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.

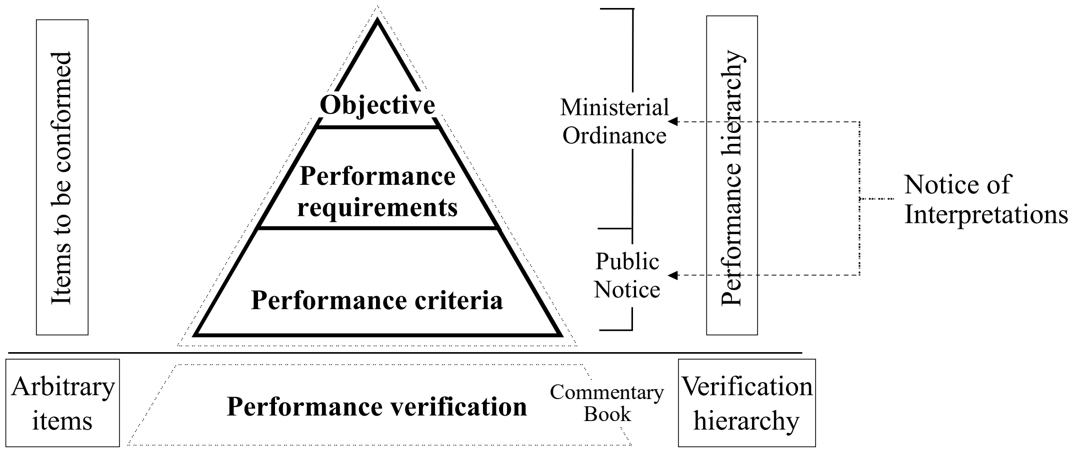

Fig. 2.1.1 Positioning of Performance Hierarchy and Performance Verification

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 "〇〇 design situation with respect to 〇〇 (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.

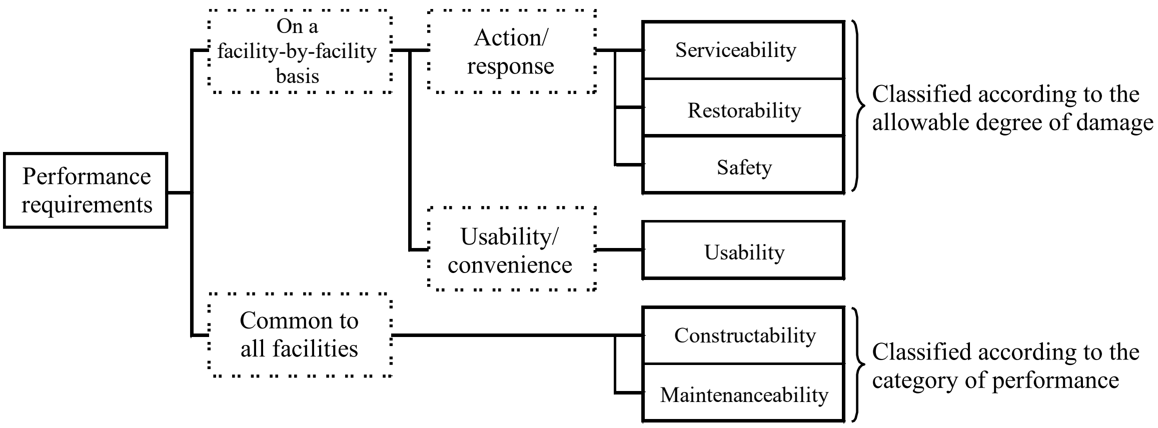

Fig. 3.7.1 Classification of Performance Requirements

(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).

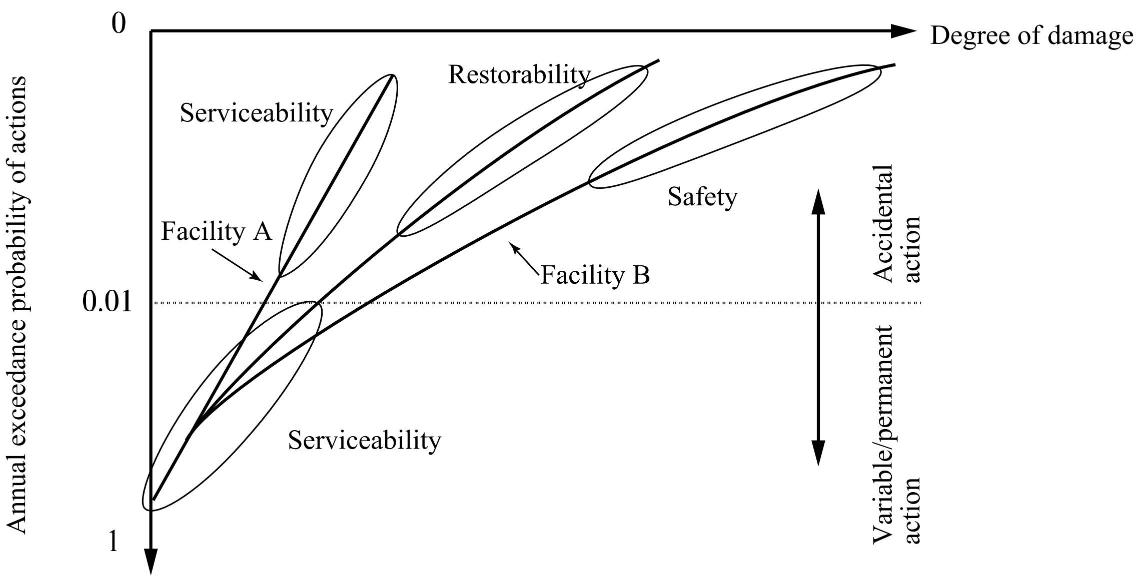

Fig. 3.7.2 Conceptual Diagram of the Relationship Between Design Situations and Performance Requirements

(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	$P_{fr} \geq P_f$	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.

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

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

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

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.

[References]

1) ISO2394: General principles on reliability for structures, 2015.
2) MLIT: Basis of Structural Design for Buildings and Public Works, 2002 (in Japanese)
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8) Takenobu, M, S. Nishioka, T. Sato and M. Miyata: Basic Study of Level 1 Reliability Design Method Based on Load and Resistance Factor Approach ~Performance verification of sliding failure and overturning failure for caisson type quay walls in permanent situation~, Technical Note of National Institute of Land and Infrastructure Management No. 880, 2015 (in Japanese)

Chapter 2 Construction, Improvement and Maintenance of Facilities Subject to the Technical Standards

[Port and Harbor Act] (Technical Standards for Port Facilities)

Article 56-2-2

1. In addition to being constructed, improved, and maintained based on any other applicable laws and regulations, waterways and basins, protective facilities for a harbour, mooring facilities, and other port and harbour facilities that Cabinet Order prescribes (hereinafter referred to as a "port and harbour facility subject to the technical standards") must be constructed, improved, and maintained so as to conform to the technical standards that Ordinance of the Ministry of Land, Infrastructure, Transport and Tourism prescribes in terms of the performance required of port and harbour facilities subject to the technical standards (hereinafter such standards are referred to as "technical standards").

2.~5. (Omitted)

1 Flow to Ensure Performance of Facilities Subject to the Technical Standards

1.1 Flow to Ensure Performance

To properly fulfill the performance requirements and functions for the construction purpose of the facilities subject to the Technical Standards during the required design working life, it is important for the organizations and persons concerned to collaborate in the construction, improvement and maintenance of the facilities as much as possible, to mutually understand the planning, investigation, design, construction, maintenance and other work at each stage and their relationships, and to proceed by following the proper procedures.[1)] It is also important to exchange the necessary information between stages, return to previous stages and review as required. This is the flow required to ensure the performance of facilities subject to the Technical Standards. **Fig. 1.1.1** shows a general project procedure at ports and harbors, and a general project flow is outlined below.

New facilities are completed through planning, investigation, design and construction stages. The maintenance stage begins just after the facilities have been completed. During this stage, checking and other activities will be conducted, including the repair and reinforcement of structural members, if necessary. If facilities are damaged by disasters, they will be returned to their original state through restoration work. Facility services may be suspended due to discontinuation of application, etc. Next, throughout the maintenance stage, existing facilities will be improved in response to changes such as social demands. Improved facilities that satisfy the purposes for improvement are also completed through planning, investigation, design and construction stages. Completed facilities will transition to maintenance again and this cycle will repeat.

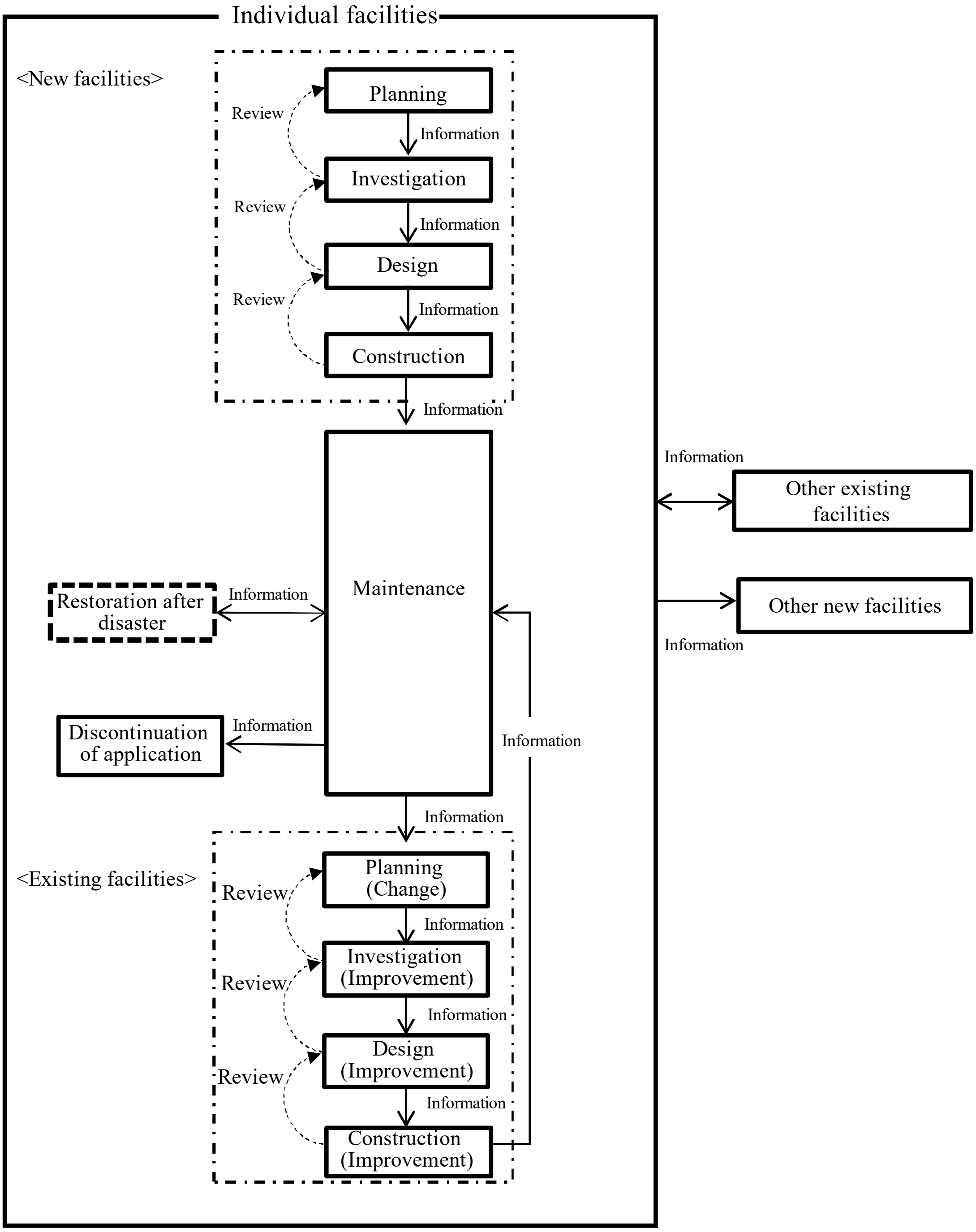

Fig. 1.1.1 General Project Flow in Port and Harbor Development Project

1.2 Extraction of Various Risk Factors in Consideration of the Influence on Project and Fundamental Countermeasures at Each Stage

(1) General

In order to streamline securing the performance indicated in **Part I, Chapter 2, 1.1**, it is desirable to extract items that may become major risk factors at each subsequent stage (factors that significantly influence the whole project such as quality, construction period, construction cost of new facilities, and effort and maintenance cost of facilities over the working life) and make decisions based on consideration of these items in the preceding work stages.

(2) Consideration for Decisions in Early Project Stages

As shown in **Fig. 1.2.1**, it is generally said that decisions on various items concerning the project in the early stages (★ in the figure) (planning, investigation, design and early stages of construction of the facilities concerned, including bidding and contract stages) of new facilities have a greater influence on the final quality, construction period, construction cost and so on than decisions made in later stages.[2) 3)] Moreover, decisions in the early stages of project for new facilities significantly influence safety, efficiency and productivity in the construction stages, methods and precision of inspection and diagnosis over a long working life after completion of the facilities, required systems, and costs for repairs and reinforcement. In the case of improvement of the facilities concerned due to changes in social demands, decisions on original structural types and other factors significantly influence the quality and quantity of various information obtained in the maintenance stage and degree of freedom and cost for selecting construction methods for improvement during the improvement stage. The same is true when service is stopped due to discontinuation of application. Therefore, it is desirable to decide various items considering optimization of the whole process in the early project stages for new facilities.

However, a variety of decisions often needs to be made with scarce information in the early project stages of new facilities because, for example, detailed information on the ground conditions at the site may be unavailable or no specific coordination with the parties concerned can be undertaken in the early stages. Therefore, it is desirable to organize information and the conditions (including assumptions) that significantly influenced the decisions and explicitly keep records for important decisions in the early project stages for new facilities as well as for the improvement of existing facilities.

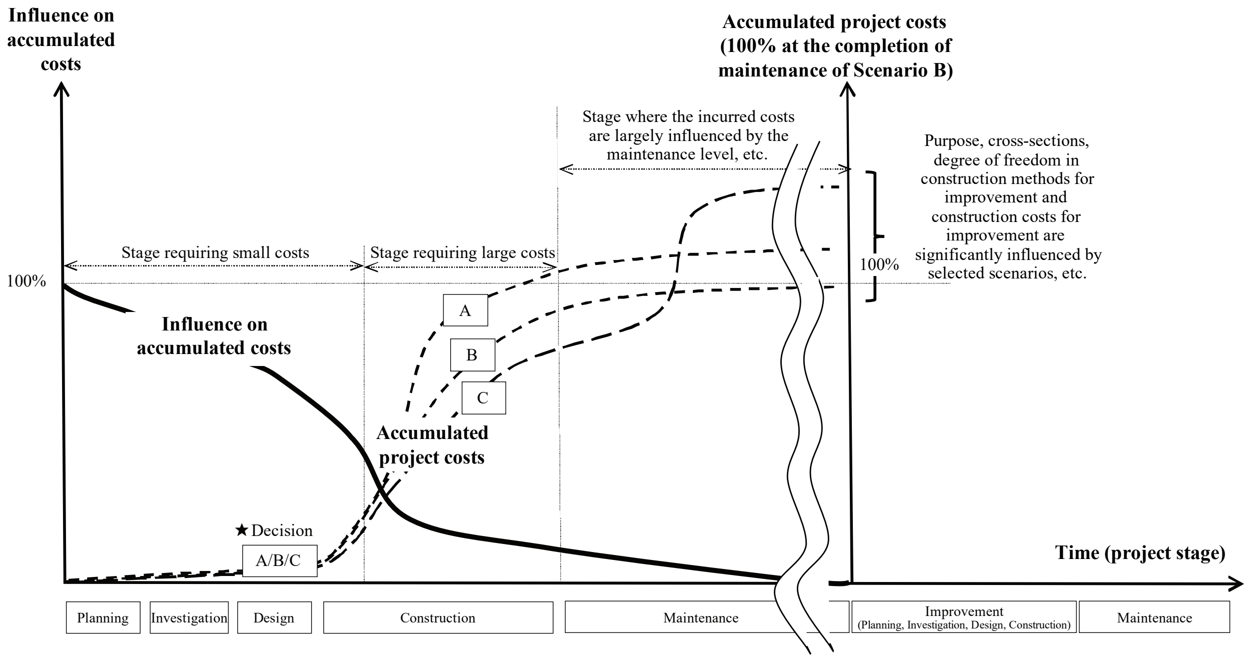

Fig. 1.2.1 Progress of Project Stages and Influence on Their Accumulated Costs (image)

1.3 Information Flow in Individual Project

In order to ensure the flow for securing the performance indicated in **Part I, Chapter 2, 1.1,**, the organizations and persons concerned must organize the items decided at each stage and important information, conditions and so on leading to such decisions (refer to **Part I, Chapter 2, 1.2**) as information required later on, and attempt to reliably transfer them to the next stage. Refer to sources such as **Reference 1)** for means of information transfer and the content of information to be organized in port and harbor project.

At minimum, the secure transfer of information requires the correct recording of information needed for books and other documents prepared at each project stage shown in **Table 1.3.1**. For example, in addition to records for books and other documents, the proper utilization of trilateral meetings[4)] conducted in the early stages of construction with the ordering party (organizations or persons in charge of design and construction), designer (design consultant, etc.) and constructor (contractor of construction) to communicate and share information is also recommended for cooperation in design and construction. Also, the transfer of information via maintenance plan, which is prepared by the ordering party before maintenance stage, is important for cooperation between design and maintenance stages. It is also important to try to utilize and share ICT (Information and Communication Technology) such as 3D data so as to improve productivity and safety throughout the construction production process (whole project process) such as design, construction and maintenance.

