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Ver. 1.0

Principles, guide**l**ines **a**nd **t**erminologies for structural design code drafting founded on the per**form**ance based design concept ver.1.0

code PLATFORM ver.1.0

Committee for basic study for drafting the principles, guidelines and terminologies for structural design code

Japan Society of Civil Engineers

Introduction

Comprehensive design codes or base codes provide basic ideas and procedures for drafting design codes and are drafted for the purpose of reference by code writers while drafting specific design codes. ISO2394 and Eurocode0 have been published overseas as comprehensive design codes. In Japan, Geotechnical Code 21 (Japanese Geotechnical Society) and the Bases of Design for Civil and Building Structures (Ministry of Land, Infrastructure and Transport) have been developed.

Technical standards for specific structures such as roads, rivers, ports and airports and buildings have been established according to their history, culture and objectives. Technical standards therefore vary substantially from structure to structure. In recent years, numerous organizations have energetically been revising design codes based on an emerging concept of “performance based design.” At present, however, they are revising design codes in a traditional framework as mentioned above, or defining terminologies and formats arbitrarily as it were. The present condition is a source of apprehension because

(1) It is necessary to plainly communicate excellent civil engineering technologies of Japan to other countries,
(2) The present conditions look like a non-tariff barrier to engineers of other countries intending to enter Japanese markets, and because
(3) The basic ideas of structural design of Japan should be transferred to next generations of engineers in a plain and systematic format.

In the future, the principles and terminologies that code writers refer to when they draft technical standards should be unified. Thereby the above conditions would be improved considerably.

The comprehensive design code described in this document (PLATFORM) was studied in a “committee for basic study for reviewing/drafting the principles, guidelines and terminologies for structural design code” that was established in the Japan Society of Civil Engineers at the request of the National Institute for Land and Infrastructure Management (NILIM), Ministry of Land, Infrastructure and Transport. Establishing a comprehensive code was expected to require long-term efforts of more than ten years if the identification of its legal positioning, coordination with the organizations concerned and implementation of the code were included. The code was therefore basically drafted to provide an appropriate design code rather than considering the codes in place at present. The committee was composed mainly of young code writers. Frontline code writers in various fields from steel structures to concrete structures, resistance to earthquakes, waves and wind, and buildings were requested to serve on the committee to draft a comprehensive code. The fact that these code writers in diverse fields have agreed on the comprehensive design code is very important let alone the code descriptions.

Drafting PLATFORM is only a step along a long way toward coordinating design methods. We would appreciate the understanding and cooperation of the organizations concerned to enable us to continue our efforts.

Osamu Kusakabe
Chairperson

Committee for basic study for drafting the principles, guidelines and terminologies for structural design code

Supplementary explanations

Supplementary explanations are provided to help you better understand the design principles.

Name of this document

Presented here are the principles, guidelines and terminologies for structural design code drafting founded on the performance-based design concept ver. 1 (code PLATFORM ver. 1) that were drafted in fiscal year 2001-2001 by a research committee established in the Japan Society of Civil Engineers at the request of the National Institute for Land and Infrastructure Management (NILIM), Ministry of Land, Infrastructure and Transport.

The committee members who participated in drafting the comprehensive code suggest that the completed document should be referred to as the principles, guidelines and terminologies for structural design code drafting founded on the performance-based design concept ver. 1 (code PLATFORM ver. 1) rather than naming it a “comprehensive design code.” The term “code” implies a design standard. The proposed name is considered preferable to the term “comprehensive code” that means a code above all the other codes, for conveying that the document has been agreed on by Japanese code writers inducing little misunderstanding about the goal of the document.

How the research was conducted

The “committee for basic study for reviewing/drafting the principles, guidelines and terminologies for structural design code” was established in the Japan Society of Civil Engineers that was requested by NILIM to make a research. Osamu Kusakabe, Professor of the Tokyo Institute of Technology and Yusuke Honjo, Professor of Gifu University were appointed Chairperson and Secretary-General of the committee, respectively as the research was assigned based on Chapter 0 of the Geotechnical Code 21.

Establishing a comprehensive code was expected to require long-term efforts of more than ten years if identifying its legal positioning, coordinating with the organizations concerned and implementing the code were included. The code was basically drafted to provide an appropriate design code rather than considering those in place at present. The committee was composed of young code writers. The committee members were experts on diverse subjects such as concrete structures, steel structures, resistance to earthquakes, wind and waves, and reliability design.

Fundamental policy

The following points were confirmed before drafting the code.

(1) Ideals shall be pursued. An appropriate code shall be drafted regardless of the present conditions.

(2) The code shall be drafted with a view to developing a uniform Asian code in the future.

(3) The comprehensive design code shall be drafted to represent the essence of the design concepts in different fields and be compatible with the design concepts, and to disrupt no future design code framework and encourage the development of new technologies.

(4) Other standards such as ISO2394 and 13822, and the "Bases of Design for Civil and Building Structures" shall be honored.

(5) Use of new terminologies shall be minimized and the terminologies used in existing authoritative documents shall be respected.

(6) No mention shall be made of the level of reliability that structures should achieve. Only the structural performance requirements shall be described.

(7) The design code shall be drafted for constructing new structures not for repairing or maintaining existing structures.

(8) The design code shall be drafted mainly for designing general purpose structures.

(9) The design code shall be neither an integration of existing codes such as the Specifications for Highway Bridges, Technical Standards for Port and Harbor Facilities and Design Standards for Railway Structures nor a mixture thereof. Ideals and simplified concepts shall be presented. (The code that code writers honor daily shall be critically assessed.)

(10) Performance requirements shall be expressed using the state (or limit state) of the structure, time and action or the combination thereof, or the combination of significance. Then, the state of the structure shall be expressed as a function of time to present durability and deterioration. The idea of maintenance shall naturally be incorporated into design.

(11) The code shall be structured as simple and easy to understand as possible. Whatever existing concepts available shall be employed.

(12) Explaining the design code to an international audience shall be kept in mind. Excessively complex concepts are little understood.

(13) The design code shall be a comprehensive design code concerning the structural design.

(14) The restorability limit should be determined based on economic factors.

(15) The limit state design method is currently most suitable for realizing performance-based design.

(16) Two types of verification procedures proposed in Geotechnical code 21 shall be adopted.

(17) In relation to the relationship between social systems and design codes, reference shall be made to the flow of exchange of information on design among the owner, designer and contractor, qualifications of design engineers, and fundamental ethics that design engineers should respect.

We found at the end of drafting the code that the above points were respected.

1. Definitions of terminologies

This chapter defines the terminologies that are used in the comprehensive design codes, and in the basic specific design codes and specific design codes that are in accordance with the comprehensive design codes.

Superscripts attached to terminologies have the following meanings.

0) Terminology defined in the comprehensive design codes
1) Terminology that is defined in ISO2394 (3rd version. 1998) and should be in accordance with the definitions in and revisions to ISO2394.
2) Terminology defined in the comprehensive design codes based on the Guidelines for Performance-based Design of Civil Engineering Steel Structures (October 2001)
3) Terminology defined in the comprehensive design codes based on Geomechanical code 21
4) Terminology defined in the comprehensive design codes based on the Bases of Design for Civil and Building Structures (October 2002)
5) Terminology that is defined in ISO13822 (1st version. 2001) and should be in accordance with the definitions in and revisions to ISO13822.

1.1 General terms

(1) General

Structure [1)]: Organized combination of connected parts designed to provide some measure of rigidity.

