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STRATEGY OF SEISMIC DISASTER PREVENTION PLAN OF GAS SUPPLY SYSTEM IN GREAT TEHRAN, IRAN

A Mallek MOHAMMADI [1] , Mohammad Reza YOUSEFI POUR,[1]
Yasunari YANOU [2],Yasuo OGAWA [2], and Hirohisa YAMADA[2]

SUMMARY

This paper outlines a basic approach toward the realization of anti-earthquake measures for the gas supply system being operated by Greater Teheran Gas Company (GTGC). The idea is to produce results as quickly as possible from the execution of these anti-earthquake measures.

The anti-earthquake measures needed by GTGC's gas supply system can be roughly divided into tow pillars: one for reinforcing existing facilities and the other for disaster prevention. Each of them is detailed in the paper, which also refers to where priorities of improvement should be placed. As for construction of the disaster-prevention system, the paper shows step-by-step procedures so that the system becomes functional even during the early stage of construction.

INTRODUCTION

Iran is no stranger to earthquakes as the country has suffered many devastating ones in the past. In December 2003, a large temblor demolished the city of Bam southeast of Tehran, leaving over 40,000 people dead. Tehran City, the nation's capital, is surrounded by active faults. To the north, there is the North Tehran Fault, and the South Ray Fault is on the opposite side, making the city extremely prone to large earthquakes. This fact makes it all the more important to draw up quake-induced disaster prevention measures for the city. In particular, no time should be lost in devising anti-quake measures for gas supply systems. Should a large quake strike Tehran directly, causing devastating damage there, its repercussions would be felt not only within the city, but across the entire country. Because of this great magnitude of problem, those anti-quake measures for gas supply systems in Tehran should be undertaken on a national level.

This paper proposes an approach to effective anti-quake measures that should be implemented to protect GTGC's gas supply systems from large earthquakes.

[1] Greater Tehran Gas Company BLK8 2th Floor GTGC BLD North Iranshahr Ave Tehran Iran
[2] Osaka Gas Co. Ltd., 4-1-2 Hiranomachi, Chuo-ku, Osaka, 541-0046, Japan

METHODOLOGY OF SEISMIC RISK ASSESSMENT

Flow chart of seismic risk assessment for Greaten Tehran Gas Company (GTGC) is shown in Fig.1.

