SPECIFICATIONS FOR HIGHWAY BRIDGES

PART Ⅰ COMMON
Interim English Translation Version

道路橋示方書　Ⅰ共通編
（英訳暫定版）

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Japan Road Association, Working Group for English Translation of the Specifications for Highway Bridges

（社）日本道路協会　英文示方書 WG

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2019年９月

日本道路協会橋梁委員会英文示方書 WG

Precautions for interim English translation of the Specifications for Highway Bridges

The Specifications for Highway Bridges are set forth by the Japanese Ministry of Land, Infrastructure, Transport and Tourism and issued to road administrators. All provisions of Part I to Part V package a series of fundamental and mandated performance requirements and corresponding widely accepted standards deemed to satisfy the requirements. The mandatory parts include the performance matrix and the required achievement levels for reliability where the level of load combinations and the level of resistance reliability are stipulated. The Japan Road Association (JRA) has a Technical Committee for Bridges comprising specialists from the Ministry of Land, Infrastructure, Transport and Tourism and related agencies, different road administrators, and specialists from the academic and industry sectors to study the future codes of practice and to develop technical guidance books, handbooks, and references to supplement the Specifications for Highway Bridges. In particular, the Japan Road Association publishes commentaries on the Specifications for Highway Bridges as the *Specifications for Highway Bridges and Commentaries*.

With this background, the Japan Road Association publishes an English translation of the *Specifications for Highway Bridges and Commentaries* and plans to publish an English translation of the latest 2017 version of the *Specifications for Highway Bridges and Commentaries*. However, the publication will take longer to translate because the 2017 version was a comprehensive revision. For this reason, the mandatory parts issued by the Ministry of Land, Infrastructure, Transport and Tourism will be translated first and sequentially made public part by part on the Japan Road Association website for the purpose of reference.

Please note the following items when using this interim English translation.

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- The Japan Road Association will assume no responsibility for any outcomes that result from the use of this interim English translation version.

The Association would appreciate any suggestions on the English translation that will improve the quality of the English translation version.

September 2019
Working Group for English translation of the Specifications for Highway Bridges,
Technical Committee for Bridges
Japan Road Association

Members of Working Group for English Translation of the Specifications for Highway Bridges

Chairman:
Akira Shiratori

Former Chairman:
Hiroshi DOBASHI
Hiroshi KOJIMA

Members :

Keiichi AOKI
Hiroki ISHIKAWA
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Masahiro HIMUKAI
○ Manabu HOSOTANI
Takeshi MATSUMOTO
○ Shuji YAMAMOTO

○ member as of December, 2018

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I COMMON

CHAPTER 1 GENERAL

1.1 Scope

(1) The Specifications for Highway Bridges shall be applied to the design and construction of a bridge with a span length of 200 m or less. For a bridge exceeding 200 m in span length, the Specification can be applied with necessary and appropriate modifications according to the type, structure, site conditions, etc. of the bridge.

(2) The Specifications consist of the following five parts: Part I. Common; Part II. Steel Bridges and Steel Members; Part III. Concrete Bridges and Concrete Members; Part IV. Substructures; Part V. Seismic Design. The scope of application of each part is listed below.

1) Part I: Common ························· Common matters such as the performance of bridges, and bearing supports, expansion joints, accessories, and the like.

2) Part II: Steel Bridges and Steel Members··· Steel superstructures and steel members in the main

3) Part III: Concrete Bridges and Concrete Members
Concrete superstructures and concrete members in the main

4) Part IV: Substructures····················· Substructures in the main

5) Part V: Seismic Design ···················· Seismic design

1.2 Definitions

1.2.1 Definitions

(1) Superstructure ··················The girders and the other structures supported by the abutments and piers.

(2) Substructure ····················The abutments and piers and their foundations, which

form a structure to transfer loads from the superstructure to the foundation ground.

(3) Connection between superstructure and substructure

Structural portion that is used to connect a superstructure and a substructure.

(4) Steel bridge ······················The bridges in which the major structural members forming the superstructure are made of steel materials.

(5) Concrete bridge ·················The bridges in which the major structural members forming the superstructure are made of concrete.

(6) Roadway ·························The portion of a roadway area (roadway, median strip, shoulders and the like) on which motor vehicle can run.

(7) Sidewalk and the like ··········The sidewalk, bicycle track and bicycle and pedestrian track defined in Article 2 of the Road Structure Ordinance.

(8) Member and the like ··········· A single member or a group of multiple members, a part or joint of a member, and surrounding ground contributing to stability.

(9) Design service life ············ The period during which the bridge is expected to deliver the required performance as a design condition on the premise that appropriate maintenance and management will be performed.

(10) Performance of a bridge ······· A set of various types of performance that is necessary for achieving the load carrying performance and durability performance of the bridge and compatibility to the purpose of use.

(11) Load carrying performance of a bridge

Performance that achieves, with the required reliability, a state in which a bridge under a certain design situation is in the intended class from the viewpoints of load carrying capacity and structural safety of the bridge.

(12) Durability performance of a bridge

Performance that achieves, with the required reliability, a state in which material degradation due to aging does not affect the load carrying performance of the bridge during its design service life.

(13) Design situation ·············· For the verification of load carrying performance of a bridge, a representative combination of actions due to the external environments of the bridge, such as topography, geology, weather, traffic of automobiles, and the like.

(14) Limit state ······················ A representative point of a state that is used to classify the state of the bridge, its members, and the like corresponding to a response value in verification of the load carrying performance of the bridge.

(15) Action ························· All types of activity that cause a change in the state of a member and the like. For example, sectional forces and deformation occurring in the member and the like.

(16) Load ··························· A force that is converted from an action acting on a member and the like

(17) Permanent action ············· An action that continuously or frequently influences on a member without substantial variations in its intensity during the design service life.