Structural element [1)]: Physically distinguished part of a structure.

EXAMPLES: Column, beam, plate.

Structural system [1)]: Load-bearing elements of building or civil engineering works and the way in which these elements function together.

Life, lifetime, life period [2)]: The period that begins with the construction of a structure and ends with the discontinuance of its use and its removal for one reason or another. Life is classified into physical, functional or economic life.

Life cycle [1)]: Total period of time during which the planning, execution and use of a construction works takes place. The life cycle begins with identification of needs and ends with demolition.

Quality [2)]: A characteristic of a product that is represented using a quantitative indicator. Experimental values of quantitative indicators can be obtained in a predetermined inspection or test. One example is the Charpy impact value.

Reliability [1)]: Ability of a structure or structural element goes fulfill the specified requirements, including the working life, for which it has been designed.

Failure [1)]: Insufficient load-bearing capacity or inadequate serviceability of a structure or structural element.

(2) Design codes and design methods

Comprehensive design codes [3]: Comprehensive design codes are that describe the basis of the design civil structures and buildings within a country or region. It is not a code for designing individual structures, rather, it provides common items such as a mean to specify the performance of the structures, the unification of terminologies, the introduction of safety margins for the design specifications, the format of verification, the standardization of the information transfer among concerned bodies, fundamental check lists for the design, etc. It is a code on the highest level of the design code system hierarchy that covers both Approach A and Approach B. It can be thought of as “a code for code writers,” but contains more basic and useful information than just that required by code writers.

Basic specific design codes [3]: Basic specific design codes are codes that specify the structural performance criteria of structures by regulating agencies such as central government agencies/local government authorities/the owner. It is likely that some recommendations for verification methods and acceptable methods for use with Approach B may be provided.

Specific design codes [3]: Specific design codes are codes that detail the performance criteria of specific structures which may be limited to a specific use or to a certain region, etc. The specification shall be based on the basic specific design code that is ranked above this code. Certain acceptable verification procedures can be attached to this code.

Performance-based design [2]: A design methodology for designing a structure exclusively to satisfy performance requirements regardless of the structural format, structural material, design procedure or construction method. This design methodology explicitly presents the objectives of the structure and the functions to achieve the objectives, defines the performance required to provide the functions and provides the functions satisfactorily by securing the performance requirements throughout the working life of the structure. Similar terms include performance-based design, performance-expressing design and performance-oriented design.

Performance-based design codes [3]: A performance-based design is a code whose specifications on structures have not been give by prescriptive means, but by outcome performances based on the requirements of society and/or the client or the owner.

NOTE: Reference 6) defines the design method that identifies the relationship between the level of performance required to meet the functional requirements of the structure and the level of action used for verifying the achievement of the requirements as the performance-based or -expressing design method.

Specification-based design [2]: A design methodology for designing a structure using the specified types and sizes of structural materials, analysis procedure, etc. Many of the existing design standards are applicable to this type of design.

Pre-verified specification [2]: The specification that exemplifies a “solution” that is considered to satisfy performance requirements. It is applied in the case where no performance verification methods can be explicitly presented. Examples include specifications for structural material and their size for which no relationship is available to performance requirements, analysis methods that do not directly verify the performance requirements considered valid based on the past practice and verification methods using resistance estimation equations. Other terms available are pre-verified criteria and approved design.

The term pre-verified specification is used because it is more appropriate than pre-verified criteria as the specification covers existing analysis methods or estimation equations specified in various standards.

Reliability-based design [2]: A design methodology that involves the stochastic verification of the probability of a structure reaching a limit state.

Target reliability level [5]: The level of reliability required to satisfy performance requirements.

Limit state design [2]: A design methodology that explicitly defines the limit states to be verified. In most cases, the partial safety factor design method at level I of the reliability theory is adopted as the verification format. The term partial safety factor design is therefore sometimes used to mean the limit state design.

Partial factors format [1]: Calculation format in which allowance is made for the uncertainties and variabilities assigned to the basic variables by means of representative values, partial factors and, if relevant additive quantities.

Partial factor design format [3]: The partial factor design format is a format in which several partial factors are applied to various sources of uncertainties in the verification formula in order to ensure a sufficient safety margin; it is usually classified into the following two approaches.

Material factor approach (MFA) [3]: MFA is a type of partial factor format in which partial factors are applied directly to the characteristic values of basic variables.

Resistance factor approach (RFA) [3]: RFA is a type of partial factor format in which partial factors are applied to resistances.

1.2 Terms on design methodology

(1) General

Design work life [1]: Assumed period for which a structure or a structural element is to be used for its intended purpose without major repair being necessary.

Structural integrity (structural robustness) [1]: Ability of a structure not to be damaged by events like fire, explosions, impact or consequences of human errors, to an extent disproportionate of the original cause.

Reliability class of structures [1]: Class of structures or structural elements for which a particular specified degree of reliability is required.

Required performance matrix [2]: A matrix indicating the grade of performance that should be provided to a structure and the grades of assumed external forces. The design engineer selects performance that should be provided to a structure from the matrix according to the significance of the structure. Reference 2) proposes required performance matrices concerning earthquakes, fatigue and wind.

Assessment [1]: Total set of activities performed in order to find out if the reliability of a structure is acceptable or not.

Pre-evaluation [2]: The verification made in the structural planning and design phases to evaluate whether the required performance is satisfied or not when fabricating, erecting, using, dismantling or re-using a structure.

Post-evaluation [2]: The verification of required performance after the fabrication and erection of a structure such as the quality inspection during the fabrication and erection of a structure, and the inspection and investigation while the structure is in service or at the time of damage to the structure due to an accidental external force.

(2) Terms on performance description

Objective [0]: The reason for building a structure expressed in general terms. The term owners/users should preferably be used as the subject of sentences.

Performance requirement [0]: The performance that a structure should possess to achieve its objectives, expressed in general terms.

Performance criterion [0]: The performance requirement described specifically to enable performance verification. Performance criterion is defined by a combination of the limit state of the structure, action and environmental influences and time.

Basic performance requirement [0]: The performance requirement that is essential to the achievement of the objectives of the structure. It may also be regarded as the “function” of the structure.

Significance of structures [0]: The degree of significance of a structure that should be determined based on the benefit that the structure produces, necessity of the structure under emergency conditions and the availability of alternatives.

Serviceability [1]: Ability of a structure or structural element to perform adequately for normal use under all expected actions.

(3) Terms on limit state

Limit states [0]: A state beyond which the structure no longer satisfies the design performance requirements.

Ultimate limit state [1]: A state associated with collapse, or with other forms of structural failure.

NOTE: This generally corresponds to the maximum load-carrying resistance of structure or structural element but in some cases to the maximum applicable strain or deformation.

Serviceability limit state [1]: A state which corresponds to conditions beyond which specified service requirements for a structure or structural element are no longer met.

Restorability limit state [0]: A limit state under which a structure can be used continuously through restoration using applicable technologies at reasonable cost in a reasonable timeframe even in the case of damage expected to be incurred due to an assumed action. It may be regarded as one of the serviceability limit states.

Irreversible limit state [1]: A limit state which will remain permanently exceeded when the actions which caused the excess are removed.

Reversible limit state [1]: A limit state which will not be exceeded when actions which caused the excess are removed.

(4) Terms on verification

Verification [2]: The determination of whether the structure satisfies the performance criteria or not. In the case of limit state design, whether equation $S \leq R$ or $f(S, R) \leq 1.0$ is satisfied or not is determined where S is the response value and R is the limit value.