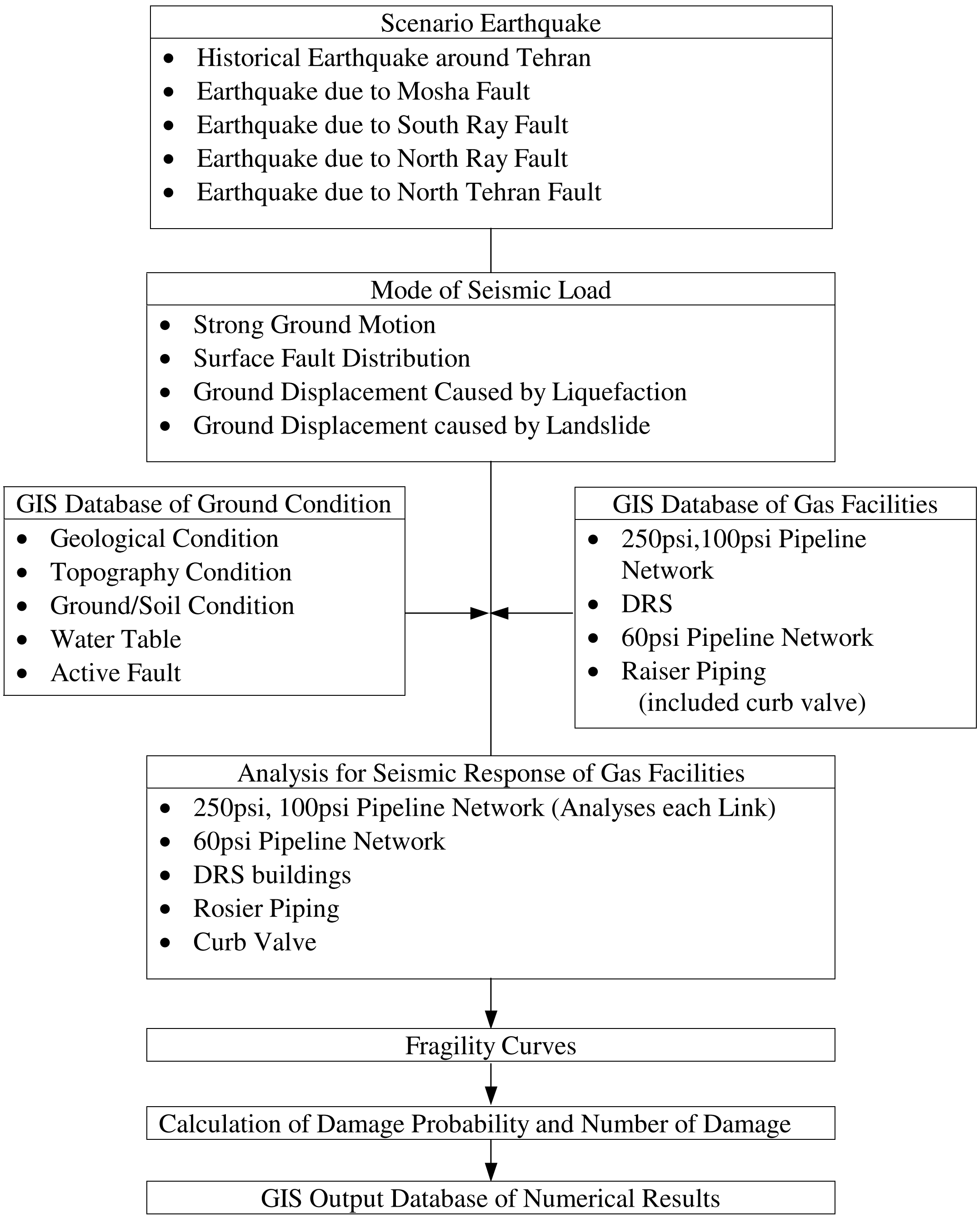

Fig. 1 Flow chart of seismic risk assessment

Scenario Earthquake

Earthquake due to active fault, which may occur in supply area of Great Tehran Gas Company (hereafter noted as GTGC) and its vicinity, was investigated for this project. After this screening process to pick up most risky earthquake for the area, some active faults and accompanying scenario faults were selected to research for countermeasures of GTGC. Then following 4 scenario earthquakes were selected. Additionally, one earthquake artificially generated from past earthquakes data was also selected as historical earthquake. It is supposed that they have their own maximum scale.

1. Earthquake due to North Tehran Fault
2. Earthquake due to South Ray Fault
3. Earthquake due to North Ray Fault
4. Earthquake due to Mosha Fault
5. Historical Earthquake around Tehran

Seismic Force

As the external force caused by 5 scenario earthquakes shown in 10.1, following 4 types of those were selected by considering geological condition, topography and ground/soil condition. These are used as the input for seismic response analyses of gas facilities of GTGC.

1. Strong Ground Motion
2. Surface Fault Dislocation
3. Ground Displacement caused by Liquefaction
4. Ground Displacement caused by Landslide

Regarding with the liquefaction, it was found, after calculation, that the magnitude of displacement by lateral spreading was negligible because of flat ground surface of the area. Then, only settlement was used in subsequent process. As for landslide, it was found that no landslide occurred in the area where gas facility existed. Therefore, landslide was also not used in subsequent process.

Input/Output Format of Seismic Reliability Assessment for Buildings in Tehran and Gas Facilities of GTGC

ArcView, one of major GIS codes, was used for data input for analysis and estimation. The result was also displayed by ArcView. As for display format of results, effective format suitable for reliability estimation and planning of disaster prevention measures was conducted.

