Part I General Section

Chapter 1 General Rules

1 Scope of Application

1.1 Overall Structure of the Technical Standards

(English translation of this section from Japanese version is currently being prepared.)

1.2 Compliance with the Technical Standards

Based on **Article 56-2-2 of the Port and Harbor Act**, port facilities subject to the Technical Standards shall be constructed, improved or maintained to comply with the standard ministry ordinance regarding the performance required for facilities subject to the Technical Standards. The performance required for these facilities means the minimum performance such facilities shall hold.

Construction, improvement or maintenance of port facilities subject to the Technical Standards generally means the following acts with regard to the Technical Standards:

① **Construction**: Work to construct new facilities subject to the Technical Standards. The facilities concerned shall be required to comply with the standard ministry ordinance, the standard notice and the construction notice at the time of construction.

② **Improvement**: Work to utilize all or part of an existing facility and achieve the following purposes by changing factors such as the use and design conditions of existing facilities subject to the Technical Standards. The facilities concerned shall be required to comply with the standard ministry ordinance, the standard notice and the construction notice at the time renovations are made.

1) Change the use of an existing facility (e.g., change of use from a mooring facility to a revetment, etc.)

2) Change the performance of an existing facility (e.g., deepening or earthquake proofing of a mooring facility, etc.)

3) Extend the service life of an existing facility

③ **Maintenance**: Work to adequately maintain a previously constructed or improved facility throughout its service life by conducting inspections and so on in order to guarantee satisfactory performance. The facilities concerned shall be required to comply with the standard ministry ordinance and the standard notice at the time of construction or improvement and the maintenance notice at the time of maintenance. Generally, the following acts are included:

1) Daily management such as inspections, cleanings and repairs to damaged portions of the facility.

2) Repairs or reinforcement of structural members and other elements in order to keep the facility in good condition and maintain the performance of existing facilities as a response to deterioration in performance due to degradation and damage during their service life.

1.3 Facilities Subject to the Technical Standards

1.3.1 Facilities Subject to the Technical Standards

(English translation of this section from Japanese version is currently being prepared.)

1.3.2 Specific Facilities Subject to the Technical Standards

(English translation of this section from Japanese version is currently being prepared.)

1.4 Relationship between the Technical Standards and Other Laws

(English translation of this section from Japanese version is currently being prepared.)

1.5 Confirmation System for Conformance to the Technical Standards

(English translation of this section from Japanese version is currently being prepared.)

1.5.1 Purpose of the Conformance Confirmation System

(English translation of this section from Japanese version is currently being prepared.)

1.5.2 Facilities Subject to Conformance Confirmation

(English translation of this section from Japanese version is currently being prepared.)

1.5.3 Conformance Confirmation Business by a Registered Confirmation Agency

(English translation of this section from Japanese version is currently being prepared.)

2 Performance-Based Design Systems

2.1 Performance-Based Design Systems

2.1.1 Performance-Based Design

Fig. 2.1.1 shows the hierarchy structure of performance and verification of a basic framework of the performance-based design of facilities subject to the Technical Standards. **References 1), 2), 3), 4) and 5)** are considered higher-level standards. In the figure, the "objective" is the reason why the facility concerned is needed, "performance requirements" is the performance of the facilities needed to achieve the objective plainly explained from the viewpoint of accountability, and the "performance criteria" are the technical explanation of a set of rules needed to verify the performance requirements. "Performance verification" is work to verify that the performance criteria are satisfied.

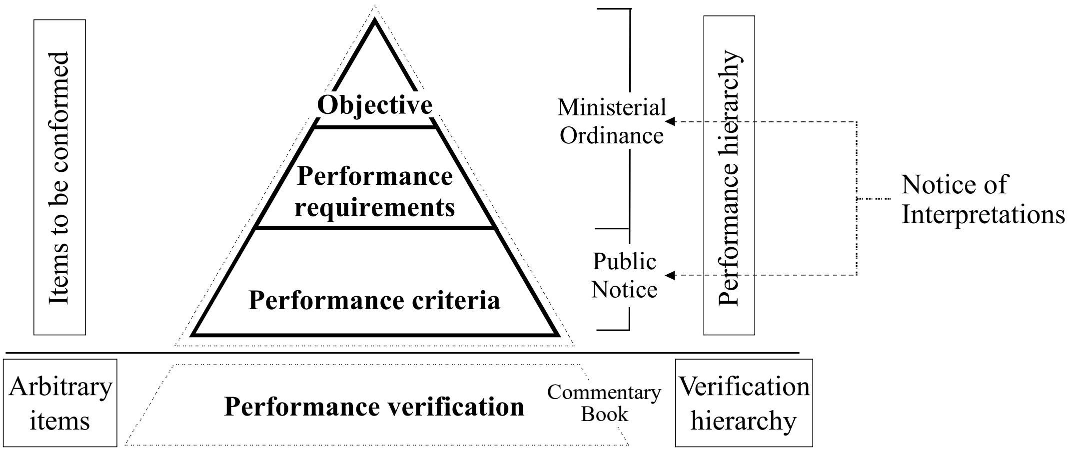

Fig. 2.1.1 Positioning of Performance Hierarchy and Performance Verification

2.1.2 Items Specified in the Technical Standards

The Technical Standards specify objectives, performance requirements and performance criteria. The Ministerial Ordinance specifies objectives and performance requirements of facilities according to the hierarchy shown in **Fig. 2.1.1**. The Public Notice specifying requirements conforming to the Ministerial Ordinance specifies performance criteria.

2.1.3 Performance Verification

Performance verification is work to verify that the performance criteria are satisfied. No specific technique is required to carry out the verification. In other words, it is up to the designer's discretion to select a specific method for performance verification and for specification of the index indicating permitted safety margins and limiting values of deformation amounts, etc. The performance verification method is described in detail in **Part I, Chapter 1, 3.6 Performance Verification**.

2.1.4 Design and Performance Verification

The "Design" in this book is shown in **Part I, Chapter 2, 2.1.3 Range and Consideration in Design**. Performance verification is considered as a part of design work.

3 Fundamental Items Concerning Performance-Based Design (Definition of Terms)

[Ministerial Ordinance] (Definition of Terms)

Article 1

Terms used in this Ministerial Ordinance are governed by the definitions of those used in the Port and Harbour Act (Act No. 218 of 1950), and definitions of terms set forth in the following items are as prescribed respectively in those items.