(18) Variable action ················ An action that constantly varies its intensity during design service life, and whose maximum or minimum value has a nonnegligible influence on a member and the like.

(19) Accidental action ············· An action that has only a very small probability of occurrence during design service life, or whose scale and frequency are difficult to handle stochastically, but that has an enormous influence on a member and the like.

(20) Response value ················ The value of an index that represents the state of a member and the like changing under an action, such as sectional forces and deformation.

(21) Characteristic value ·········· An index value that is defined as a value most appropriately representing the characteristic of a material or an action or the characteristic of the response of a member and the like for design calculation.

(22) Secondary member··········· A member that is not considered the effect of presence for specific verification of the load carrying performance of the bridge.

(23) Design durability life of a member and the like

The period during which the mechanical properties, mechanical characteristics, and other properties of the materials composing each member and the like are expected to stay in a range that conforms to the preconditions for design of the load carrying performance of the member and the like under the effects of age on the premise that appropriate maintenance and management will be performed.

1.2.2 Meaning of Language

The meanings of the language used in the provisions shall be described in Table 1.2.1.

Table 1.2.1 Meaning of Language

Language	Meaning of Language
shall	Mandatory term. Mandatory language is used when providing requirements that must be followed exactly as written or referenced, as in specifications.
shall generally	The same regulation cannot uniformly be applied under different surroundings. However, the provision is specified to satisfy the practical necessity of applying uniform standards and handling. Accordingly, a relaxed provision can be applied unless it deviates from the purpose of the provision.
should may can	(1) The provision specifies a simplified method that will be applied when design that should be performed on the basis of an exact examination in principle needs to be simplified for convenience. Accordingly, when an exact examination is to be performed, higher priority shall be given to the examination than to the relevant provision. (2) The provision is specified to relax a provision that is specified completely on the safe side and is too strict to apply it as it is. Accordingly, the relaxed provision can be applied when a provision specified as a principle or a standard is obviously too far on the safe side.

1.3 Basic Principles of Design

In designing a bridge, the compatibility to the purpose of use, safety of structures, durability, reliability and ease of maintenance and management, securing of construction quality, environmental compatibility, and economy shall be taken into consideration.

1.4 Importance of Bridge

(1) The performance of a bridge to be achieved in bridge design shall be determined by considering its importance in physical distribution and other social and economic activities, in disaster prevention plans, and the importance and redundancy of the relevant route in the road network.

(2) The importance of the bridge in seismic design shall be determined according to Clause 2.1(2) of Part V.

1.5 Design Service Life

In designing a bridge, a design service life shall be determined as the period during which the bridge is expected to deliver its performance on the premise that appropriate maintenance and management will be performed. The design service life shall generally be 100 years.

1.6 Investigation

Necessary investigation shall be done for appropriate bridge design, construction and maintenance and management according to the construction site conditions, structure scale, etc. The investigation shall be done according to related provisions specified in Part II to Part V in addition to those specified in this part.

1.7 Planning

1.7.1 Selection of Bridge Site and Bridge Type

In planning a bridge, a bridge site and a bridge type shall be selected with consideration given to various external conditions such as route alignment, topography, geology, weather, and crossing objects, fitness to the purpose of use, the safety and durability of structures, the reliability and ease of maintenance and management, ensuring of construction quality, environmental compatibility, and economy in such a manner as to ensure consistency with the regional disaster prevention plan and related road network plans.

1.7.2 Relationship with Crossing Objects

Bridge site, span arrangement, pier positions, pier shapes, space under the bridge, and the like shall be determined by considering fitness to the purpose of use, the safety and durability of structures, the reliability and ease of maintenance and management, ensuring of construction quality, environmental harmony, and economy and by holding sufficient consultations with the administrators of crossing objects.

1.8 Design

1.8.1 Basic Policies on Design

(1) In designing a bridge, the necessary bridge performance shall appropriately be determined from the viewpoints of the load carrying performance and durability performance of the bridge and fitness to the purpose of use, and these shall be satisfied.

(2) To satisfy the load carrying performance of the bridge, it shall be designed to achieve, with the required reliability, both a safe state against fatal states, such as bridge collapse, under situations that will occur during its design service life, such as traffic situations, topology, geology, and weather, and an appropriate state for satisfying bridge functions needed according to such situations.

(3) To satisfy the durability performance of the bridge, it shall be designed with consideration given to degradation due to aging so as to ensure, with the required reliability, the required load carrying performance of the bridge until the end of its design service life.

(4) In designing a bridge, performance necessary for allowing pedestrians to use it safely and comfortably, performance desired taking matters such as past experiences of damage to highway bridges into consideration, and other types of necessary performance shall be examined and appropriately applied to the design in order to satisfy fitness to the purpose of use of the bridge.

(5) When designed according to the provisions specified in Chapter 2 or later, provision (1) may be deemed to be satisfied.

(6) In designing a bridge, conditions for the maintenance and management that are required in order to allow the bridge to deliver its performance shall be determined.

(7) In designing a bridge, conditions for the construction that is required in order to allow the bridge to deliver its performance shall be determined.

1.8.2 Design Method

The design shall be executed based on theoretically valid methods, experimentally verified methods or other appropriate knowledge.

1.8.3 Considerations Related to Structural Designs

(1) In designing a bridge, matters that can be considered for structural design, and methods for applying those matters to structural design shall be examined from viewpoints 1) to 5) below. The matters that can be considered for structural design shall be applied to the structural design of the bridge on an as-needed basis.

1) Viewpoint of the reliability and ease of checks on construction quality.

2) Viewpoint of the possibility that a problem, such as damage to some of the members and connections of the bridge, will cause the bridge to reach a fatal state, such as bridge collapse, or to become difficult to restore its function.

3) Viewpoint of consistency with the regional disaster prevention plan and related road-network plans.