Seismic Reliability Analysis for Gas facility of GTGC

Pipeline network of GTGC is classified into 2 ranks by inner pressure. They are 250psi network and 60psi network. 100psi network is stratified to 250psi class.

As for 250psi network, its level of importance is very high. Therefore, network was segmentized into 80 links and each link was analyzed to calculate its probability of failure.

As for 60psi network extending to 7,000km of total length, it consists of vast amount of components. After comprehensive consideration for importance of network, disaster prevention method in future, effectiveness of analysis and other factors, 500m x 500m mesh was defined as the unit of analysis. Probability of failure was obtained through the same process as 250psi, but the format of final output became a number of damages for a mesh because this output was referred as database for planning of disaster prevention measures.

For probability of failure, rank of “Ma (major)”, “Mo (moderate)” and “Mi (miner)” was set. Definition is as follows.

Ma: Extremely high possibility of gas leakage occurrence

Mo: Possible to keep safe from leakage but needs leakage detection (if necessary repair) after an earthquake

Mi: No damage

Fragility Curve (vulnerability function) for probability analysis was conducted for each kind of gas facility and input condition. Latest study result was introduced for this process.

Reliability of governor, valve and other facilities within CGS station were assessed comprehensively by considering above research result, performance of gas facilities of Osaka Gas Co. during Kobe Earthquake and other research results.

After several site investigations, curb valve and riser were pointed out as vulnerable facilities. Curb valve uses mechanical joint without anti-slip out features. This type of joint was judged as “vulnerable to earthquake” according to the “Recommended Practice for earthquake Resistant Design of Gas Pipeline” issued from JGA. Slip out had occurred in this type of joint when Kushiro-oki earthquake (1993).

House pipe for the customer dwelling, called “riser”, contains house regulator. This regulator is installed with screw joints. Most of gas facility damage of Osaka Gas co. when Kobe Earthquake had occurred at this type of joint. It is obviously “vulnerable to earthquake” same as mechanical joint.

Regarding with curb valve and riser, experimental tests with actual components were done in Iran. Results were referred when setting their bearing force of ultimate limit state.

Consideration of Analytical Results and Result of Seismic Reliability Assessment

Because welded steel pipe is used for 250psi and 100psi networks. According to the results, major damage state (Ma) was only supposed to occur against fault dislocation by Mosha earthquake and North Tehran earthquake. There was no damage caused by wave propagation or displacement due to liquefaction by all 5scenario earthquake. And the area of occurrence of Ma is limited narrow area in northern part of Tehran city. This tendency was harmonic to the result that there was no damage for welded steel pipe following current specification for welding when Kobe earthquake.

As for welded line valves and gas facilities within CGS station, they were concluded as no damage or slight damage could occur. But line valves with flange joint was judged as vulnerable as causing gas leakage.

Buildings of DRS and TBS were judged as vulnerable. Equipments and facilities for gas shut off system will be installed in the buildings of DRS and TBS. It is therefore very important to improve buildings. But it was concluded that the governors and pipings in DRS and TBS had earthquake resistance.

As for 60psi pipeline network, the same results as 250psi pipeline network were obtained.

As for curb valves, major damage state (Ma) was only supposed to occur by North Ray earthquake and North Tehran earthquake. Most of curb valves belonged to damage state of moderate (Mo) and miner (Mi). But it is said that gas leakage from curb valve occur at all times. That should be considered for evaluation of earthquake proof of curb valves.

As for riser, it was defined that its fragility is identical to that of customer's building. Distribution of damage was spreading all over the supply area of GTGC.

Based on above mentioned analytical results, reliability of gas facilities of GTGC against earthquake is summarized as follows.

Network of 250psi and 60psi has enough reliability as a whole. But curb valve and riser are two main weakness of GTGC system. As a great number of them are located at the end of network tree, their damage has to be distributed over the wide area.

Result of Phase2 in this project is considered very effective for planning process of practical disaster prevention measures. This result indicates that GTGC needs the comprehensive disaster prevention plan integrating remote control shut-off system making supply-stop just after earthquake and countermeasures which prioritize components such as aforementioned riser, curb valve at the end of network and scattered flange valve over the network. Fig.2 shows a case of damage distribution of raiser pipes.