1 "Performance requirements" means the performance required for facilities subject to the Technical Standards.

2 "Designed tsunami" means tsunamis that are supposed to occur at the place where the facilities subject to the Technical Standards are constructed with a low possibility of occurrence within the design service life (the period during which the facilities continue to satisfy the performance requirements in designing facilities subject to the Technical Standards; the same applies hereinafter) of the facilities and that exert massive effect on the facilities.

3 "Variable waves" means waves that are supposed to occur at the place where the facilities subject to the Technical Standards are constructed with a high possibility of occurrence within the design service life of the facilities.

4 "Accidental waves" means waves that are supposed to occur at the place where the facilities subject to the Technical Standards are constructed with a low possibility of occurrence within the design service life of the facilities and which exert massive effect on the facilities.

5 "Level 1 earthquake ground motions" means earthquake ground motions that are supposed to occur at the place where the facilities subject to the Technical Standards are constructed with a high possibility of occurrence during the design working life of the facilities when considering the relationship between the return period of the earthquake motion and the design service life of the facilities.

6 "Level 2 earthquake ground motions" means the strongest earthquake ground motions that are supposed to occur at the place where the facilities subject to the Technical Standards are constructed.

7 "High earthquake-resistance facilities" means facilities subject to the Technical Standards, as countermeasure facilities against large-scale earthquakes set forth in Article 16 of the Ministerial Ordinance (Order of the Ministry of Transport No. 35 of 1974) Specifying Criteria Concerning Fundamental Items of Port Planning, or as facilities that should have the equivalent functions when large-scale earthquake occurs.

[Public Notice] (Definition of Terms)

Article 1

Terms used in this public notice are governed by the definitions of those used in the Ministerial Ordinance for the Technical Standards for Port and Harbour Facilities (Order of the Ministry of Land, Infrastructure, Transport and Tourism No. 15 of 2007, hereinafter referred to as "Ministerial Ordinance"), and definitions of terms set forth in the following items are as prescribed respectively in those items.

1 "Permanent actions" means actions that are supposed to occur at all times during the design working life such as self-weight, earth pressure, environmental actions (mechanical, physical, chemical or biological actions that may deteriorate the structural materials of facilities and diminish performance; the same applies hereinafter).

2 "Variable actions" means actions that are supposed to be highly probable to occur during the design working life due to wind, waves, water pressure, water flow, berthing and traction of ships, level 1 earthquake ground motions, imposed load, etc.

3 "Accidental actions" means actions with a low possibility of occurrence during the design working life which exert massive effect on the facilities, such as tsunamis, level 2 earthquake ground motions, accidental waves, ship collisions, fires, etc.

4 "Performance criteria" means specifications that specifically describe performance requirements so that performance can be verified.

5 "Performance verification" means an action of confirming that the facilities subject to the Technical Standards satisfy the performance criteria.

6 "Permanent states" means states in which the dominating actions are permanent, among those in which one or

more actions considered in performance criteria and performance verification are combined.

7 "Variable situations" means situations in which the dominating actions are variable, among those in which one or more combined actions considered in performance criteria and performance verification are combined.

8 "Accidental situations" means situations in which the dominating actions are accidental, among those in which one or more combined actions considered in performance criteria and performance verification are combined.

9 "Property of hypocenter" means the effect that the fracture process of the hypocenter fault gives to earthquake ground motions.

10 "Propagation path property" means the effect that the propagation path from the hypocenter to the seismic bedrock of the point concerned gives to earthquake ground motions.

11 "Site characteristics" means the effect that deposit layers above the seismic bedrock and the like give to earthquake ground motions.

12 "Hazardous cargo" means hazardous cargo set forth in the public notice (Ministry of Transport Public Notice No. 547 of 1979) which specifies the kinds of hazardous cargoes in the Ordinance for Enforcement of the Port and Harbor Act.

13 "Datum level for port administration" means the lowest astronomical tide set forth based on the specifications of Article 1 of the Order for Enforcement of the Hydrographic Activities Act (Cabinet Order No. 433 of 2001), which is referenced when facilities subject to the Technical Standards are constructed, improved or maintained. However, the datum level for the port administration of facilities subject to the Technical Standards concerning lakes and rivers where tides cause minor effects shall be specified in consideration of extremely low water levels during a drought season, etc., in order to ensure safety when using ports.

[Interpretation]

3. Definition of Terms

The terms used in this notification shall be examples of terms used in the Ministerial Ordinance and the public notice, and will comply with the definitions hereinafter.

(1) Performance Requirements

① **Serviceability**

"Serviceability" means the capability to use facilities and the like without issues occurring. In the expected structural response of facilities to actions, it means that the possibility of damage is sufficiently low or remains at a level to promptly enable resumption of the required functions with minor repairs. The standard Ministerial Ordinance specifies serviceability with the statement that, in principle, "damages due to actions do not affect the ability to continuously use the facilities and do not hinder their functions." Since the serviceability, restorability and safety in item (1) ① - ③ are classified according to the degree of structural response assumed for such actions, ensuring serviceability may be interpreted to mean that restorability and safety are also ensured simultaneously.

② **Restorability**

"Restorability" means the capability to continuously use facilities by making repairs within a technically possible and economically feasible range. In the expected structural response of facilities to actions, it means that the damage remains at a level in which the required functions can be restored with only minor repairs in a short period of time. The Ministerial Ordinance specifies restorability with the statement that, in principle, "damages due to actions do not affect the restoration of the performance of the facilities following minor repairs." Ensuring restorability may be interpreted to mean that safety is also ensured simultaneously for the same reason as for serviceability.

③ **Safety**

"Safety" means the capability that facilities can ensure the safety of human lives, etc. In the expected structural response of facilities to actions, it means that the damage remains at a level in which the safety of human lives is not in jeopardy, and even if a certain degree of damage occurs, the facility's structure remains sufficiently stable. The Ministerial Ordinance specifies safety with the statement that, "even if damages due to actions impair the functions of the facilities concerned, they do not significantly affect the structural stability of the facilities."

