

PROGRESS REPORT OF SEISMIC EVALUATION AND RETROFIT OF OLD BUILDINGS LOCATED ALONG THE SPECIFIC EMERGENCY TRANSPORTATION ROADS IN TOKYO

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Abstract

Japanese seismic codes were revised fundamentally in 1981. There are currently known facts that old buildings constructed before 1981, had emerged as poor seismic performance on previous earthquakes. In Tokyo, the emergency transportation roads are officially designated in order to secure the transportation of relief supplies after earthquakes by Tokyo Metropolitan Office. The roads which play a particularly important role are named as “The specific emergency transportation roads”. There are about 1000 km in extended length and in total about 18,500 buildings, of which about 5,000 old buildings that shall be required to have good seismic performances for the smooth transportation of relief supplies. In June 2011, Tokyo Metropolitan Office enacted and enforced the code that the old buildings shall be secured good seismic performance. The Japan Structural Consultants Association as JSCA have cooperated in rating for seismic evaluation of these old buildings. This paper reports the progress of the seismic evaluation and retrofit renovation of these old buildings.

Introduction

More than 20% of earthquakes measuring magnitude 6 or stronger have been recorded in Japan, which comprises only 0.25% of the Earth's landmass. There is a high possibility that the Capital Tokyo will be struck by a big earthquake, the government's Earthquake Research Committee compiled a report that predicts that the probability of occurring earthquake is 70% on the south side of Kanto region between 30 years from 2007.

Japanese seismic codes were revised fundamentally in 1981. There are currently known facts that old buildings constructed before 1981, which is called an old seismic building, had emerged as poor seismic performance on previous earthquakes. The owners of old buildings should carry out seismic evaluation, seismic retrofit design and retrofit renovation.

Tokyo Metropolitan Office drew up new laws to “Seismic Retrofit Promotion Plan of Tokyo” in March 2007. They set forth goals of promotion and execution plan, who have been undertaking various measures to reach goals. As we know, Tokyo will host the Olympic games in July 2010, many people will visit Tokyo from Japan and abroad. The plan was revised in 2016, which have a basic philosophy of “Realization of the safest and the most secure city Tokyo in the world, for a large earthquake”, and set new target until March 2020. The target is to secure the accesses to destinations such as disaster prevention bases from outside Tokyo by taking a detour, with making sure of rescue operations, emergency medication and transportation of emergency relief supplies just after earthquake until The Olympic and Paralympic Games Tokyo 2020.

Dr. Okoshi reported about seismic state of old buildings located along the specific emergency transportation roads at 14th U.S.-Japan Workshop in 2012. This paper is a follow-up report and introduces new approach.

0. Seismic Adequacy of Old Buildings in Japan

In Japan, there was the Act for Promotion of Rehabilitation for Earthquake-Resistant Structures, which was enacted based on the lesson from the Kobe Earthquake of 1995. The purpose of this law is to protect the lives, bodies and property of citizens from being damaged such as collapse of building by earthquakes, and to improved safety of buildings with facilitating seismic retrofit renovation of old buildings, thereby contributing to improvement of public welfare.

In this law, building over a certain scale utilized by many people is enacted for “Specific Building”, and owners of old seismic buildings are required to carry out seismic evaluation and retrofit renovation in order to ensure its seismic performance equal to or higher than the current standard.

This law was revised in 2006 and 2013. And the goals were set until 2015 such as achieving earthquake resistance rate of houses and specific buildings to be over 90%. Objects of specific buildings were expanded including buildings located along emergency transportation roads, which is pointed out that owners of old seismic buildings shall be taken on own initiative in solving problems.

To realize such targets, the administrative agency shall enact to draw up of “Seismic Retrofit Promotion Plan”, all prefectures have carried out the plan, the municipality is proceeding with to plan and carry out one after another.

1. Effort to Promote Building Retrofit Located along Emergency Transportation Roads in Tokyo

1.1. Specification of Emergency Transportation Roads. Tokyo Metropolitan Office drew up new laws to “Seismic Retrofit Promotion Plan of Tokyo” in March 2007. They issued code in 2011 first in Japan, which is a plan to promote retrofiting buildings located along emergency transportation roads in Tokyo (e.g., Photo 1). As we know, in March 2011, The 2011 off the Pacific coast of Tohoku Earthquake occurred.