Project stage	Classification	Summary	Books and other documents needed for each stage of project	Books and other documents prepared at each stage of project
Planning*	Port plan	• The port plan is a statutory plan specified in the Port and Harbour Act and developed by port management bodies. This is a fundamental plan used as a guideline for the long-term development, usage and maintenance of each port and harbor, and which describes their size, capability and facility development policies.		[Port plan] • Main text • Port plan drawing • Appendix
		• The port environment plan corresponds to the purposes of the Port and Harbour Act, "to plan development of ports in consideration of environmental conservation," as a detailed level plan that is part of the port plan and is developed by port management bodies. This plan shows a model of the environment around the port and coastal area and the implementation policy of the measures.		[Port environment plan]
	Project evaluation	• Project evaluation is conducted by port-related offices of the Ministry of Land, Infrastructure, Transport and Tourism to help with making decisions for project budget allocation. This stage analyzes cost effectiveness (cost-benefit analysis) and involves a comprehensive evaluation from the viewpoint of necessity, efficiency and effectiveness according to project characteristics.		[Project evaluation]
	Environmental assessment	• An environmental assessment investigates, estimates and evaluates the influence of project on the environment by environmental component. And it also examines measures to conserve the environment in project processes and comprehensively assesses the environment when such measures are taken.		[Consideration document] [Method documents] [Preparation documents] [Evaluation documents] [Reports]
	Preventive maintenance plan	• A five-year plan in which the port management body and the country (Ministry of Land, Infrastructure, Transport and Tourism) develop and implement measures against aging (degradation) of port facilities. This plan comprehensively considers aging and the usage conditions of facilities composing the port, and develops policies and priorities to take countermeasures against aging based on the importance of the facilities.		[Preventive maintenance plan]
Planning* to maintenance*	Coordination	• Coordination of various conditions (such as planning, conditions for design, construction and maintenance) required for each project stage with the organizations and persons concerned.	(Project description)	(Meeting minutes)
Investigation*	Surveys Investigations Tests	• Various on-site investigations (surveys, ground investigations, environmental research, etc.) and tests (pre-mixture tests, pile loading tests, hydraulic model experiments, etc.), various analyses (numeric calculations, data analysis and other methods of input seismic motion, wave conditions, etc.) are conducted for layout	[Project contract books] • Contracts • Special specifications (investigation specifications, etc.)	[Report on survey results] [Report on investigation results] [Report on test results] [Report on analysis

Project stage	Classification	Summary	Books and other documents needed for each stage of project	Books and other documents prepared at each stage of project
		planning, setting design conditions and other stages when improving existing facilities and building new facilities.		results]
Design*	Design	• Setting of various design and limit conditions, selection of performance verification methods corresponding to specific performance criteria, setting of structural types and outline cross-sections, setting of detailed structures, performance verification, development of design documents and a maintenance plan (draft) are carried out in the design activity. • A maintenance plan (draft) of the target facility is generally developed by the facility owner during the design stage.	Project contract books • Contracts • Special specifications (design specifications, etc.)	[Deliverables of preliminary designs] [Deliverables of basic designs] [Deliverables of detailed designs] [Deliverables of implementation designs] [Maintenance Plan (Draft)]
Construction*	Construction	• During the construction stage, preparation of construction work completion reports and other documents according to the contract are carried out. • A facility maintenance plan is prepared by the facility owner at the completion of the facilities.	Construction work contract books • Contract • Design books (drawings, etc.)	[Construction work completion reports] • As-built drawings of construction work • Make management documents • As-built management documents • Photographs of construction work, etc. [Maintenance plan]
Maintenance*	Maintenance	• Periodic inspection and diagnosis by visual check and other methods are conducted during maintenance by facility owners or facility management bodies based on the maintenance plan. If any abnormality is found, a detailed inspection and diagnosis is conducted, the cause of deterioration is examined, and repairs are carried out as needed. A history of these activities is accumulated in the maintenance record and utilized at later revisions of the maintenance plan.	(Management commission contract) [Maintenance plan] • Main body • Inspection and diagnosis recording format • Maintenance recording format	[Maintenance plan (revision)] • Main body • Inspection and diagnosis record (history) • Maintenance record (history)
Disaster recovery*	Disaster recovery	• Disaster recovery activities after an abnormal natural phenomenon consist of investigations, design and construction required to restore facilities to their original condition (restore facilities of the same shape, dimensions and material at the same location where the facilities were located before the disaster).		[Disaster-related reports] [Reports on surveys, investigations, etc.] [Deliverables of recovery designs] [Recovery work completion reports] [Maintenance plan (revision)]

* Project stages for both newly built facilities and existing facilities.

1.4 Information Flow in the Whole Port Project

It is extremely important to verify a variety of information on design, construction and maintenance from objective and scientific viewpoints through processes involving planning, investigation, design, construction, maintenance and discontinuation of the application of target individual facilities and reflect feedback from the verification in newly built facilities, as well as maintenance and improvement designs of other existing facilities, in order to advance various port-related technologies and build reliable port structures **(Fig. 1.1.1)**. In particular, since ports function as a group of facilities composed of several facilities in maintenance stages, it is also important to adequately reflect the aforementioned feedback for the elimination, consolidation, intensification and diversion of existing stocks due to restructuring of the wharves. Consequently, it is desired that at each stage the organizations and persons concerned summarize information and data that are considered helpful by using durable media.

[References]

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2 Design of Facilities Subject to the Technical Standards

[Ministerial Ordinance] (Design of Facilities Subject to the Technical Standards)

Article 2

1 The facilities subject to the Technical Standards shall be properly designed to satisfy their performance requirements and to avoid adverse effects on their structural stability during construction while considering environmental conditions, usage conditions, and other conditions to which the facilities are subjected.

2 Design of facilities subject to the Technical Standards shall be made by properly setting their design service life.

3 Requirements other than those specified in the preceding two paragraphs for designing the facilities subject to the Technical Standards shall be provided by the Public Notice.

[Public Notice] (Consideration for Construction and Maintenance in Design)

Article 4

In designing the facilities subject to the Technical Standards, necessary measures shall be taken for proper construction and maintenance of the facilities.

[Interpretation]

4. Design of the Facilities Subject to the Technical Standards

(3) Consideration for construction and maintenance in design (Article 2 of the Ministerial Ordinance and Interpretations related to Article 4 of the Public Notice)

Conditions to which facilities are subject, including the purpose of the facilities concerned, significance, design service life, performance requirements, planning conditions, usage conditions, natural environmental conditions, material conditions, construction conditions, maintenance conditions, consideration for events exceeding design conditions, consideration for the environment and economic efficiency, shall be adequately considered in the design stage so that construction and maintenance are properly carried out. It is also desirable to consider productivity improvement by utilization of ICT (Information and Communication Technology) and utilization of normalized and standardized members and other components in order to promote more efficiency in the construction production process of investigation, design, construction and maintenance.

2.1 Fundamental Principles of Design

2.1.1 Fundamental Principles of Design

The purpose of designing facilities subject to the Technical Standards is to determine structural cross-sections and used members and materials considered to be most appropriate from a comprehensive viewpoint so that the performance requirements of the target facilities are continuously satisfied over the design service life. This is carried out by properly setting and considering conditions to which facilities are subject such as their purpose, significance, design service life, performance requirements, planning conditions, usage conditions, natural environmental conditions, material conditions, construction conditions, maintenance conditions, consideration for events exceeding design conditions, consideration for the environment and economic efficiency of the facilities concerned, irrespective of designing newly built facilities or improving the designs of existing facilities.

In other words, design means technical activities to draw structures considered to be most appropriate in the space where structures are established over a long time frame from construction of the facilities concerned to completion of their design service life. Therefore, when setting structural cross-sections and selecting members and materials, the design shall be as reasonable as possible according to conditions subject to the facilities concerned without restricting existing structural types, standard construction methods, members and materials. Moreover, when considering a construction method and used members and materials in the design stage, it is necessary to promote more efficiency in the construction production process in order to respond to labor shortages and other issues at future construction sites. Thus, it is desirable to also consider productivity improvement by utilization of ICT, normalized and standardized members, introduction of industrialized and labor-saving construction methods. Abovementioned efforts are expected to apply in this technical standards system (Performance-based design scheme).

Fundamental items in actual design are described in detail in **Part I, Chapter 2, 2.3 Fundamental Items in Design** as common items to new and existing facilities. Points to pay close attention to in the improvement (upgrading) design of existing facilities are described in detail in **Part I, Chapter 2, 2.4 Fundamental Items of Improvement Design**.

2.1.2 Prerequisites for Design

As prerequisites for design, it is required that construction and maintenance of the target facilities can be properly done. Proper construction means that quality assumed in the design stage is ensured in the construction stage and construction can surely and safely be done within the specified construction period. On the other hand, proper maintenance means that the performance and functions required for the facilities can be properly maintained throughout the design service life if managed based on the maintenance plan.

Information required for proper construction and maintenance shall surely be conveyed to the organizations and persons concerned in the design, construction and maintenance stages. In particular, when new structural types, technology and materials are to be adopted, these prerequisites for design need to be sufficiently confirmed to make sure that they are satisfied. Prerequisites for design are described in detail in "**2.2 Consideration at Each Stage**" in this Chapter.

2.1.3 Range of Design and Consideration

(1) Range of Design

Design activities are composed of a series of activities such as setting various design and limit conditions, selecting performance verification methods corresponding to specific performance criteria, setting structural types and outline cross-sections (including used materials), setting detailed structures, performance verifications (including structural calculations), developing design books (including design drawings and quantity calculation sheets) and a proposal of a maintenance plan (draft).

(2) Consideration (Necessity for Comprehensive Consideration)

Cross-sections considered to be most appropriate in design largely vary according to different factors such as:

- Various design and limit conditions
- Specific items and limit values of performance criteria to be specified by the performance requirements
- Performance verification methods selected corresponding to performance criteria
- Limit conditions in the construction stage and requirements for securing safety in the construction stage
- Utilization of ICT (Information and Communication Technology) and usability of normalized and standardized members
- Availability of computerized construction methods, requirements for adaptability to the surrounding environment
- Cost, personnel, machines and other items that can be devoted to inspections during the maintenance stage
- Necessity for considering how to make the maintenance of processes such as inspection and diagnosis easier
- Possibility to continuously use facilities beyond their design service life
- Consideration for actions exceeding the design conditions, etc.

The cross-sections considered to be most appropriate may change significantly according to the degree of consideration given including settings, selections and economic efficiency of conditions considered in the design stage. Therefore, in order to create a more reasonable design, it will be necessary to have comprehensive consideration from different viewpoints that is not held down by precedents, including a review of limit conditions and introduction of new performance verification methods.

2.1.4 Fundamental Concept of Maintenance

(1) Setting of the Basic Concept of Maintenance in the Design Stage

When designing facilities subject to the Technical Standards, the maintenance level needs to be properly specified as the basic concept of maintenance. And when determining the maintenance level, various factors should be considered such as the purpose and significance of the facilities concerned, their design service life, performance requirements, conditions surrounding the facilities such as the natural environmental and usage conditions, structural types of the facilities, structural characteristics of members, types and characteristics of used materials, the difficulty of carrying out inspections, diagnoses, repair work and other tasks, and life cycle costs. The design must also be conducted so as to reasonably enable to set a maintenance level with proper consideration given from the design stage of the facilities concerned so that inspection, diagnosis, repair and other work corresponding to the set maintenance level can be carried out smoothly. Moreover, the actual conditions such as different limit conditions in maintenance and the maintenance system must be anticipated, and the whole facility should be divided to the proper members and spaces, and the maintenance level should be set for all divisions. The concept for setting the maintenance level is described in detail in **Part I, Chapter 2, 2.3.8 Maintenance Conditions** and **Part I, Chapter 2, 4 Maintenance of Facilities Subject to the Technical Standards**.

It is necessary to set a physical working life that can be assumed based on the design, specifically study the content of an inspection and diagnosis of required members as well as timing and methods for carrying out tasks such as repairs and replacement, and set the maintenance level so that performance requirements are satisfied throughout the design service life for each member and facility division. Past records for the facilities concerned and knowledge obtained from past cases and research need to be adequately utilized in setting the physical working life.

(2) Formulation of a Maintenance Plan (Draft) in the Design Stage

It is desirable to formulate a maintenance plan (draft) that reflects the content shown in (1) in the basic design stage where structural types, key specifications, materials and other items are determined. This is because an efficient and effective maintenance plan can be prepared by setting the structural cross-sections and used materials of target facilities together with examining the content and method of the inspection and diagnosis of each member, repair method, etc.

The maintenance plan (draft) is expected to clearly describe a basic concept for the design of the target facilities and its corresponding maintenance policy as a result of careful consideration by the persons concerned and engineers in the aforementioned design stage. This clarifies if items such as design cross-sections and used materials can be changed as well as their limit conditions in detailed designs, execution designs and the construction stage, and makes it possible to properly respond to each stage. In particular, since a slight change in the cross-sections and other items in the construction stage may have a significant influence on maintenance, the abovementioned measures clarify what information and changes in the construction stage should be reflected in the final version of maintenance plan, leading to ensured maintenance.

Details about the maintenance plan and items described therein are discussed in **Part I, Chapter 4 Maintenance of Facilities Subject to the Technical Standards**.

2.2 Consideration at Each Stage

2.2.1 Importance of Consideration at Each Stage

When designing facilities subject to the Technical Standards, it is important to adequately consider the construction and maintenance stages. Refer to **Part I, Chapter 2, 2.2.2** for items to be considered in the design stage for the construction stage, and refer to **Part I, Chapter 2, 2.2.3** in this Chapter for items to be considered in the design stage for the maintenance stage.

Refer to **Part I, Chapter 2, 3.4.1 (3) Reflection of the Maintenance Plan and Other Plans** for items to be considered in the construction stage for the maintenance stage.

2.2.2 Consideration for Construction in the Design Stage

Measures necessary to be taken into consideration for construction when designing facilities subject to the Technical Standards are to fully understand the construction conditions of the facilities concerned in the design stage, confirm in the design stage that the construction quality of the target facility and stability of the body and temporary structures, etc., during construction as premises for the design are assured, organize items to be conveyed at the construction stage so that these prerequisites for design are accomplished at this stage, clearly describe the items in design documents (design calculation sheets, design drawings, etc.), and consider how to convey them to the persons concerned and engineers in the construction stage.

In particular, important items in design, or conditions that must be observed in the construction stage should be indicated in design drawings as notes. Especially, above-mentioned activities should be carefully done in the design stage for projects where new methods (construction methods, structural types, members, materials) or special methods (complex construction procedures, construction methods requiring large temporary construction, etc.) are adopted. Moreover, it is also important to aim at streamlining a series of construction production processes such as design, ordering, purchase of members and materials, construction of each kind of work item for the target facility and improvement of productivity through the introduction of industrialized and labor-saving construction methods with the utilization of the ICT or introduction of the total optimization design concept.

Refer to the **"Common Specification of Marine Construction Works" published by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism**[1)] for securing quality and managing safety in the construction stage in general marine construction works. Refer to the **"Design and Construction Guideline to Improvement of Safety in Large Temporary Construction and Others in Marine Construction Works" published by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism**[2)] for the basic concept for safe construction in marine construction works adopting complex construction procedures, large temporary construction or others in the construction stage.

2.2.3 Consideration for Maintenance in the Design Stage

(1) Fundamental Items

Measures necessary to be taken into consideration for maintenance when designing facilities subject to the Technical Standards are to 1) properly specify maintenance levels for each member as a basic concept of maintenance in the design stage, 2) create designs to reasonably achieve the set maintenance levels, 3) create structural details so that all processes such as inspection, diagnosis, maintenance work and repair work corresponding to the set maintenance level can be smoothly conducted, 4) organize items to be conveyed to the persons concerned and engineers in the maintenance stage so that maintenance work can be properly carried out, 5) clearly describe the items in the maintenance plan (draft) developed in the design stage and 6) consider how to convey them to the persons concerned and engineers in the maintenance stage.

In particular, important items in design, or conditions that must be observed in the maintenance stage need consideration such as indicating them on the maintenance plan (draft) as notes. It is necessary to carefully examine the considerations for maintenance shown here in the design stage when new methods (construction methods, structural forms, materials, etc.) or special methods (complex construction procedures, etc.) are adopted in the design stage.

Refer to **Part I, Chapter 2, 4 Maintenance of Facilities Subject to the Technical Standards for maintenance of facilities subject to the Technical Standards**.

(2) Consideration for Easiness of Maintenance

① Consideration for inspection, diagnosis, maintenance work, repair work and other tasks

For proper maintenance of facilities, it is necessary to precisely understand the change of conditions such as deterioration and damage of facilities through timely and suitable inspection and diagnosis, comprehensively estimate the results, and implement countermeasures such as required maintenance work and repair work. However, such inspection and diagnosis may require enormous cost and labor to be undertaken depending on types of degradation, location and type of members. Therefore, when designing facilities subject to the Technical Standards, it is desirable to consider the feasibility of the maintenance work, repair work and other tasks in response to the inspection and diagnosis results so as to make inspection and diagnosis during the service life as easy as possible.

For countermeasures such as repair work during the service life, a variety of repairs, reinforcement, replacement and other measures may be taken depending on the degree of performance deterioration to members and other components. The cost of these countermeasures may be enormous depending on the degree of performance deterioration, so it is desirable to consider the structural types, used materials and other items in the design stage so that tasks such as inspection, diagnosis and repair work over the service life are done efficiently, and so the cost for countermeasures and influence on facility usage are minimized as much as possible.

It is also desirable to consider whether maintenance equipment such as scaffolds for inspections and monitoring devices may be installed in order to make it easier to inspect and diagnose positions and members that significantly influence the performance of facilities due to the change of conditions and damage. A typical example for a breakwater covered with wave-dissipating blocks (caisson breakwater) is a drilled observation hole to see how sand within the caisson is running off from the superstructure so that a hole in the side wall of the caisson made by wave-dissipating blocks placed in front of it can be promptly and easily detected. In piled pier type mooring facilities, an observation hole is opened that allows inspectors to enter the lower side of the piled pier from the superstructure to promptly and easily inspect how the reinforced concrete members on the lower surface are deteriorating.

② Consideration for durability

Sites and members that are difficult to inspect and diagnose may exist or enormous cost may be required for inspection and diagnosis depending on the installation conditions of the facilities. Moreover, impossibility of proper inspection and diagnosis may require setting strict (safty side) usage restrictions during the service life of the facilities to ensure safety, so an increase in lost costs due to restrictions during the service life is expected. In this case, it is necessary to consider the structural types, select durable members and other materials with high resistance to material deterioration as well as consider measures to reduce the total cost (initial construction cost of the structures concerned, maintenance costs, including inspection and diagnosis, in addition to maintenance and repair work) in the design stage.

(3) Example of Consideration for Maintenance in the Design Stage

Refer to an example of structural details and items posted on the references website 3), with labor-saving for the maintenance of port structures as an example of consideration for maintenance in the design stage. For methods and notes regarding consideration for maintenance in the design stage, see References 4) through 9).