Verification approach A [0]: A verification approach that imposes no restrictions on the structural verification method but requires that the design engineer should prove that the structure satisfies the specified performance requirement and ensures an appropriate level of reliability.

Verification approach B [0]: A verification approach that makes verification of the structure based on the specific base design codes or specific design codes specified by an administrative organization, local public body or business that governs the structural performance of the structure, and according to the procedure shown in such codes e.g. a design calculation procedure.

(5) Design examination, accreditation and others

Design examination [0]: The detailed inspection of a series of design procedures from the definition of an objective to verification made by an accredited third-party organization. Upon the passage of the examination, the third-party organization certifies the design work.

Accreditation [0]: The appointment of organizations that are authorized to carry out examinations.

Certification [0]: The examination of a series of design procedures from the definition of an objective to verification and the issue of a certificate.

Compliance [1]: The satisfaction of requirements.

1.3 Terms relating to actions, action effects and environmental influences

Action [1]:

a) An assembly of concentrated or distributed mechanical forces acting on a structure (direct actions).

b) The cause of deformation imposed on the structure or constrained in it (indirect action).

NOTE [0]: In some categorizations, environmental influences are regarded as an action.

Representative value of action [1]: A value used for the verification of a limit state.

NOTE: Representative values consist of characteristic values, combination values, frequent values and quasi-permanent values, but may also consist of other values.

Characteristic value of an action [1]: Principal representative value

NOTE 1: It is either on a statistical basis, so that it can be considered to have a specified probability of not being exceeded towards unfavorable values during a reference period, or on acquired experience, or on physical constraints.

NOTE 2: **Characteristic value** [3]: Representative value of parameter estimated to be most suitable to the model for predicting the limit state that is examined in design. Characteristic values should be determined based on a theory or acquired experience fully considering variations and the applicability of a simplified model.

Design values of an action, F_d [1]: Value obtained by multiplying the representative value by the partial factor γ_F.

Permanent action [1]:

a) Action which is likely to act continuously throughout a given reference period and for which variations in magnitude with time are small compared with the mean value.

b) Action whose variation is only in one sense and can lead to some limiting value.

Variable action [1]: Action for which the variation in magnitude with time is neither negligible in relation to the mean value nor monotonic.

Accidental action [1]: Action that is unlikely to occur with a significant value on a given structure over a given reference period.

NOTE: Accidental action is in most cases of short duration.

Fixed action [1]: Action which has a fixed distribution on a structure, such as its magnitude and direction are determined unambiguously for the whole structure when determined at one point in the structure.

Free action [1]: Action which may have an arbitrary spatial distribution over the structure within given limits.

Static action [1]: Action which will not cause significant acceleration of the structure or structural elements.

Dynamic action [1]: Action which may cause significant acceleration of the structure or structural elements.

Bounded action [1]: Action which has a limiting value which cannot be exceeded and which is exactly or approximately known.

Unbounded action [1]: Action which has no known limiting values.

Combination value [1]: Value chosen, in so far as it can be fixed on statistical bases, so that the probability that the action effect values caused by the combination will be exceeded is approximately the same as when a single action is considered.

Frequent value [1]: Value determined, in so far as it can be fixed on statistical bases, so that:

- the total time, within a chosen period or time, during which is exceeded is only a small given part of the chosen period of time; or
- the frequency of its exceedance is limited to a given value.

Quasi-permanent value [1]: Value determined, in so far as it can be fixed on statistical bases, so that the total time, within a chosen period of time, during which is exceeded is of the magnitude of half period.

Action combination [0]: A combination of design values used for verifying the structural reliability in a limit state where different actions are considered simultaneously. It is also referred to as load combination.

Environmental influence [1]: Mechanical, physical, chemical or biological influence which may cause deterioration of the materials constituting a structure, which in turn may effect its serviceability and safety in an unfavorable way.

Load [4]: Action acting on the structure that is converted to a combination of mechanical forces loaded directly on the structure. It is input for calculating stress resultant, stress, displacement and other parameters using an action model for the purpose of design.

Reference period [1]: A chosen period of time which is used as a basis for assessing values of variable actions, time-independent material properties, etc.

Design situation [1]: Set of physical conditions representing a certain time interval for which the design demonstrates that relevant limit states are not exceeded.

Persistent situation [1]: Normal condition of use for the structure, generally related to its design working life.

NOTE: "Normal use" includes possible extreme loading conditions due to wind, snow, imposed loads, earthquakes in areas of high seismicity, etc.

Transient situation [3]: Provisional condition of use or exposure for the structure.

EXAMPLE: During its construction or repair, which represents a time period much shorter than the design working life.

1.4 Terms relating to structural response, resistance, material properties and geometrical quantities

Characteristic value of a material property [1]: A prior specified fractile of the statistical distribution of the material property in the supply produced within the scope of the relevant material standard.

Characteristic value of a geometrical quantity [1]: A quantity usually corresponding to dimensions specified by the designer.

Design value of a material property [1]: Value obtained by dividing the characteristic value by a partial factor γ_M or, in special circumstance, by direct assessment.

Design value of a geometrical quantity [1]: Characteristic value plus or minus a additive geometrical quantity.

Conversion factor [1]: Factor which converts properties obtained from test specimens to properties corresponding to the assumptions made in calculation models.

Conversion function [1]: Function which converts properties obtained from test specimens to properties corresponding to the assumptions made in calculation models.

Fractile value [4]: The value of a random variable with a cumulative probability lower than specified.

NOTE: Expressed like “x% fractile is y.”

Design value [3]: The design value is the value obtained by multiplying a partial factor by a characteristic value in the case of an MFA partial factor format.

Demand, response value *S* [2]: The physical quantity that occurs in the structure due to an external force.

Capacity, limit value of performance *R* [2]: The limit value allowed for the response value. A physical quantity that is determined according to the type of “limit state.” If the response value exceeds the limit value, the performance requirement is not satisfied.

Statistical uncertainty [1]: Uncertainty related to the accuracy of the distribution and estimation of parameters

Basic variable [1]: Part of a specified set of variables representing physical quantities which characterize actions and environmental influences, material properties including soil properties, and geometrical quantities.

Primary basic variable [1]: Variables whose value is of primary importance to the design results.

Limit state function [1]: A function *g* of the basic variables, which characterizes a limit state when $g(X_1, X_2, ..., Xn) = 0$: $g > 0$ identifies with the desired state and $g < 0$ with the undesired state.

Reliability index, β [1]: A substitute for the failure probability P_f, defined by $\beta = -\phi^{-1}(p_f)$, where ϕ^{-1} is the inverse standardized normal distribution.

Reliability element [1]: Numerical quantity used in the partial factors format, by which the specified degree of reliability is assumed to be reached.

Element reliability [1]: Reliability of a single structural element which has one single failure dominating failure mode.

System reliability [1]: Reliability of a structural element which has more than one relevant failure mode or the reliability of a system of more than one relevant structural element.

Model [1]: Simplified mathematical description or experimental set-up simulating actions, material properties, the behavior of a structure, etc.

NOTE: Models should generally take an account of decisive factors and neglect the less important ones.

Model uncertainty [1]: Related to the accuracy of models, physical or statistical.

1.5 Terms on performance assessment of existing structures

Assessment [5]: Total set of activities performed in order to find out if the reliability of structure is acceptable or not.

Rehabilitation [0]: The improvement of the resistance of a structure to performance deterioration with time.