The specification in the Ministerial Ordinance states that, "even if a tsunami having a strength exceeding that of designed tsunamis occurs, the effects from the damage to the stability of the structure of the facilities concerned can be delayed as much as possible." This means that the facilities' structural stability will be maintained as much as possible in order to ensure natural disaster reduction and harbor calmness after a disaster.

④ **Usability**

"Serviceability" means the capability that facilities shall have from the standpoint of service and convenience. Specifically, it means that the facilities are appropriately arranged, that the structural specifications (length, width, water depth, crest elevation, clearance limits, etc.) and harbor calmness, etc., satisfy the required values, and that they have the required ancillary facilities as appropriate. The Ministerial Ordinance specifies serviceability with the statement that it "satisfies the requirements set forth by the Minister of Land, Infrastructure, Transport and Tourism in order to do A."

⑤ **Constructability**

"Constructability" means the capability to perform construction by utilizing reliable and appropriate methods, and ensuring safety of the works for a reasonable construction period. Article 3 of the standard Ministerial Ordinance specifies constructability as a capability required for all facilities. A construction notice is specified for construction of the facilities subject to the Technical Standards.

⑥ **Maintenanceability**

"Maintenanceability" means the capability to continuously ensure the required performance for the facilities by repairing and reinforcing, etc., the deterioration and damage of facilities due to use and expected actions within a technically possible and economically feasible range. Article 4 of the Ministerial Ordinance specifies maintenanceability as a capability required for all facilities. A maintenance notice is specified for maintenance of the facilities subject to the Technical Standards.

(2) Design Service life

"Design Service Life," in the context of the Technical Standards, means a period to be appropriately set as the time during which the performance requirements of the facilities concerned shall be continuously satisfied when they are designed. It should be noted that the definitions of the period that the facilities concerned are actually in service and the return period of the expected actions for performance verification are different from that of the design service life.

(3) Annual Exceedance Probability

When verifying the performance of facilities subject to the Technical Standards, annual exceedance probability or the return period of actions required to calculate the characteristic values of actions shall be appropriately set according to the characteristics of the actions and the importance of the facilities. The magnitude of the characteristic values of the variable actions and accidental actions differ according to their annual exceedance probability or return period, and their magnitude affects the degree of damage to the facilities. Generally, it is not permitted that facilities be significantly damaged due to permanent actions and variable actions, the annual exceedance probability of which is at a certain level. On the other hand, a certain level of damage due to accidental actions, the annual exceedance probability of which is extremely low, is permitted because it is unreasonable for such actions to not cause any damage to the facilities from an economic standpoint, etc.

The return period in the context of the Technical Standards means a mean time interval (expressed in years) between events that occur at a certain level of magnitude or higher, and which are expressed as an inverse number of the annual exceedance probability (the probability of an action of assumed magnitude or higher occurring once or more in a year).

(4) Classification of Actions

The standard notice classifies actions as permanent actions, variable actions and accidental actions, mainly according to their temporal variation of magnitude and risks to be socially addressed. Refer to the following for details regarding the classification of these actions.

① **Permanent Actions**

"Permanent actions" means actions assumed to be constantly performed on facilities throughout their design working lives. Their temporal variations are smaller than the mean value or tend to monotonically and constantly increase or decrease within their design working lives until their certain limit values are reached.

② **Variable Actions**

"Variable actions" means actions for which the temporal variations within their design working lives are multidirectional and not negligible compared to the mean value. Their characteristic values are given stochastically.

③ **Accidental Actions**

"Accidental actions" means actions difficult to predict stochastically, or when possible to predict stochastically, are actions for which the annual exceedance probabilities are smaller than those of variable actions, and that cannot be socially negligible as their characteristic values are extremely large.

(5) Dominating Actions and Subordinate Actions

In the context of the standard notice, "dominating actions" means main actions to be considered during performance verification that are individually set to one design state in principle. "subordinate actions" generically means actions other than dominating actions to be considered simultaneously in combination with the dominating actions during performance verification. The standard notice states an action is "condition B where the dominating action is A" where "A" is a dominating action and "condition B" is a design state considering the combination of dominating and subordinate actions.

(6) Design State

① **Permanent State or Variable Situation**

If the design state is a permanent state or a variable situation, serviceability is specified as the performance requirements.

② **Accidental Situation**

If the design state is an accidental situation, either serviceability, restorability or safety is specified as the performance requirements in accordance with the function or importance of facilities. In principle, the ordinance specifies performance requirements for accidental situations only for specific facilities.

(7) Specific Facilities that Specify Performance Requirements for Accidental Situations

The Ministerial Ordinance specifies the performance requirements for accidental situations at high earthquake-resistant facilities, facilities that function in combination with high earthquake-resistant facilities, and facilities that may significantly affect human lives, property or social and economic activities when struck by disaster (hereinafter called "facilities prepared for accidental incident"). Refer to the following for these facilities.

① **High Earthquake-Resistant Facilities**

High earthquake-resistant facilities include quay walls, piled piers and shallow draft quays that contribute to the transport of emergency goods and trunk line cargoes, and green spaces and open spaces, etc., that function as disaster prevention bases (bases that contribute to the restoration and reconstruction of ports and their surrounding areas).

② **Facilities That Function in Combination with High Earthquake-Resistant Facilities**

Facilities that function in combination with high earthquake-resistant facilities include bridges and tunnels along roads leading to high earthquake-resistant facilities, cargo handling equipment (including foundations for cargo handling equipment) and cargo sorting areas that contribute to the transport of emergency goods and trunk line cargoes.

③ **Facilities Prepared for Accidental Incident**

Facilities prepared for accidental incident include breakwaters, revetments, seawalls, water gates, mooring buoys, piled piers, and lock and water gates that are located in front of populated areas, facilities that handle hazardous cargo, port transportation facilities used by the general public and vehicles, tunnels and bridges for trunk line harbor roads. Revetments include those that need to function in combination with high earthquake-resistant facilities, and tunnels and bridges include those along roads leading to these facilities

(8) Datum Level for Port Administration

The reason why the standard notice specifies the datum level for port administration as the lowest astronomical tide is to clarify the relationship between the datum level that indicates water depth required for navigation and the datum level used for the administration of port facilities. The handling and setting of the datum level for port administration comply with the "correction of hydrographic charts associated with port construction work and handling of datum levels for port administration (Nation Port Construction No. 32-3, dated April 28, 2006, Nation Port Environment No. 9-4 Port Authority Notification)."