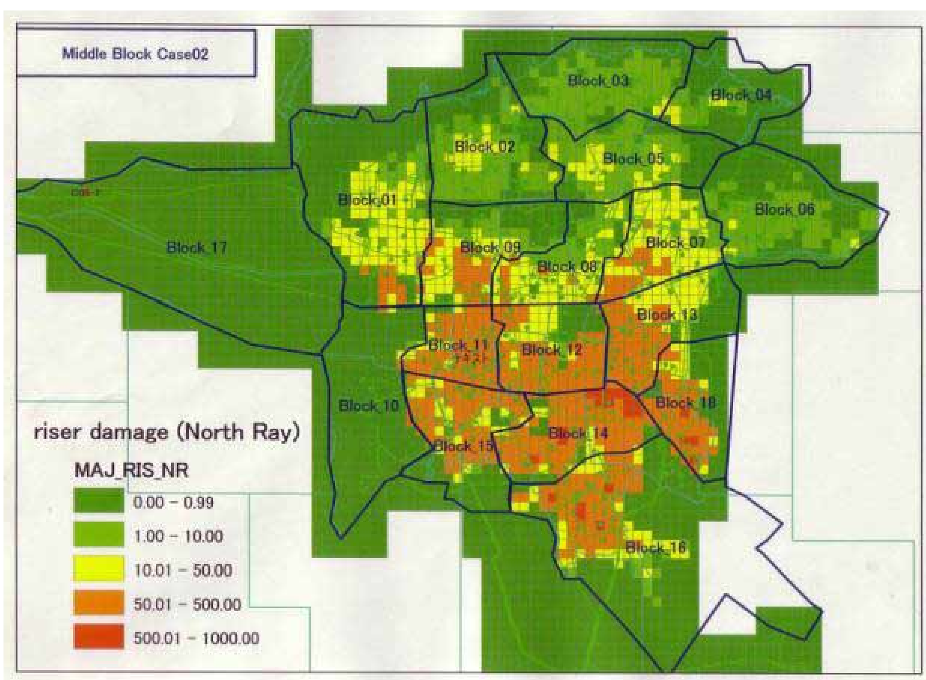

Fig. 2 Damage distribution of raiser pipes due to North Ray Earthquake

STRATEGY FOR EARTHQUAKE DISASTER PREVENTION COUNTERMEASURES OF GREATER TEHERAN GAS COMPANY

In order to make strategy for the Earthquake Disaster Prevention Countermeasures of Greater Teheran Gas Company (hereinafter referred as GTGC), four elements are considered as follows.

① Seismic hazard in Tehran city

② Earthquake resistance of GTGC's gas facilities.

③ Features of disaster prevention for GTGC's supply system.

④ Earthquake resistance of the buildings in Tehran city

Regarding ①, the possibility of an earthquake in Tehran city and its surroundings should be fully considered. Earthquake disaster prevention countermeasures should be determined based on the thinking that a major earthquake may directly hit Tehran city tomorrow. This means that the occurrence of an earthquake should viewed as a reality, not just a probability.

Regarding ②, most of the pipeline network of the gas supply system consists of welding pipes and PE pipes. Therefore, the network has high earthquake disaster protection overall. However, screw joints in the rising part, called curb valves and raisers, in the service pipes that are located at the end of the network for each customer, are considered to have a lower degree of earthquake disaster resistance. There are about 650,000 service pipes for customers, and to switch the entire earthquake disaster protection equipment within them to ones with a higher degree resistance would require immeasurable cost and time. This is a very important point to consider regarding GTGC's earthquake disaster prevention countermeasures.

Regarding ③, gas pressure of gas supply system of GTGC should be focused on. A house regulator to depressurize the 60 psi gas pressure to 180 mm H_2O is installed in the raiser. This means that a very high pressure of 60 psi exists right up to the customer. Assuming that the gas pipe will be damaged by an earthquake and cause a gas leak, the high gas pressure should be considered as a potential risk in earthquake disaster prevention.