Upgrading [0]: Efforts to enhance the mechanical performance of a structure.

Damage [5]: Changes in condition of a structure that may have an adverse effect on its performance.

Deterioration [5]: The reduction of performance and reliability of a structure with time.

Deterioration model [5]: A model of deterioration with time representing the performance of a structure as a function of time.

Inspection [5]: A nondestructive test conducted in the field to determine the present state of a structure.

Investigation [5]: The collection of data and evaluation through inspection, data surveys, loading tests and other testing.

Loading test [5]: A test conducted applying the load or imposed displacement to evaluate the behavior or properties of an entire structure or part thereof or to estimate load bearing capacity.

Maintenance [5]: Total set of activities performed during the design working life of a structure to enable it to fulfill the requirements for reliability.

Monitoring [5]: Frequent or continuous observation or measurement of the condition of a structure or the action applied to the structure. Monitoring generally takes place over a long period of time.

Remaining working life [5]: The period during which an existing structure is assumed to be maintained and placed in service.

Note: The criteria for the comprehensive code are classified into three categories, REQ, REC or POS. The applicable category is specified at the beginning of each criterion.

- **REQ:** The criterion defined by the code. “It is necessary to ”
- **REC:** The criterion is the one recommended more than any other alternative. “It is desirable to ”
- **POS:** One of the alternative methods or criteria. “It is possible to ”

2. General

2.1 Scope

(1) [REQ] The objective of this comprehensive structural design code is to disseminate the concept of performance-based design as it pertains to structural design, and thereby encourage rational design and technological progress so as to build superior infrastructure for future generations.

(2) [REQ] This code, in principle, can be applied to all kinds of structures.

(3) [REQ] This comprehensive design code is based on the concept of performance-based design and stands at the top of the hierarchy of the structural design code system in Japan.

(4) [REQ] Performance-based design is defined as a design concept that requires designed structures to satisfy specified performance requirements, and does not define requirements for any specific structure type, material, design method or construction method.

(5) [REQ] Design codes of the lower hierarchy should be drafted under the following specifications:

1) This comprehensive design code should be referred to.
2) Internationally accepted codes and rules should be respected.

(6) [REQ] This comprehensive design code consists of six main policies:

1) Present the fundamental views and format/system of performance based design codes.
2) Encourage rational design by facilitating communication between those involved in structural design work.
3) Encourage the development of structural construction-related technologies that have scope to deal with the progress of construction technology, as well as alteration of values and the environment.
4) Harmonize codes in accordance with internationally recognized concepts of performance based design.
5) Take conventional design methods into consideration.
6) Encourage maintenance of high engineering ethics among structural design engineers.

(7) [REQ] This comprehensive design code specifies the following items:

1) Method to specify the performance requirements of a structure.
2) Definition of the relationship between the performance requirements and the issues that should be verified in design (performance criteria).
3) Acceptable verification methods including institutions.
4) Definition of terminologies that are used in structural design and design codes.
5) Processing of the information concerning structural design.
6) Qualifications and accountability of engineers.

[Description]

(1) The objective of this comprehensive structural design code is defined.

(2) This comprehensive structural design code is described basically for newly constructed structures. There is, however, no need to limit its application to new structures. In the case where applying the comprehensive structural design code without modification is considered inappropriate, however, deviation from the criteria specified in the comprehensive code is allowed in view of such a special condition. Examples include the construction of a structure with a special purpose or functions and the repair or upgrade of an existing structure.

The application of this comprehensive structural design code is not limited to the structural aspects of a structure such as safety and serviceability. With changes in social value, non-structural performance has been actively demanded in the design of structures on an increasing number of occasions. Such performance is related to the environment and aesthetics.

(3) This comprehensive structural design code has no legal force. It, however, stands on top of the code hierarchy in Japan. Criteria are defined because it is considered important that the comprehensive structural design code is authorized by engineering societies involved in structural design including the Japan Society of Civil Engineers, forms a basis for establishing a code system in Japan and contributes to the enhancement of accountability and transparency of Japan's structural design system to other countries and to the transfer of easy-to-understand technologies to next generations of engineers.

(4) The definition of "performance-based design" in the comprehensive structural design code is provided. In the description of the comprehensive structural design code, (i) identifying and describing performance requirements and the (ii) methods of verification (including the verification of systems) are important. The comprehensive structural design code subsequently describes the basic ideas concerning these two points inasmuch as necessary.

(5) When drafting a design code at a lower level in the code hierarchy than the comprehensive design code, the code should be compatible with the comprehensive design code and other international standards or criteria. If the comprehensive design code is in conflict with international standards or criteria, the former should have precedence over the latter. International standards and criteria here include ISO2394 and 13822.

(6) Basic policies of the comprehensive structural design code are given.

1) The comprehensive structural design code, positioned at the highest level in the code hierarchy concerning performance-based design, naturally governs the basic concepts and framework of performance-based design. The comprehensive design code is also reflected in the rules and terminologies that are respected when the codes at lower levels are drafted.

2) Those involved in structural design work include not only engineers (design engineers) directly involved in design work but also all the engineers and citizens involved in planning, construction and use of structures. Specifically, owners (operating bodies, owners and administrators), investigators, designers, constructors, construction material suppliers and users are included. The basic idea is that the development of excellent social infrastructure should not be based on exclusive decision-making by a group of experts but

should be achieved through active consensus building among those concerned. This idea is reflected in the handling of technical data and terminologies.

3) Future technical advancements are taken into consideration. They are reflected in the performance requirements and performance criteria for the comprehensive design code established and in the allowable verification methods.

4) Design codes are a type of criterion. Attention is paid to international compatibility in view of the globalization of construction industries and deregulation. To achieve the international compatibility of design codes, either Japanese rules may be made compatible with existing international rules (passive compatibility) or Japanese rules may be presented as international rules (active compatibility). An active approach is preferable in relation to technical systems for performance-based design, and is reflected in the code system and terminologies.

5) Continuity with existing technologies and design methods are considered. Continuity is reflected mainly in allowable verification methods.

6) Designing structures is important to the development of infrastructure systems for the public and to the guarantee of public safety. Professional engineers who are requested to make judgments based on their expertise should maintain high sense of ethics in the process of design work. Their contributions increase social appreciation of professional engineers.

(7) Details of the comprehensive structural design code are provided.

1), 2) The comprehensive design code specifies performance in sections under the titles of objectives, performance requirements and performance criteria.

3) The comprehensive design code specifies allowable verification methods and systems concerning verification in view of the existing codes and future technical advancements.

4) The comprehensive design code defines basic terminologies concerning performance-based design for smooth exchange of accurate information and accurate understanding.

5) The comprehensive design code specifies the methods for handling technical information to encourage smooth information exchange and assume accountability. The handling of technical information means the standardization of information exchange methods, identification of senders and receivers of information and specification of the means of communication.

6) Professional engineers are required to maintain high sense of ethics. In order for them to assume the responsibility, they are authorized to exclusively use their qualifications and titles. Qualifications of professional engineers are therefore important in design. Explicitly presenting the accountability of professional engineers is necessary because structural design is closely related to public safety.

2.2 Framework of design codes

(1) [REQ] As shown in Fig. 1, this comprehensive design code forms the basis for the construction of a design code system that incorporates internationally recognized design codes and standards, guidelines on actions, comprehensive design codes for different categories of structures, and specific base design codes and specific codes.