The lowest astronomical tide is based on the specifications in table reference No. 1 of Article 1 of the Order for Enforcement of the Hydrographic Activities Act (Cabinet Order No. 433 of 2001) and is set forth in the public notice of the Japan Coast Guard: "Public notice on the height of mean water level, the highest water level and the lowest astronomical tide." (Notice No. 103 of 2002.)

3.1 Purpose of Facilities Subject to the Technical Standards

In the context of the Technical Standards, the objective of the facilities subject to the Technical Standards is the reason why the facilities concerned are needed and it becomes the foundation of the performance requirements of the facilities concerned. The Technical Standards specify the objective of the facilities by their type in the Ministerial Ordinance. They also specify the objective of the facilities as the minimum role the facilities concerned should play from the viewpoint of the common welfare. Therefore, organizations or persons who construct, improve or maintain facilities subject to the Technical Standards may, as appropriate, make items other than what is set forth in the Ministerial Ordinance a purpose of the facilities concerned in consideration of the situation of those facilities.

3.2 Design Service life

The Technical Standards define the design service life as the "period to be appropriately set as the time during which the performance requirements of the facilities concerned shall be continuously satisfied when they are designed." The design service life needs to be specified as one of the design conditions since the specification of design service life makes it possible to quantitatively verify that the required functions and performance of the facilities concerned are retained.

3.3 Annual Exceedance Probability

(1) Annual Exceedance Probability and Return Period

"Annual Exceedance Probability" means the probability that an event of an assumed magnitude or higher occurs once or more in a year. "Return period" means a mean time interval (expressed in years) between events occurring at a certain level of magnitude or higher, and expressed in the inverse number of an annual exceedance probability.

(2) Encounter Probability

"Encounter Probability" means the probability that the facilities concerned encounter an event that is larger than the corresponding event within a certain return period during its design service life. The encounter probability can be obtained using the equation (3.3.1).

$$E_1 = 1 - \left(1 - 1/T_1\right)^{L_1} \qquad \textbf{(3.3.1)}$$

where,

E_1 : encounter probability

L_1 : design service life (year)

T_1 : return period (year)

3.4 Classification of Actions

Actions are classified into ① permanent actions, ② variable actions and ③ accidental actions mainly according to the size of time variations and the social risks that need to be addressed. **Table 3.4.1** shows examples of classified dominating actions to be considered in the performance verification of facilities subject to the Technical Standards.

① **Permanent Actions**: Actions which are assumed to apply constantly on structures throughout their design service lives. Their temporal variations are smaller than the mean value or tend to monotonically and constantly increase or decrease within their design working lives until the variance reaches a certain limit value.

② **Variable Actions**: Actions for which the variations within their design service lives are multidirectional and not negligible compared to the mean value. Their characteristic values are given probabilistically.

③ **Accidental Actions**: Actions difficult to predict probabilistically or actions for which the annual exceedance probabilities are smaller than those of variable actions, but which cannot be socially negligible as their characteristic values are extremely large.

Table 3.4.1 Classification of Dominating Actions

	Action
Permanent actions	Self-weight, earth pressure, environmental actions such as temperature stress, corrosion, freezing and thawing, etc.
Variable actions	Waves, wind, water level (tide level), surcharge of cargo or vehicles, action due to ship berthing/traction, level 1 earthquake ground motion, etc.
Accidental actions	Collision with a ship or other object except when berthing, fire, tsunami, level 2 earthquake ground motion, accidental waves, etc.

Performance verification of facilities shall properly take account of the actions on the facility concerned. The return periods of actions taken into consideration during performance verification shall be appropriately set based on the characteristics of the individual actions, the significance of the structures, and the design service life. At the construction of the facilities, actions to the facilities concerned and the relevant temporary structures shall be appropriately set by the construction phase considering the construction method and the effect when the stability of the structures is lost in the course of construction, etc.

3.5 Dominating Actions and Subordinate Actions

When considering a combination of actions, they are generally classified into dominating and subordinate actions. In cases where the possibility of simultaneous occurrence of dominating and subordinate actions is low, the characteristic values of the subordinate actions may be those frequently occurring in a design service life with a relatively high annual exceedance probability. This is because it is considered to be unreasonable to set all characteristic values of actions with a low possibility of simultaneous occurrence at values with a low annual exceedance probability and to combine them. The general principle regarding the combination of such actions is called "Turkstra's rule."

Performance verification of facilities subject to the Technical Standards may find several situations where dominating actions differ within one design situation. This book, therefore, states "○○ design situation with respect to ○○ (dominating) action" to clarify the dominating actions. For example, "variable design situation with respect to waves" is used if a dominating action is variable waves.

When a combination of correlational actions is to be considered, Turkstra's rule cannot always be applied. For example, in the case of offshore wind power generation facilities, wave actions and wind actions are highly correlative dominating actions. Therefore, application of Turkstra's rule may be dangerous considering the high possibility of simultaneous occurrence. On the other hand, combining both local maximal values could become a case of overdesign. In this situation, it may be desirable to set the characteristic value of the effect of the actions to a condition where the combined total value is adequate and the possibility of occurrence of combined conditions is highest. Specific methods mentioned in **Reference 6)** may be helpful.

3.6 Design Situation

When conducting performance verification, a "Design Situation," which means a combination of actions taken into account in the verification, shall be set. Design situations are classified into three categories: permanent, variable (where variable actions are dominating actions), and accidental (where accidental actions are dominating actions) situations. Design situations are defined as follows:

① **Permanent design situation**: A situation where permanent actions are the dominating actions.

② **Variable design situation**: A situation where variable actions are the dominating actions.

③ **Accidental design situation**: A situation where accidental actions are the dominating actions.

3.7 Performance Requirements

3.7.1 Positioning of the Performance Requirements in the Technical Standards

In the context of the Technical Standards, “performance requirements” means the required performance which the facilities concerned should have in order to achieve their objectives and which form the foundation of the performance criteria of the facilities concerned. The Technical Standards specify performance requirements for facilities in the Ministerial Ordinance by their type. The Ministerial Ordinance specifies the performance requirements for facilities subject to the Technical Standards as the minimum requirements that individual facilities should have from the viewpoint of the common welfare. Responsible organizations or persons for the construction, improvement, and maintenance of the subject facilities of the Technical Standards can therefore set as necessary performance levels higher than those in the Ministerial Ordinance as the performance requirements for the facilities, taking into account their importance and surrounding situations.