2.3 Fundamental Items in Design

2.3.1 General

Items to be generally considered in designing facilities subject to the Technical Standards are listed below. Structural cross-sections, used materials and other items thought to be most appropriate as a whole are determined by properly setting and taking into consideration these conditions so that the performance requirements for the target facilities are continually met throughout the design service life. These items should carefully be set as they influence each other. **Table 2.3.1** shows a list of general design conditions necessary for the design of typical port facilities (breakwaters, revetments and mooring facilities).

(1) Purpose of Installation of Facilities **(2.3.2)**

(2) Design Service Life **(2.3.3)**

(3) Performance Requirements **(2.3.4)**

(4) Performance Criteria **(2.3.4)**

(5) Performance Verification Method **(2.3.4)**

(6) Planning Conditions **(2.3.5)**

(7) Usage Conditions **(2.3.5)**

(8) Natural Environmental Conditions **(2.3.6)**

(9) Material Conditions **(2.3.7)**

(10) Construction Conditions **(2.3.7)**

(11) Maintenance Conditions **(2.3.8)**

(12) Consideration for Events Exceeding Design Conditions **(2.3.9)**

(13) Consideration for Environment **(2.3.10)**

(14) Economic Efficiency **(2.3.11)**

Table 2.3.1 List of General Design Conditions Necessary for the Design of Typical Port Facilities (Breakwaters, Revetments and Mooring Facilities)

	Protective facilities for harbor		Mooring facility	Remarks
	Breakwaters	Revetments		
Planning conditions				
(1) Purpose of facilities	○	○	○	
(2) Performance requirements	○	○	○	
Usage conditions				
(1) Performance criteria	○	○	○	
(2) Project process	○	○	○	
(3) Design service life	○	○	○	
(4) Extension of planning	○	○	○	
(5) Planning crown height	○	○	○	
(6) Planning depth, design water depth	○	○	○	
(7) Datum level	○	○	○	T.P., A.P., Y.P., etc.
(8) Width and gradient of the apron	−	−	○	
(9) Design ship	−	−	○	
(10) Berthing condition of the design ship	−	−	○	
(11) Tractive force	−	−	○	
(12) Dead weight	△	○	○	Cargo handling equipment
(13) Other	△	△	△	Amenity-oriented functions, consideration for safe navigation of small crafts, etc.
Natural environmental conditions				
(1) Tide level conditions	○	○	○	Abnormal tide level
(2) Residual water level conditions	−	○	○	
(3) Wave conditions	○	○	△	
(4) Ground conditions	○	○	○	
(5) Earthquake conditions	○	○	○	
(6) Tsunami conditions	△	△	△	
(7) Other	△	△	△	Wind, air temperature, flow of sea water, snowfall, mist, etc.
Material conditions				
(1) Used materials	○	○	○	New materials, new members, procurement conditions (carry-in route, supply quantity), reuse of members, etc.
(2) Corrosion control conditions, corrosion rate	○	○	○	
(3) Other	△	△	△	Friction coefficient, etc.
Construction conditions, etc.				
(1) Coordinate	○	○	○	
(2) Construction conditions	○	○	○	Structure fabrication conditions, constraints from neighboring facilities (navigation channels, mooring facilities, airports, bridges, overhead wires, submarine cables, etc.), hazardous cargo, etc.
(3) Other	○	○	○	Construction period, construction working rate, construction method, working ship machines, construction accuracy, etc.
Maintenance conditions				
(1) Inspection and diagnosis plans	○	○	○	Inspection facilities, measurement instruments, etc.
(2) Other	△	△	△	Usage conditions

	Protective facilities for harbor		Mooring facility	Remarks
	Breakwaters	Revetments		
Consideration for environment				
(1) Consideration for environment	△	△	△	Structures for cohabitation with living things Consideration for water quality, landscape, sediment, air quality, etc.
Consideration for improvement design				
(1) Purpose of improvement	○	○	○	Change of use, change of performance, extension of the working life, etc.

(Legend) ○: required as a design condition; △: may be required as a design condition; ―: not required as a design condition

2.3.2 Purpose of Installation of Facilities

(1) Fundamentals

For fundamentals of the purpose of installation of facilities subject to the Technical Standards, refer to **Part I, Chapter 1, 3.1 Purpose of Facilities Subject to the Technical Standards**.

(2) Consideration

The technical standards specify the purpose of installation of facilities as the minimum role the facilities concerned should serve, but new roles can be added as long as they do not interfere with the original role of the facilities. However, when new roles are added, since they affect a range of items to be set, such as significance, design service life and performance requirements of the facilities, the purpose of installation needs to be properly set by carefully considering its impact.

2.3.3 Design Service Life

(1) Fundamentals

For fundamentals of the design service life of facilities subject to the Technical Standards, refer to **Part I, Chapter 1, 3.2 Design Service Life.**

(2) Consideration

The design service life of port facilities is "the period to be properly set in the design stage of facilities as the period during which the facilities concerned continue to meet their performance requirements." This design service life is generally set using comprehensive judgement by considering the purpose of installation and significance of the facilities concerned, usage conditions such as the relationship with the surrounding usage conditions (e.g., other facilities), and how the length of the set design service life affects the selection of materials considering the setting of actions and environmental actions, construction cost and other factors. The service life is judged in the design stage to be able to surely maintain the functions and performance required during the facility's design service life if the originally set maintenance policy is complied with.

It is desirable to properly set the design service life by considering the various types defined below.

① **Physical working period**

Physical working period refers to the number of years after which facilities will not be able to maintain the required performance because of actions such as corrosion and weathering to members and materials composing the facilities.

② **Functional working period**

Functional working period refers to the number of years after which facilities will not be used because of issues regarding their function such as insufficient water depth at basins due to increases in ship size.

③ **Economical working period**

Economical working period refers to the number of years after which the facilities concerned will lose out economically to other facilities unless improvements are made.

④ **Working period from the viewpoint of social programs**

This refers to the number of years after which new plans will replace originally targeted functions or other functions will be demanded.

(3) Examples of Standard Design Service Life Setting

① **Example in ISO2394 (1998)**

The classification of design service life concept defined in **ISO 2394 (1998)**[10] shown in **Table 2.3.2** may be referred to when setting the design service life.

Table 2.3.2 Classification of Design Service Life Concept in ISO 2394 (1998)

Class	Expected design working life (years)	Example
1	1-5	Temporary structures
2	25	Replaceable structural elements such as bridge abutment beams and bearings
3	50	Buildings and other public structures, structures other than the below
4	100 or more	Memorial buildings, special or important structures, large-scale bridges

② **Examples of standard settings in existing port facilities**

The design service lives of existing port facilities are often set to 50 or 100 years in Japan. **Table 2.3.3** shows design service lives and the return periods of variable actions for typical facilities.

Table 2.3.3 Design Service Lives and Return Periods of Variable Actions for Typical Facilities

Case example	Design working life	Return period of main variable actions
Breakwater	50 years	• Level 1 earthquake ground motion: 75 years • Design wave: 50 years
Tsunami Breakwater	100 years	• Level 1 earthquake ground motion: 150 years • Design wave: 100 years
Mooring facility	50 years	• Level 1 earthquake ground motion: 75 years
Immersed tunnel	100 years	• Level 1 earthquake ground motion: 150 years
Bridge	100 years	• Level 1 earthquake ground motion: 150 years

(4) Relationship between Setting the Action Characteristic Value and Design Service Life

When the design service life is set to be much longer than the standard period, a greater action is usually adopted as a characteristic value by setting a return period necessary for calculating an action characteristic value longer than the standard (the annual exceedance probability becomes smaller). In this case, an action return period is often set so that the probability of encountering (encounter probability) an action greater than a set action becomes the same as that of the standard design during the design service life of the facilities.

On the other hand, it is undesirable from the viewpoint of the public interest to set a design service life significantly shorter than the standard life, and correspondingly, an action return period shorter than the standard period (annual exceedance probability becomes greater), in addition to adopting a smaller action as a characteristic value, and should be avoided. For example, when breakwater or mooring facilities that support logistics at a port collapse in a minor earthquake with less than level 1 earthquake ground motion, the logistics at the entire port will decline significantly and the economic activities around the port will be largely affected even if the collapsed facilities are just a part of the entire port.

2.3.4 Performance Requirements, Performance Criteria, and Performance Verification Methods

(1) Fundamentals

For fundamentals regarding performance requirements, performance criteria and performance verification methods of facilities subject to the Technical Standards, refer to **Part I, Chapter 1, 3.7 Performance Requirements, 3.8 Performance Criteria** and **3.9 Performance Verification Methods**.

(2) Consideration

① Setting of performance requirements, performance criteria and performance verification methods

Designing in the performance design system requires setting performance requirements, indices of performance criteria to make specific verifications based on the performance requirements, their limit values, and methods for verifying the indices. That is, what level of function and performance should be ensured when target facilities encounter actions by estimating how long they will be used, what kind and size of actions will be encountered in what combinations, and at what frequency during that period. Moreover, it should be determined how significant the influence of damage to the target facilities will be to the surroundings and to what degree the influence will be suppressed, in addition to the proper index and its limit value to verify if the required performance is ensured, and what verification method will be adequate. Furthermore, even during the construction process, it is required to properly establish how the same items as above should be assessed with consideration for maintaining harmony between economic efficiency, environment and landscape and under time constraints (construction period) until the start of the working life.[11)]

② Design focused on "performance"

This book introduces the setting of actions under standard design conditions, the content of performance criteria, standard performance verification methods and limit values targeting port structures in Japan.

However, the framework of performance design places considerable significance on the comprehensive assessment as stated in ① through constant research, even with existing structural types and design methods. In other words, it is always required to check the following items as example: 1) whether assumed design situations in past are really sufficient, 2) whether an index of the performance criteria is really appropriate, and 3) whether a more appropriate method, such as switching from the safety factor method to the reliability-based design method, can be introduced so that the limit state is confirmed when verifying indices. In particular, the aforementioned careful research will be necessary when introducing new construction methods, structural types, materials and so on because no existing standards or manuals can be followed. The framework of performance design also has a role in preventing oversights because an action that causes no issues with previous structural types can have a substantial impact on a new structural type in unexpected ways.

In regard to performance requirements, it is desirable to confirm if new performance needs to be added or set according to the purpose of the facilities concerned, social situation or other factors in the design stage. For example, as part of efforts toward creating a sustainable society, it is also possible to introduce a framework to set performance requirements to suppress the impact on the environment in construction work and to quantitatively verify the amount of CO_2 emission as performance criteria.[12) 13)]

2.3.5 Planning Conditions and Usage Conditions

(1) Fundamentals

Usage conditions during the design service life, which is a premise of design, for facilities subject to the Technical Standards need to be properly set in the design stage.

Planning and usage conditions have to be fully set based on the principle of the plan concerned and by complying with higher-level statutory plans such as port planning.

(2) Items to Be Set in Planning Conditions and Usage Conditions

Major planning and usage conditions to be set in the design stage are as follows:

① Layout of facilities (extension of planning, facility crown height, alignment, etc.)
② Dimensions of facilities (planning depth, design water depth, apron width and its gradient, etc.)
③ Items concerning the design ship (hull form, berthing velocity, tractive force, use of smaller ships, etc.)
④ Items concerning the cargo handling equipment (types of machines, weight, wheel load, driving route, etc.)

⑤ Items concerning dead weight other than the cargo handling equipment (types of live load, snow load, live load of automobiles and other vehicles, etc.)
⑥ Items concerning safety measures for cargo handling operation, etc.
⑦ Items concerning port security measures (revised SOLAS Treaty, etc.)
⑧ Items concerning use by many and unspecified users (barrier-free, etc.)
⑨ Items concerning use of periphery facilities (unified operation with neighboring berth, entry of cargo handling equipment to neighboring berths, etc.)
⑩ Other

2.3.6 Natural Environmental Conditions

(1) Fundamentals

Natural environmental conditions as premises for design need to be properly set in designing facilities subject to the Technical Standards. Refer to each Chapter in **Part II** for specifics regarding the setting of methods of natural environmental conditions.

When setting natural environmental conditions, it is necessary to be sure to extract the conditions which significantly influence design such as the layout and configuration of the facilities, decisions on basic cross-sections, used materials and other components, and setting of maintenance policy, and to carefully set their conditions. In particular, it is desirable to analyze the history of disasters and characteristics of deterioration events of similar structures adjacent to the target facilities (including similar structures not only near the target facilities, but those under similar conditions throughout the country), as well as issues with using facilities, as much as possible and to have the results be reflected in the natural environmental conditions to be newly set.

(2) Items to Be Set in Natural Environmental Conditions

Major natural environmental conditions to be set in the design stage are as follows:

① Wind

② Tide level

③ Residual water level (water level in the hinterland ground of mooring facilities, etc.)

④ Ocean waves (including ship waves)

⑤ Water flow

⑥ Ground condition (including topography on land and underwater)

⑦ Earthquakes

⑧ Tsunamis

⑨ Sea water quality

⑩ Other (precipitation, mist, snowfall, sea ice, air temperature, humidity, water temperature, seismic crustal movement, rise in sea level, etc.)

2.3.7 Material Conditions and Construction Conditions

(1) Fundamentals

Material conditions and construction conditions as premises for design need to be properly set in designing facilities subject to the Technical Standards. Refer to each Chapter in **Part II**, for specifics regarding the setting of methods for material conditions and to **Part I, Chapter 2, 3 Construction of Facilities Subject to the Technical Standards** for the construction of facilities subject to the Technical Standards.

(2) Consideration for the Setting of Material Conditions

① Influence on construction cost and period

Port structures are generally large in size and often have hard off-shore construction conditions and procurement conditions for the materials themselves. Thus, the selection of materials in design may significantly influence the construction period and cost of the target facilities. To avoid the above situation available materials in the design stage need to be carefully selected by understanding the latest trends regarding difficulties in procuring materials in the vicinity of the target facilities and other trends.

② **Adoption of items such as new materials and new members**

The premise for the adoption of new materials and members is that the quality needed in design is ensured in addition to a stable supply. For this purpose, the construction method, specific method for quality management, decision criteria for inspections and other tasks need to be considered at the same time during the design stage. Similarly, expected deterioration events in newly adopted materials, members and other components, inspection and diagnosis methods, repair and replacement methods and other tasks need to be considered in the design stage for the maintenance stage.

③ **Consideration for durability**

The durability of materials has to be considered when making designs. For what factors need to be considered, refer to **Part I, Chapter 2, 2.2.3 Consideration for Maintenance in the Design Stage (2) ② Consideration for Durability**. In order to confirm the durability of materials to be considered in the design stage, it is necessary to properly set the conditions for the confirmation of durability of materials such as the deterioration condition of materials and corrosion rate of steel materials, then assess whether the materials concerned can be used in the facilities subject to design.

④ **Use of precast or normalized and standardized members**

The use of precast or normalized and standardized members may result in a shorter construction period, an improvement in construction safety and quality, and a reduction in the total construction cost. Thus, it is desirable to research usage result and applicability to the facilities subject to design of the precast members and properly set available alternatives for members in the design stage.

(3) Consideration for the Setting of Construction Conditions

① **Construction period**

The construction period often has a significant influence on the determination of fundamental cross-sections, used materials and other components, and on an increase or decrease of the project cost. Consequently, for construction periods requested from higher-level plans, site conditions need to be closely investigated and checked to confirm if the requested period is reasonable.

② **Other construction conditions**

A variety of restrictions described below, in addition to the construction period shown in ①, need to be properly set as construction conditions in the design stage.

Port facilities are subject to a number of restrictions regarding construction because they are often built at sea. That is, a strong influence from ocean waves, tides and tidal currents, in addition to rain, wind and air temperature, leads to a restriction in work hours. Construction time may also be restricted by wind waves in winter as well as farming and egg-laying seasons at sea. Special ships and machines for offshore operation such as crane ships and dredgers must be used in comparison with onshore operation. Underwater operation often involved in subsea work restricts construction abilities according to how well the materials, equipment, staff and so on are secured for carrying out this specialized work. Similarly, onshore fabrication facilities such as caisson yards and block yards, and the availability of earth and land disposal fields, and how well they are secured, may restrict the selection of structural types. Seawater pollution due to construction may also become a big issue, so consideration for fishery operators and the surrounding environment during the construction period needs to be made.

③ **Coordinate system and datum level**

A coordinate system and a datum level of altitude must be set in the design stage. In principle, the coordinate system and the location applied in the construction stage are the coordinate system and datum level applied in the design stage. Refer to **Part I, Chapter 1 [Interpretation] (8) Datum Level for Port Administration** for the datum level.

When designing a new facility adjacent to existing ones, it may be possible that coordinate values on the drawings of existing facilities have been altered due to earthquakes or other causes. In this case, it is needed to adequately transfer the information to the construction stage since the coordinate value must be updated between the completion of the design and the start of construction work.

2.3.8 Maintenance Conditions

(1) Fundamentals

Maintenance conditions as premises for design need to be properly set in designing facilities subject to the Technical Standards. Refer to **"2.1.4 Fundamental Concept of Maintenance"** in this Chapter for fundamentals regarding maintenance level setting.

(2) Consideration for the Setting of Maintenance Conditions

① **Work conditions for maintenance**

Work conditions for maintenance such as whether facilities may be totally suspended and how long working hours may be secured may significantly influence the determination of structural types, used materials and other components when members are changed, repaired or reinforced in the maintenance stage. Thus, it is desirable to clarify the work conditions for maintenance as much as possible when making a design.

② **Consideration for inspection and diagnosis**

Whichever structure and material is adopted, the original performance may be degraded over time and lead to damage and other issues. Thus, it is desirable to have a structure that makes it possible to easily inspect and diagnose the areas which are structurally important or may significantly influence third parties, among others.

Part I, Chapter 2, 2.2.3 (3) Example of Consideration for Maintenance in the Design Stage may be referred to for examples of consideration for conducting an inspection and diagnosis.

③ **Consideration for changes in responsible entities**

When developing port facilities in Japan, the responsible entities may change at each project stage from planning to maintenance. In particular, when a government directly develops the facilities, the government is the responsible entity for the design and construction and will develop the maintenance plan as national facilities. Once the facilities are completed, management is usually commissioned by the government to port management bodies, who will then become the responsible entity for inspection, diagnosis and other tasks (**Fig. 2.3.1**). If the responsible entities in the design and maintenance stages differ, it is desirable to confirm items in the design stage such as the system and budget for inspection, diagnosis and other activities conducted by the responsible entities in the maintenance stage, and to make sure that the facilities are properly maintained.