4) Viewpoint of the reliability and ease of implementation of maintenance and management.

5) Viewpoint of economy.

(2) Matters that can be considered for structural design shall generally be examined at least on considerations 1) to 5) below.

1) Consideration for constructing a structure that allows checks to be reliably and easily performed to confirm that the construction quality required in design has been satisfied.

2) Consideration for preventing the occurrence of any fatal state, such as collapse, by arranging members to ensure complementarity or redundancy, taking measures to prevent phenomena that will be uncontrollable once they occur, or separately arranging members and the like to prevent the impact of damage to a portion from spreading and affecting the safety of the bridge against the possibility that damage or some other problem occurring in some of the members and joints of the bridge

will cause a fatal state of the bridge, such as bridge collapse.

3) Consideration for implementability of repair and renewal of members and the like against the possibility that damage or some other problem occurring in some of the members and joints of the bridge will lead to difficulty of restoring the function of the bridge. Particularly for members supposed to be renewed during the design service life, consideration for constructing a structure that allows renewal to be reliably made as easily as possible.

4) Consideration for constructing a structure that allows inspections performed during the design service life, investigations for evaluation of the state of the bridge after an accident, a disaster, or the like, and planned maintenance and management to be performed appropriately. Maintenance and management facilities, inspection facilities, and the like shall be constructed according to provisions specified in 11.4.

5) Consideration for providing constructional details that are capable of reducing the differences between design preconditions for satisfying durability performance and the local stress characteristic and exposure environment of each portion of members.

1.9 Matters to Be Described on Design Drawings, and the Like.

Design drawings and other documents shall describe at least (1) to (5) below.

(1) Route name and bridging location

(2) Bridge name

(3) Responsible engineer

(4) Date of design

(5) Major design conditions

1) Bridge classification

2) Design outline

3) Load conditions

4) Topographical, geological and ground conditions

5) Material conditions

6) Manufacturing and construction conditions

7) Maintenance and management conditions

8) Other relevant matters

1.10 Construction

(1) For the construction of a bridge, at least 1) to 3) below shall be considered.

1) Conditions required in design shall be satisfied.

2) Safety shall be ensured for construction work.

3) Impacts on the surrounding environment, traffic, and the like shall be controlled within ranges planned in advance.

(2) For the construction of a bridge, necessary surveys shall be performed, and methods for confirming that appropriate construction work is performed at each construction stage shall be considered in advance and established.

(3) Construction records shall be stored so that it can be confirmed that appropriate construction procedures have been taken.

(4) Construction records regarding matters that are to be used in maintenance and management shall be stored after completion of construction work.

CHAPTER 2 FUNDAMENTALS REGARDING THE LOAD CARRYING PERFORMANCE OF BRIDGES

2.1 Classification of Situations to Be Considered in Design for the Load Carrying Performance of a Bridge

(1) In design, situations 1) to 3) described below shall be considered.

1) Situation in which the influence of a permanent action is dominant (situation dominated by permanent action)

2) Situation in which the influence of a variable action is dominant (situation dominated by variable action)

3) Situation in which the influence of an accidental action is dominant (situation dominated by accidental action)

2.2 Classification of Bridge States to Be Considered in Design for the Load Carrying Performance of a Bridge

In design, bridge states to be considered as states that will occur during the design service life shall be set according to classifications 1) and 2) below.

1) Viewpoint of the load-supporting capability of a bridge

   i) State in which the load-supporting capability of the bridge is not lost

   ii) State in which although the load-supporting capacity is partially degraded, it is within the range of the capacity of supporting loads that were considered for the bridge in advance

2) Viewpoint of the structural safety of a bridge

   i) State in which although the load-supporting capacity of a bridge is degraded and the degradation is progressing, the degradation does not cause a fatal event, such as bridge collapse

2.3 Load Carrying Performance of Bridges

(1) The load carrying performance of a bridge shall be classified as Load carrying

performance 1 or 2 specified in 1) and 2) below, with consideration given to the importance and redundancy of the relevant route in the road network, the bridge site, relationships with crossing objects, and the like.

1) Load carrying performance 1 of a bridge shall be performance that satisfies the required reliability both in i) on the basis of the viewpoint of the load-supporting capability of a bridge and in ii) and iii) on the basis of the Viewpoint of the structural safety of a bridge.

   i) In a situation dominated by permanent action or a situation dominated by variable action, the bridge shall achieve a state in which it does not lose its load-supporting capacity without even developing partial damage.

   ii) In a situation dominated by permanent action or a situation dominated by variable action, the bridge shall not only satisfy i), but also realize a state having sufficient ultimate strength not to reach a fatal state, such as bridge collapse.

   iii) In a situation dominated by accidental action, although the bridge develops degradation in the load-supporting capacity of a bridge, it shall achieve a state that is not a fatal state for a bridge, such as bridge collapse.

2) Load carrying performance 2 of a bridge shall be performance that satisfies the required reliability both in i) and iii) on the basis of the viewpoint of the load-supporting capability of a bridge and in ii) and iv) on the basis of the Viewpoint of the structural safety of a bridge.

   i) In a situation dominated by permanent action or a situation dominated by variable action, the bridge shall achieve a state in which it does not lose its load-supporting capacity without even developing partial damage.

   ii) In a situation dominated by permanent action or a situation dominated by variable action, the bridge shall not only satisfy i), but also realize a state having sufficient ultimate strength not to reach a fatal state, such as bridge collapse.

   iii) In a situation dominated by accidental action, the bridge shall achieve a state in which it can quickly restore the load-supporting capacity that is required for a bridge immediately after the action.

   iv) In a situation dominated by accidental action, the bridge shall not only satisfy iii), but also, although it develops degradation in the load-supporting capacity of a bridge, achieve a state that is not a fatal state for a bridge, such as bridge collapse.