(2) [REQ] A code drafted based on this comprehensive design code should specify the performance of a structure in a hierarchy as shown in Fig. 2. The objective(s) of the structure should be translated into performance requirements, and then into performance criteria that can be directly used in verification. The process of translation from the objectives to the performance requirements, and then to performance criteria, should be transparent.

(3) [REQ] A designer should ensure that all performance criteria are followed in verification. In doing so, the designer can choose one of two verification approaches, A or B: In approach A, any verification procedure can be employed, whereas in approach B, procedures specified in an appropriate specific base design code or specific design code should be used.

[Description]

(1) This comprehensive structural design code should aim at a design code system that organically incorporates various domestic specific base codes around a comprehensive design code. Then, various domestic design codes could respect region-specific culture and technologies and be in harmony with international standards.

The action and environmental influences used to specify structural performance criteria should be described in specific design codes. Comprehensive guidelines on action as a common basis for action and environmental influences are required to ensure compatibility among specific design codes and compliance with international standards.

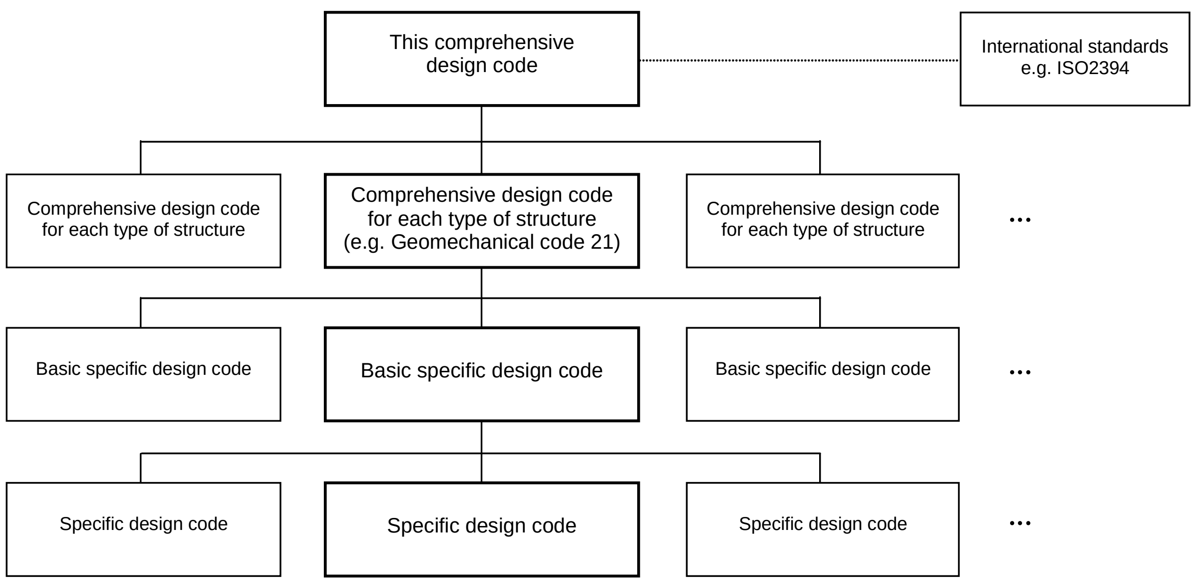


Figure 1 Design code system

(2) The levels of performance description are specified. Three levels, objectives, performance requirements and performance criteria are adopted. Detailed descriptions are presented at respective levels in subsequent chapters.

This comprehensive structural design code also specifies the framework of design systems. When drafting specific base design codes and specific design codes, the framework is respected and more specific descriptions are provided according to the type and use of the structure.

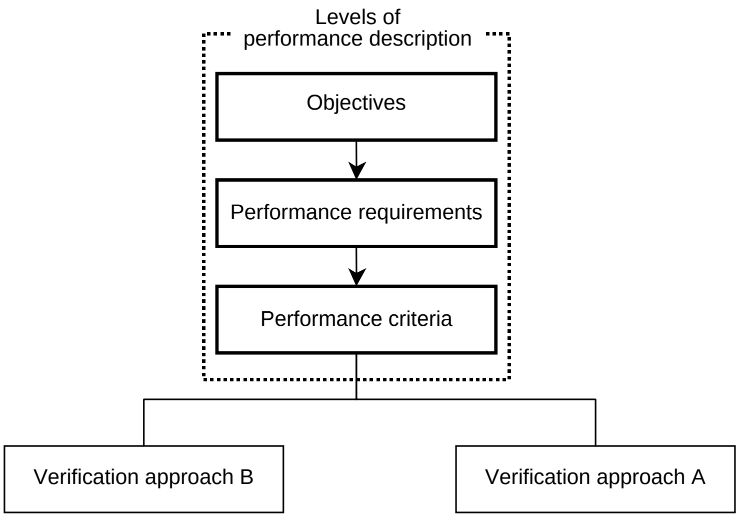


Figure 2 Concept of design code format

It is mandatory that the level of performance requirements higher than that specified in the performance criteria can be specified. In the case where the writer of a specific base design code or specific design code defines the performance criteria implicitly assuming an existing design method, there is a concern that the extraordinary restrictions may be imposed on the verification method. In order to prevent disadvantages under the above condition in case of the emergence of a new technology better than assumed in existing design methods, examining the compatibility of translation of performance criteria based on the performance requirements is important.

(3) Performance verification should be made by design engineers. Verification is an action to prove that the performance criteria translated from the objectives and performance requirements are satisfied.

Verification is classified into the following two categories according to whether the verification method is specified or not.

- Verification approach A specifying no verification method: The design engineer is required to prove by an appropriate method that performance requirements are satisfied. The case where only the performance requirements are given and the design engineer defines the performance criteria based on the requirements and makes verification is also categorized under verification approach A.

- Verification approach B specifying a verification method: The design engineer verifies performance using a lower level of design code (specific based design code or specific design code) specified by the owner. Then, this comprehensive design code serves as “a code for code writers” for drafting a specific design code.

Verification approaches A and B are described in detail in the chapters below.

3. Performance requirements of structures

3.1 Objectives of a structure

(1) [REQ] The objectives of a structure are explanations of the necessity of the structure in plain language.

(2) [REC] The objectives should preferably use the owners/users as the subject of sentences.

[Description]

(1) Objectives of structures are classified into major categories such as private use, commercial use, development of industrial infrastructure, development of social infrastructure and preservation of national land. Explicitly presenting the objectives of structures is necessary because the objectives of design vary greatly as the cost and benefit of structures and performance requirements vary according to the objectives of structures. The objectives of structures are bases for extracting the required performance. The objectives should therefore be defined with the performance in mind that should be taken into consideration in structural design.

Explicitly defining the objectives of structures is important also from a viewpoint of accountability of design engineers. Explicit definition at the time of design is expected to help avoid unnecessary disputes in case where the objectives of structures alter.

A structure sometimes constitutes a larger structure, network or system. Highway bridges, for example, are part of a highway network. Thus, structures have hierarchical objectives. The hierarchical nature of objectives may be reflected in the description of objectives.

The objectives of multi-purpose dams, for example, include the provision of benefit to businesses through power generation and water use, development of regional industries by irrigation and enhancement of public welfare by preventing flood disasters. The objectives of highway bridges are the development of regional economy by constituting a highway network, enhancement of public welfare through assistance in emergency rescue activities during a disaster and others.

(2) The objectives of structures here refer to the objectives of construction of structures in society. The objectives should therefore naturally be specified in sentences using the owners or users as the subject.