3.7.2 Classification of Performance Requirements in the Technical Standards

(1) Fundamentals

Fig. 3.7.1 shows the classification of performance requirements in the Technical Standards.

The performance requirements in the Technical Standards are broadly classified into performance requirements specified by facilities (2) and (4) below) and performance requirements common to all facilities (5) below. Performance requirements specified by facilities are classified into performance related to the structural response of the facilities (serviceability, restorability, safety) and performance related to structural specifications (usability). Performance requirements common to all facilities are classified into constructability, maintenanceability, etc.

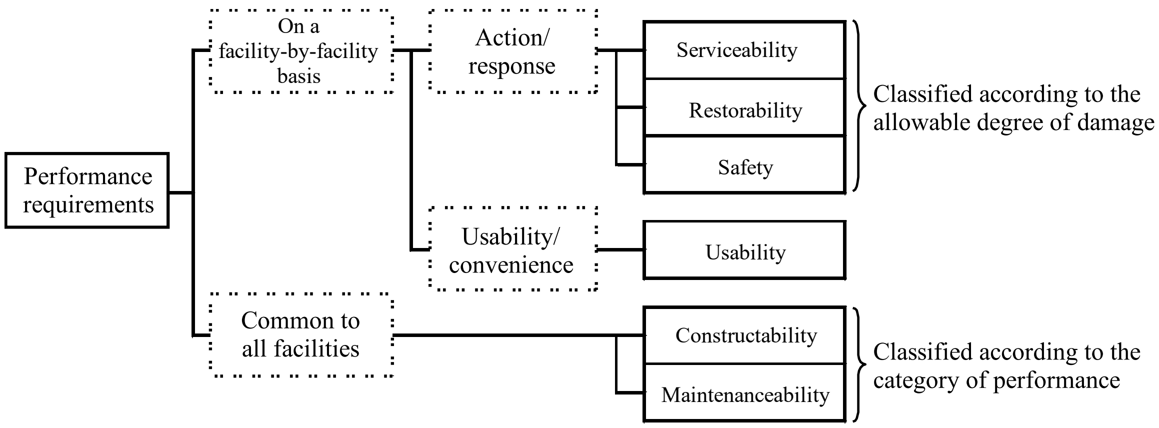

Fig. 3.7.1 Classification of Performance Requirements

(2) Performance Related to the Structural Response of Facilities (Serviceability, Restorability, Safety)

Performance for the structural response of a facility is classified into: ①serviceability, ②restorability and ③ safety according to the allowable degree of damage and is defined as follows. The order of the allowable degree of damage is: ③safety > ②restorability > ①serviceability.

① **Serviceability**: The capability to use facilities without issues occurring. No damage occurs from the expected actions or damage remains at a level in which the required functions can be quickly and fully restored with only minor repairs.

② **Restorability**: The capability to continuously use facilities by making repairs within a technically possible and economically feasible range. Damage resulting from the expected actions remains at a level in which the required functions can be restored with minor repairs in a short period of time.

③ **Safety**: The capability to ensure the safety of human lives, etc. Damage resulting from the expected actions does not become fatal to the facilities and remains at a level that does not put the safety of human lives in jeopardy, etc. even if a certain level of damage occurs.

The fundamental idea of performance requirements related to structural responses for facilities subject to the Technical Standards is as follows.

① For permanent and variable actions (with an annual exceedance probability of about 0.01 or more), the basic requirement is serviceability. It can be assumed that ensuring serviceability also ensures restorability and safety against permanent and variable actions.

② For accidental actions (with an annual exceedance probability of about 0.01 or less), performance either of serviceability, restorability or safety may be selected according to the expected functions and significance of the facilities. Except for high earthquake-resistance facilities and facilities prepared for accidental incidents, performance against accidental actions is essentially not required. It does not, however, deny the necessity of verification against accidental actions judged by the persons or organizations responsible for performance verification among facility owners, etc.

In the above, the threshold of 0.01 for the annual exceedance probability discriminating permanent actions and variable actions from accidental actions is determined just for convenience and serves as a guide when the design service life is in the standard range (approximately 50 years).

Fig. 3.7.2 shows the performance requirements related to the structural response of facilities subject to the Technical Standards. The vertical and horizontal axes of **Fig. 3.7.2** show the annual exceedance probability of action and the degree of damage, respectively. The curve in the figure shows the performance of the facilities. Severe damage to facilities caused by variable or permanent actions with a relatively high annual exceedance probability is not acceptable. On the other hand, since avoiding facilities from any damage by accidental actions with a very low annual exceedance probability is economically unreasonable, a small amount of damage to facilities caused by accidental actions is acceptable. For example, when designing a facility having a function of transporting emergency supply materials immediately after a large earthquake, it is required to set its degree of damage caused by accidental actions to minor, as shown by facility A in the figure (ensuring serviceability). When designing a facility that ensures a minimum function against accidental actions, it may be necessary to set an allowable degree of damage at a large value and consider making sure that the facility, such as facility B, does not suffer fatal damage (ensuring safety).