Photo 1. Emergency transportation road.

1.2. Purpose of This Law. The purpose of this law is to maintain the function of Capital and to protect the lives, bodies and property of citizens from being damaged by earthquakes, because of the urgency of the crisis that the earthquake might occur directly under areas around Tokyo is pointed out.

Emergency transportation roads are key to sustain escape, firefighting, rescue operations, emergency medication, transportation of emergency relief supplies and recovery and rehabilitation activities just after earthquake (e.g., Photo 2, 3). With proceeding seismic retrofit renovation of old buildings located along the roads, we can secure the function of Capital.



Photo 2. Firefighting and rescue operation.



Photo 3. Collapse of building on a road.

1.3. The Specific Emergency Transportation Roads. Tokyo Metropolitan Office officially designated 1000 km as for the specific emergency transportation roads from total of 2000 km (e.g., Figure 1). These roads lead up to key harbor, airport, Tokyo Metropolitan Office headquarters and disaster prevention center to play a central role of emergency measure, and buildings located along these roads should have good seismic capacity.

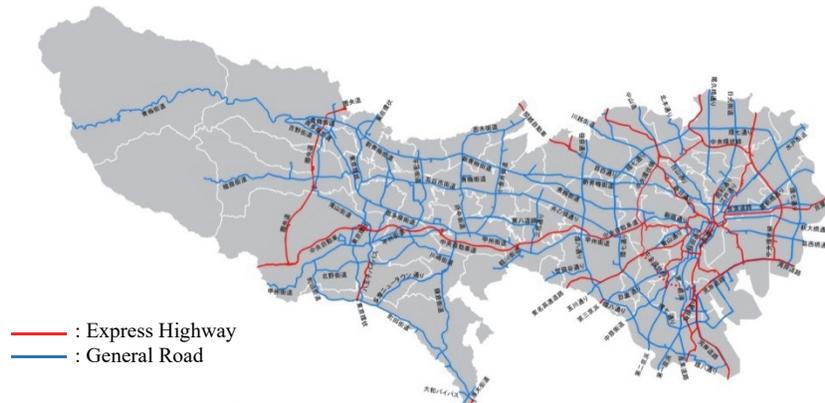


Figure 1. The specific emergency transportation roads.

1.4. Purpose of Rate of Seismic Buildings. The law set numerical targets of rate of seismic buildings (e.g., Table 1).

Rate of seismic buildings

$$= \frac{\text{(buildings by the new standards + seismic buildings by evaluation + seismic buildings by retrofit)}}{\text{all buildings}}$$

Table 1. Numerical Targets of Rate of Seismic Buildings and Attitude

Time	March 2020	March 2026
Numerical Target	90% as rate of seismic buildings and to minimize buildings of high-risk collapse	100% as rate of seismic buildings
Attitude	accessible state to destination such as local disaster prevention base from outside Tokyo by taking a detour, through the specific emergency transportation roads just after earthquake	accessible state at the shortest distance through the specific emergency transportation roads just after earthquake

1.5. Buildings Located Along the Specific Emergency Transportation Roads. The buildings that fit all of the following are set as specific roadside buildings.

- #1. The buildings which are located along the specific emergency transportation roads.
- #2. The buildings which were built before May 1981, what are called old seismic buildings.
- #3. The buildings which have the height of about half or more of the road width (e.g., Figure 2).

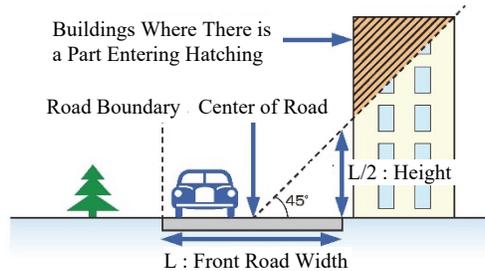


Figure 2. Concept of building height and road width.