3.2 Performance requirements

(1) [REQ] Performance requirements are statements expressed in plain language describing the performance of the structure with respect to the given objectives.

(2) [REC] The structure should be the subject of sentences pertaining to performance requirements.

(3) [POS] It is possible to classify the performance requirements into basic performance requirements (or "functions") and additional performance requirements. The former are essential requirements to achieve the objectives of the structure, whereas the latter are of secondary importance.

(4) [REC] The performance requirements include, but are not limited to, safety, serviceability, environmental, construction, and economic requirements.

(5) [REC] It is desirable to specify the performance requirements of a structure taking into account not only situations encountered during the service period of the structure but also all possible situations from the start of construction, to demolition and renewal.

[Description]

(1) Performance requirements are a basis of performance criteria, so they should be presented with the performance that should be considered in structural design in mind. Performance requirements may, however, be specified without regarding any verification methods.

(2) The structure should be the subject of sentences describing performance requirements while the owners or users should be used as the subject of sentences describing the objectives of structures.

(3) The base performance requirement of highway bridges, for example, is "to carry a designated volume of traffic." Additional performance requirements include "to be free from any deformation that causes user discomfort (serviceability)," "to satisfy base performance requirements during a designated working life including the time of an ordinary disaster (serviceability)," "to cause no human damage during an extremely rare disaster (safety)" or "to carry a minimum volume of traffic to ensure emergency rescue operation during an extremely rare disaster (safety)." Not only minimum performance requirements for structures but also additional performance requirements are listed. Enhancing or increasing the number of structural performance requirements naturally increases the construction cost and value added of structures. When defining performance requirements, cost-benefit analysis may be required. Performance requirements define the balance between the value added and cost of the structure. Performance requirements are sometimes contradictory to one another. Trade-offs and priorities should therefore be taken into consideration in some cases.

(4) Safety refers to safety against failure, safety of drivers, public safety and fail-safe requirements. Economic requirements include recovery from a disaster, minimization of life-cycle cost and maintainability. Listed as serviceability parameters are economic requirements, comforts of vehicle occupants, appearance, water tightness, and freedom from noise and vibration. Environmental requirements refer to the consideration of regional and global environments, reusability, and ease of refreshing or changing objectives.

3.3 Performance criteria

3.3.1 Definitions

(1) [REQ] Performance criteria represent the group of performance items extended from the performance requirements, and should be described in a specific way that can be verified by appropriate procedures.

(2) [REQ] Each performance criterion is specified by a combination of three factors: limit states of a structure, actions/environmental influences and their combinations, and time. Note that in some cases, performance criteria are specified by the maximization/minimization of some quantities that cannot be specified by any limit states. In these cases, limit states can be replaced by states described by the maximization/minimization of these quantities.

(3) [REC] It is desirable to take the importance of a structure into account in specifying the performance criteria.

(4) [REC] It is recommended that, in specifying a performance criterion, the relationship between the performance requirement and content specified by the performance criterion should be transparent and clearly understood by designers so that the performance requirement itself can be more directly reflected in the design.

(5) [REQ] Performance requirements concerning structural safety should be specified for structures that have the potential to cause human injury and loss of life.

(6) [REC] Note that those performance requirements that are not translated into performance criteria are not necessarily less important, and should preferably be taken into account when designing a structure.

[Description]

(1) Performance criteria define an interface between the structural plan and design. They are a component of the hierarchy of objectives, performance requirements and performance criteria. Performance criteria should have a link with verification methods. It is mandatory that compliance with performance criteria can be proved (verified). No structural performance therefore can be specified in performance criteria unless it can be verified. Performance criteria should be expressed in technical language.

Design codes present the minimum judicial and social requirements for structural performance and reliability but not "how to consulate" structures. Then, design codes limit the discretion of design engineers. In view of the objectives of performance-based design, on the other hand, design engineers should be given as much discretion as possible when drafting design codes. In order to meet the conflicting requirements, performance criteria find a trade-off between the freedom of design engineers and the limits imposed on them by society.

(2) One of the major characteristics of this comprehensive structural design code is the proposal to specify performance criteria based on the combination of "limit states of a structure," "actions/environmental influences and their combinations" and "time." Respective components are described below.

As a means of specifying (explicitly presenting) structural performance, the idea of performance matrix is well known that expresses performance using combinations of the "frequency and magnitude of action" and "limit states of the structure." This comprehensive structural design code uses the two parameters plus time-based fluctuations of structural performance e.g. deterioration, a third parameter. Thus, this design code demands that structures satisfy designated performance criteria not only in the early days after construction but also throughout the specified period. Verification should therefore be made after the action and environmental influences and resultant fluctuations of structural performance are all expressed as a function of time. The magnitude of action and environmental influences fluctuates according to the time considered in design. Performance including structural resistance also fluctuates with time. Explicitly presenting time is essential when defining performance criteria. For example, performance criteria concerning seismic safety may read, "Structural response to the maximum ground motion conceivable at the location should not exceed the ultimate limit at any point in the working life."

The limit state design method has conventionally been adopted. In most cases, certain limit states were adopted to represent performance requirements. If economic or environmental indices rather than mechanical indices are employed, the performance criterion may not be represented using specific limit states. This comprehensive structural design code suggests that limit states should be applied not only to structural performance but also to other types of performance.

(6) Performance requirements not translated into performance criteria should not be fully ignored in design. Such performance requirements do exist but may have not been translated into performance criteria for making performance verification for some reasons. In such cases, the performance requirements should be respected in design as much as possible. In the case, for example, where an environmental performance requirement suggests that "the burden on the global environment should be minimized" but the requirement has not been translated into performance criteria, an alternative should be selected in design that minimizes environmental burden.

3.3.2 Limit states of structures

(1) [REQ] A limit state is a state that can separate the intended condition of a structure from an unintended condition based on a performance criterion.

(2) [REC] It is desirable to specify limit states in terms of quantitative measures of the performance of a structure.

(3) [POS] It should be recognized that there are performance criteria that are not suitable to be specified in terms of limit states.

[Description]

(1) The limit states referred to in conventional limit state design methods are related to structural properties. Ultimate and serviceability limit states are typical examples.

(3) This comprehensive structural design code suggests that the idea of limit state should be applied not only to the structural properties such as safety and serviceability but also to non-structural properties such as environmental, construction and economic requirements.

3.3.3 Actions and environmental influences: magnitude and their combinations

(1) [REQ] Actions are classified as permanent, variable or accidental actions based on the time fluctuation characteristics from the mean value during the design working life of a structure.

(2) [REQ] In the verification process for each performance criterion, magnitudes and combinations of actions and environmental influences should be considered appropriately.

(3) [REQ] Appropriate consideration is required when actions and environmental influences change with time, and repeated actions have some influence on structure performance.

[Description]

(1) Actions are classified into the following categories according to their fluctuation with time relative to the mean value during the period under study.

Permanent actions : The fluctuation of the magnitude of the action is almost none or sufficiently small relative to the mean value to be ignored.

Variable actions : The magnitude of the action frequently fluctuates with time. The fluctuation of magnitude is so large relative to the mean value that it cannot be ignored.

Accidental actions : The probability of the action occurring during the period under study is small. The action, however, has serious impact on the structure.