(2) The load carrying performance of a bridge shall be determined on the basis of its importance in seismic design as defined in Clause 2.1(2) of Part V and shall generally be set to Load carrying performance 1 when its importance in seismic design is Type A, and Load carrying performance 2 when its importance in seismic design is Type B.

CHAPTER 3 DESIGN SITUATIONS

3.1 Types of Actions

(1) The following loads or effects shall be considered as actions for setting situations that are to be considered in design.

1) Dead load (D)
2) Live load (L)
3) Effect of impact (I)
4) Prestress force (PS)
5) Effect of concrete creep (CR)
6) Effect of drying shrinkage of concrete (SH)
7) Earth pressure (E)
8) Water pressure (HP)
9) Buoyancy or uplift (U)
10) Effect of temperature change (TH)
11) Effect of temperature difference (TF)
12) Snow load (SW)
13) Effect of ground deformation (GD)
14) Effect of support displacement (SD)
15) Centrifugal load (CF)
16) Braking load (BK)
17) Wind load on girders (WS)
18) Wind load on vehicles (WL)
19) Wave pressure (WP)

20) Effect of earthquake (EQ)

21) Collision load (CO)

22) Other loads and effects

(2) The characteristic values of the actions shall be set according to the provisions specified in Chapter 8.

(3) For the construction process, situations considering in design for construction shall be considered according to the following, regardless of (1) or (2), by using appropriate loads or effects so that the required performance is obtained from the completed bridge.

1) To ensure safety for construction of the bridge, necessary examinations shall be performed on its own weight, materials and equipment to be used for the construction, the effects of winds and earthquakes, and the like to determine the erection load (ER) by appropriately considering conditions, such as the construction method and the structure formed at each stage of the construction.

2) The characteristic value of the erection load (ER) shall appropriately be determined according to the construction period and other conditions.

3) To satisfy preconditions for design that allows the required performance to be obtained from the completed bridge, the erection load (ER) shall be determined by appropriately considering conditions, such as the construction method and the structure formed at each stage of the construction. In addition, the conditions, such as the construction method and the structure formed at each stage of the construction, shall appropriately be considered in the design of the completed system.

3.2 Setting of Design Situations

(1) In design, the design situations specified in the provisions of Clause 2.1 shall appropriately be set by using the actions specified in Clause 3.1. In the setting of the design situations, a combination of actions that are the most disadvantageous to the bridge in the classifications of the individual design situations shall generally be considered.

(2) When the setting is made according to (3) or (4), (1) may be deemed to be satisfied.

(3) A combination of actions shall be set according to the provisions of Clause 3.3.

(4) Design situations for construction stages shall appropriately be set by considering

construction conditions so that the required bridge performance will be obtained, regardless of whether the setting is made according to (3).

3.3 Combination of Actions

(1) The design situations specified in Clause 2.1 may be deemed to be satisfied the provision of Clause 3.2(1) when a representative combination of the actions specified in Clause 3.1 is made by selecting actions according to the following provisions (2) to (5).

(2) At least, the combination of the actions following 1) to 3) shall be considered. In this case, actions enclosed in parentheses in each combination shall be combined in such a manner that the conditions will be the most disadvantageous to the bridge.

1) Situation in which the influence of a permanent action is dominant (situation dominated by permanent action)

i) D + PS + CR + SH + E + HP + (U) + (TF) + GD + SD + WP + (ER)

2) Situation in which the influence of a variable action is dominant (situation dominated by variable action)

ii) D + L + I + PS + CR + SH + E + HP + (U) + (TF) + (SW) + GD + SD + (CF) + (BK) + WP + (ER)

iii) D + PS + CR + SH + E + HP + (U) + TH + (TF) + GD + SD + WP + (ER)

iv) D + PS + CR + SH + E + HP + (U) + TH + (TF) + GD + SD + WS + WP + (ER)

v) D +L + I + PS + CR + SH + E + HP + (U) + TH + (TF) + (SW) + GD + SD + (CF) + (BK) + WP + (ER)

vi) D + L + I + PS + CR + SH + E + HP + (U) + (TF) + GD + SD + (CF) + (BK) + WS + WL + WP + (ER)

vii) D + L + I + PS + CR + SH + E + HP + (U) + TH + (TF) + GD + SD + (CF) + (BK) + WS + WL + WP + (ER)

viii) D + PS + CR + SH + E + HP + (U) + (TF) + GD + SD + WS + WP + (ER)

ix) D + PS + CR + SH + E + HP + (U) + TH + (TF) + (SW) + GD + SD + WP + EQ + (ER)

x) D + PS + CR + SH + E + HP + (U) + (TF) + GD + SD + WP + EQ + (ER)

3) Situation in which the influence of an accidental action is dominant (situation dominated by accidental action)

xi) D + PS + CR + SH + E + HP + (U) + GD + SD + EQ

xii) D + PS + CR + SH + E + HP + (U) + GD + SD + CO

(3) For the combinations of actions specified in provisions (2) 1) to (2) 3), the load combination factors and load factors listed in Table 3.3.1 shall be used.

The meanings of γ_p and γ_q appearing in the table are as follows:

γ_p: A load combination factor for correcting the scale of an action to be considered in design, in accordance with the situation of simultaneous application of different actions;

γ_q: A load factor for correcting the scale of an action to be considered in design, in accordance to variations in the characteristic value of the action.

When the effect of impact (I) on the live load is to be considered, it is not necessary to multiply the effect of impact (I) by the load combination factor, γ_p, or the load factor, γ_q.

(4) For wind loads, conditions other than (2) 1) and 2) shall appropriately be set on an as-needed basis, for example, when other actions are excluded from consideration.

(5) For collision loads and braking loads, conditions other than (2) 1) and 2) shall appropriately be set, for example, when they are combined only with the dead load and the live load.