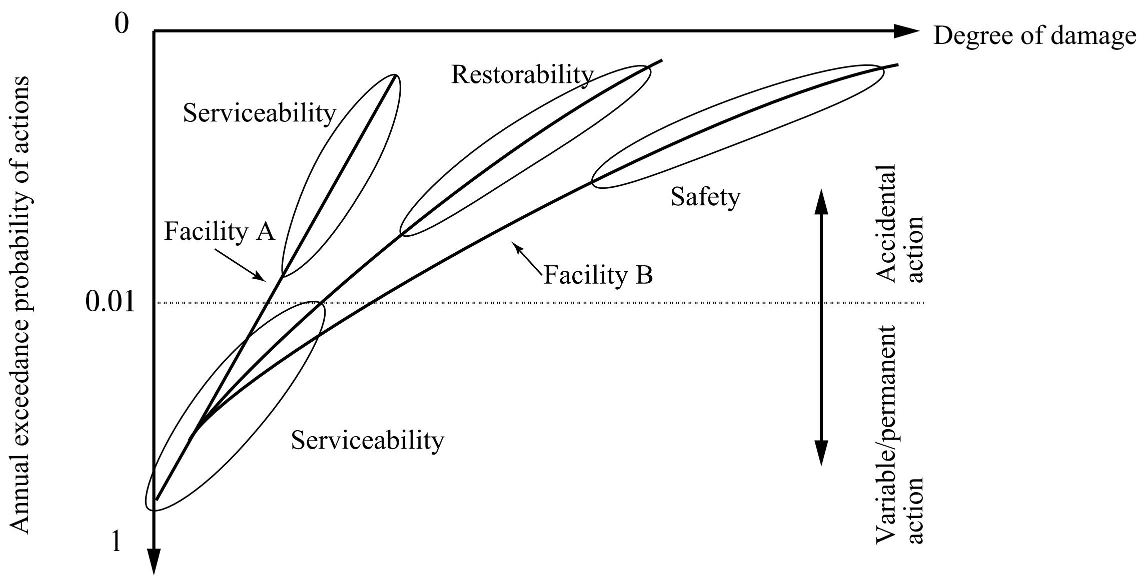

Fig. 3.7.2 Conceptual Diagram of the Relationship Between Design Situations and Performance Requirements

(3) Countermeasures against Actions Exceeding Design Conditions

① **Countermeasures against Tsunamis**

The Technical Standards specify basic design concepts against tsunamis of a magnitude exceeding design tsunamis (tsunamis viewed as an accidental action set by the design conditions) for facilities (breakwaters, seawalls, water gates and locks as facilities prepared for accidental actions) that may significantly affect human lives, property or social and economic activities by damage. Specifically, the Ministerial Ordinance specifies that "even if a tsunami having a strength exceeding that of design tsunamis occurs, the effects from the damage to the stability of the structure of the facilities concerned can be delayed as much as possible." Therefore, breakwaters, seawalls, water gates and locks as facilities prepared for accidental actions are required to have "toughness" irrespective of performance requirements for accidental actions (serviceability, restorability and safety).

For example, a breakwater is required to have "resilience" with a maximal structural design in a restricted construction budget so that the destruction of a breakwater is delayed as long as possible even if overflow occurs due to a tsunami strong enough to exceed the designed tsunamis (desirably, for a tsunami of the expected maximum scale) in order to ensure the effect of natural disaster reduction.

② **Countermeasures against Other Actions**

Although these Technical Standards specify only performance for tsunami effects on breakwaters, seawalls, water gates and locks, as stated above, for facilities prepared for accidental actions which require "toughness," it is desirable to understand the behavior of actions exceeding the design conditions for every type of facility and to structurally plan and design them to have redundancy and robustness as much as possible so that the condition of the facilities does not abruptly become catastrophic by actions exceeding the design conditions.

(4) Performance Requirements for Structural Specifications (Usability)

The Technical Standards specify usability as performance requirements for structural specifications, etc.

"Usability" means the capability that facilities shall have from the standpoint of the service and convenience of the facilities. Specifically, it means that the facilities are appropriately arranged, that the structural specifications (length, width, water depth, crest elevation, clearance limits, etc.) and harbor calmness, etc., satisfy the required values, and that they have the required ancillary facilities as appropriate.

(5) Performance Requirements for the Construction and Maintenance of Facilities (Constructability, Maintenanceability)

In the Ministerial Ordinance, performance requirements for structural responses shown in (2) and (4), and for structural specifications, etc., are specified by facility. However, performance requirements for constructability and maintenanceability shown below are inclusively specified as common to all facilities.

① **Constructability**

"Constructability" means the capability to perform construction by utilizing reliable and appropriate methods and ensuring safety of the works for a reasonable construction period. Constructability can be considered to be satisfied by complying with the construction notice.

② **Maintenanceability**

"Maintenanceability" means the capability to continuously ensure the required performance for the facilities by repairing and reinforcing, etc., the deterioration and damage of facilities due to use and expected actions within a technically possible and economically feasible range. Maintenanceability can be considered to be satisfied by complying with the maintenance notice.

3.8 Performance Criteria

[Public Notice] (Fundamentals of Performance Criteria)

Article 2

The performance criteria for the facilities subject to the Technical Standards specified in this Public Notice can be used as the requirements for verification of the performance requirements of the facilities concerned. The same applies to the performance criteria not specified in this Public Notice but proved to satisfy the performance requirements of the facilities subject to the Technical Standards.

[Interpretation]

4. Design of Facilities Subject to the Technical Standards

(1) Fundamentals of Performance Criteria (Article 2 of the Ministerial Ordinance and Interpretations related to Article 2 of the Public Notice)

① **Performance Criteria for Facilities Subject to the Technical Standards**

The performance criteria for facilities subject to the Technical Standards as specified in the Public Notice can be used as the requirements for verification of the performance requirements of the facilities concerned. However, the same applies to the performance criteria not specified in the Public Notice but which satisfies the performance requirements of the facilities subject to the Technical Standards.

Performance criteria are the specifications of verifications needed to satisfy performance requirements from a technical viewpoint. Meeting the performance criteria given here is hence considered as meeting the performance requirements. The Public Notice specifies performance criteria on dominating structural types only. In constructing, improving, or maintaining the subject facilities of the Technical Standards of other structural types, or in assuming special design situations, performance criteria shall be properly specified by taking account of the performance criteria for similar structural types and the surrounding situations of the facilities concerned.

3.9 Performance Verification

[Public Notice] (Fundamentals of Performance Verification)

Article 3

Performance verification of the facilities subject to the Technical Standards shall be conducted using a method which can take account of the actions, requirements for services, and the uncertainty of the performance of the facilities, or other methods that are highly reliable.

2 In the performance verification of the facilities subject to the Technical Standards, the subsequent items shall be conducted in consideration of the situations the facilities encounter during their design service life:

(1) Appropriately set the actions in consideration of the environmental conditions and others surrounding the facilities.

(2) Appropriately set the combination of the actions in consideration of the possible simultaneous occurrence of dominant and non-dominant actions.

(3) Select the materials in consideration of their characteristics, the environmental influences on them, etc., and appropriately set their physical properties.