(2) Safety performance should be verified for all the actions that occur throughout the period under study. Verifications are made for combinations of actions that have the maximum impact on structural safety during the period under study. Actions acting on structures are rarely caused by a single phenomenon. Multiple phenomena should therefore generally be considered. Even where fluctuating actions occur simultaneously, the probability of maximum expectation values occurring simultaneously is generally considered small. In the case where multiple fluctuating actions are combined, adjusting the magnitude of the combination according to the combination under study is effective. One way of safety verification is to divide fluctuating actions into primary and secondary actions, and to use the maximum expectation value as the characteristic value of the primary fluctuating action and determine the characteristic value of secondary fluctuating action appropriately according to the combination with the primary fluctuating action or accidental action. Accidental actions are combined only with permanent actions but not with other fluctuating actions.

For other types of performance than safety performance, verifications may generally be made in numerous cases for the magnitude that occurs frequently although the significance of the structure sometimes has an influence.

(3) Fatigue failure may occur if the structure is subjected to fluctuating actions repeatedly. Where there is a concern about fatigue failure, not only the magnitude of the action but also the effect of its repetition should be considered.

For dynamic phenomena for which the relationship between the fluctuation of the magnitude of the action and time cannot be ignored such as earthquakes and travels in vehicle, the method appropriate to their effect should be adopted for verification. Then, attention should be paid to the fluctuations of magnitude of the effects of the action on the structure according to the combination of the characteristics of action and structure. For example, when multiple seismic waves are examined to assess the influences of an earthquake, the type of seismic wave that has the greatest influence on the structure may fluctuate according to the predominant period or duration of the seismic wave, or the natural period of the structure.

3.3.4 Time

(1) [REQ] An appropriate time period should be defined in verifying the performance of structures.

(2) [REQ] Temporal fluctuations of actions, environmental influences and the characteristics of structures and their elements within the considered time period should be considered in the verification of structure performance.

(3) [REC] It is desirable to clearly describe methods and frequencies of maintenance schemes, i.e. inspection, rehabilitation and upgrading, in the considered time period.

[Description]

(1) In performance verification of a structure, whether the designated performance requirement is satisfied or not is confirmed during a certain period of time. For the performance verification of a structure, the period of time should be determined.

(2) Fluctuations of structural characteristics with time during the period of time specified for verification are caused by material deterioration for environmental reasons or by the damage to the structure due to accidental actions. Where such fluctuations of structural characteristics are expected, their effects should be taken into consideration in advance.

The effects of fluctuations of action characteristics are described in 3.3.3 Actions and environmental influences - magnitude and their combinations. Note that variations of structural characteristics lead to the variation of the effect of an action on the structure. In the case where stiffness fluctuates due to the deterioration of or damage to a structure, response to one and the same action varies. Such a phenomenon should be taken into consideration.

In structural performance verification, explicitly presenting the maintenance method is important. If the maintenance method considered in verification is not implemented, verification may be of no significance.

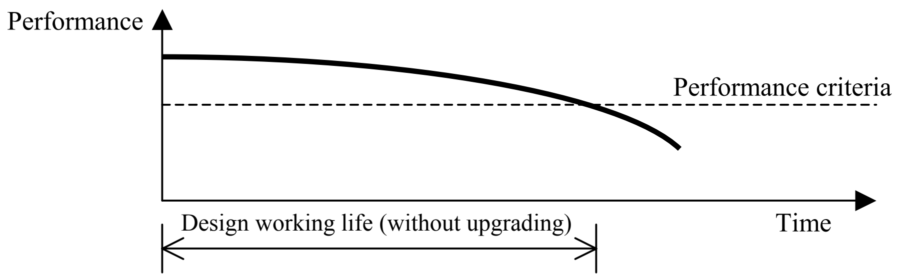
(3) Rehabilitation here means the improvement of resistance of the structure to performance reduction due to the deterioration with time, or prolonging of the working life of a structure. Upgrading refers to the enhancement of mechanical performance of the structure.

The relationship between time and structural performance is shown in Figure 3. In the figure, the design working life is specified as the period for verification.

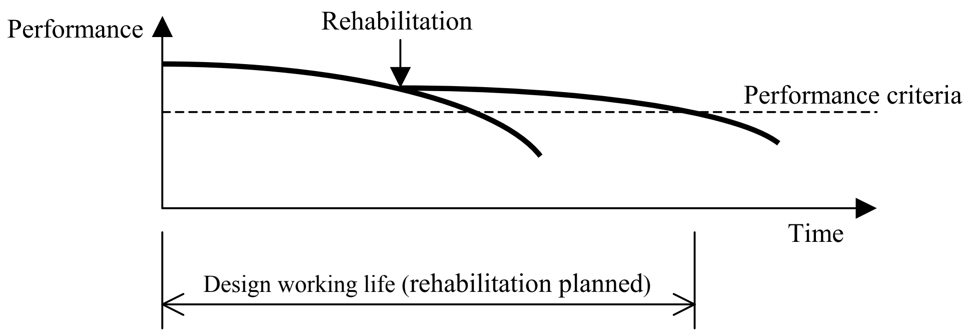
Figure 3 (a) is the case with neither rehabilitation nor upgrading. Structures may deteriorate with time. Performance criteria may not be satisfied beyond the design working life. Then, the structure is discarded or replaced with another.

Figures 3 (b) and (c) show cases with rehabilitation and upgrading during the design working life, respectively. Performance deterioration of a structure is controlled or performance is enhanced through rehabilitation or upgrading during the design working life. Then it is ensured that the structure satisfies the performance criteria. A relatively long period of time can be set for verification. To that end, the structure should be modularized or simplified in the construction phase to facilitate rehabilitation or upgrading.

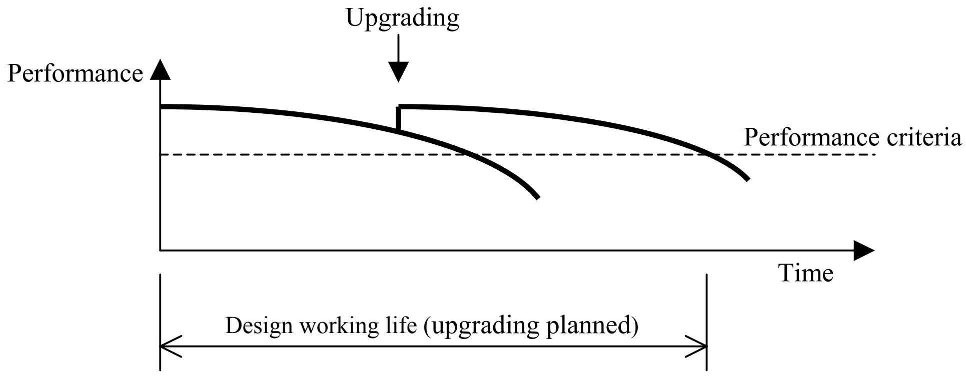
In any case, appropriate maintenance is required. Regular inspections, performance confirmation during the working life and rehabilitation or upgrading based on the assessment results are required.



(a) Without rehabilitation or upgrading during the design working life



(b) With rehabilitation during the design working life



(c) With upgrading during the design working life

Figure 3 Time and structural performance

3.3.5 Significance of structures

(1) [REQ] The significance of structures should be evaluated based on construction cost, benefit earned by the structure, necessity in case of emergency, existence of alternative facilities, and other aspects.

[Description]

(1) The significance of structures is basically determined by economic influences. For designing structures in the future, the most economical design should be selected based on the results of cost-benefit analysis or other types of analyses after evaluating the construction cost, benefit and the damage cost and cost of recovery from a disaster. Note, however, that no economic verification may be possible for safety or other parameter.