Item ④ is related to need for gas supply and damage to the house pipe after an earthquake. If major earthquake were to directly hit Tehran city, a considerable number of houses will probably collapse. Of course gas supply is not needed for customers whose homes are destroyed. Actually, supplying gas to such a customer itself can be a danger, leading to a secondary disaster. This point should also be seriously considered in earthquake disaster prevention.

Therefore, based on these four elements, the following strategy for earthquake disaster prevention countermeasures is proposed.

The overall picture of GTGC's earthquake disaster prevention countermeasures should continue to steadily promote earthquake disaster prevention countermeasures of gas equipment with greater earthquake-resistance, and establish, as quickly as possible, a disaster prevention system that can achieve gas supply discontinuation.

To promote these two countermeasures concurrently is ideal. However, since revenue spent on earthquake disaster prevention countermeasures has its limits, and such drastic earthquake disaster prevention countermeasures usually requires several years, construction of a disaster prevention system should be prioritized. If there is a major earthquake while improvements in the earthquake disaster prevention countermeasures are still being made, gas leak damage will occur. Construction of a disaster prevention system is essential to minimize this damage as much as possible.

The disaster prevention system needed for GTGC consists of the following five systems.

1. Central Control System
2. Radio Communication System
3. Remote Control Shut off System of gas equipment within the network
4. Earthquake motion and TV camera Image Monitoring System
5. The block system of the pipeline network

These five systems make up the essential core of the disaster prevention system of GTGC. A disaster prevention system cannot be established if even one of them is missing. It should be understood that these five systems combine to form one disaster prevention system. It will require at least five years to construct such general disaster prevention system. It may even take 5～10 years, depending on the circumstances.

Countermeasures for when a major earthquake hits during construction of the disaster prevention system should also be considered. Even if all the system were to be established in a short period, many concerns are raised from the practical viewpoint, such as can all the system be fully utilized, how can a sufficient and continuous maintenance management be carried out, and can it be adapted to the existing operational management of GTGC. In response, this survey recommends the gradual construction of a disaster prevention system.

In other words, construct the pilot model of the disaster prevention system. The pilot model should have the minimum functions of the disaster prevention system. It should also be used to clarify the various problems in constructing a practical system, and provide solutions. According to these results, a full-scaled disaster prevention system can be constructed. Of course the pilot model should be installed as part of the full-scale disaster prevention system.

And, although details of the block system of the pipeline network shall be described later, a super block should be constructed first, then the broken down into middle blocks, and finally the middle block should be divided to complete the block system.

If construction of the disaster prevention system proceeds in this manner, functions of the disaster system can be implemented at each phase of construction, and the function of the disaster prevention system can be stepped-up with each successive phase. In this way, improvements in disaster prevention can be expected even in mid-construction of the disaster prevention system.

Strategy of preparation for earthquake disaster prevention measures was described as stated above. Next, Strategy in case of real earthquake occurrence is mentioned. The most important measure after an earthquake is a decision-making with in 1hour, or at most 12hours. Timely and appropriate decisions make successful countermeasures and restoration works possible.

The most important decision is a judgment of gas shut-off. It is estimated that many buildings break down in the event of an earthquake and gas leakage Occur at many places in Tehran. In result, gas shut-off system is the most effective measure for a safety of people in Tehran.

Training for decision-making staff in advance is also very important to realize effective measures. Fig.3 shows a frame work of earthquake disaster prevention measures.