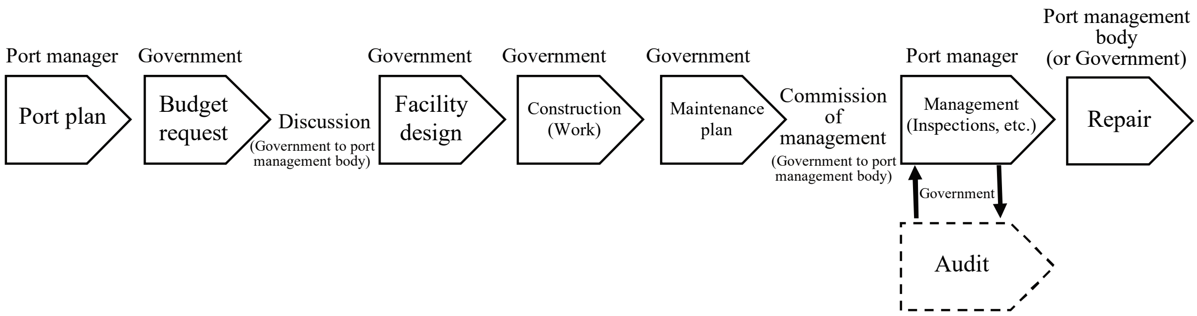

Fig. 2.3.1 Example of Changes in Responsible Entities of Port Facilities Directly Developed by the Government

2.3.9 Consideration for Events Exceeding Design Conditions

(1) Fundamentals

Performance verification is a process conducted under set conditions (design conditions) and confirms whether required performance is being achieved under such conditions. However, it is necessary to recognize that events exceeding the design conditions may actually occur.

(2) Structural Robustness

When designing facilities subject to the Technical Standards, it is desirable to consider ensuring structural robustness of the facilities concerned in addition to verifying their performance (confirmation that the performance requirements specified by the standard ministerial ordinance are met). Here, structural robustness means the performance that actions to the facilities such as unexpected fires or collisions, or partial destruction of the facilities, do not catastrophically affect the whole structural system.

(3) Diversity of Structural Forms

As consideration for events exceeding the design conditions, a response adopting different kinds of structural types (diversity of structural types) may be possible. When a large-scale earthquake strikes a port, it is thought that mooring facilities with similar structural cross-sections will all be damaged in the same way. An example of this is a case that occurred during the Hyogo-ken Nanbu Earthquake in 1995 when a number of gravity-type quay walls on the ground that was improved with replacement sand all received similar damage due to liquefaction. For this reason, it is desirable to consider the diversity of structural types, for example, designing mooring facilities by avoiding a single structural type or similar cross-sections as much as possible in the same port.

2.3.10 Consideration for Environment

(1) Fundamentals

When designing facilities subject to the Technical Standards, it is desirable to consider the environment such as preservation of the port environment, forming a good port landscape and securing port security by considering the conditions under which the facilities concerned exist. In facilities used by an unspecified large number of people, it is desirable to make considerations so that all persons, including senior citizens and disabled persons, can safely and smoothly use facilities equipped with ship boarding and unboarding functions and amenity-oriented functions, as well as other facilities.

For specific items regarding consideration for the environment, refer to **Part I, Chapter 3 Consideration for Environment**.

2.3.11 Economic Efficiency

(1) Fundamentals

When designing facilities subject to the Technical Standards, it is necessary to set structural cross-sections, used materials and other components by adequately considering the content and conditions described in **Part I, Chapter 2, 2.1 Fundamental Principles of Design, 2.2 Consideration at Each Stage** and **2.3 Fundamental Items in Design (2.3.1 to 2.3.10)**, and comparing the economic efficiency of construction costs, etc.

As indices of economic efficiency, the initial construction costs (including compensation costs), direct costs such as maintenance costs (e.g., repair costs, reinforcement costs, inspection costs) and demolition costs, as well as indirect costs such as losses accompanying the loss of functions in neighboring facilities due to the construction may be considered.

2.4 Fundamental Items of Improvement Design

2.4.1 General

(1) Fundamentals

When designing existing facilities to improve (upgrade), it is important to determine structural cross-sections, used materials and other components comprehensively considered to be most appropriate for the purpose of improvement by setting a new design service life and performance requirements, and utilizing various history records and the current state data concerning the facilities before improvement as much as possible, and properly establishing and considering the design conditions under which the facilities concerned will exist , so as to make sure that the facilities continue to meet the performance requirements throughout the design service life based on the demands for the facilities concerned (purpose of improvement).

A feature of designing with the intent of improving existing facilities is that, unlike with designing new facilities, a range of history record and the current state data concerning the facilities can be obtained (the flowchart on the left side of **Fig. 2.4.1**). That is, improvement design makes it possible to set realistic design conditions, limit values for verification and other items based on actual utility situations, load conditions, corrosion rates, actions such as earthquakes and ocean waves, history of damage and so on, which may lead to setting more reasonable improved cross-sections.

On the other hand, improvement design may continue to use some structural members to make reasonably improved cross-sections. However, it is also a feature of improvement design that quantitative evaluation of deterioration and damage may not be possible for members for which inspection and diagnosis is difficult, such as underground members (flowchart on the right side of **Fig. 2.4.1**). In this case, the performance and future changes of the members concerned are often obliged to rely on engineering judgement. If such existing members should be used in structurally important portions, it is desirable to fully recognize the risks and assess them beforehand so that defects can be detected early through inspection and diagnosis in the maintenance stage and countermeasures can be taken when an issue occurs.

As shown above, improvement design of existing facilities makes it important to handle information for existing facilities. For fundamental consideration for improvement design of existing facilities and improvement examples, refer to summaries found in **Reference 14)** and **15)**.

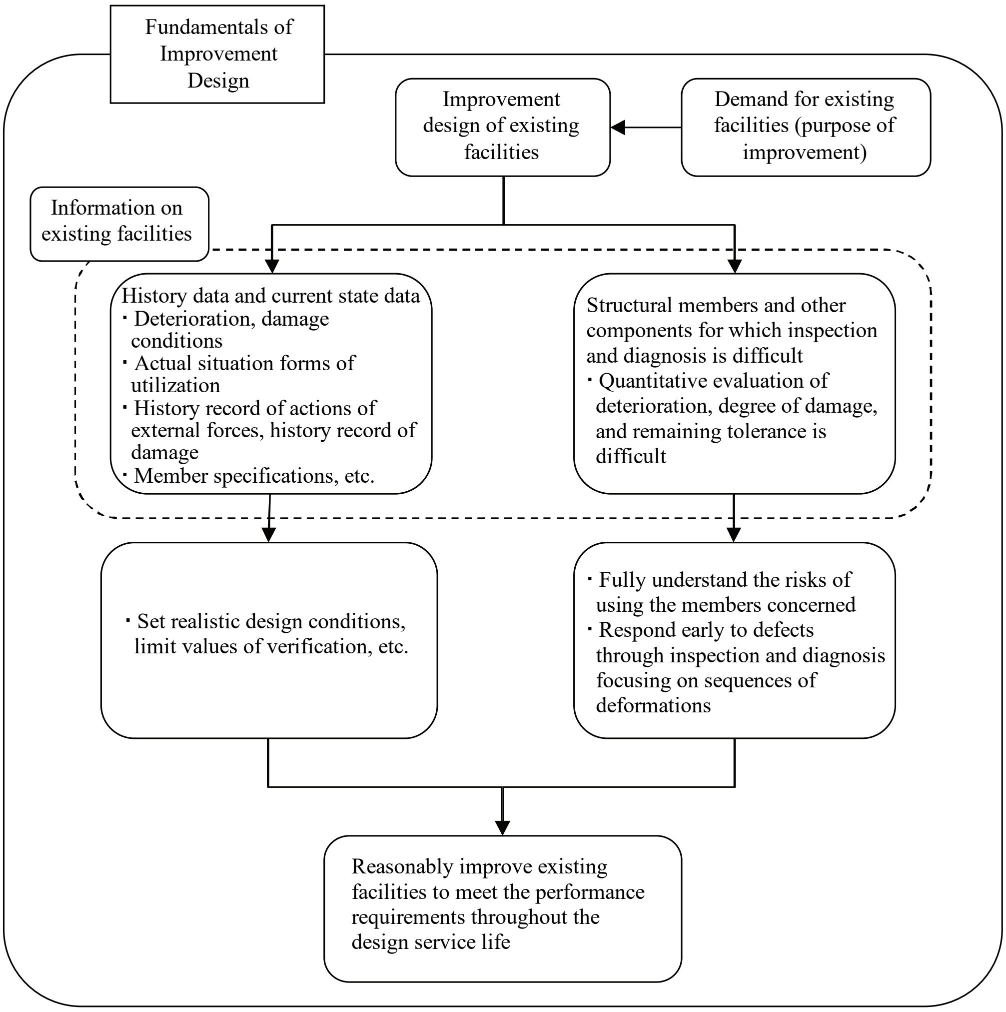

Fig. 2.4.1 Features of Improvement Design of Existing Facilities

(2) Compliance to the Technical Standards

As shown in **Part I, Chapter 1, 1.2 Compliance to the Technical Standards**, improvement design of existing facilities requires compliance to the Technical Standards as of the date of improvement. If members or other portions of the existing facilities are still used, uniformly applying a present standard performance verification method (a simplified method assuming the design of new facilities) and limit values assumed by the Technical Standards at the time of improvement to all verification items concerning the target facilities may be notably unreasonable because they require excessive improvement costs in light of the original purpose of improvement. In this case, a designer may set another performance verification method (such as an advanced numerical analysis, model experiment or methods based on the past record or experience), limit values and so on, and apply them to certain verification items under the judgement of experts or professional engineers.

2.4.2 Purpose of Improvement of Existing Facilities

(1) Major Classification of Purposes of Improvement of Existing Facilities

Although demand for the improvement of existing facilities (purpose of improvement) varies according to the type of target facilities, structural types, social conditions at the time of improvement and so on, it is classified into the following, as shown in **Part I, Chapter 1, 1.2 Compliance to the Technical Standards**:

① Change of use of existing facilities

② Change of performance of existing facilities

③ Extension of the working life of existing facilities

(2) Characteristics and Examples of Each Purpose of Improvement

Characteristics of each purpose of improvement are listed below. **Table 2.4.1** shows a classification of each purpose of improvement and typical examples of improvement.

① Change of use of existing facilities

"Change of use of existing facilities" means changes in use of the facilities themselves including purposes of installation and basic functions of existing facilities.

Improvement to change the purpose of installation or use of facilities, including, for example, changing from a breakwater to a revetment, or from a quay wall to a revetment, fall into this category.

② Change of performance of existing facilities

"Change of performance of existing facilities" means upgrading or downgrading performance or ability by changing the performance requirements without changing the purpose of installation or basic functions of the existing facilities.

For example, upgrading performance includes heightening breakwater or revetment crowns as a result of reviewing the design wave height, and strengthening seismic performance of quay walls or piled piers as a result of reviewing the design input earthquake ground motion. Examples of downgrading performance include an improvement to reduce depth (depth reduction) of quay walls reflecting the downsizing of used ships in conjunction with countermeasures against quay wall aging.

③ Extension of the working life of existing facilities

"Extension of the working life of existing facilities" means a significant extension of the working life of facilities approaching the end of their originally set design service life through the large-scale reinforcement of members, a total repair of members and setting a new design service life without changing the purpose of installation and basic functions of existing facilities shown in ① or the performance requirements shown in ②. Facilities whose originally set design service life has not yet expired are also included in this category.

An example of this is to set a new design service life (e.g., 50 years) and undergo repairs anticorrosive covering and the large-scale replacement of cathodic protection of a sheet pile wharf that is soon approaching its original design service life without degrading facility performance and with expected continued use as a mooring facility. However, in this case, it is necessary to verify that the facility meets its performance requirements throughout the new design service life set at the time of the improvement design. If not, the repair or reinforcement of existing members and other components will be required. A case of removal or restoration of a piled pier's superstructure also falls into this category.

Whichever purpose for improvement (①-③) is adopted, a new design service life and performance requirements need to be set based on the demands for the facilities concerned (purpose of improvement) when doing improvement design of existing facilities as shown in **Part I, Chapter 2, 2.4.1 General**. However, there may be no changes between performance requirements before and after improvement depending on the adopted purpose of improvement.

Table 2.4.1 Classification of Purposes of Improvement and Typical Examples of Improvement

Purpose for improvement	Description	Content, etc.	Typical examples
① Change of use	When changing purposes of installation and use (function) of existing facilities	Change of purposes of installation and use	• Change from a breakwater to a revetment • Change from a revetment to a quay wall or other structure • Change from a quay wall or other structure to a revetment
② Change of performance	When changing performance requirements and changing (upgrade or downgrade) performance or ability without changing the purposes of installation and use (function) of existing facilities	Review of design wave	• Heightening of a breakwater or revetment
		Review of design tsunami	• Improvement of performance of a breakwater or revetment against a tsunami
		Change in design ship	• Deepening or shallowing of quay walls and other structures
		Review of design input earthquake ground motion	• Strengthening of seismic performance of quay walls and other structures
		Change of cargo handling equipment	• Introduction of cargo handling equipment to quay walls and other structures, and response to larger cargo handling equipment
		Response to convenience	• Change of the crown height of quay walls and other structures
		Response to amenity	• Change of the guard method of a breakwater or revetment for ocean waves
		Improvement of safety in ship navigation and anchoring	• Deepening of navigation channels and basins
③ Extension of the working life	When significantly extending the working life of existing facilities approaching the end of their design service life (including changes during the initially set design service life)	Setting of a new design service life	• Replacement of cathodic protection • Replacement of the superstructure or understructure of piled piers

2.4.3 Overall Procedure to Improve Existing Facilities

Same as in the case of new facilities, the improvement of existing facilities will be completed through planning, investigation, design and construction stages, with the maintenance stage beginning just after completion. **Fig. 2.4.2** shows an overall procedure for improving existing facilities together with a procedure for building new facilities. Fundamental consideration for improving existing facilities is outlined below in accordance with the procedure found in the diagram.

(1) Planning Stage

In the planning stage, it is important to set the purpose of improvement of facilities considering the preventive maintenance plan of the port, the maintenance plan of the facilities concerned and surrounding facilities, and necessity of individual facilities, as well as the significance and positioning of the facilities concerned in the entire port. Based on this goal, decisions for the discontinuation of use of existing facilities or the purpose of improvement are established, the port plan is revised or changed as appropriate, and a project plan is developed.

Next, it is necessary to investigate the fundamental policy regarding the improvement of existing facilities based on the project plan and results of past inspections and diagnoses. In investigating the fundamental policy, an outline of improvement methods and methods for using existing members and other components are investigated, and a plan for a detailed investigation (done in the investigation stage) of existing facilities to use existing members and other components in the improvement design is developed.

(2) Investigation Stage

In the investigation stage, it is necessary to investigate in detail the state of members which cannot be confirmed only using the results of past inspections and diagnoses, according to the purpose of improvement and the fundamental policy set in the planning stage, and to check the soundness of existing members and other components.

In particular, although the improvement of existing facilities will involve the reuse of all or part of the existing facilities, the degree of deterioration, damage and performance degradation of existing members and other components for reuse greatly changes the selection range of construction methods and cross-sections for improvement and significantly influences the cost of improvement work and other tasks. Thus, an investigation for improvement of existing facilities needs to be conducted carefully and with an attention to detail using the results of periodic inspections and diagnoses.

Structural members and other components that make it difficult to evaluate the soundness of existing members need to be understood in this investigation stage and summarized in consideration of the following design, construction and maintenance stages.

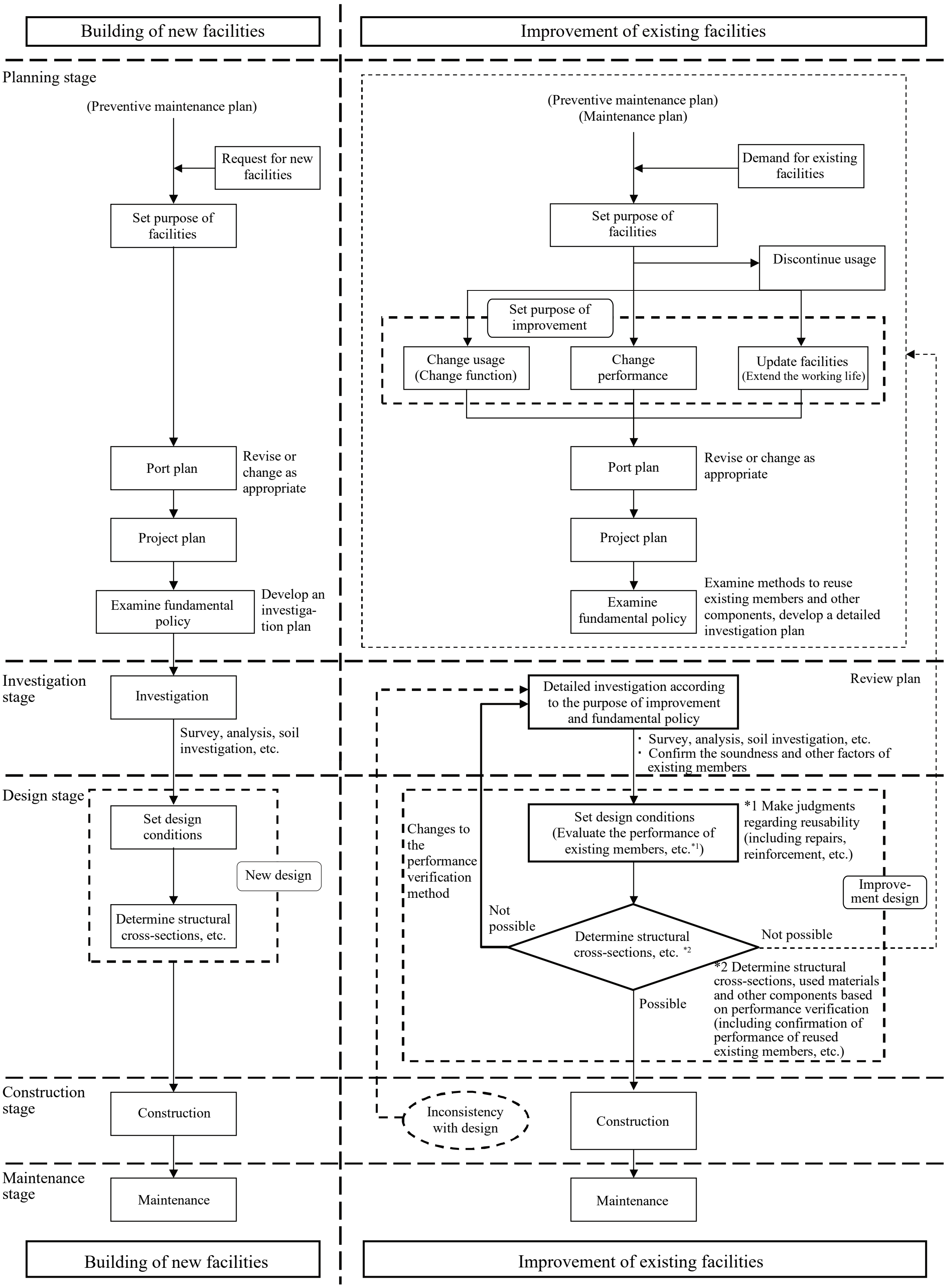

Fig. 2.4.2 Overall Procedure for Building New Facilities and Improving Existing Facilities

(3) Design Stage

In the design stage, the design conditions are set first based on the purpose of improvement, the fundamental policy and a detailed investigation. Design conditions include planning conditions, usage conditions, natural environmental conditions, construction conditions and material conditions. For material conditions, organize as a premise for improvement design after properly evaluating the performance of existing members and other components to be reused and assess their reusability, repairs, reinforcement, and so on.