1.6. Third Phases of Duty to Owner. Owners of specific roadside buildings are required third phases of duty to have good seismic performance of buildings.

Phase 1 Duty to report

Owners have duty to report about implementation status of seismic evaluation and retrofit renovation.

Phase 2 Duty to carry out

Owners have duty to carry out seismic evaluation.

Phase 3 Duty to effort

Owners have duty to effort of seismic retrofit renovation, if buildings have not good seismic performance.

1.7. Agreement on Cooperation with the Concerned Organizations. The Metropolitan Office has concluded an agreement on cooperation with the concerned three organizations, for the supporting system to owners. The Japan Structural Consultants Association as JSCA is one of them, which has cooperated in rating for seismic evaluation of these old buildings.

2. Progress Data Report

This is new report about seismic state in June 2018. The data is referenced from “Tokyo Seismic Portal Site” in terms described later.

The total buildings along the specific emergency transportation roads are 18,450 as in Figure 3 -- $E=(A+B+C+D)$ in symbols. Seismic buildings are 15,550, the rate of seismic state is 84.3% -- $(C+D) / E$ in symbols. Old seismic buildings under the obligation to do seismic evaluation are 4,837 -- $F=(A+B+C)$ in symbols, the rate to whole is 26.2% -- F / E in symbols. Breakdown of old seismic buildings show as in Figure 4, buildings have completed seismic evaluation are 4,709, the rate is 97.4% -- $(B+C) / F$ in symbols, retrofitted old buildings are 1,937, the rate is 40.0% -- C / F in symbols.

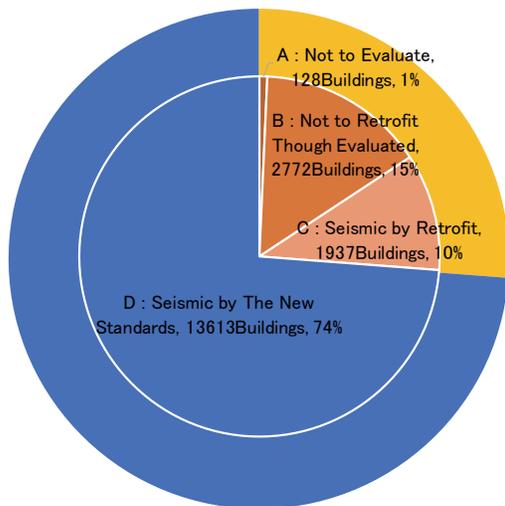


Figure 3. E : State of seismic performance of whole the specific buildings located along emergency transportation roads.

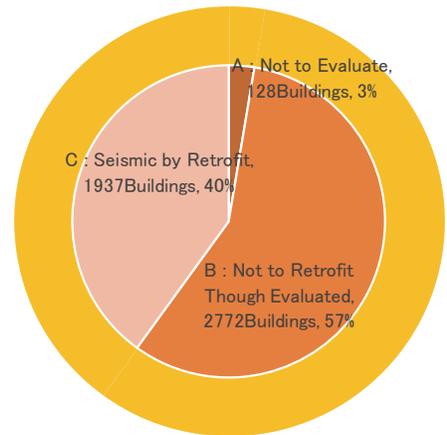


Figure 4. F : Breakdown of old seismic buildings.

3. Public Financial Support of the Project

3.1. Public Financial Support of Seismic Evaluation

Period. The financial supports basically have finished by 2016, but some are effective until March 2019.

Amount of public financial support. There are multiple patterns based on total floor area and uses.

Example of public financial support.

Office building, five-stories with a total floor area of about 500m² : 1,800,000 JPY or 16,000 USD

Condominium, ten-stories with a total floor area of about 1.500m² : 4,115,000 JPY or 37,000 USD

Rate. Full amount in some cases

Subject. The cost of inspection, such as actual state, concrete compressive strength and presence or absence of asbestos, restoration of drawings and seismic evaluation. Owners who have small buildings, non-condominiums or buildings which need restoration of drawings need to cover own expenses, even if the amount of inspection and evaluation exceed a baseline.