Table 3.3.1 Load Combination Factors and Load Factors Corresponding to Combinations of Actions

Combination of actions		Classification of design situations	Value of load combination factor γ_p and that of load factor γ_q																											
			D		L		TH		WS		WL		EQ		PS, CR, SH		E, HP, U		TF		SW		GD SD		CF BK		WP		CO	
			γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q	γ_p	γ_q
(1)	D	Situation dominated by permanent action	1.00	1.05	–	–	–	–	–	–	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	–	–	1.00	1.00	–	–
(2)	D + L	Situation dominated by variable action	1.00	1.05	1.00	1.25	–	–	–	–	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	–	–
(3)	D + TH		1.00	1.05	–	–	1.00	1.00	–	–	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	–	–	1.00	1.00	–	–
(4)	D + TH + WS		1.00	1.05	–	–	0.75	1.00	0.75	1.25	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	–	–	1.00	1.00	–	–
(5)	D + L + TH		1.00	1.05	0.95	1.25	0.75	1.00	–	–	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	–	–
(6)	D + L + WS + WL		1.00	1.05	0.95	1.25	–	–	0.50	1.25	0.50	1.25	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	1.00	1.00	1.00	1.00	–	–
(7)	D + L + TH + WS + WL		1.00	1.05	0.95	1.25	0.50	1.00	0.50	1.25	0.50	1.25	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	1.00	1.00	1.00	1.00	–	–
(8)	D + WS		1.00	1.05	–	–	–	–	1.00	1.25	–	–	–	–	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	–	–	1.00	1.00	–	–
(9)	D + TH + EQ		1.00	1.05	–	–	0.50	1.00	–	–	–	–	0.50	1.00	1.00	1.05	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	–	–	1.00	1.00	–	–
(10)	D + EQ		1.00	1.05	–	–	–	–	–	–	–	–	1.00	1.00	1.00	1.05	1.00	1.05	1.00	1.00	–	–	1.00	1.00	–	–	1.00	1.00	–	–
(11)	D + EQ	Situation dominated by accidental action	1.00	1.05	–	–	–	–	–	–	–	–	1.00	1.00	1.00	1.05	1.00	1.05	–	–	–	–	1.00	1.00	–	–	–	–	–	–
(12)	D + CO		1.00	1.05	–	–	–	–	–	–	–	–	–	–	1.00	1.05	1.00	1.05	–	–	–	–	1.00	1.00	–	–	–	–	1.00	1.00

CHAPTER 4 LIMIT STATES OF BRIDGES

4.1 Limit States of Bridges

(1) To verify that a bridge stays in the state required in order to satisfy the required load carrying performance, the appropriate limit states of the bridge shall generally be set in order to classify the states of the bridge.

(2) When set according to provisions (3) to (5), the limit states of the bridge may be regarded as appropriately set.

(3) As the limit states of the bridge, Limit states 1 to 3 shall be set for the bridge from the viewpoint of the load-supporting capacity of the bridge and the viewpoint of the structural safety of the bridge.

1) Limit state 1 of the bridge

The limit state at which the load-supporting capacity of the bridge is not lost

2) Limit state 2 of the bridge

The limit state at which the load-supporting capacity is still within the assumed range because the degradation has only a limited influence on the load-supporting capacity of the bridge, although partial degradation in the load-supporting capacity has occurred

3) Limit state 3 of the bridge

The limit state in which the structural safety will be lost if it is exceeded

(4) The limit states of the bridge that will be used for verification of the load carrying performance of the bridge can be represented by the limit states of the members and the like of the bridge and those of the stability and the like of the surrounding ground related to the safety of the bridge.

(5) When the limit states of the bridge are to be represented by those of superstructures, substructures, and the connections between the superstructures and the substructures, the limit states of them shall appropriately be set according to the provisions of Clause 4.2.

(6) The characteristic values and partial factors that associate the limit states of the bridge that are to be considered in design shall comply with the provisions specified in Chapter 5 and Parts II, III, IV, and V.

4.2 Limit States of Superstructures, Substructures, and Connections between Superstructures and Substructures

(1) When the limit states of a bridge that are specified in Clause 4.1 are to be represented by the limit states of superstructures, substructures, and the connections between the superstructures and the substructures, the limit states of the bridge shall be represented by appropriately setting the individual limit states and appropriately combining the set limit states according to the limit states of the bridge.

(2) When the limit states of the superstructures, the substructures, and the connections between the superstructures and the substructures are set according to provisions (3) to (8) and combined, provision (1) may be deemed to be satisfied.

(3) Limit states 1 to 3 of the superstructures, the substructures, and the connections between the superstructures and the substructures shall appropriately be set according to Table 4.2.1.

(4) Limit state 1 of the bridge shall be a state in which a superstructure, a substructure, or a connection between a superstructure and a substructure has reached Limit state 1 of superstructures, substructures, or the connections between superstructures and substructures as described in Table 4.2.1.

(5) For Limit state 2 of the bridge, structures whose plastic behavior is to be considered shall be appropriately specified among superstructures, substructures, and the connections between superstructures and substructures. Limit state 2 of the bridge shall be a state in which a structure whose plastic behavior is to be considered has reached Limit state 2 of superstructures, substructures, or the connections between superstructures and substructures, or a state in which a structure whose plastic behavior is not to be considered has reached Limit state 1 of superstructures, substructures, or the connections between superstructures and substructures.

(6) Limit state 3 of the bridge shall be a state in which a superstructure, a substructure, or a connection between a superstructure and a substructure has reached Limit state 3 of superstructures, substructures, or the connections between superstructures and substructures as described in Table 4.2.1.

(7) When the limit states of superstructures, substructures, and the connections between superstructures and substructures as described in Table 4.2.1 are appropriately set according to the provisions of Parts II to V and combined, provisions (4) to (6) may be deemed to be satisfied.

