and wind excitation utilizing the performance of highly efficient sensor/actuator devices.

Disaster mitigation or reduction systems in the productive (sometimes including nonproductive ) industries are devided into two subsystems: One is a hardware subsystem composed of disaster mitigation facilities and another is a software sub-system or a manpower network system having required staffs and communication systems.

Figure 3 is a typical frame-work of this system by which disaster mitigation capacity or capability can be evaluated either qualitatively or quantatively. One of major local government,Kanagawa prefecture, has developed this type of evaluation system which can be applied to the oil refinery and petro-chemical industries. Numerical evaluation by this program can be semi-automatically conducted by use of lap-top type computers.

### 3.2 Programs for nonproductive industries

Seismic disaster mitigation program for nonproductive industries such as utility companies, information service companies,hotels and shopping stores have been established in Japan since the 1970's when serious damages on these sectors at the 1971 San Fernando earthquake were reported. Particularly,"life line companies" such as electric power and gas supply companies and telecommunication companies have specifically investigated and settled the basic concept of pre-disaster countermeasures and damage recovery strategies. These programs are basically laying stresses on life-safety of residents and customers in earthquake zone.

In addition to technological approach,socio-political,economical and mass-psychological aspects are taken into consideration for the establishment of the program. From this point, Japan has developed a national wide spread electronix emergency alarm system that will turn on radio/TV sets by a joint project among government,electronic companies and broadcasting corporation(NHK).

Typical items in these programs are summerized as below;

1.Electric power supply companies
- Security of power supply and transmission facilities
- Establishment of emergency power supply and transmission measures

2.Gas supply companies
- Prevention of succeeding secondary disaster by gas diffusion
- Urgent turning-off of gas in dangerous zone

3.Telecommunication and information service companies
- Security of emergency network systems
- Urgent recovery of communication service facilities

4.Hotels and department stores
- Rescue of seriously injured guests and customers and prevention of a "panic"
- Partinent information and urgent induction to refuge for guests and customers

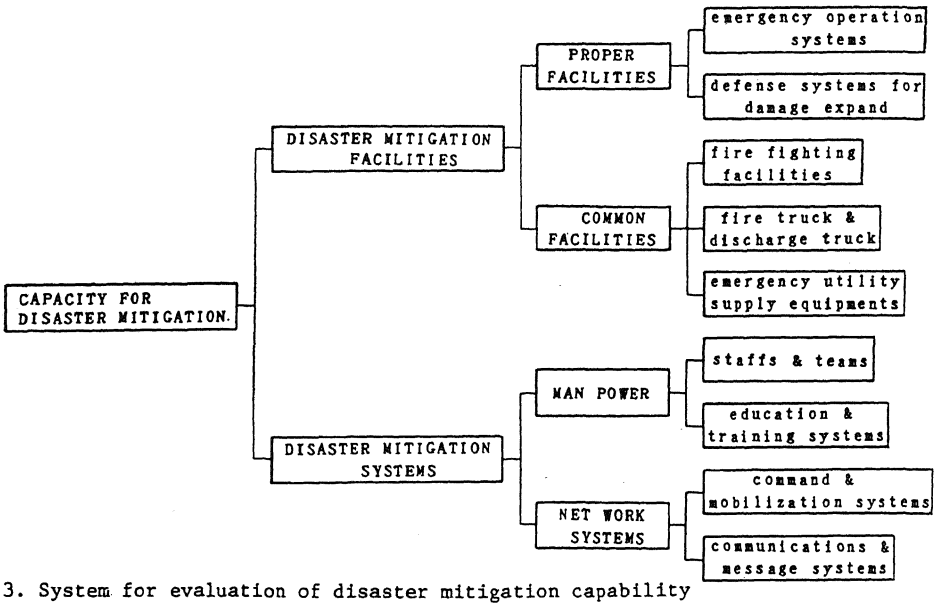


Figure 3. System for evaluation of disaster mitigation capability

## 4. CONTRIBUTION OF INDUSTRIES TO INTEGRATED DISASTER MITIGATION PROGRAM

In order to proceed earthquake disaster mitigation planning,a basic idea concerning relationship among industries and other sectors is proposed as Fig.4. Particular intension is devoted to the cooperation among industries, reidents and government. Currently,in Japan, local residential sectors are keeping quite aggressive power to promote their residential environment to make better.Interchange of information among individual sectors has to be highly required.By using such a cooperative relationship , integrated countermeasure concept will be established for urban industrial areas including productive and nonproductive industries.

## 5. CONCLUDING REMARKS

In this short article,the authors showed some issues concerning earthquake disaster mitigation program mainly from the viewpoint of Japanese industrial sectors.

Firstly,brief historical survey was done on the seismic damages to industrial facilities and the assorciated progress of technological countermeasures over past 3 decades.

Secondly,some key cocept with respect to the establishment of integrated seismic disaster mitigation criteria is proposed. It covers both of hardware and software systems.

Finally,what the cooperative relation among industries,residents and government should be is investigated.

The authors would like to demonstrate detailed data and materials about this work at the poster session at the Conference.

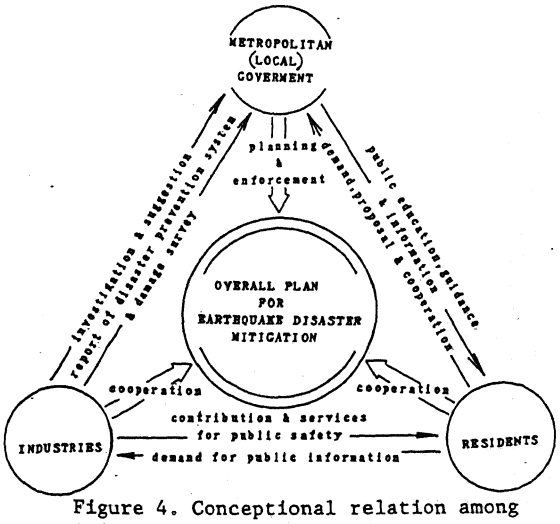


Figure 4. Conceptional relation among industries, residents and government

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