3.2. Public Financial Support of Seismic Retrofit Design

Period. Necessary to undertake by March 2019

Rate. Full amount of seismic retrofit design in some cases

It varies greatly depending on the municipality. If the municipality has subsidy system in addition to system by Government or The Metropolitan Office, the owners do not need to bear the cost. If the municipality does not have subsidy system, the owners have to bear the cost about 60% of total.

3.3. Public Financial Support of Seismic Retrofit Renovation

Period. Necessary to start seismic retrofit design before March 2019

Rate. 90% of amount in some cases

It varies greatly depending on the municipality of buildings site. If the municipality has subsidy system in addition to system by Government or The Metropolitan Office, the owners bear the cost of 10% of total.

If the municipality does not have subsidy system, the owners have to bear the cost between 60% and 80% of total.

3.4. Tax Incentive. Owners who finished retrofit renovation of certain conditions are filled, can have tax incentive such as income tax, corporate tax, fixed asset tax or city planning tax.

4. Investigation Technique for the Case of Reinforced Concrete Buildings

General investigation of old buildings in Japan is as follows. Engineers must investigate typical structural members, structural planning, and concrete compressive strength by cylindrical test piece taken off over three pieces per each floor. After these, they proceed to seismic evaluation and retrofit design.

If building's design drawings are lost for old buildings, engineers inspect present of state including shape of building by span and story height, seismic elements of column, girder and wall, structural plans, reinforcing-bar arrangement of typical members, concrete compressive strength by cylindrical test piece taken off over three pieces per each floor. And they must restore to revised structural drawing, get the minimum information for seismic evaluation.

There are two ways of investigation of reinforcing-bar arrangement of the member. One is non-destructive test by radar with electromagnetic wave, which turns out the number of main rebar, and pitch of hoop, stirrup and horizontal or vertical rebar of wall (e.g., Photo 4, 5). Another way is destructive test by hollowing with core boring machine, which turns out the diameter and material of rebar (e.g., Photo 6, Figure 5).



Photo 4. Investigation of re-bar arrangement by non-destructive test.



Photo 5. Marking of re-bar arrangement.

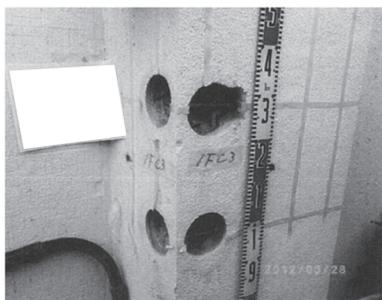


Photo 6. Investigation of the diameter and material by destructive test.

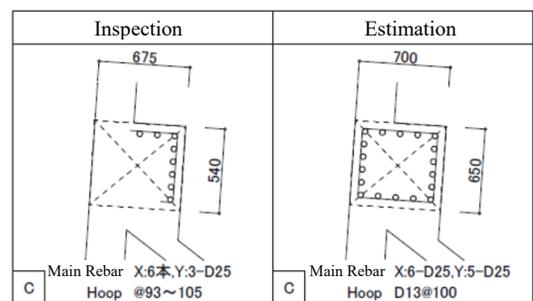


Figure 5. Estimation example of member.

5. Feedback for Citizens

The Metropolitan Office operates the website named “Tokyo Seismic Portal Site” and makes state of seismic public. They expect that owners get notices and initiatives, by wide announcements of this information, which have serious effects on rescue operations, emergency medication, transportation of emergency relief supplies at earthquake.

The site has given a public notice of the numbers of building located along the specific transportation roads which has not carried out seismic evaluation, and names and addresses of buildings against owners who have not proceeded out seismic evaluation for no justifiable reason. The names and addresses will be deleted, when The Metropolitan Office recognizes that the owners made a start on seismic evaluation.

6 New Approach

6.1. Visualization. As in Photo 7, the construction site has display of “Under Retrofit”. The Metropolitan Office expects the momentum for Retrofit renovation will grow, by citizen’s attention on the sign of progressing condition of retrofit renovation on a daily basis.



Photo 7. Display of “under retrofit”.