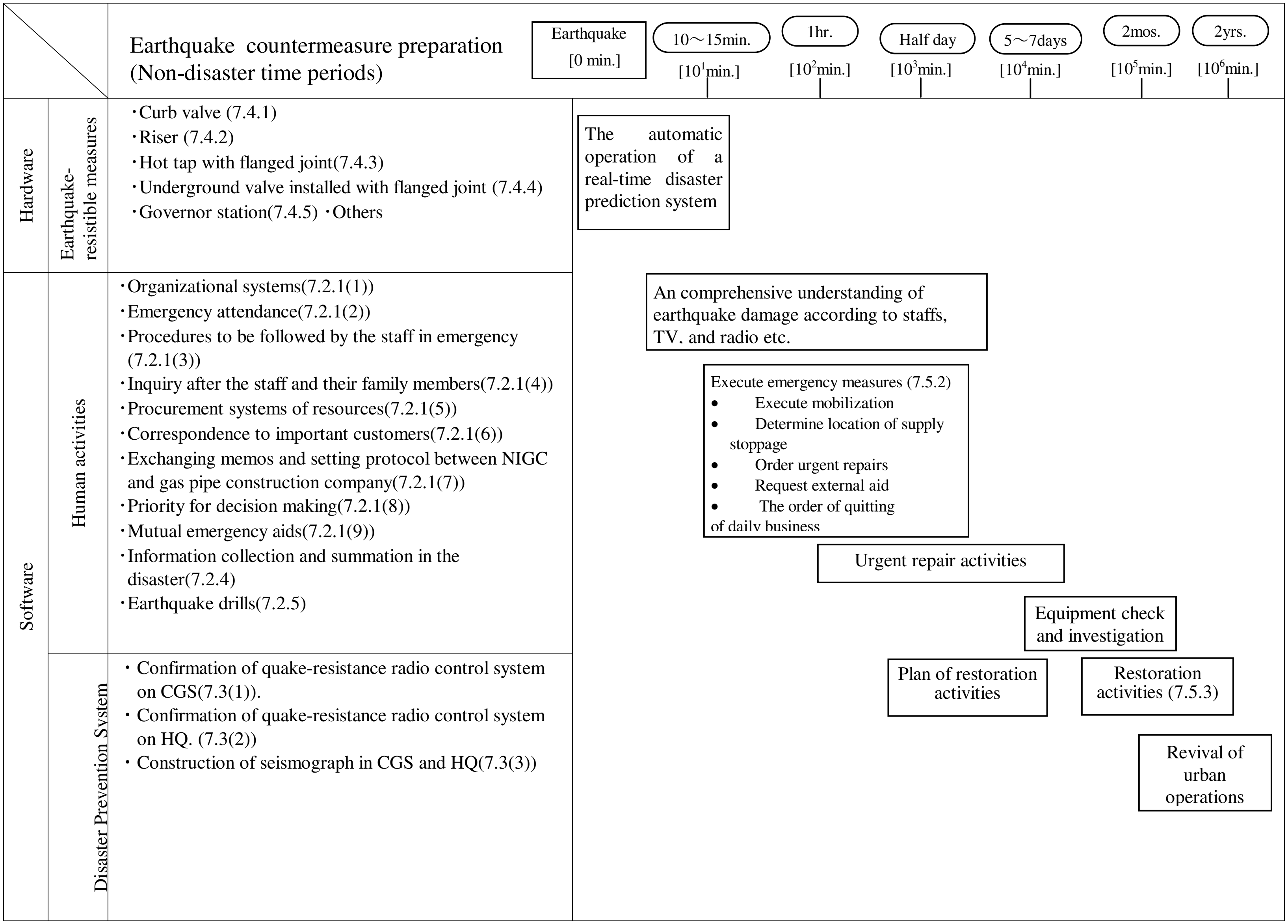

Fig.3 Framework of Comprehensive Earthquake Countermeasures with Reference to Time-sequenced Concepts

CONCLUSION

1. GTGC's gas pipeline networks have high quake-resistance because they are welding steel pipes or polyethylene pipes.
2. Service pipes and house pipes are estimated to be damaged seriously in an earthquake.
3. Therefore, gas remote shut –off system or gas automatic shut-off system should be installed by top priority as emergency measures in GTGC's earthquake disaster prevention measures.
4. Practical and actual training is also very important for all measures involved in earthquake disaster prevention measures, authority, experts, engineers and staffs.

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