[Interpretation]

4. Design of Facilities Subject to the Technical Standards

(2) Fundamentals of Performance Verification (Article 2 of the Ministerial Ordinance and Interpretations of Article 3 of the Public Notice)

① **Methods Capable of Taking Account of Actions and the Uncertainty of the Performance of the Facilities Concerned**

The methods capable of taking account of actions and the uncertainty of the performance of the facilities concerned are the performance verification methods capable of these duties such as the uncertainty of actions and strengths caused by the uncertainty inherent in various design parameters such as natural conditions, material characteristics, and analysis methods. Reliability-based design methods shall be generally used.

Performance verification using a reliability-based design method properly evaluates actions and the uncertainty inherent to various design parameters relating to the performance of the facilities concerned in addition to properly setting target failure probabilities or reliability indices.

Performance verification using a reliability-based design method based on a partial factor method properly evaluates the uncertainty of design parameters and sets the partial factors reflecting target failure probabilities or reliability indices.

② **Other Reliable Methods**

Other reliable methods are in principle performance verification methods to specifically and quantitatively evaluate the performance of the facilities concerned. They generally include numerical analysis methods, methods based on model experiments or in-situ testing. If these methods are inappropriate, however, methods to indirectly evaluate the performance of the facilities concerned based on past experiences, taking account of various conditions such as natural conditions, can be interpreted as one of the other reliable methods.

③ **Materials**

a) Selection of Materials

Materials used for facilities subject to the Technical Standards need to be selected by properly evaluating factors such as quality, durability, economic efficiency and constructability.

b) Setting of Physical Properties

The quality and characteristics of materials and the deterioration of materials by environmental actions shall be properly considered when setting the physical properties of materials used for performance verification of facilities subject to the Technical Standards. Steel products, among others, used for facilities subject to the Technical Standards shall be properly corrosion-controlled using a cathodic protection method, coating method or other corrosion protection method since they are placed in a highly corrosive environment.

3.9.1 Performance Verification Methods

(1) Selection of Performance Verification Methods

Performance verification is work to verify that performance criteria are satisfied. The Ministerial Ordinances and the Public Notices do not define specific methods for verification. Consequently, designers conducting performance verifications shall take responsibility for using reliable methods.

(2) Types of Performance Verification Methods

Methods for performance verification of structural responses to actions may be classified as follows, and may be used individually or combined to verify performance. The **Part III** of this book provides standard performance verification methods by design situations of each structural type, but it is possible to adopt non-standard performance verification methods at the designer's discretion and responsibility.

Whichever performance verification method is adopted, it shall be applied carefully by judging reliability of the whole design method using past examples of disasters and construction, etc.

① **Reliability-Based Design Method**

The reliability-based design method clearly defines limit states of performance required for target structures and quantitatively verifies the possibility to exceed the limit state (generally called the "Failure Probability") using a technique based on probability theory. It has three design levels according to the verification method of failure probability.[7)] The level 3 reliability-based design method (the highest level) is evaluated with using the structure's failure probability P_f, while level 2 uses a reliability index β, and the simplest, level 1, uses partial factors (refer to **Table 3.9.1**).

Table 3.9.1 The Three Levels of the Reliability-Based Design Method

Design level	Performance verification equation	Evaluation parameter
Level 3 reliability-based design method	$P_{fT} \geq P_f$	Failure Probability
Level 2 reliability-based design method	$\beta_T \leq \beta$	Reliability Index
Level 1 reliability-based design method	$R_d \geq S_d$	Design Value

In performance verification using a reliability design method, it is necessary to properly evaluate uncertainty inherent to various design parameters (actions and strength), design models and others relating to the performance of the facilities concerned, and properly set the target safety level (target failure probabilities or reliability indices). In performance verification using the level 1 reliability-based design method (partial factors method), it is necessary to properly evaluate the uncertainty of design parameters, design models and others, and properly set the partial factors reflecting the target failure probability or reliability indices.

Lack of knowledge about the uncertainty of design parameters and design models of the facilities to be designed may make it improper to use a performance verification method based on the reliability-based design method. In such cases, other performance verification methods shown below should be considered.

② **Methods Based on Numerical Analysis**

Methods based on numerical analysis calculate response values (stress, deformation, etc.) to actions of target structures with a numeric approximate method such as the finite element method (FEM) and finite difference method (FDM), and quantitatively verify that the response value does not exceed the limit state (stress, deformation, etc.) where performance requirements of the target structure are not satisfied.

In performance verification using a numerical analysis method, it is necessary to examine the reasonability and applicability of the method concerned from the viewpoints of comparisons to exact analytical solutions, the behaviors of actual structures in the past and the reproducibility of test results, and carefully judge the reliability of the method concerned.

③ **Model Test Methods or In-Situ Test Methods**

The model test method evaluates important items in designing the structure concerned such as response value to actions, load and destruction forms of the target structure with experiments using a reduced model (hydraulic model experiment, centrifugal load model experiment, shaking table model experiment, etc.), and verifies the performance required for the target structures. In-situ test methods verify by testing using a full scale model of the facility to be designed instead of a reduced model.

In performance verification using a model test method or an in-situ test method, it is necessary to carefully evaluate the performance of the facilities concerned taking account of differences in response between models and actual structures, as well as preconditions, applicable limits, and test accuracy of experiments or tests.

④ **Methods Based on Past Experiences**

Methods based on past experiences are well-proven methods with many examples of past application, such as the safety factor method and allowable stress method used in the past.

Methods based on past experiences, however, are unable to quantitatively evaluate the possibility of exceeding the limit state, unlike in the reliability-based design method shown in ①. Moreover, note that the high number of applications based on past experiences does not necessarily mean that they are highly reliable.

3.9.2 Setting of actions

(1) Setting of Actions

In performance verification of a subject facility of the Technical Standards, it is necessary to take account of its design service life, the performance requirements, and properly set the amount of actions, etc. The setting of actions needs to properly take account of various conditions, such as natural conditions, and as necessary, actions during the design service life which are affected by estuarine hydraulics, littoral drift, ground settlement, ground liquefaction and environmental actions. For further details on the setting of actions, refer to the regulations and corresponding commentaries in Article 5 to Article 20 of the standard notice.