Next, for determining the structural cross-sections, consider organized prerequisites and conditions under which the facilities concerned exist, determine the structural cross-sections, used materials and other components based on the current technical standards and standard performance verification method, then update as maintenance plan (draft). The content of countermeasures to repair and reinforce existing members and other components is also determined as appropriate. Application of the standard performance verification method at the time of improvement to existing members may make the determination of reasonable structural cross-sections, used materials and other components difficult. In this case, it may be possible to change the verification method and proceed with the design work while referring to a numerical analysis or performance verification method based on past performance. However, it is desirable to return to the investigation stage and conduct a detailed reinvestigation if existing information on the facilities concerned is insufficient due to a change in verification method.

For the response in the investigation and design stages, it may become necessary to return to the planning stage and reexamine the fundamental policy of improvement if it is difficult to determine reasonable structural cross-sections, used materials and other components. As such, it is desirable to proceed with the work while affording ample time and considering costs for improvement design assuming the possibility that a reexamination is required when designing improvements of existing facilities.

(4) Construction Stage

Existing members and other components which were difficult to check in detail in the design stage may become possible to check relatively easily during construction. Thus, it is desirable to include necessary detailed investigations for the existing members in the construction plan beforehand if they are considered to be structurally important with the cross-sections determined in the design stage and can additionally be checked in detail in the construction stage. If members judged to be healthy in the design stage are inconsistent during construction, such as those found to be deteriorated or damaged, it is necessary to return to the investigation stage and reexamine the design. For the improvement of exsiting facilities, it is desirable to proceed by allowing ample time and considering costs for a reexamination

(5) Maintenance Stage

In the maintenance stage, facilities must be properly maintained with inspection, diagnosis, repairs and other work based on the maintenance plan changed in the design and construction stages. In particular, it is necessary to carefully check the maintenance plan because the maintenance level may be altered due to changes in structural types or reinforcement of members in existing facilities due to improvement.

In the maintenance stage of facilities improved by reusing existing members and other components, particular attention should be given to the existing members since they may suffer unexpected deterioration and damage due to a long-time exposure to load and natural environment actions, compared with the newer members.

2.4.4 Consideration for Improvement Design

Although items to be considered for improvement design of existing facilities subject to the Technical Standards are the same as for the design of new facilities subject to the Technical Standards (refer to **Part I, Chapter 2, 2.3 Fundamental Items in Design**), there are some items to be noted which are specific to improvement design and are described below.

(1) Extraction of Improvement Construction Methods and Performance Evaluation of Improved Cross-sections

In improvement design of existing facilities, a wide variety of alternatives for improvement construction methods are available because improved cross-sections tend to be more complicated compared to the design of new structures. On the other hand, to obtain reasonable improved cross-sections, improvement construction methods need to be exhaustively extracted so that no proper improvement construction methods corresponding to the structural cross-sections of existing structures are overlooked. In addition, improved cross-sections combining existing and new structures need performance evaluation of not only the behavior and deformation performance of each structure, but as a whole structure considering the influence of interactions between existing and new structures. For the extraction of improvement construction methods and the fundamental concept of performance evaluation of improved cross-sections, refer to sections such as **Reference 15)**.

(2) Design Service Life

The design service life of existing facilities for improvement design is "the period to be properly set in the design stage of facilities as the time during which the facilities concerned continue to meet their performance requirements" and is the same as that of new facilities. The design service life for improvement design is generally defined as starting when the working life of an improved facility begins.

(3) Performance Requirements, Performance Criteria and Performance Verification Methods

Performance requirements and performance criteria of existing facilities for improvement design need to be set according to the purposes of the facility's installation and improvement. The purpose of improvement needs to be fully understood and set because it may be completely different than the performance requirements and the performance criteria held by existing facilities before improvement or may be added depending on the purpose of improvement.

(4) Planning Conditions and Usage Conditions

① **Common items**

While the design work of new facilities generally proceeds based on planning and usage conditions set prior to the design, for the improvement design of existing facilities, some conditions such as the position of a face line and apron gradient are determined in the design stage according to the situation of the existing facilities. When no utilization forms of the facilities are changed as a result of improvements made, items concerning design ships and cargo handling equipment may be reassigned based on ships and cargo handling equipment that are actually used.

② **Face line of mooring facilities**

In the improvement design of mooring facilities, the possibility and possible ranges of forward-putting face lines of existing facilities considerably influence the selection range of structural types, structural cross-sections and construction methods. In other words, limiting conditions of the position of the face lines in improvement design considerably influences the whole construction period and construction cost. Thus, when face lines are changed, and if the preparation work, such as requests for reclamation, takes time, careful attention is required and planning conditions regarding face line changes must be well assessed early.

(5) Natural Environmental Conditions

Information on the facilities concerned can be effectively used in the improvement design of existing facilities. Consequently, when setting natural environmental conditions, it may be possible to set conditions based on the results of the best possible analysis of the history of actions and damage, characteristics of deterioration events and so on; some of which may be ocean waves that acted on the facilities in the past, corrosion rates of steel materials, or the strength of the consolidated cohesive soil ground.

(6) Material Conditions

When setting material conditions for the improvement design of existing facilities, the following items need to be given attention in addition to items in **Part I, Chapter 2, 2.3.7 Material Conditions and Construction Conditions**.

① **Setting of conditions of existing members**

Some component elements of existing facilities, such as materials, members, improved ground and products (hereinafter called "existing members") are reused for the improvement of existing facilities, and the reusability of these existing members will considerably influence the selection range of structural types, design cross-sections and construction methods. That is, whether existing members can be reused considerably influences the whole construction period and the construction cost. Thus, conditions such as the reusability of existing members need to be carefully set as design conditions in the improvement design.

Specifically, the following items need to be studied and organized as a part of the design conditions prior to undertaking design for each component element of the existing facilities:

－ Setting of input parameters for physical properties, stress states and history in order to evaluate

－ Expected performance (for newly set design service life)

－ Evaluation method of expected performance

－ Prerequisites for improvement design (evaluation result of the necessity of repairs and reinforcement)

② **Performance evaluation of existing members**

Fig. 2.4.3 shows an example of a performance evaluation procedure for existing members.

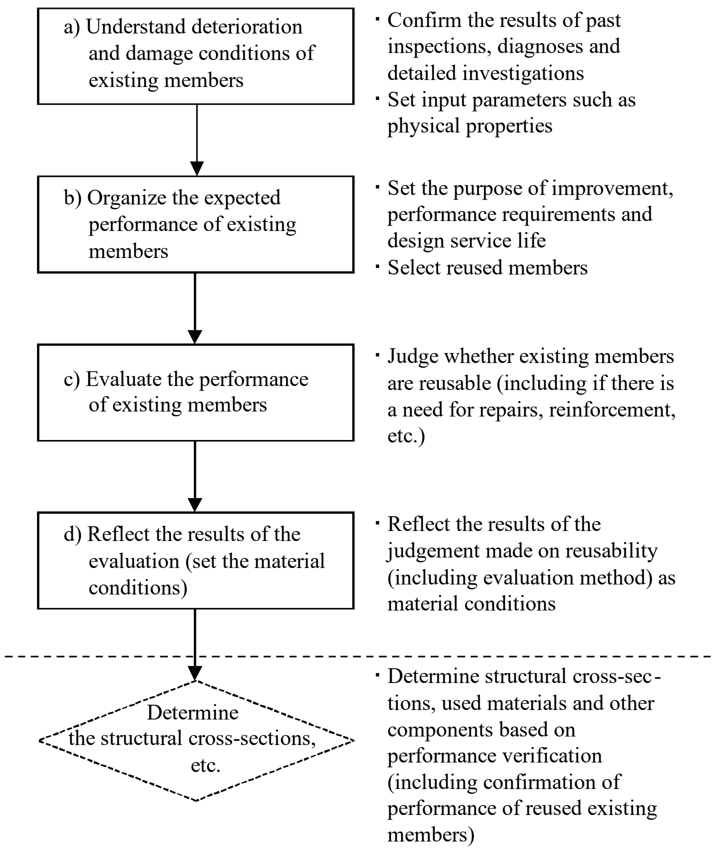

Fig. 2.4.3 Performance Evaluation Procedure of Existing Members

(a) Understand Deterioration and Damage Conditions of Existing Members

Deterioration and damage conditions of the target existing members must be understood when evaluating their performance. To understand these conditions, the soundness of existing members is checked based on the results of past inspections and diagnoses (record of maintenance plan) and of detailed preliminary investigations. In addition, input parameters for physical properties, stress states and history of existing members required for performance evaluation are set.

(b) Set the Expected Performance of Existing Members

Next, it is necessary to set the performance expected for the existing members. To do so, check the purpose of improvement of the facilities concerned and set the performance requirements and design service life targeting the entire facility and according to the purpose of improvement. Based on these factors, select a candidate for the existing members reused for the improvement of the facilities concerned and set their expected performance.

(c) Evaluate the Performance of Existing Members

Next, it is necessary to evaluate the performance of existing members. To do so, estimate performance degradation of reused existing members during the design service life, and properly evaluate if the expected performance is maintained throughout that period. Then, judge their reusability by referring to **Fig. 2.4.4** and organize as premises (material conditions) for improvement design.

When judging reusability, note that existing members can be reused as they are if the performance is ensured throughout the design service life, but if not, they may become reusable by taking countermeasures such as repairs or reinforcement. If such countermeasures are not available, it will be necessary to plan measures in the maintenance stage and reuse the existing members, or determine if their reuse will be difficult. In situations where existing members are conditionally reused, their design is carried out assuming that the existing members will be subject to major repairs or reinforcement during the design service life. When the reuse of existing members is judged to be too difficult, determine if the members concerned will be removed or left where they are in consideration of the influence they will have on the improvement of the facilities.

The key fundamental of performance evaluation is quantitative verification of expected performance through analysis based on actual measurement data obtained from detailed investigations. However, if it is necessary to reuse members and portions whose actual measurement data are not available from investigations, or to reuse members and portions for which the usage conditions of the facilities make investigation itself difficult, or which are underwater or underground and make investigation difficult, it is necessary to have experts or professional engineers judge whether the performance throughout the design service life may be ensured based on estimates of the degree of transitional deterioration of existing members or past records of similar members.

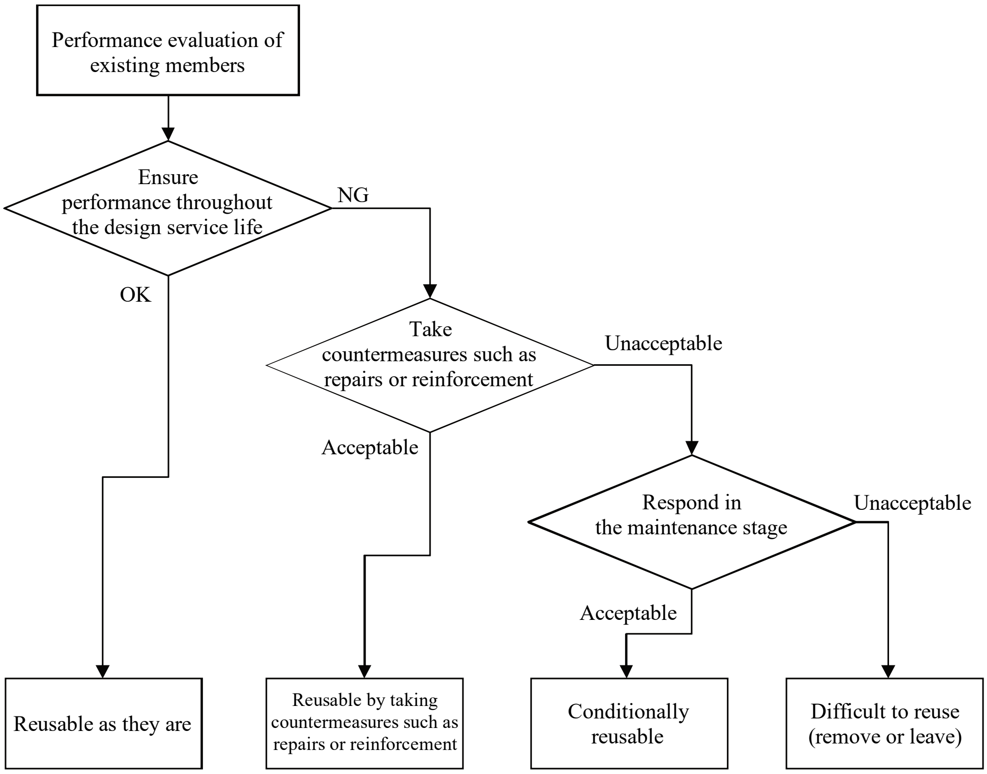

Fig. 2.4.4 Judgement Flowchart of Reusability for Existing Members

(d) Reflect the Results of the Evaluation

The results of the performance evaluation of existing members shown in (c) need to be reflected as material conditions to be an important prerequisite for determining the structural cross-sections and other components. Next, the reasoning behind the judgement made, including whether it was evaluated quantitatively or qualitatively, needs to be clearly recorded in the design document or other documgents together with the results of the judgement regarding reusability.

③ **Influence from joining existing members and new members**

As for joining members and materials in existing facilities with newly added members and materials in improvement design, it is necessary to consider how reliably they are joined, and that deterioration or corrosion is not accelerated by joining members and materials with different characteristics.

(7) Construction Conditions

For the improvement design of existing facilities, it is important to adequately investigate and coordinate in-service (operation) conditions and other conditions of the facilities concerned as well as neighboring facilities before undertaking the improvement design and setting the design conditions because they constrain the construction method, range, time and period, and considerably influence the selection of construction method for improvement, construction period and cost. Such conditions may include, for example, the availability of an alternate facility at the time of construction, berth shift or in-service construction, and constraints on offshore or onshore construction.

In regard to construction for the improvement of existing facilities, it is necessary to properly set conditions to limit construction works, including the construction procedure and preliminary investigation, so as not to incur structurally unstable conditions during construction because there is a possibility that structural capacity of existing members has been lowered beyond what was expected.

(8) Maintenance Conditions

When setting maintenance conditions for the improvement design of existing facilities, same as in the design of new facilities, it is required to consider conditions which make it easier to inspect each structural member and respond to deterioration or damage. The improvement of existing facilities assumes efficient reuse of existing members, and additional members due to improvement may bring about more complicated structures than the originally constructed cross-sections. Thus, it is desirable to select structural cross-sections and members which make maintenance easy.

(9) Consideration for Events Exceeding the Design Conditions

As consideration for events exceeding the design conditions for the building or improvement of facilities, it is desirable to set structural cross-sections and members so that local damage and collapse of the facilities concerned due to unexpected actions do not catastrophically impact the whole facility. Thus, for existing members for which it is difficult to quantitatively evaluate their soundness or remaining capacity, it is desirable to avoid designs that ask for excessive redundancy. Instead, it is preferable to make structural designs that anticipate robustness, with using newly installed members and existing members whose structural capacity has been quantitatively evaluated.

(10) Consideration for Environment

Whether facilities are newly built or improved, considerations for environment such as preservation of the port environment, formation of a good port landscape and ensuring of port security, should be done considering the surrounding conditions the facilities concerned.

Even if the existing facilities are improved only aiming to extend their working life, increasing new social demands such as the reduction of CO_2, consideration for landscape and amenity-oriented facilities, preservation as a Civil Engineering Heritage site and demand for symbiosis port structures, should be well considered in the improvement design.

(11) Economic Efficiency

For the improvement design of existing facilities, it is necessary to adequately consider construction, maintenance and conditions the facilities concerned are put into, and to compare the economic efficiency of improvement costs and set cross-sections, used materials and other components.

As indices of economic efficiency, improvement costs (including compensation costs), direct costs such as maintenance costs (e.g., repair costs, reinforcement costs, inspection costs) and demolition costs, as well as indirect costs such as losses accompanying a suspension of service due to improvement work may be considered.

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3 Construction of Facilities Subject to the Technical Standards

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

3.1 General

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

3.2 Details and Others to Specify as a Construction Plan

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

3.2.1 General

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

3.2.2 Basic Points in Construction

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

3.2.3 Preparation of a Construction Plan

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

3.3 Details to Specify as a Construction Method

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

3.4 Details and Others of Construction Management

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

3.4.1 General

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

3.4.2 Construction Management

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

3.5 Details of Safety Management

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

3.5.1 General

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

3.5.2 Application of Safety Management

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

3.5.3 Items to be Considered in Offshore Operation

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

3.6 Construction Managers and Safety Managers

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

3.7 Stability during Construction

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

4 Maintenance of Facilities Subject to the Technical Standards

[Ministerial Ordinance] (Maintenance of Facilities Subject to the Technical Standards)

Article 4

1 Facilities subject to the Technical Standards shall be properly maintained according to their maintenance programs (including items related to inspections) to satisfy their performance requirements through their working life.