6.2. Door-to-Door Campaign. The Metropolitan Office have tried to spread the importance of retrofit renovation and the subsidy system. The Metropolitan Office have made door-to-door visits to owners who have not carried out retrofit renovation after seismic evaluation after June in 2016, in cooperation with the municipality and the concerned organizations.

As a result, the various reasons are recognized why the seismic retrofits have not being proceeded by uses or ownership patterns. These reasons include the construction cost and decline in building functions, stagnation by lack of knowledge how to proceed, and non-cooperation of tenants.

6.3. Creation and Proposal of Committee. The Metropolitan Office created the committee up for promotion of retrofit renovation. The committee made up entirely of academic experts and legal experts, the period set from January in 2017 to March in 2018, thereby reported for conclusion. In the report, they revealed the need for acceleration of retrofit renovation and proposed specific promotions, based on the result of door-to-door campaign.

These promotions include that public announcement of building name, new responsibility for owners, supporting measures for building possessors such as lessee or tenant, in addition to owners. Especially measures for possessors have never happened before and shall be new steps.

The facts were recognized that The Metropolitan Office shall figure out about problem for owners, create a system that can advise on a continuous basis until retrofit realization, and needs for further cooperation with the municipality and the concerned organizations.

7. Reference of Approach Outside of Tokyo

Tokyo and the surrounding region have just started discussing about establishment the consultative organization in which carry out to retrofit buildings located along emergency transportation roads into perspective standpoint in full coordination with nine prefectures and cities after the meeting in May 2017.

Osaka Prefectural Office specified the roads distance of 260 km in 2013, as to proceed to retrofit renovation on a priority basis for to secure the functionality when earthquake is occurred. There is public financial support of subsidy system for seismic evaluation, seismic retrofit design and retrofit renovation just like Tokyo.

Ministry of Land, Infrastructure, Transport and Tourism summarizes that the backward situation of the seismic assessments results of large-scale buildings is obliged by the seismic promotion law. Of the total of 10,600 prefectures, there were about 1,000 buildings with a seismic intensity of 6 or more and high risk of collapse, and about 700 buildings with a risk of collapse were found. About 100 buildings were reported as yet unreported.

Conclusion

This paper reported about the progress of seismic evaluation and retrofit renovation of old buildings located along the specific emergency transportation roads in Tokyo, as had reported previously. The rate of seismic state is 84.3% in the end of June 2018, promotion of retrofit renovation is necessary for reaching up to goals, which are “to achieve 90% as rate of seismic state and to make zero of building with high risk of collapse in March 2020, and 100% as rate of seismic state in March 2026”.

The number of seismic buildings is certainly increased more than our previous report, but seismic retrofit renovation is not over yet although 6 years have passed. However, many seismic evaluations and retrofit renovations do not proceed so much on short period. Urgency of the crisis that the earthquake might occur directly under the capital city is particularly pointed out in Japan. So, we must keep up proceeding to retrofit, therefore to protect the lives, bodies and property of citizens from earthquake and to secure the building’s functionality.

We hope that Tokyo Metropolitan Office shall lead for any further cooperation with the municipality and the concerned organizations, proceed to retrofit buildings located along the emergency transportation roads as fast as possible and produce a steady progress of successful results for resilient Tokyo.

References

Toshio Okoshi, 2012, “*Seismic Evaluation and Retrofit of Old Buildings located along the specific emergency transportation roads in Tokyo*”, 14th U.S.-Japan Workshop on Improvement of Structural Design and Construction Practices, Applied Technology Council, Redwood City, California.

JSCA Special Committee for Seismic Evaluation and Retrofit, 2014, “*Issue and Resolution at Seismic Evaluation Practice*”, JSCA, Tokyo, Japan.

Tokyo Seismic Portal Site <http://www.taishin.metro.tokyo.jp/>

Nine Prefectures and Cities Meeting <http://www.9tokenshi-syunoukaigi.jp/>

Osaka Prefectural Office http://www.pref.osaka.lg.jp/kenshi_kikaku/kikaku_bousai/kouiki-kouhyou.html

Ministry of Land, Infrastructure, Transport and Tourism http://www.mlit.go.jp/jutakukentiku/build/jutakukentiku_house_fr_000054.html