(8) In cases where superstructures are connected with a bearing and the like at a midpoint of a span to form a consecutive structure, when the building frame of the

corresponding substructures and the foundation are not consecutively joined but connected with a bearing and the like, the limit states of each connection shall appropriately be determined by referring to the limit states of the connection between superstructures and substructures.

(9) When the limit states of a superstructure, a substructure, and a connection between a superstructure and a substructure are to be represented by the limit states of a member and the like, the limit states of the member and the like and a combination of the limit states shall appropriately be set according to the provisions of Clause 4.3.

Table 4.2.1 Limit States of Superstructures, Substructures, and the Connections between Superstructures and Substructures

Limit state 1 of superstructures, substructures, and the connections between superstructures and substructures	The limit state at which the relevant structure has not even partially degraded in terms of load-supporting capacity and can be used without special caution from the viewpoint of the load-carrying capacity
Limit state 2 of superstructures, substructures, and the connections between superstructures and substructures	The limit state at which the relevant structure can be used with special caution because there is only limited degradation, although partial degradation in the load-supporting capacity has occurred, and within the assumed range from the viewpoint of the load-carrying capacity
Limit state 3 of superstructures, substructures, and the connections between superstructures and substructures	The limit state at which the load-supporting capacity of the member and the like will completely be lost if it is exceeded

4.3 Limit States of Members and the Like

(1) When the limit states of a superstructure, a substructure, or a connection between a superstructure and a substructure that are specified in Clause 4.2 are to be represented by the limit states of its members and the like, the limit states of the superstructure, the substructure, or the connection between a superstructure and a substructure shall be represented by appropriately setting the limit states of the members and the like and

appropriately combining the set limit states according to the limit states of the superstructure, the substructure, or the connection between a superstructure and a substructure.

(2) When the limit states of the members and the like are set according to provisions (3) to (7) and combined, provision (1) may be deemed to be satisfied.

(3) Limit states 1 to 3 of the members and the like shall appropriately be set according to Table 4.3.1.

(4) Limit state 1 of a superstructure, a substructure, or a connection between a superstructure and a substructure shall be a state in which a member and the like of the superstructure, the substructure, or the connection between a superstructure and a substructure has reached Limit state 1 of members and the like.

(5) Limit state 2 of a superstructure shall be the limit state at which the major members and the like of the superstructure except its secondary members do not exceed Limit state 1 of the members and the like. Limit state 2 of a substructure or a connection between a superstructure and a substructure shall be a state in which a member and the like of the substructure or the connection between a superstructure and a substructure has reached Limit state 2 of members and the like.

(6) Limit state 3 of a superstructure, a substructure, or a connection between a superstructure and a substructure shall be a state in which a member and the like of the superstructure, the substructure, or the connection between a superstructure and a substructure has reached Limit state 3 of members and the like. However, when the superstructure, the substructure, or the connection between a superstructure and a substructure has some structural characteristics, each limit state cannot always be represented by the limit states of members and the like due to the effect of the geometrical nonlinearity in its behavior. In such cases, in addition to Limit state 3 represented by the limit states of members and the like, a separate Limit state 3 for the entire structure of the superstructure, the substructure, or the connection between a superstructure and a substructure shall be determined appropriately according to the provisions of Clause 4.2.

(7) When the limit states of members and the like as described in Table 4.3.1 are appropriately set according to the provisions of Parts II to V and combined, provisions (4) to (6) may be deemed to be satisfied.

Table 4.3.1 Limit States of Members and the Like

Limit state 1 of	The limit state at which the load-supporting capacity of the

members and the like	member and the like is ensured
Limit state 2 of members and the like	The limit state at which the load-supporting capacity of the member and the like has been degraded but is within the assumed capacity range
Limit state 3 of members and the like	The limit state at which the load-supporting capacity of the member and the like will completely be lost if it is exceeded

4.4 Structural Details

When verification of the load carrying performance of a bridge is to be performed by using the limit states of members and the like specified in Clause 4.3, the structure of the bridge shall at least satisfy provisions 1) and 2) as preconditions.

1) The bridge shall have a structure in which the entire bridge structure and each part have a certain amount of stiffness and maintain the section shape of the bridge at a required level under various actions.

2) In the situations considered in the design stage for the load carrying performance of the bridge, the superstructures shall smoothly transfer vertically and horizontally acting loads to bearing supports and substructures.

CHAPTER 5 VERIFICATION OF LOAD CARRYING PERFORMANCE OF BRIDGES

5.1 General

(1) Verification of the load carrying performance of a bridge shall be performed by using an appropriate method to confirm that performance requirements selected for the bridge according to the provisions of Clause 2.3 are satisfied.

(2) When provisions (3) to (6) are complied with, provision (1) may be deemed to be satisfied.

(3) For bridges that satisfy Load carrying performance 1 or 2 of bridges, verification shall be performed to confirm that the requirement that their state does not exceed Limit states 1 and 3 of bridges under the situation dominated by permanent action and situation dominated by variable action that are specified in Clause 3.3 is satisfied with required reliability that is obtained for design situation and the corresponding combination of limit states.

(4) For bridges that satisfy Load carrying performance 1 or 2 of bridges, verification shall be performed to confirm that the requirement that their state does not exceed Limit state 3 of bridges under the situation dominated by accidental action specified in Clause 3.3 is satisfied with the required reliability.

(5) For bridges that satisfy Load carrying performance 2 of bridges, verification shall be performed to confirm that the requirement that their state does not exceed Limit state 2 of bridges under the situation dominated by accidental action specified in Clause 3.3 is satisfied with the required reliability.

(6) Verification in provisions (3) to (5) shall be performed by evaluating the state of the bridge in each of the principal and lateral directions of the bridge.

