Study on performance-based seismic design theory

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Abstract. There are many other names for performance-based design, such as "performance based", "performance evaluation", "performance explicit standards" and "performance-based standards". The so-called "performance-based" refers to the performance specified in the specification or the performance proposed in the specification. When designing the design method, the specification only specifies the target performance, and leaves the checking method to the designer. In other words, performance-based design is a technology to set reliable performance goals and achieve them through reasonable structural analysis methods.

1. Introduction

The advantages of performance-based design are obvious compared with the disadvantages of traditional design methods. In fact, the traditional design method is also to achieve a certain performance goal, but the method only is applicable to a certain structure or other methods have certain defects. In order to make up for these defects, the safety method will be adopted. Therefore, the relationship between the methods must be considered to determine the method adopted.

2. Development of performance-based seismic design

In order to coordinate the construction standards of Nordic countries, the Nordic Building Standards Committee (NKB) started the research on performance-based design in 1963 and determined the final action process in 1972 for the purpose of technological innovation and economic integration. The purpose of the process is to expand the commercial circulation of construction systems and related products between the Nordic countries, and to ensure the flow of labor between countries. In this process, in order to understand and revise the construction standards of various countries, the building standards are divided into five levels, forming a pyramid type grade, and becoming the Nordic building standards committee grade system, as shown in Table 1.

| Standard                  | Meaning                                                                 |
|---------------------------|-------------------------------------------------------------------------|
| Purpose                   | All descriptions of important buildings from the perspective of society and its constituents |
| Performance requirement   | In order to clarify the special purpose and intention, all objectives specified are classified according to functional items and principles |
Specific requirements for each performance are proposed

Compliance verification method of performance requirements

Specific design method meeting performance requirements

In terms of building standards, Britain has formulated a variety of methods, but since the late 1970s, the criticism that these standards will reduce the vitality of the construction industry has gradually emerged. Therefore, in 1984, a new construction law was formulated, which abolished the method provisions and replaced them with concise building standards. The traditional methods and standards were regarded as recognized but not mandatory standards.

Since 1986, the study of building standards aiming at performance-based design has been carried out in New Zealand, and the scheme (nzbc) [3] was established in 1990. The 5-step pyramid level.

3. Relationship between performance-based seismic design and traditional design methods

Performance based design is not never existed before, but is extended and developed in the past seismic design methods. It only further clarifies the checking methods and projects, and systematizes them.

When performance-based design method is used, many problems need to be considered. For example, although the flexibility and freedom of design have been increased, it may lead to insufficient response ability of field technicians. Because the evaluation method is not clear, and the design results will vary from person to person, it is difficult to verify the rationality of its provisions. Therefore, the corresponding verification method must exist.

4. Relationship between performance-based seismic design and traditional design methods

4.1. Overview of "development of new building structure system"

In order to determine the performance within the minimum level specified in the code, it is necessary to study the determination method of the necessary target level, performance evaluation system and the social system supporting the method. Therefore, Japan carried out the research on the comprehensive technology development project "new building structure system development" in the 7th to 9th year of Heisei (1995-1997). In this project, the form of structural design system based on performance evaluation has the following assumptions:

1. On the basis of negotiation between the owner and the structural designer, determine the structural performance of the building.
2. According to the structural characteristics and other conditions, structural designers choose appropriate design and calculation methods to design the frame and components.
3. Confirm that the frame has the determined structural performance.

In other words, it is necessary to define the required performance. On the basis of meeting the performance requirements, the structural designer will judge the detailed contents of the design method to achieve the performance requirements, and take the more flexible and reliable structural design system as the goal as far as possible. The significance of this method is to clarify the performance of building structure, introduce market mechanism, promote the development of structural design technology, and provide designers with large design space, and these results can meet the requirements of international coordination.

In the "new building structure system development" of the comprehensive technology development project of construction Province, the "structural performance evaluation guide" has put forward the structural performance evaluation system composed of "determining structural performance objectives", "performance verification" and "performance description".
4.2. Basic performance of structure
When determining the structural performance objectives, the basic performance requirements of the structure are firstly determined as "safety", "repairability" and "applicability", which correspond to "protecting personal safety", "ensuring property safety" and "maintaining function and habitability".

1. "Safety" refers to the performance of avoiding direct threat to the life safety of people inside and outside the building (to protect personal safety). It is an index to evaluate whether damage can be properly prevented without damaging the ability to protect personal safety.

2. "Repairability" refers to that the damage caused by the external influence of the building is easy to be repaired (property protection), and it is the ability to protect the property without damaging it. Through simple repair evaluation (the recoverability of structural performance, the difficulty of repair, the cost of repair, etc.) can the deterioration damage be controlled within the required range.

3. "Applicability" refers to the performance of the building that is easy to use and habitable (to ensure function and habitability), and it is also an index to evaluate whether the function and living requirements of the building can be eliminated properly.

These three properties are closely related. For example, in order to improve the safety of the structure frame in earthquake, it is the most effective to improve the bearing capacity and deformation capacity of the structure, but when the method of increasing the bearing capacity is adopted, the excessive acceleration response will reduce the safety and applicability of the structure. Improving seismic safety by relying on deformation capacity will also reduce the repairability of structural frames and components. Therefore, these performance levels must be coordinated and the performance requirements should be determined comprehensively.

4.3. Target performance level of structure
The target performance level of the structure is determined according to the following principles:

1. The performance level of the structure shall be determined through negotiation between the owner and the structural designer, and shall not be lower than the lower limit specified in the specification.

2. The performance level of the structure is determined according to each performance evaluation item, which is expressed by various loads, various limit states and external force combinations.

When determining the performance level, it is necessary to comprehensively consider the technical and economic feasibility of improving the level according to the use, importance, service life and load change with service life, the threat to personal safety and the impact on economy, society and environment when the required conditions cannot be met. Considering the performance level from the experience, it can be determined according to the level determined by the current technical level and the minimum level specified in the specification according to the past design experience and the disasters suffered; in addition, from the perspective of probability, the difference degree between the evaluation object and the specified state of the performance evaluation project can be described directly with the reliability index and failure probability.

Considering these evaluation factors and scales, the performance level is generally determined by the designer and the owner through negotiation. In principle, the structural performance level should be determined by the owner, but usually the designer has more knowledge of the building structure technology than the owner, and plays a major role in determining the structural performance level, which can provide a lot of help for the owner to accurately determine the performance level.

5. Conclusion
(1) This paper introduces the background of performance-based seismic design, gives the definition of performance-based seismic design, and summarizes its research progress in the world and its application in engineering.

(2) Compared with the traditional seismic design method, it can be seen that the performance-based seismic design method is more flexible and free, the performance objectives to be achieved are more clear, can promote technical progress, and is of great significance to the international
(3) The method to determine the neutral performance objective of performance-based seismic design is given. The basic performance of the structure is determined as "safety", "repairability" and "applicability", which correspond to "protecting personal safety", "ensuring property safety" and "maintaining function and habitability", respectively. Negotiate with the owner to determine the performance objectives of the structure.

(4) With the rapid development of society, in order to meet the various performance requirements of the society, it is necessary to introduce performance-based seismic design method and the development of new structure and new material technology. Therefore, it is the only way to adopt new materials or new structure technology in the future.

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