2 Maintenance of facilities subject to the Technical Standards shall be carried out while considering environmental conditions, usage conditions and other conditions to which the facilities are subjected as well as structural characteristics, material characteristics, etc.

3 For maintenance of facilities subject to the Technical Standards, necessary maintenance work and other activities shall be appropriately executed upon a comprehensive assessment in the state of the facilities in its entirety based on the results of periodic and extraordinal inspection and diagnosis of deformation such as damage and deterioration.

4 For maintenance of facilities subject to the Technical Standards, the result of the preceding paragraph and other items necessary to properly maintain the facilities shall be properly recorded and stored.

5 For maintenance of facilities subject to the Technical Standards, appropriate safety countermeasures shall be undertaken, which include establishing well-defined operational manuals and other methods of hazard prevention, to ensure the safe usage of the facilities and other surrounding facilities.

6 Requirements other than those specified in the preceding paragraphs for the maintenance of facilities subject to the Technical Standards shall be provided by the Public Notice.

[Interpretation]

6. Maintenance of Facilities Subject to the Technical Standards

(1) Maintenance of Facilities Subject to the Technical Standards (the interpretation related to Article 4 of the Ministerial Ordinance)

① Since facilities subject to the Technical Standards are generally placed under severe natural conditions, performance degradation during the design working life of the facilities is often caused by material deterioration, damage of members, scouring, settlement and sedimentation of the foundation mounds. Planned and proper maintenance is hence needed to prevent the facilities concerned from failing to satisfy their performance requirements during their design working life. Therefore, effective and accurate maintenance plans shall be established.

② Facilities subject to the Technical Standards need to be properly maintained based on the appropriate maintenance plans and criteria taking into account structural types, structural characteristics of members, and types and qualities of materials, as well as the natural conditions surrounding the facilities concerned, their usage status, future plans, design working life, importance, substitutions and difficulty levels in inspection, diagnosis and maintenance work.

③ Maintenance of facilities subject to the Technical Standards means a series of actions to accurately grasp changes in the facilities, such as degradation and damage through timely and appropriate inspections and diagnoses, comprehensively evaluate the results and take proper measures such as necessary maintenance work.

Here, “damage” refers to changes in structures or members caused by accidental actions, and “deterioration” means slow changes in the qualities and characteristics of materials caused by environmental effects over a period of time. Damage and degradation, including displacement and deformation occurring in structures and members, is collectively called “changes of structures and members.”

④ The maintenance of facilities subject to the Technical Standards requires planned and proper inspection and diagnosis, comprehensive evaluation, and maintenance work of the facilities concerned. When analyzing methods and other aspects of inspection and diagnosis, it is desirable to assess how to improve accuracy, efficiency and other areas of the monitoring method by utilizing ITC, etc.

Maintenance work required as a result of a comprehensive evaluation includes not only measures on the hardware side, such as maintenance work, repair work and strengthening work to recover the performance of structures and members and prevent performance degradation from occurring, but also measures on the software side, such as restriction of use, suspension of use and prohibition of entry.

⑤ Since the results of inspections, diagnoses, comprehensive evaluations, maintenance work described in the maintenance plan and other items required for maintenance of facilities are essential for efficient maintenance, they need to be properly recorded and stored during the working life together with design, construction and other data.

⑥ Since facilities subject to the Technical Standards include not only structures such as protective facilities for harbor and mooring facilities, but also mechanical equipment such as cargo handling facilities and passenger boarding facilities, the maintenance of facilities subject to the Technical Standards requires the proper use and operation of the facilities concerned by sufficiently taking account of their characteristics. Furthermore, the use of the facilities requires specifying in advance actual safety measures, responsibility, and operational rules in order to widely ensure safety to the operators and the general public, not only during normal operation, but also in rough weather, and to prevent other port facilities integrally functioning with the facilities concerned, such as the quaywalls where cargo handling facilities are installed, from having operational difficulties.

4.1 General

(1) Maintenance should be continuously performed over the design working life specified by the maintenance plans so that the performance of the structures and members of the facilities does not fall below the required level. For maintenance, it is desirable to assure the maintenance level required for structures or members and items considered at each stage to smoothly conduct inspection, diagnosis, maintenance work and other activities in the records of design and construction stages, and to consider and devise ways to make it possible to maintain more efficiency in the maintenance stage. Here, the working life refers to the period during which the facilities are in service. The working life may be considered as the design working life of the facilities concerned at the initial stages of their construction or improvement.

(2) Performance degradation of the structures or members of facilities progresses slowly, such as the deterioration of structural materials, ground settlement and washing out of sand. Facilities subject to the Technical Standards are usually exposed to severe environments where structural materials such as concrete and steel are easily deteriorated, and the soft ground tends to cause sand to wash out and ground settlement. Accidental actions such as earthquakes and impact loads may also cause sudden damage to the facilities.

(3) Maintenance of facilities subject to the Technical Standards is a series of procedures for grasping changes such as the degradation of structures or members due to damage caused by their physical changes and aging deterioration through timely and accurate inspection and diagnosis, as well as comprehensively evaluating the results and taking proper measures such as necessary maintenance work. This process needs to be performed based on appropriate plans and criteria. Here, the appropriate plans refer to the maintenance programs described in **Part I, Chapter 2, 4.2 Planning of Maintenance Programs and the Implementation of Items Specified in the Maintenance Plans, etc.** and appropriate criteria indicated in the **Guidelines for Inspection and Diagnosis of Port Facilities** [1], the **Technical Manual for Maintenance and Rehabilitation of Port Facilities** [2] and the **Guidelines for Planning Maintenance Programs of Port Facilities** [3] **etc.** The **Guidelines for Inspection and Diagnosis of Port Facilities** elaborates the frequency, concept of method and other items for maintenance and diagnosis of facilities subject to the Technical Standards.

(4) Generally, facilities subject to the Technical Standards do not function independently, but as a group of facilities composed of several homogeneous and heterogeneous facilities. Thus, it is desirable for plural owners or managers, if any, of a group of facilities connected closely from the viewpoint of the function of the facilities to cooperatively maintain the group of facilities. In order to efficiently and effectively maintain and renew facilities subject to the Technical Standards, there is a precautious maintenance plan, which is a midterm plan intended to specify priority and other factors regarding maintenance and renewal for each facility by ports and to level costs based on the maintenance plan developed by the facilities. **Fig. 4.1.1** is a conceptual diagram showing the relationship between a maintenance plan and a preventive maintenance plan.

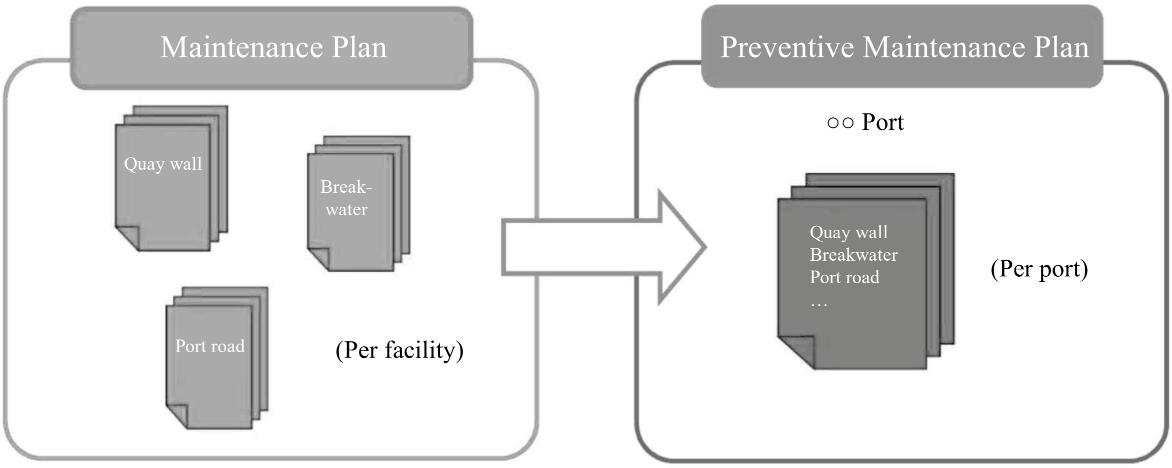


Fig. 4.1.1 Conceptual Diagram of the Relationship between a Maintenance Plan and a Preventive Maintenance Plan[10)]

(5) Results of inspections, diagnoses, comprehensive evaluations, maintenance work and other activities described in the maintenance plan and other items required for the maintenance of facilities shall be recorded and stored properly together with design, construction and other data. Since they are essential for efficient maintenance, they shall be stored throughout the working life. Recording methods, space for storage and other items should be pre-determined for easy reference to the records. To efficiently manage a large amount of data from many facilities, it is desirable to utilize an efficient database system such as a general-purpose data management system or the maintenance information database promoted by the Port and Harbour Bureau of the Ministry of Land, Infrastructure, Transport and Tourism.

(6) Specially designated facilities subject to the Technical Standards (facilities subject to the Technical Standards which are protective facilities for harbors residing within 20 meters inside and outside of the port area; mooring facilities; bridges; roads, railways and tracks with tunnel structures; fixed and track running cargo handling equipment; and waste disposal sites (Article 28, Paragraph 22 of the Ordinance for Enforcement of the Ports and Harbours Act) need to be properly maintained based on the maintenance plan and other plans so as to meet the performance requirements during the working life. It is important for port managers to understand if they are properly maintained by collecting reports from private businesses and other entities and by other measures. Procedures and ideas for methods when port managers collect reports from managers of specially designated facilities subject to the Technical Standards such as private businesses and on-the-spot inspections are summarized in the **Guidelines for Collection of Reports, On-the-Spot Inspection and Others on Specially Designated Facilities Subject to the Technical Standards** [4)], which may be referred to.

(7) A variety of research and development, such as installation of sensors in structures and utilization of unmanned aircraft (drones), are in progress as new technology development for facility inspections [5) 6) 7)]. It is desirable to improve efficiency by considering characteristics of, studying and applying these technologies (including combining them with traditional methods).

(8) Details on the maintenance of facilities subject to the Technical Standards are specified in the Public Notice for Maintenance.

4.2 Formulation of Maintenance Programs and Implementation of Subjects Specified in the Maintenance Plans, etc.

[Public Notice for Maintenance]

(Definition of Terms)

Article 1

Terms used in this public notice are listed in the examples used in the ministerial ordinance to set forth the Technical Standards for Port and Harbour Facilities(Ordinance No.15 of the Ministry of Land, Infrastructure, Transport and Tourism of 2007; hereinafter called “Ministerial Ordinance”.)

(Maintenance Programs and Related Plans)

Article 2

1 The owners of the facilities subject to the Technical Standards shall normally prepare maintenance plans.

2 Maintenance programs and others shall set forth timing for planned and proper inspections and diagnoses of deformation such as damage and deterioration of the facilities concerned, target regions, methods and other areas.

3 In addition to the preceding two provisions, maintenance plans shall be specified the subjects in the following items:

(1) The basic concepts of design working life of the facilities and the maintenance of the facilities as a whole and their structural members

(2) Planned and proper maintenance work on deformation such as damage and deterioration in the state of the facilities

(3) Maintenance efforts other than those listed in the preceding two items required for maintaining the facilities concerned in a good state

4 The formulation determination of maintenance plans shall take into account the conditions under which the facilities concerned are placed based on Article 6 of the Ministerial Ordinance, such as design working life, structural characteristics, material characteristics, difficulty levels in inspection, diagnosis, maintenance work and the degree of importance of the facilities concerned.

5 For formulating the maintenance plans, it is recommended to consult with experts who have technical knowledge on maintenance such as damage to the facilities concerned, inspections and diagnoses of deformation such as damage and deterioration in the state of the facilities, comprehensive assessment of the maintenance of the whole facilities, maintenance work and other maintenance activities. The above shall not apply, however, to cases where the persons responsible for the maintenance programs are experts in these fields.

6 Maintenance plans shall normally be modified when required by changes in uses of the facilities concerned or innovations in maintenance technologies.

7 Provisions for the fourth and fifth items shall apply to the modification of maintenance programs.

(Implementation of Items Set Forth in the Maintenance Programs, etc.)

Article 3

Items set forth in the maintenance programs and others shall normally be implemented under the direction of persons with professional knowledge and skills regarding the inspection and diagnosis of damage, deterioration and other abnormalities of the facilities concerned, comprehensive evaluation of maintenance of the whole facilities, maintenance work and other activities.

(Inspection and Diagnosis of the Facilities Subject to the Technical Standards)

Article 4

1 The facilities subject to the Technical Standards shall be inspected and diagnosed at a proper time and with a proper method in consideration of the conditions set based on Article 6 of the Ministerial Ordinance and to which the facilities concerned are subject, as well as the design working life, structural characteristics, material characteristics, difficulties of inspection, diagnosis, maintenance work and significance of the facilities.

2 The facilities subject to the Technical Standards shall be periodically inspected and diagnosed within every five years (or within every three years if destruction of the facilities concerned could significantly affect human lives, property or social and economic activities.)

3 For revetments, quaywalls and piled piers managed by those other than the port managers (except for national and local governments) which may significantly prevent traffic of vessels in waterways and basins (only navigation channels and basins that ensure the function of quaywalls and piled piers, of which only those specified in the port plan set forth in Article 3, Paragraph 3 Item 1 of the Port and Harbour Law as applied to the port as facilities to prevent damage caused by large-scale earthquakes), as well as facilities that prevent damage caused by large-scale earthquakes set forth in Article 16 of the Ministerial Ordinance (Ordinance of the Ministry of Transport No. 35 of 1974) that specify the criteria for basic port planning items within the port area adjacent to emergency navigation channels set forth in Article 55, Paragraph 3, Item 5-1 of the Port and Harbour Law (Act No. 218 of 1950), and specially designated facilities subject to the Technical Standards set forth in Article 56, Paragraph 2, Item 21-1 of the Port and Harbour Law destroyed in disasters, periodic inspection and diagnosis shall be conducted within every two years notwithstanding the provisions of the previous paragraph.

4 Detailed inspection and diagnosis among periodic inspections and diagnoses set forth in the previous two paragraphs shall be conducted with proper timing in consideration of the significance of the facilities concerned.

5 The facilities subject to the Technical Standards shall be inspected and diagnosed according to Paragraphs 2 and 3, daily and ad interim as appropriate.

[Interpretation]

6. Maintenance of the Facilities Subject to the Technical Standards

(2) Maintenance Programs, etc.(Article 4 of the Ministerial Ordinance and the interpretation related to Article 2 of the Public Notice)

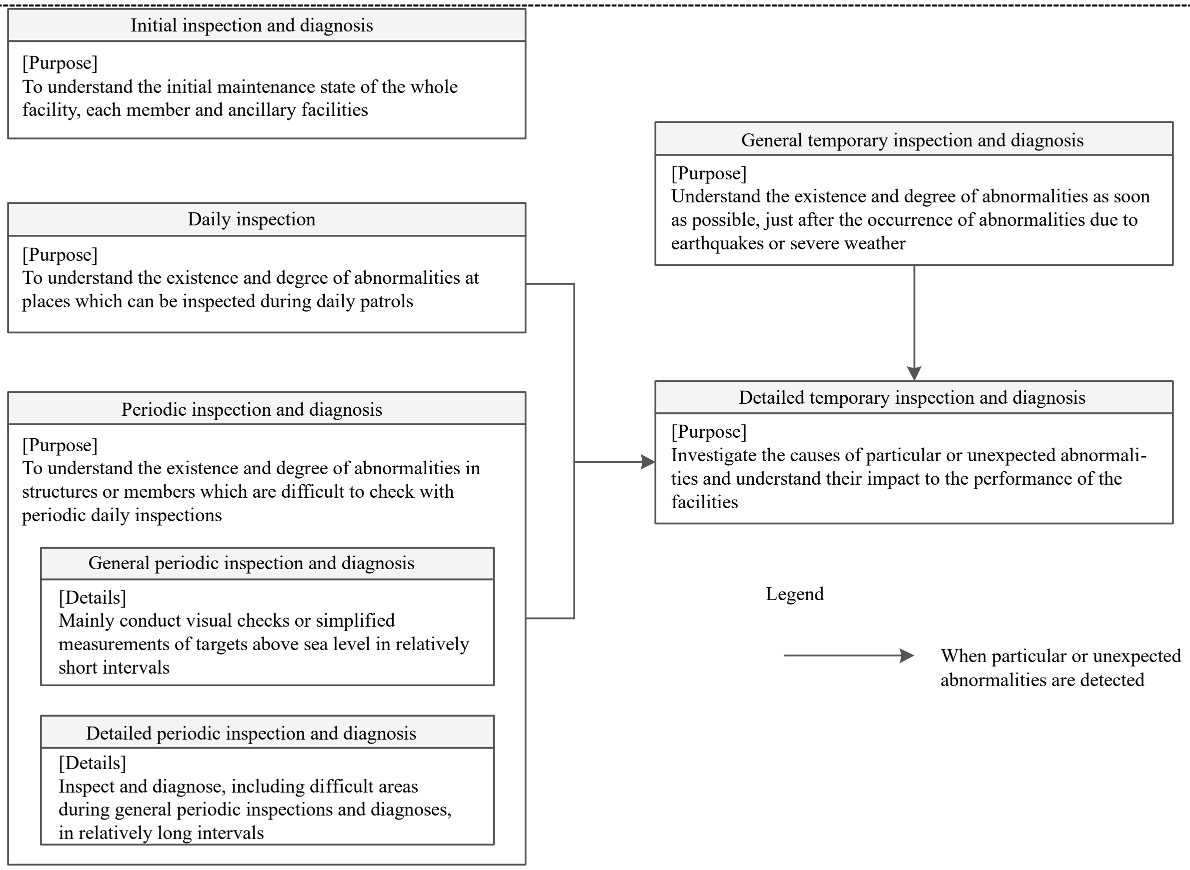
① The owners of facilities subject to the Technical Standards must prepare maintenance programs at the initial time of maintenance.

② The determination of maintenance programs as standards of maintenance programs, etc. shall properly specify the maintenance levels shown in **Attached Table 6.1** as the basic concepts of maintenance, taking account of the objectives for installing the facilities concerned, their design working life and performance requirements.