5.2 Verification Methods

(1) Verification of the load carrying performance of a bridge may be represented by verification of the load carrying performance of its members and the like.

(2) When verification of the load carrying performance of a bridge is to be represented by verification of the load carrying performance of its members and the like, the verification shall generally be performed to confirm that the state of the members and the like does not exceed Limit states 1 and 3 of the members and the like under the situation dominated by permanent action and the situation dominated by variable

action, and that the state of the members and the like does not exceed Limit state 1 or 2 of the members and the like and does not exceed Limit state 3 of the members and the like under the situation dominated by accidental action, thereby confirming that the members and the like satisfy the requirement with the required reliability that their state does not exceed each limit state under each of the combinations of actions specified in Table 3.3.1.

(3) The load carrying performance of a member and the like shall generally be confirmed by using Equation 5.2.1.

$\Sigma S_i(\gamma_{qi}\ \gamma_{pi}\ P_i) \leq \zeta_1\ \zeta_2\ \phi_R\ R(f_c,\Delta_c)$ ⋯⋯ (5.2.1)

where

P_i: Characteristic value of action;

S_i: Effect of action, which expresses the bridge state corresponding to the combination of actions;

R: Characteristic value related to the resistance of the member and the like; This value is calculated from the characteristic value of material, f_c, and the characteristic value of dimensions, Δc;

f_c: Characteristic value of material;

Δ_c: Characteristic value of dimensions;

γ_{pi}: Load combination factor;

γ_{qi}: Load factor;

ζ_1: Modifier for structural modeling uncertainties;

ζ_2: Modifier for the consequence of failure;

ϕ_R: Resistance factor.

(4) The characteristic value of action in Equation 5.2.1, P_i, shall comply with the provisions of Chapter 8. In both the principal and lateral directions of the bridge, the combination of actions shall comply with the provisions of Clause 3.3. The effect of action in Equation 5.2.1, S_i, shall appropriately be calculated according to the related provisions of individual Parts. In the calculation of the effect of action, the action shall be applied in such a manner as to produce a state that is the most disadvantageous to the relevant member and the like.

(5) The characteristic value related to the resistance of the member and the like in Equation 5.2.1, R, shall be expressed by using an engineering indicator that represents the limit state of the relevant member and the like appropriately for the purpose of the

verification. When related provisions are specified in individual Parts, the characteristic value shall appropriately be calculated according to the provisions.

(6) The load combination factor γ_{pi} is a factor for taking into account a simultaneous loading situation occurring during the design service life and the load factor γ_{qi} in Equation 5.2.1 is a factor for taking into account the maximum value of the effect that is brought about by the characteristic value of action specified in Chapter 8 on the bridge during the design service life. They shall comply with the provisions of Clause 3.3.

(7) The resistance factor in Equation 5.2.1, ϕ_R, is a factor for taking into account the degree of probabilistic reliability that is directly related to the evaluation of resistance R. When related provisions are specified in Parts II to V, its value can be determined according to the provisions.

(8) The modifier for structural modeling uncertainties in Equation 5.2.1, ζ_1, is a factor for correcting the resistance factor ϕ_R by taking into account uncertainties involved in the process of the calculation of the effect of action of a modeled bridge structure. Its value shall generally be 0.90, and can be set to a value no greater than 0.95 on the basis of sufficient examination. However, when a different specification exists in a provision of Parts II to V, higher priority shall be placed on the provision.

(9) The modifier for the consequence of failure in Equation 5.2.1, ζ_2, is a factor for correcting the resistance factor ϕ_R according to the difference of the characteristic of strength increase or decrease in the inelastic range of the member and the like. The modifier also takes into account the possibility that verification of the load carrying performance of a bridge is represented by verification of the load carrying performance of its members and the like. When a provision is specified somewhere in Parts II to V, its value can be determined according to the provision.

(10) Verification items, a combination of actions, a verification method, and the like appropriate for the purpose shall be determined according to the necessity of performing design to satisfy allowable displacement determined from the design of a superstructure or a substructure, and the like, and verification shall appropriately be performed.

(11) Verification on the load carrying performance of steel member and concrete member shall be is performed according to the related provisions of Chapter 10 and Parts II to V.

(12) When safety verification is to be performed under particular conditions for the entire bridge structure, in addition to compliance with provision (1), a combination of actions shall appropriately be set as specified in Clause 3.3, and the types and values of partial

factors shall appropriately be set according to the purpose of the examination and the characteristics of the structure.

CHAPTER 6 BASIC MATTERS OF DURABILITY PERFORMANCE OF BRIDGES AND ITS VERIFICATION

6.1 General

(1) In designing a bridge, necessary durability shall be ensured for each member and the like by considering its importance in physical distribution and other social and economic activities, the degree of the effect of the performance degradation of the member and the like on the performance of the bridge, the degree of the influence of repair on the bridge and road traffic, and the degree of the ease of the detection of abnormalities and repair on them.

(2) When provisions (3) to (5) and the provisions of Clause 6.2 are complied with, provision (1) may be deemed to be satisfied.

(3) Design durability life is the period during which the mechanical characteristics, and the like of a material are expected to stay within ranges that are in conformance with the preconditions of the design of the load carrying performance of a member and the like. A design durability life shall appropriately be set for each member and the like by taking into account, restrictions on maintenance and management related to bridge site conditions and the like, the function of the member and the like, the degree of the ease of detection of abnormalities and implementation of measures to deal with the abnormalities, economy, and the like.

(4) Durability shall be ensured for each member on the basis of estimation of the effects of aging so that the period during which the mechanical characteristics, dynamic characteristics, and the like of a material stay within ranges that are in conformance with the preconditions of the design of the load carrying performance of the member and the like will be no shorter than the design durability life of the relevant member and the like.