(2) Setting of a Combination of Actions

A “combination of actions” means the types and amounts of actions simultaneously considered in performance verification. In setting a combination of actions, it is necessary to properly take account of the design service life of the facility concerned and its performance requirements. Furthermore, the combination of dominating and subordinate actions needs to be properly considered in combining actions. For the combination of dominating and subordinate actions assumed in the performance criteria specified in the Public Notices, refer to the tables shown in the commentaries of individual facilities. In setting the combination of actions, subordinate actions can be assumed to have an amount with a relatively high annual exceedance probability and occur frequently in the design service life if the possibility of the simultaneous occurrence of dominating and subordinate actions is low.

3.9.3 Materials

(1) Selection of Materials

The selection of materials needs to properly take account of their quality and durability. Major materials include steel products, concrete, bituminous materials, stone, wood, various metallic materials, plastics, rubber, coating materials, injectable materials, landfill materials (including wastes), and recyclable resource materials (slag, coal ash, crushed concrete, dredged soil, asphalt concrete modules, etc.). Materials conforming to the Japanese Industrial Standards (JIS) can be assumed to have the quality needed to meet the performance requirements of the facilities subject to the Technical Standards.

(2) Physical Properties of Materials

“Physical Properties of Materials” means material properties such as strength, weight per unit volume, friction coefficient and others. The physical properties of materials need to be set properly based on JIS Standards or quality data obtained using other reliable tests. The setting of the physical properties of materials and cross sectional specifications requires proper consideration of material degradation and others due to environmental actions.

3.9.4 Characteristic Values

"Characteristic values" means values indicating characteristics of actions or materials quantitatively considered in design. When setting each characteristic value for design factor in each chapter of **Part II** may be referred to.

This book utilizes characteristic values classified as below:

① Various standard values (e.g. yield strength of steel materials) specified in JIS, etc.

② Expected values (design waves, level 1 earthquake motion, etc.)

③ Corrected mean values to be set by taking account of variation in survey data and statistical errors of estimates of mean values (shear strength of ground, etc.)

④ Standard settings utilized as in the past (weight per unit volume of plain concrete, design berthing velocity, etc.)

⑤ Values calculated with empiric or theoretical equations (wave force equations, etc.)

3.9.5 Performance Verification Equation

(1) General

Generally, performance verification using the partial factor method in this book can be conducted by utilizing **equations (3.9.1)** to **(3.9.3)**. The performance verification equation shown below is based on a partial factor method using a load and resistance factor approach. For details regarding this approach, refer to **Reference (Part I), Chapter 2: Fundamentals of the Reliability-Based Design Method**, and **Reference 8**, etc.

$$m \times \left(\gamma_i \frac{S_d}{R_d} \right) \leq 1.0 \qquad \textbf{(3.9.1)}$$

$$S_d = f(\gamma_{S_1} S_{1k}, \cdots, \gamma_{S_n} S_{nk}) = f(\gamma_{S_1} S_{1k}(x_{1k} \cdots x_{pk,}), \cdots, \gamma_{S_n} S_{nk}(x_{1k} \cdots x_{pk})) \qquad \textbf{(3.9.2)}$$

$$R_d = g(\gamma_{R_1} R_{1k}, \cdots, \gamma_{R_m} R_{mk}) = g(\gamma_{R_1} R_{1k}(x_{1k} \cdots x_{pk,}), \cdots, \gamma_{R_m} R_{mk}(x_{1k} \cdots x_{pk})) \qquad \textbf{(3.9.3)}$$

Where,

S_d : design value of response value

R_d : design value of limit value

γ_i : factor to take account of the significance of the structure, social impact when the limit state is reached and so on (structural factor). Unless otherwise specified, γ_i=1.0 and is not shown in this book.

m : adjustment factor (refer to the description in "**(3) Adjustment Factor**" below)

S_{jk} : characteristic value of action effect j (j=1..n)

γ_{Sj} : partial factor to multiply to the characteristic value S_{jk} of action effect j

S_j ( ) : equation to calculate the characteristic value S_{jk} of action effect j

R_{jk} : characteristic value of resistance (strength) j (j=1..m)

γ_{Rj} : partial factor to multiply to the characteristic value R_{jk} of resistance (strength) j

R_j ( ) : equation to calculate the characteristic value R_{jk} of resistance (strength) j

x_{jk} : characteristic value of the design factor x_j (j=1..p)

Performance verification using the partial factor method in this book is a method to verify the performance of structures by confirming the ratio of design value of the response value (stress, cross-sectional force, total action value, displacement, etc.) which occurs due to actions made to the structure and design value of the limit value (yield strength, cross-sectional strength, total resistance value, allowable displacement, etc.) based on the resistance (strength) of the structure (hereinafter called "Ratio of Strength against Action") multiplied by the structure factor and the adjustment factor is 1.0 or less, as shown in the above equation.

(2) Partial Factor

The partial factor in this book is the value calculated using a statistical analysis or reliable method as a factor to multiply the characteristic value of action effect or resistance (including characteristic value of design factors) to ensure the target performance of the objective structures. A partial factor calculated with statistical analysis means a factor calculated with calibration using a reliability analysis. Unless otherwise specified, the partial factor concerned shows that it has been calculated with a statistical analysis if the values of partial factors (γ_{Sj}, γ_{Rj}) in **equations (3.9.2)** and **(3.9.3)** are not 1.0 in this book. In this case, while no adjustment factor shown in (3) below is necessary in principle, performance verification may be carried out using the adjustment factor of 1.0 for the sake of convenience based on **equation (3.9.1)**.

(3) Adjustment Factor

As shown in **Part I, Chapter 1, 3.9 Performance Verification [Interpretation]**, “Methods Based on Past Experiences” (well-proven methods with many examples of past applications, such as the safety factor method, allowable stress method used as in the past) shown in **Part I, Chapter 1, 3.9.1 (2) ④** may also be deemed as a reliable method. In this case, verification may be carried out using an adjustment factor by setting all partial factors to 1.0 for the sake of convenience in order to clearly indicate that it differs from verification using a partial factor calculated with statistical analysis. The adjustment factor is a factor for adjustment to have an equivalent structural cross-section to the safety level specified in “Methods Based on Past Experiences,” and corresponds to the allowable safety factor of an existing safety factor method or allowable stress method. The adjustment factor corresponds to what was processed in the structural analysis factor in the previous standards (OCDI 2009) and their commentaries.

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