Attached Table 6.1 Maintenance Levels of Facilities Subject to the Technical Standards

Classification	Concept of dealing with damage and deterioration
Maintenance level I	Implementing high-level measures against damage and deterioration to prevent the facilities concerned from failing to satisfy performance requirements during their design working life
Maintenance level II	Preventing the facilities concerned from failing to satisfy performance requirements during their design working life at a stage of minor damage and deterioration
Maintenance level III	Allowing a certain degree of performance degradation within the scope of meeting performance requirements and implementing large-scale measures once or twice in a design working life to deal with damage and degradation ex post facto

③ In the maintenance program, the inspection, diagnosis and others shown in **Attached Fig. 6.1** shall be properly specified in order to efficiently and accurately understand the existence and degree of abnormalities at the facilities concerned. Maintenance plans shall specify the methods, details and implementation timing for inspection and diagnosis, comprehensive evaluations and maintenance work according to the maintenance levels of the facilities. In formulating the plans, it is necessary to consider the conditions under which the facilities are placed, their design working life, structural characteristics, material characteristics, difficulty levels in inspections, diagnoses and maintenance work, and the importance of the facilities. The future performance changes over time for the structural members of the facilities shall also be considered.



Attached Fig. 6.1 Types, Purposes and Other Factors regarding Inspections and Diagnoses

④ Since professional knowledge and advanced technology or skills for the maintenance of the facilities concerned are often required when developing a maintenance program, the opinions of professional engineers who have these capabilities shall normally be collected.

⑤ Items of maintenance programs to be orderly and properly conducted shall be clearly depicted in a maintenance program document.

(3) Implementation of Items Specified in Maintenance Programs and Others (Interpretation related to Article 4 of the Standard Ministerial Ordinance and Articles 3 and 4 of the Public Notice for Maintenance)

① To carry out maintenance based on the maintenance program for facilities subject to the Technical Standards and others, inspect, diagnose, conduct comprehensive evaluations and take proper measures such as required maintenance work by carefully considering the conditions around the facilities concerned, their structural types, material characteristics and the mechanism behind linked changes.

② Inspection of facilities subject to the Technical Standards needs to be done efficiently and effectively based on units of members and the criteria for determining the degree of deterioration predetermined in the inspection and diagnosis program according to the type and structural type of the facilities concerned. Periodical inspection and diagnosis shall be properly conducted based on the significance and other factors regarding the facilities using **Attached Tables 6.2** and **6.3** as a standard.

Attached Table 6.2 Concept of the Timing of Periodical Inspection and Diagnosis

Type of inspection and diagnosis		Facilities subject to normal inspection and diagnosis	Facilities subject to focused inspection and diagnosis
Periodic inspection and diagnosis	General inspection and diagnosis	• At least once within every 5 years	• At least once within every 3 years
	Detailed periodic inspection and diagnosis	• At least once with appropriate timing during the working life • During the extended working life	• At least once within every 10-15 years • Specially designated facilities subject to the Technical Standards facing main navigation channels, etc., at least once within every 10 years

Attached Table 6.3 Concept of Setting Normal/Focused Inspection and Diagnosis for Facilities

	Concept of setting
Facilities subject to normal inspection and diagnosis	Facilities subject to the Technical Standards but not subject to focused inspection and diagnosis
Facilities subject to focused inspection and diagnosis	Comprehensively determined facilities whose destruction may significantly impact human lives, property or social and economic activities, in consideration of the degree of progression of abnormalities in reference to the examples below: (Example of facilities of significance) ① Facilities that significantly impact economic activities (used for trunk line cargo transport or hazardous cargo handling, and specially designated facilities subject to the Technical Standards facing main navigation channels, etc.) ② Important facilities for disaster prevention (high earthquake- resistance quaywalls, tsunami protection breakwaters, etc.) ③ Facilities whose destruction significantly impacts human lives (facilities used by passengers, etc.)

③ When it is determined that maintenance work and other activities are necessary, the method and timing of maintenance and repair must be assessed while considering the effects to performance improvement, economic efficiency, constructability, natural environmental conditions, influence on cargo handling and other uses, and other factors based on the maintenance and repair plan set forth in the maintenance program and others.

④ Since inspections, diagnoses, comprehensive evaluations, maintenance work and other activities stated here often require related professional knowledge and advanced technology or skills, they shall normally be conducted under the direction of qualified engineers.

⑤ Maintenance programs such as inspection and diagnosis plans, maintenance and repair plans need to be reviewed as necessary reflecting the result of inspection, diagnosis and comprehensive evaluation and history of maintenance work, etc.

⑥ Article 4, Paragraph 3 of the Public Notice for Maintenance stipulates a measure resulting from the special taxation measures to ensure earthquake-resistant performance of revetments, quaywalls, piled piers and other structures along navigation channels leading to high earthquake-resistance quaywalls at ports that connect navigation channels for emergencies. Refer to the notification "Receipt, certification and others by port managers on the special depreciation for earthquake-resistance repair work of specially designated facilities subject to the Technical Standards" (Government Port Marine No. 266 of 2018).

4.2.1 General

(1) The owners of the facilities concerned shall normally prepare the maintenance programs of the facilities. The development of the programs need a consistent philosophy throughout the planning, design, construction and maintenance of the facilities, and it is hence most reasonable for the owners of the facilities who are the most familiar with these processes to develop the programs.

(2) Maintenance plans aim to deliberately and properly maintain the facilities concerned, and maintenance programs shall be normally used to specify the maintenance program documents. Other methods may also be used if they substantially cover the items specified in the maintenance program documents to properly maintain the facilities concerned.

(3) The development of maintenance programs shall materialize the basic concepts of maintenance (refer to **Part I, Chapter 2, 2.1.4 Basic Concepts of Maintenanceer**) to the actual work levels of the facilities concerned upon sufficiently assessing what their maintenance should be and possible changes based on the installation objectives, design working life and performance requirements.

(4) Facilities subject to the Technical Standards shall maintain the performance requirements corresponding to the maintenance levels shown in **Table 4.2.1** at any time during their design working life. For this purpose, the initial design must satisfy the designated maintenance levels and properly take account of the smooth implementation of inspections, diagnoses and maintenance works corresponding to the designated maintenance levels.

(5) The setting of maintenance levels shall be conducted by estimating the performance changes over time of the facilities concerned from the conditions surrounding the facilities such as natural environmental conditions and usage conditions, the structural types of the facilities and the characteristics of their structural members, as well as the types and quality of the materials used for the facilities, based on the installation objectives, design working life and performance requirements of the facilities. Maintenance levels are normally set for the whole facility, but in most actual cases, estimating the performance changes over time of the whole facility is difficult, and setting the same maintenance levels for all members and ancillary equipment is unreasonable. Proper maintenance levels shall be hence set for each structural member of the facilities concerned, taking account of the assessment results of the performance changes over time of the structural members of the facilities and the difficulty levels in inspections, diagnoses and maintenance work, the importance of the facilities, and drawing up a maintenance scenario for the facilities as a whole. **Table 4.2.1** shows the concept of setting the maintenance level.

(6) Maintenance programs shall specify inspection and diagnosis plans and the methods, details, timing, frequencies, procedures, etc., of maintenance work, corresponding to the maintenance levels of the facilities concerned and following the basic stages of maintenance. The proposal of maintenance plan is normally composed of an overview summarizing the basic concept of maintenance and conditions in which facilities are placed, the inspection and diagnosis plan, comprehensive evaluation, maintenance and repair plans, etc. (Refer to **Fig. 4.2.1.**)

(7) The preparation of maintenance program documents may apply to the Guidelines for the Formulation of Maintenance Programs for Port Facilities [3], the Guide for the Preparation of Maintenance Program Documents for Port Facilities [8] and the Basic Concepts for the Preparation of Maintenance Program Documents for Port Facilities [9]. The Guideline for the Formulation of Maintenance Programs for Cargo Handling Equipment [10] may be applied to cargo handling equipment at ports.

(8) For specific inspection and diagnosis methods and details of maintenance and repair construction methods to maintain facilities subject to the **Technical Standards, the Guideline for Inspection and Diagnosis of Port Facilities** [1] and the **Technical Manual for Maintenance of Port Facilities** [2] may be applied.

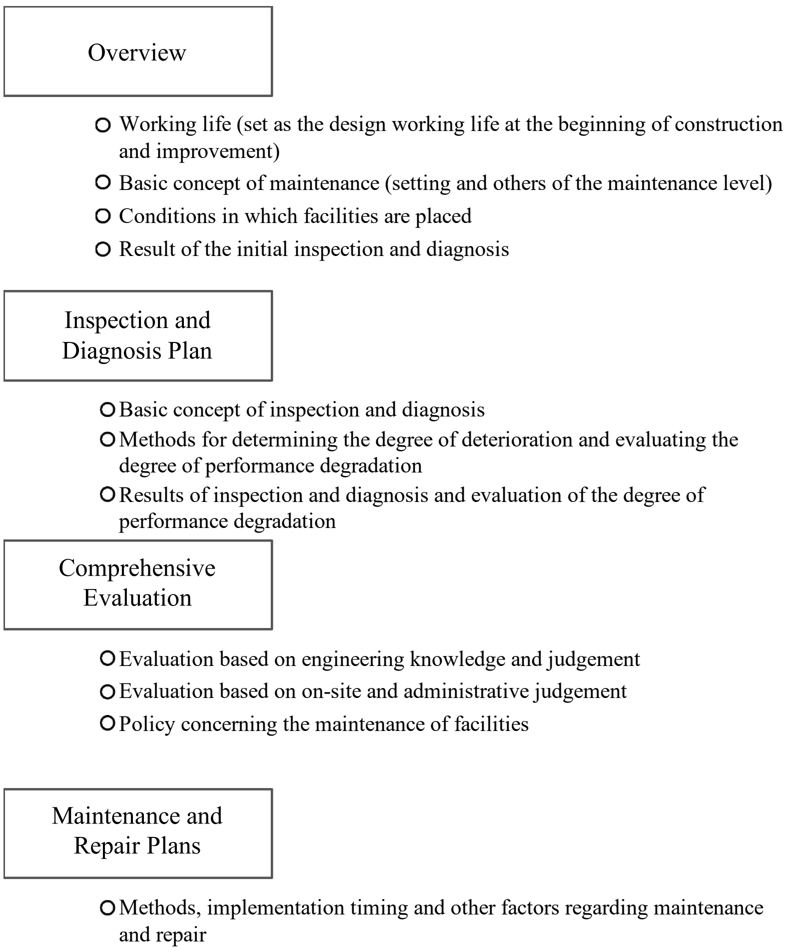
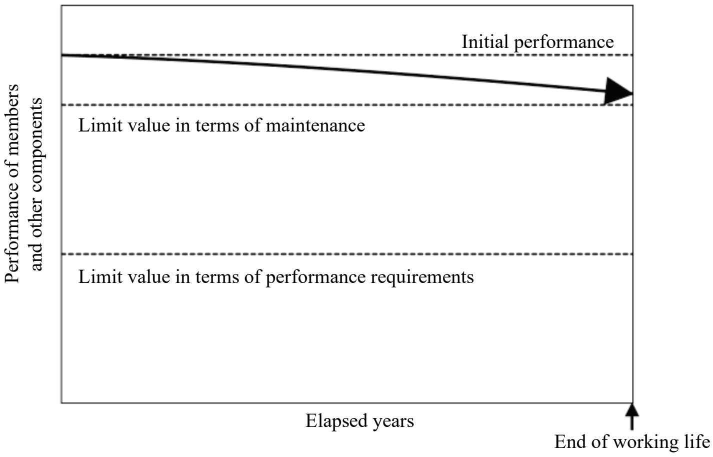
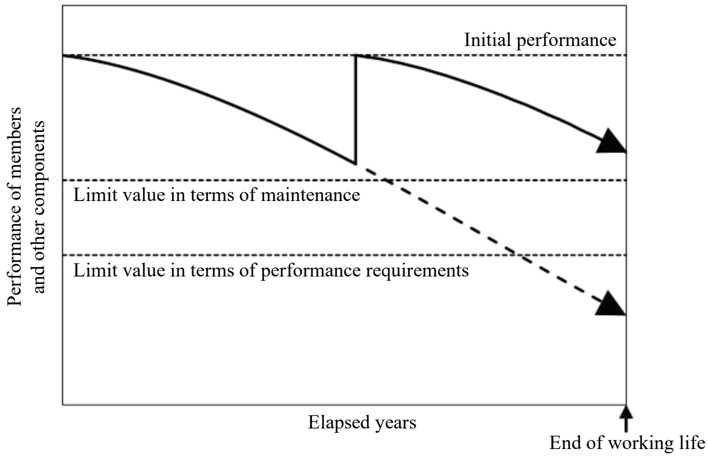
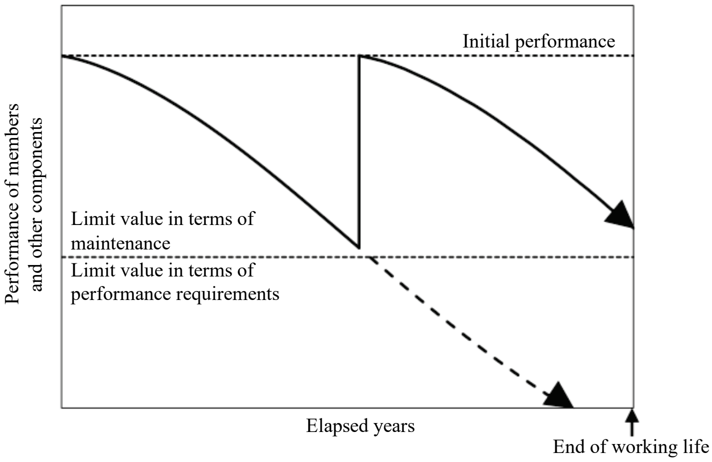


Fig. 4.2.1 Standard Configuration and Details of the Proposal of Maintenance Plan

Table 4.2.1 Maintenance Level of Members and Other Components

Concept of maintenance levels based on the estimated performance degradation of members and other components	
Maintenance level I The maintenance level for members and other components that have been verified that abnormalities due to damage, degradation and other hazards that affect the performance of members and other components during the working life are sufficiently minor (the maintenance limit state is not reached) in the estimation of performance degradation.	 Diagram of performance degradation at Maintenance level I
Maintenance level II The maintenance level for members and other components that are designed to enable maintenance and repair before the limit state in maintenance is reached by planning at the design stage to maintain and repair during the maintenance stage, even though the occurrence of abnormalities that influence the performance of members and other components (the limit state in maintenance) within the working life is anticipated in the estimation of performance degradation.	 Diagram of performance degradation at Maintenance level II
Maintenance level III The maintenance level for members and other components that are supposed to be maintained and repaired before they fail to meet the performance requirements because the maintenance at Maintenance level II is difficult or uneconomical, even though performance degradation of the members and other components due to abnormalities is anticipated in the estimation of performance degradation.	 Diagram of performance degradation at Maintenance level III

4.2.2 Inspection and Diagnosis

(1) General

① Since the changes in the state of structural members of facilities subject to the Technical Standards due to damage and degradation are strongly correlated with each other, inspection and diagnosis plans must select items, methods and procedures for efficient and effective inspections with a full understanding of the linked changes described in Item ②.

② Facilities subject to the Technical Standards have relatively complex structures and their structural members are correlated with each other, and since various external factors act on the structures, the occurrence and development of changes are complicated. Therefore, it is desirable for reasonable maintenance to select inspectable changes that have a significant impact on component performance as major changes in the state of the structure, and conduct an inspection and diagnosis. The selection of major changes in state shall fully take account of the linked changes, which are the progressive processes of the causes, occurrence and effects of changes resulting in the performance deterioration of the facilities. Focusing on and making an inspection and diagnosis of the most important linked changes is useful for reasonable maintenance. Refer to Sakata et al.[11] and Kato et al.[12] for the linked changes.

③ The implementation of planned and proper inspections and diagnoses based on the above-mentioned concept of linked changes is essential to effectively detect changes which have occurred at the facilities subject to the Technical Standards. The following constitute the inspections and diagnosis of such facilities:

(a) Initial inspections and diagnoses: Performed to understand the initial maintenance state of not only the facilities concerned as a whole, but also their members and ancillary equipment at the completion stages of construction or improvement work, or at the preparation stages of maintenance programs for the existing facilities. When inspections and diagnoses are performed after the completion of construction or improvement work, the initial state may be understood based on the results of quality inspections and workmanship inspections performed at the time of completion, although it is preferable that they be performed within two years after completion.

(b) Daily inspections: Performed to check routinely inspectable parts for changes in state and to what degree.

(c) Periodic inspections and diagnoses: Performed to periodically check routinely uninspectable structures and members including the details of changes in state and to what degree. These tasks are classified into general periodic inspections and diagnoses and detailed periodic inspections and diagnoses. The former are conducted on parts above sea level, mainly through visual inspections or simplified measurement at relatively short intervals. The latter are conducted at relatively long intervals and their objects include the parts on which the former are unpractical.

(d) General ad hock inspections and diagnoses: Performed to check the facilities for changes and to what degree, mainly through visual inspections or simplified measurement at the earliest possible stage at abnormal times after the occurrence of earthquakes or rough weather.

(e) Detailed temporary inspections and diagnoses: Performed when particular or unexpected abnormalities are found from the results of periodic or general temporary inspections and diagnoses.

④ In order to ensure objectivity, reliability and consistency of the inspection and diagnosis results, items, methods, procedures and decision criteria of inspections and diagnoses must be unified to some extent. Refer to the **Guideline for Inspection and Diagnosis of Port Facilities** [2] for these topics. Note that the degree of performance degradation should be evaluated by comprehensively assessing the impact on the performance of the facilities, not routinely from the number of results of degradation evaluation. Refer to the **Guideline for Inspection and Diagnosis of Cargo Handling Equipment at Ports** [13] for procedures and other items regarding cargo handling equipment at ports.

(2) Timing for inspection and diagnosis according to the importance of the facilities

The timing and method of inspection and diagnosis shall be properly specified in the proposal of maintenance plan in accordance with the importance of the facilities.

The public notice for maintenance specifies this as “within every five (or three) years” in Article 4, Paragraph 2 as a seemingly minimal frequency of periodic inspection and diagnosis according to importance and other factors, and the owner and manager of the facilities need to discuss and properly specify the frequency of periodic inspections and diagnoses according to the condition of the facilities concerned.

The timing of periodic inspections and diagnoses is properly set based on the units of members and the criteria for determining the degree of deterioration predetermined in the inspection and diagnosis program according to the type and structural type of facilities. However, it should be planned so as to be conducted at the same time, as much as possible, at one facility, or so that the same inspection and diagnosis items be conducted at the same time at multiple facilities for the sake of efficiency.