Providing high level of performance to costly structures, structures producing great benefits and structures required under emergency conditions prevents confusion and reduces damage cost during a disaster. For structures with less social influences on the other hand, construction cost can be reduced by curtailing their performance.

Performance criteria including seismic serviceability should be specified using economic indices to objectively reflect the significance of structures in the performance criteria without defining the significance in explicit ways.

4. Verification procedures

4.1 Allowable verification procedures

4.1.1 General

(1) [REQ] In verification, it should be demonstrated that a structure satisfies all the performance criteria described in Chapter 3.

(2) [REQ] Verification should be accomplished by verification approach A or B as specified in section 4.2.

[Description]

(2) Two verification approaches are available. Design engineers decide whether they adopt verification approach A or B in numerous cases. There are, however, cases where the owner specifies the verification approach. Even where the owner specifies a verification approach, the design engineer may propose the other. This comprehensive structural design code does not specify which verification approach should be adopted. Once the approach has been selected, the regulations in Section 4.2 or 4.3 should be respected.

4.1.2 Designers

(1) [REQ] Designers should have a thorough knowledge and understanding of structural design in specific fields.

(2) [REC] It is preferable that designers are qualified engineers in a specific field and are accredited by a publicly recognized institute.

[Description]

(2) In the specific base design code or specific design code used in verification approach B, qualifications of professional engineers should be explicitly specified wherever necessary.

4.2 Verification approach A

(1) [REQ] In verification approach A, there is no restriction on the methods used for performance verification. However, designers are requested to prove that the designed structures satisfy all the performance criteria described in the format specified in Chapter 3 of this comprehensive design code with sufficient reliability.

(2) [REC] It is recommended that the designer submit a structural design report to an appropriate institute for design examination.

(3) [REC] It is desirable that the design report be prepared according to the specifications described in chapter 5 of this comprehensive design code.

(4) [REC] It is desirable that an appropriate design examination institute examine and judge the designed structure with respect to satisfaction of all performance criteria based on the structure design report submitted by appropriate procedures.

(5) [REC] It is recommended that the design examination institute archives all documents created at the time of examination during the period that the structure remains in operation.

[Description]

(1) Verification approach A is defined here. It is extremely different from conventional design methods. How to establish a design examination institute and its role have been little known. This section simply presents a verification procedure conceivable at present. An alternative may be “authorizing a design organization that is capable of design taking verification approach A and approving the design by the authorized organization.” The descriptions in (2) and subsequent sections have been categorized as [REQ] because such uncertain factors as described above have been taken into consideration.

(2) An appropriate institute refers to a neutral third party organization independent both of the owner and of the designer.

(4) Appropriate procedures include the formation of a committee staffed with those who are familiar with the expertise related to the design of the structure and independent of the owner and the designer. No discussions have yet been fully made on examination institutes in the capacity of a “neutral third party organization independent both of the owner and of the designer” mentioned in 4. 2 (2). At present, therefore, specifically describing the details and levels of examination is difficult. Discussions should be made in the future on the responsibilities of the owner, designer and examiner and on other related matters.

4.3 Verification approach B

(1) [REQ] Designers should verify the performance of structures based on design codes of lower hierarchy (i.e. “specific base design codes” or “specific design codes”) specified by the owner of the structures.

(2) [REQ] Specific base design codes and specific design codes should be drafted according to the rules described in this comprehensive design code.

(3) [REC] In specific base design codes and specific design codes, it is desirable to specify criteria in a specific and quantitative manner such that structures and structural members can be verified in a straightforward manner.

(4) [POS] In specific base design codes and specific design codes, multiple methods, such as structural analyses, loading tests, model experiments, monitoring, observational design and construction methods, and “Deemed to Satisfy” solutions, should be considered when specifying verification methods.

(5) [REC] In adopting pre-verified specifications (i.e. “Deemed to Satisfy” solutions) in specific base design codes and specific design codes, it is recommended that the performance requirements that the specifications are intending to verify be described.

(6) [REC]It is recommended to adopt a “partial factors format” in drafting specific base design codes and specific design codes.

(7) [REQ] The “partial factors format,” if adopted for specific base design codes and specific design codes, should be drafted with reference to ISO2394.

[Description]

(1) In verification approach B, performance should be verified based on a lower level of code in the code hierarchy specified by the owner of the structure (specific base design code or specific design code). This section describes the requirements for the lower level of design code.

(2) Appropriate procedures include the formation of a committee staffed with those who are familiar with the expertise related to the design of the structure and independent of the owner and the designer.

(3) Not only structures but also structural members are mentioned. This is because specific base design code and specific design code, like conventional design codes, often verify structural members instead of structures.

(6) The “partial factors format” is recommended in ISO2394 and the “Bases of Design for Civil and Building Structures.”

(7) The third version of ISO2394 includes “9. Partial factors format.” For basic variables, analysis models and principles of probability-based design, refer to “6. Basic variables,” “7. Models” and “8. Principles of probability-based design” of the third version of ISO2394. It is also desirable to refer to “Annex D Design based on experimental models,” “Annex E Principles of reliability-based design” and “Annex F Combinations of actions and estimation of action values” of the third version of ISO2394 for the design methods based on experimental models, principles of reliability-based design and combinations of actions and estimation of action values.

5. Structural design report

(1) [REQ] Designers should report the results of structural design to the owner of the structure in the form of a structural design report.

(2) [REQ] The structural design report should describe key design matters.

(3) [REC] The structural design report should include a summary of the main information used in the design, as well as the objective, performance requirements and performance criteria of the structure, limit states, assumptions made in design, conditions on actions and environmental influences, material/ground parameters and characteristic values as well as their temporal changes, appropriateness of chosen structural type, design calculation model and procedures, verification methods for given performance criteria, results, and the designers' names and qualifications.

(4) [REC] Grades of detail and elaboration of structural design reports will differ depending on the scale and significance of the structure.

(5) [REQ] The owner should retain the structural design report for as long as the structure remains in operation.

[Description]

(3) The structural design report should contain the following descriptions but not limited thereto.

1) Descriptions of the site and surrounding areas. Descriptions of geological conditions and supporting materials.
2) Descriptions of the objectives, performance requirements and performance criteria of the structure to be designed.
3) Descriptions of limit states of the structure.
4) Descriptions of actions and combinations thereof.
5) Descriptions of evaluations of actions dependent on site characteristics such as seismic and wind actions.
6) Descriptions of justifications and bases for determining the material and ground parameters and their characteristic values.
7) Descriptions of the design codes and technical materials applied.
8) Descriptions of appropriateness of the chosen structural type.
9) Descriptions of structural risk and justification for the reliability of performance criteria adopted.
10) Descriptions of preconditions of construction.
11) Design calculations and drawings of the structure.
12) Descriptions of items to be checked for monitoring during construction and for maintenance.

<References>

1) ISO: ISO2394 General principles on reliability for structure 3rd edition, June 1998.
2) Japanese Society of Steel Construction: Guidelines for Performance-based Design of Civil Engineering Steel Structures, October 2001.
3) Japanese Geotechnical Society: Comprehensive Foundation Design Code : Geo-code 21 Ver. 1, March 2000.
4) Ministry of Land, Infrastructure and Transport: Bases of Design for Civil and Building Structures, October 2002.
5) ISO: ISO13822 Bases for design of structures - Assessment of existing structures, 1st edition, December 2001.
6) Fukui, J.: Performance-based design of highway bridge foundations, The Foundation Engineering & Equipment, Vol. 29 No. 8 pp. 17-20, August 2001.