Response to various uncertainties in the processes of planning and establishing technical standards

FUKUYAMA Hiroshi(Ph. D.), Director, Building Department

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1. Introduction

The mission of Building Department is to respond to various needs of citizens and society that keep changing with movements around the world and realize the safe, secure, and comfortable building environment. Therefore, the Building Department is providing administrative support based on scientific and technical knowledge upon planning, drafting, establishment, and revision of various technical standards, including the Building Standards Act. Other activities of the Building Department include on-site investigations at the scene of natural disasters, examination of measures to implement in the future, application and promulgation of investigations and research findings to the society, and the supply of technical support to organizations inside and outside of Japan.

2. Response to various uncertainties in the processes of planning and establishment of technical standards

This article introduces how the Building Department has perceived and responded to various uncertainties that we face while drafting technical standards using the Measure to Respond to Long-period Ground Motion caused by Massive Earthquake along the Nankai Trough[1] that entered into force in April 2017.

1) Basic concept

Engineering is a field where manufacturing is required even when there are unknowns, and experiences are lacking. Such uncertainties have long been handled to a certain extent by providing a proper allowance. Therefore, the position of seismic motions to enter for designs is first organized as shown in Figure 1.

Some of the past earthquakes have recorded seismic motion that exceeded standard seismic motion to be entered for designs and seismic motion of which properties, such as frequency characteristics, greatly differed from standard motion. This means we cannot deny the possibility that seismic motion that differs from or is much greater than ones entered for designs would affect a building. In addition, in the 2016 Kumamoto Earthquakes, level-7 seismic motion on the Japan Meteorological Agency's seismic intensity scale occurred twice. This series of earthquakes made some scientists think that building designs would need to be adjusted accordingly. In reality, however, it is difficult to forecast the types of earthquakes to occur and how many times. Even when such predictions can be made, structural calculations would be extremely complicated. Based on the above observations combined, a reasonable way to handle seismic motion to be entered for designs is to position the motion as representative seismic motion used in examinations and to ensure a certain level of safety for other phenomena by adding a certain allowance to the designs.

Response to uncertain factors・In engineering, manufacturing needs to be done even when there are unknowns, and experiences are lacking.
→ In response to unknowns and uncertainties, a proper "allowance" is set.

The position of seismic motion to be entered for designs
=Representative seismic motion used in examinations
・ The effect of seismic motions which differ from the representative motion in property and levels is also possible.
Yet, prediction is difficult. (Great seismic motions may hit an area multiple times.)
・Examination is conducted focusing on the entry of a representative motion to keep the structural calculation simple.
→ By giving a certain allowance to a representative phenomenon, a certain level of safety can be ensured with other phenomena.

Figure 1 Position of seismic motion to input for designs

2) Ways to provide engineering allowances

Figure 2 shows an example of how to provide the allowance in designs based on the above observations. The figure exhibits the relationship between the horizontal force on a building during an earthquake and deformation. The safety limit indicates the upper limit up to which structural safety is ensured. If the response to a large earthquake remains around the response range (ensuring safety) in front of the safety limit, it means that a collapse that would lower durability would not occur to a building, and structural safety can be ensured. If seismic motion is greater than expected, however, it may exceed the safety limit, and a certain variation will be seen in the evaluation of the response. Therefore, it is important that a building can change its shape without causing damage or collapse to an extent at which the building can absorb earthquake energy, which is somewhat greater than the safety limit.

In regard to providing such allowance in the design, the New RC Structure Design Guideline[2] for example,

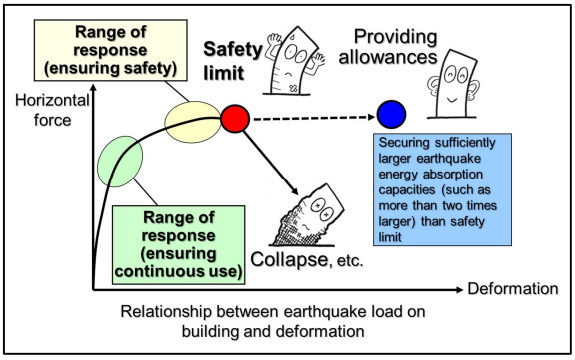

Figure 2 Idea of responses to uncertain factors

requires having more than double the energy amount compared to when responding to a large earthquake. Based on this guideline, the appropriateness of individual performance is being assessed in the scene of the performance evaluation.

Meanwhile, since many people use super high-rise buildings, earthquake-caused damage that would make such buildings unusable should be avoided as much as possible since its effects are extremely extensive. Thus, it is recommended that the response to a large earthquake should be kept approximately within the response range (ensuring continuous uses) to keep a building usable after an earthquake without any repair or with quick repairs. By doing so, a sense of security can be added that even in the case of an unexpected phenomenon, the building can withstand it thanks to the allowance up to the safety limit. A design policy like this is one of the ways to respond to social demand on super high-rise buildings.

3. Main research themes that are now in progress

The section below introduces main research themes that are now in progress. All of these research projects are aiming to realize a safe and secure society and to create and revitalize attractive rural areas, which is one of the recent needs as General Technology Development Projects.

1) Technological development to support the use of already available buildings through the rationalization of fire safety and evacuation regulations (2016-2020)

The government of Japan set 2015 as the first year of rural revitalization and is conducting activities to ensure safe, secure, and delightful lives for the future by solving various challenges associated with regional characteristics in order to overcome depopulation and the shrinkage of rural economies. In relation to the above, local governments and private businesses engaging in town development are expected to utilize currently available buildings, such as historical architectures, which are useful regional assets, as lodging facilities or restaurants for tourism promotion and invigoration of their regions. The environment thus needs to be developed to smoothly enable such activities. Therefore, the objective of this research theme is to develop technologies to ensure rationalization and smooth operation of fire safety and evacuation regulations and regulations on the purposes, thereby realizing smooth utilization of currently available buildings.

In June 2018, the Enforcement Ordinance for the Building Standards Act was revised using outcomes of this research theme among other aspects. Currently, notices and description of technical standards are being prepared.

2) Development of design and construction technologies of mixed-structure buildings using new types of wooden materials (2017-2021)

A statement, “the development and promulgation of CLT and the promotion of the use of wood materials in public buildings will further be strengthened in order to accelerate the use of wooden structures and materials in buildings” was included in the Basic Policy of the Regional Empowerment for Japan’s Growth, which determined in the Cabinet in 2015 in order to respond to issues of the vitalization of rural areas and environmental problems and to create spaces where wood is used. The purpose of this research is to conduct technological development of structures, fire safety, and durability to advance design and construction technologies for mixed-structure midrise buildings constructed by combining wooden structure using large wooden panels, such as CLT with an RC structure or steel structure in order to satisfy various needs, such as the use of wood materials, the increase of variability, reduction of construction periods, and response to user needs to use wood materials on the surface.

Under this research theme, researchers are going to organize examples of designs related to multiple prototype buildings, their characteristics, and precautions using outcomes of various tests and experiments and accelerate the spread of relevant technologies.

☞For detailed information

1) Building Guidance Division, Housing Bureau, Ministry of Land, Infrastructure, Transport and Tourism: Measures on Super High-rise Buildings to Respond to Long-period Ground Motion caused by a Massive Earthquake along the Nankai Trough (June 2016)
http://www.mlit.go.jp/jutakukentiku/build/jutakukentiku_house_fr_000080.html

2) Building Research Institute: Development of Technologies to Realize Ultra-Light Weight and Ultra-High-Rise Reinforced Concrete Structure Buildings, 6. New RC Structure Design Guideline (draft), Architectural Research Report No. 139, 2001