4.2.3 Comprehensive Evaluation

(1) General

① Comprehensive evaluation is conducted based on the results of the inspection and diagnosis, but the following actions are preplanned in the proposal of maintenance plan. Evaluation of the degree of performance degradation of facilities indicates (a), while comprehensive evaluation means judgement of the policy of facility maintenance based on (a) and (b).

(a) Summarize the result of inspection and diagnosis of members and parts, and arrange and evaluate what kind of abnormalities, such as damage and deterioration, are occurring and developing (referred to as evaluation based on engineering knowledge and judgement).

(Examples of items to arrange)

- Occurrence condition of abnormalities (arranged from the viewpoint of quantity and spatial)
- Progress of abnormalities (arranged from the viewpoint of severity by region and effects on performance)

(Examples of items to determine)

- Urgency of maintenance and repair of abnormalities (degree of performance degradation of facilities)

(Examples of items to assess)

- Occurrence condition of abnormalities in members and other components to which Maintenance level I was set (→ review the “proposal of maintenance plan”)
- Gap between estimated deterioration and actual deterioration condition of members and other components to which Maintenance level II was set (→ review the “proposal of inspection and diagnosis plan”)
- Estimation of the cause of abnormalities in members and other components to which Maintenance level III was set (→ countermeasures in operation of facilities based on the estimated cause, elimination of estimated cause, etc.)

(b) Arrange problems for conducting maintenance and repairs to deal with and assess the possibilities of a proactive response in terms of finance, usage, importance of facilities and other factors, as well as alternatives when such responses are difficult such as due to temporary actions or usage limitations (referred to as evaluation based on on-site administrative judgement).

② A tentative proposal for decision criteria indicated in the **Guideline for Inspection and Diagnosis of Port Facilities** [1] and the **Technical Manual for Maintenance of Port Facilities** [2] may be referred to.

③ If the comprehensive evaluator (manager of the facility) is not the owner of the facility, it is desirable for them to discuss a comprehensive evaluation as appropriate. The results of the comprehensive evaluation should be promptly informed to the owner in order to receive their opinion.

(2) Policy on the maintenance of facilities

① Judge the necessity of maintenance and other work based on the results of the comprehensive evaluation. Maintenance work and other activities need to be properly judged from various viewpoints such as the importance of the facilities, progress of abnormalities, economic efficiency, usage situation of the facility to which measures are taken or the surrounding facilities. In addition to maintenance and other work shown in **Table 4.2.2,** the necessity for review of the follow-up observation and inspection and diagnosis plan are judged if necessary.

Table 4.2.2 An Example of Types and Details of Maintenance Work

Type of maintenance work, etc.	Details of maintenance work, etc.
Repair	Restore initial level of performance and durability
Reinforcement	Improve performance and durability on or above the initial level
Usage limitation (suspension)	Limits on weight, velocity, lane, draft, etc.
Off-limits	Completely off-limits, authorized personnel only, etc.
Renewal	Renew if a renewal is more reasonable than repairs or reinforcement
Removal	Remove when a facility or member is no longer required

② Judge the following items when determining the policy of facility maintenance.

a) Emergency actions (determination of location and range of members requiring countermeasures as soon as possible)

Actions to limit usage by using barricades and other devices to ensure user safety. Emergency actions need to be accompanied with actions b) and c) below:

b) Temporary actions (determination of location and range of members requiring rapid countermeasures)

Actions taken with alternative members, temporary restoration (e.g., repairing pot holes in roads by filling them with stone materials, etc.), and alternative facilities to maintain the facility's function temporarily.

c) Planned actions (determination of location and range of members requiring systematic countermeasures)

Fundamental measures to be taken to restore the facility's mid- and long-term functions when there are structural problems or measures to be taken to restore the functions in advance when there are no current structural problems.

d) Follow-up actions (determination of timing, method, etc., of the next implementation)

Actions to judge the necessity for and conduct improvement of daily inspections, review of the timing for the next periodic inspection and diagnosis, and changes to the inspection and diagnosis items in order to follow and understand the abnormalities.

4.2.4 Maintenance and Repair Plans

Methods, timing and so on of predictable maintenance and repairs are preplanned in the proposal of maintenance plan according to the maintenance level, while maintenance and repair implementation plans (maintenance and repair plans) are developed from the results of comprehensive evaluations based on the results of the inspection and diagnosis. This plan will be modified each time as necessitated by the results of the comprehensive evaluations. Items to consider and procedures to develop maintenance and repair implementation plans (maintenance and repair plans) for originally unpredictable abnormalities of facilities should be clarified in advance in the proposal of maintenance plan.

4.2.5 Implementation of Maintenance Work, etc.

(1) If required, maintenance work and other activities are properly implemented based on the results of comprehensive evaluations. When implementing maintenance and repairs, conduct detailed investigations for the design, construct a scenario based on the performance requirements and working life of the structure after maintenance and repairs, and select the type and construction method of countermeasures to be applied to members. The countermeasures should be determined considering the efficiency, economic efficiency and so on for the construction of the applied method. For details regarding maintenance and repair, manuals such as the **Technical Manual for Maintenance of Port Facilities** [2), the **Manual for Corrosion Control and Repair of Steel Structures in Ports** [14)] and the **Manual for Repair and Design of Concrete Structures in Ports** [15)] may be referred to.

(2) When considering countermeasures, and if abnormalities that influence safety of port users are found, it is necessary to first take emergency actions to ensure the safety of facility users and to assess detailed temporary inspections, diagnoses and actions aiming at subsequent actions with those who have professional knowledge, technology and skills. Coordination with users and others and recording and storing details and ranges of actions are needed when taking actions. When emergency actions are taken, they shall be released after safe use of the facilities concerned is ensured by way of temporary and planned actions. **Fig. 4.2.2** shows a general flow of the concept for ensuring safety of port facilities in conducting maintenance based on the maintenance program.

Maintenance according to **Fig. 4.2.2** must be restricted to the range of emergency actions; other ranges even in the same facility are subject to planned maintenance.

(3) **Part I, Chapter 2, 2 Design of Facilities Subject to the Technical Standards** and **Part I, Chapter 2, 3 Construction of Facilities Subject to the Technical Standards** may be applied to design and construction for maintenance and repair.

4.2.6 Review of the Maintenance Plan

(1) If comprehensive evaluation is reviewed or maintenance work and other activities are conducted in response to the results of the inspection and diagnosis, the maintenance plan will be reviewed. It shall normally include review by the owner of the facility and discussion with the manager of the facility.

4.2.7 Professional Engineers

(1) Professional engineers having knowledge and skills at least need to complete training and courses to acquire the necessary knowledge or gain the equivalent abilities, and are preferably professional engineers (construction) or have private qualifications registered with the Ministry of Land, Infrastructure, Transport and Tourism's Registered Engineer qualification system.

(2) If a person who makes decisions for the maintenance program and other programs for the facilities concerned has ample work experience in maintenance of the facilities subject to the Technical Standards and has professional knowledge and skills, there is no need to get other professional opinions, but this person may develop a maintenance or other program and carry out the items defined in the program. Otherwise, it is desirable to utilize the abilities of contracted persons or institutions that can properly serve to develop a maintenance program.

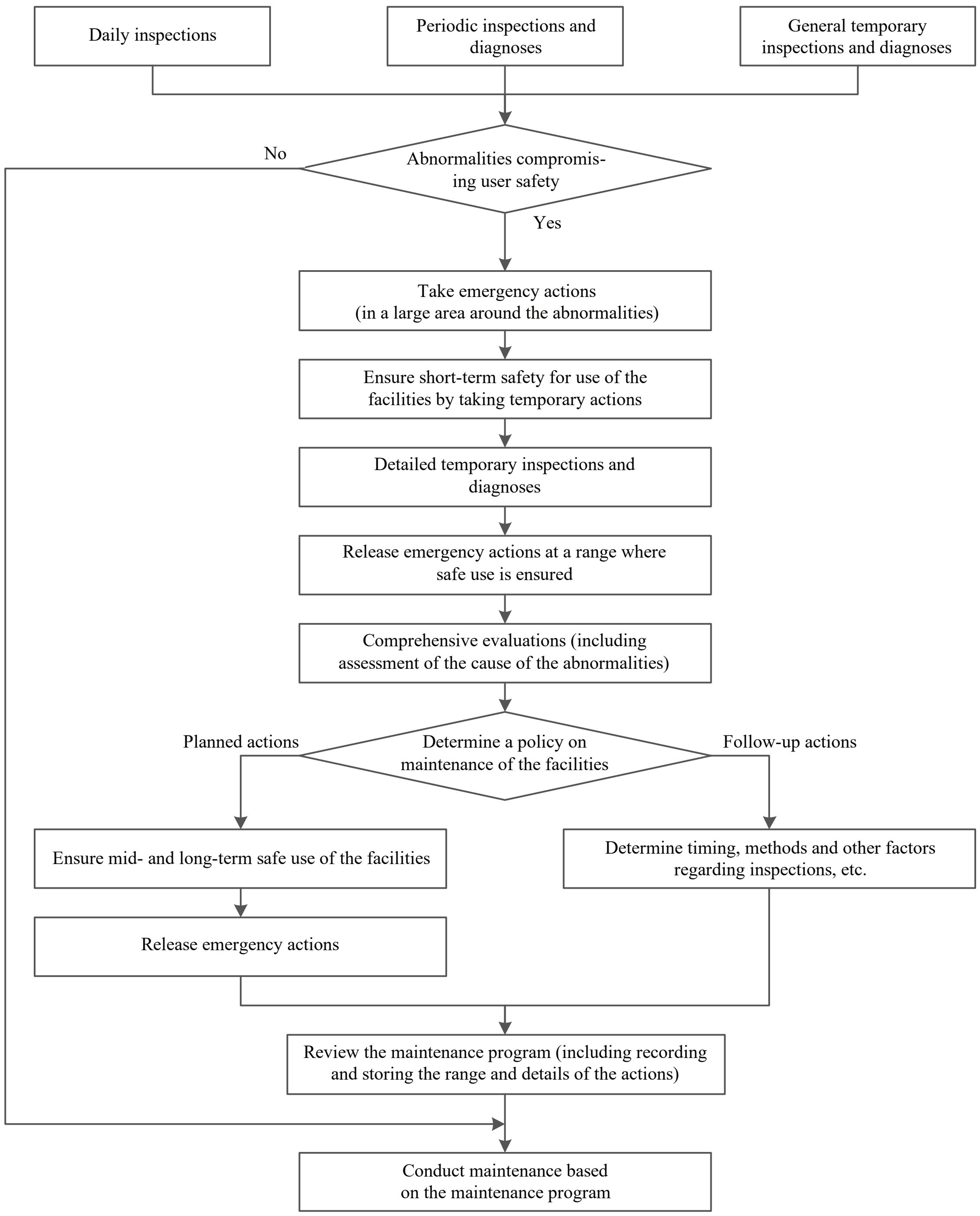


Fig. 4.2.2 General Flow of Concept for Ensuring Safety of Port Facilities in Conducting Maintenance Based on the Maintenance Program

4.2.8 Record

Refer to **Part I, Chapter 2, 4.1 General (5)**.

4.3 Countermeasures for Hazard Prevention

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

4.3.1 Professional Engineers

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

4.4 National Port Facilities Managed by Commissioning

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

4.5 Countermeasures for Suspended Facilities

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

Chapter 3 Consideration for Environment

[Ministerial Ordinance] (Consideration for Environment)

Article 5

1 The design, construction and maintenance of facilities subject to the Technical Standards shall endeavor to consider preserving the environment around a port, forming good port landscapes and ensuring security of the port, by considering the environmental conditions, usage conditions and other conditions to which the facilities are subjected.

2 Installation of facilities subject to the Technical Standards to be utilized by an unspecified large number of people shall endeavor to consider the safe and smooth usage of the facilities by seniors , minorities and others whose daily or social lives are restricted due to physical limitations while considering environmental conditions, usage conditions and other conditions to which the facilities are subjected.

1 Fundamental Idea

It is desirable for the design, construction and maintenance of facilities subject to the Technical Standards to consider the natural environment, the good regional landscapes and securing safety, taking account of the constructability, economy and other factors of the facilities concerned when determining their layouts, scales and specifications, as well as selecting the structural types, materials used and construction methods. As consideration for preserving the port's natural environment, it is necessary to focus on creating a good natural environment, as well as ensuring to reduce the negative effects on the environment as much as possible. For the creation of good natural environments such as beaches, in particular, a comprehensive planning method, which is an integrated approach through the design, construction and maintenance of the facilities concerned, and an adaptive management method taking account of the variability and uncertainty of the natural environment can be applied. Here, the elements of a port's natural environment include water quality, bottom sediment quality, air quality, living organisms and ecosystems. It is expected for the design, construction and maintenance of facilities subject to the Technical Standards to take account of their effects on the habitation of living organisms around the facilities through changes in these environmental elements due to the presence of the facilities.

In order to ensure a good regional landscape, it is desirable to preserve, utilize and improve its landscape value by understanding the spatial potential in terms of the landscape, and to not only focus on the external appearance of individual facilities.

When installing facilities to be utilized by an unspecified large number of people, it is desirable to consider safe, secure, smooth and comfortable usage by all persons including senior citizens and disabled persons while considering the environmental conditions, usage conditions and other conditions to which the facilities are subjected.

2 Important Viewpoints in Considering Environment

(1) Primary Factors Controlling the Natural Environment

At ports, the actions of tides, waves and so on are the primary factors controlling material advection and diffusion and the habitats for living organisms related to the natural environment of ports (**Part II, Chapter 2, 7 Water Flow**). The design, construction and maintenance of facilities subject to the Technical Standards must be considered properly that the changes in these actions due to construction of the facilities concerned and related activities will be widespread in terms of the amount of area and time.

(2) Consideration for Environmental Factors

① For water quality, it is desirable to focus not only on CODs, nutrients and the level of water pollutants such as floating suspended substances (**Reference (Part I), Chapter 3, 1 General**), but also on phenomena such as red tides, hypoxia water masses and blue tides resulting from water pollution, and to make an assessment from the viewpoint of sound material circulation.

② For bottom sediment quality, the focus will be on areas such as content and particle size distributions of organic matter, trace chemical substances, heavy metals, etc. (**Reference (Part I), Chapter 3, 1 General**). It is also necessary to pay attention to the spread of influence on water quality, avoiding secondary pollution such as accelerated oxygen depletion in bottom water due to decomposition of sediment, and accelerated elution of nutrients due to hypoxic environments. Moreover, it is necessary to note that fine particles deposited in calm areas tend to adsorb toxic substances such as heavy metals.

③ For air quality, the focus will be on heat, gases (e.g., NO_X, SO_X, CO_2), fine particles and other pollutants emitted into the air by ships, vehicles, port cargo handling equipment and by activities of firms located in port areas, etc. Although these pollutants are mostly caused by port activities, it is necessary to carefully select working vessels, machines and other equipment for construction or other activities of the facilities concerned when designing, constructing and maintaining facilities subject to the Technical Standards. Energy-oriented CO_2 has a significant impact on global warming and is a major greenhouse gas emitted from ports, and since it accounts for about 90% of emitted greenhouse gases in Japan,[1)] it is desirable to endeavor to reduce emissions and utilize sinks (blue carbon ecosystems).[2)]

④ For living organisms (animals and plants) and ecosystems, the focus will be on preservation of biodiversity and natural environments (**Part II, Chapter 11, 3.6 Preservation of Natural Environment**) and on the influence on indicator species in the ecosystem, which features areas of seaweed beds, tidal flats, coral communities, etc. Indicator species are species extracted in terms of their superiority (those near the top of the food chain in their ecosystem), typicality (typically represents characteristics of the regional ecosystem) and particularity (an index indicating a particular environment). Since some species move between habitats and nursery grounds in the course of their growth (life history), an organic connection of habitats and nursery grounds (ecosystem network) may be considered for important species.[3) 4) 5)] The ecosystem is composed of living organisms, non-living matter and the varied environments surrounding them, and serves as a habitat for living organisms with a water purification function, matter cycling function, carbon (blue carbon) segregation and storage function,[2)] biological production function, amenity-oriented function, etc. It is desirable to note the influence on these functions in the design, construction and maintenance of facilities subject to the Technical Standards[3) 6) 7) 8) 9) 10)] (**Reference (Part I), Chapter 3, 3 Preservation and Regeneration of Nature Regeneration**).

(3) Adaptive Management Methods

It is desirable to introduce a mechanism (adaptive management) to check conditions using proper information and technology (monitoring), regularly verify that objectives individually set for the environment are achieved and modify plans if necessary, while considering the changes in the natural environment and social backgrounds[6)] (**Part II, Chapter 11, 3.6 Preservation of Natural Environment**).

(4) Consideration for the Recycling of Resources

It is required for the design, construction and maintenance of facilities subject to the Technical Standards to consider the recycling of resources through the proper treatment of construction byproducts, the utilization of recycled resources, etc. (**Reference (Part I), Chapter 3, 3 Preservation and Regeneration of Nature Regeneration**).

(5) Consideration for Creating Good Regional Landscapes

For consideration for creating good regional landscapes, it is desirable to perform the design, construction and maintenance of facilities subject to the Technical Standards based on a consistent objective and design concept for landscapes at all stages.[11), 12), 13), 14), 15), 16), 17), 18), 19)]

(6) Consideration for Port Security

It is desirable to consider ensuring port security by securing monitoring functions and eliminating structural blind spots from monitoring according to the characteristics of the facilities.

The important international wharf facilities specified in **the Act on Assurance of Security of International Ships and Port Facility** (Law No. 31 of April 14, 2004) also need to meet the technical standards for wharf security facilities and other facilities stipulated in the Law.

(7) Consideration for Senior Citizens, Disabled Persons and Others for Facilities Used by Unspecified Large Numbers of People

It is desirable for facilities used by an unspecified large number of people, such as mooring facilities for passenger ships, beaches, green spaces and revetments, to make considerations during the planning, the layout, detailed design and other stages of the facility so that all persons, including senior citizens and disabled persons, can safely, smoothly and comfortably use facilities equipped with ship boarding and unboarding functions and amenity-oriented functions, as well as other facilities.[20) 21) 22)]

The passenger ship terminals and other facilities specified in t**he Act on Promotion of Smooth Transportation, etc., of Senior Citizens, Disabled Persons, etc.** (Law No. 91 of June 21, 2006) also need to meet the standards stipulated in the Law.

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