(5) As the effects of aging, at least the following events shall be considered.

1) Fatigue of steel members and concrete members

2) Corrosion of steels

3) Fatigue of rubber materials and their degradation due to the environmental effects of heat, light, ultraviolet ray, and the like

(6) When the design durability life of a member and the like is set according to Table 6.1.1, provision (3) shall be satisfied.

Table 6.1.1 Standards on Combinations of Types of Members and the Like and Design Durability Life

Type of a member and the like	Design durability life of the member and the like
Member and the like that does not require renewal during the design service life of the bridge	Shall be the design service life of the bridge.
Member and the like that requires renewal during the design service life of the bridge	Shall appropriately be set so as not to exceed the design service life of the bridge.

6.2 Methods for Ensuring Durability and Verification

(1) Methods for ensuring the required durability for the design durability life of members and the like shall be classified into Methods 1 to 3 below and assumed maintenance and management, such as repair, renewal and the like shall be reflected in the design properly.

Method 1: Preventing changes due to the aging of a material in its mechanical characteristics, dynamic characteristics, and the like from affecting the load carrying performance of the member and the like during its design durability life, by forming a cross section on the basis of the quantitative evaluation of changes on the premise that the material will develop the changes during the design durability life

Method 2: Preventing changes due to the aging of a material in its mechanical characteristics, dynamic characteristics, and the like from affecting the load carrying performance of the member and the like during its design durability life, by additionally provided separate means, such as measures to prevent the cross section of the member and the like from being affected, on the premise that the material will develop the changes during the design durability life

Method 3: Preventing the effects of the aging of a material on its mechanical characteristics, dynamic characteristics, and the like from affecting the load carrying performance of the member and the like during its design durability life, by eliminating the possibility of occurrence of the effects or reducing them to a negligible level

(2) Verification of the durability of a steel member or a concrete member shall be performed according to the related provisions specified in Chapter 6 of Part II, Chapter

6 of Part III, and Chapter 6 of Part IV.

CHAPTER 7 OTHER EXAMINATIONS NECESSARY FOR CONFORMANCE WITH THE PURPOSES OF USE OF BRIDGES

7.1 General

(1) Matters that need to be examined at least in terms of 1) and 2) shall appropriately be set when performance that is not necessarily directly associated with the load carrying performance or durability performance of the bridge but is needed from the viewpoint of conformance with the purpose of the use of the bridge is to be satisfied.

1) Degree of the possibility that occurrence of damage to the bridge will cause damage to a third party

2) Degree of the possibility of occurrence of vibration, noise, and the like, or degree of the effect of the occurrence on the users of the bridge and its surrounding environment

(2) When an examination is to be performed in response to provision (1), the purpose of the examination and the characteristics of the structure shall be considered and appropriately applied to design.

CHAPTER 8 CHARACTERISTIC VALUES OF ACTIONS

8.1 Dead Load

(1) The dead load shall be determined by appropriately estimating the unit weights of materials.

(2) When the dead load is calculated by using the unit weights listed in Table 8.1.1, provision (1) may be deemed to be satisfied.

Table 8.1.1 Unit Weights of Materials (kN/m^3)

Material	Unit weight
Steel, cast steel and forged steel	77.0
Cast iron	71.0
Aluminum	27.5
Reinforced concrete	24.5
Prestressed concrete (design reference strength: 60 N/mm^2 or less)	24.5
Prestressed concrete (design reference strength: Higher than 60 N/mm^2 but 80 N/mm^2 or lower)	25.0
Concrete	23.0
Cement mortar	21.0
Wood	8.0
Pitch (for waterproofing)	11.0
Asphalt pavement	22.5

(3) When the unit weight of a material is not to be determined according to provision (2), provisions (4) to (6) shall be complied with.

(4) Variations in the unit weights of materials shall be evaluated appropriately.

(5) When a material for which the upper and lower limit values of variations in its unit weight, member dimensions, and the like have been adjusted according to JIS or other public standards is to be used, evaluation shall be performed by using variations corresponding to a population that consists only of elements satisfying the standards.

(6) The characteristic value of the unit weight of a material shall generally be set to a value equivalent to a non-exceedance probability of 50% when the population is regarded as being in the normal distribution.

8.2 Live Load

(1) The live load shall include vehicle load (T-load and L-load), sidewalk live load, and the vehicle load on the railway, and it shall be divided into A-live load and B-live load

depending on the traffic of large vehicles.

(2) The live load shall be loaded on the road surface in such a manner that the response of the relevant member and the like will be the most disadvantageous.

(3) B-live load shall be applied in designing bridges of a national expressway, national highway or prefectural road, or a municipal road that forms a trunk road network with those three classes of road. A-live load or B-live load shall be applied depending on the traffic situation of large vehicles in designing bridges of the other municipal roads.

(4) Live load in designing a slab or floor system

The live load in designing a slab or floor system shall be set as follows:

1) For the roadway, the concentrated loads (T-loads) illustrated in Figure 8.2.1 shall be loaded. One set of T-loads shall be loaded in the longitudinal direction to the bridge axis; no limit shall be applied to the number of sets of T-loads in the transverse direction to the bridge axis. They shall be loaded in such a manner that the most disadvantageous stress will be developed in the design member. The loading position of the T-load in the bridge's transverse direction shall be such that the center of the loaded surface is at up to 250 mm from the end of the roadway portion. The side length of the loading area shall be 200 mm and 500 mm in the bridge's longitudinal and transverse directions respectively.
In designing the floor system of a bridge to be subjected to application of a B-live load, a value obtained by multiplying the sectional force and the like calculated in response to application of T-loads by the factor shown in Table 8.2.1 shall be used. However, this factor shall not exceed 1.5.
Girders with a particularly long span length shall be designed by using a load that gives disadvantageous stress among T-loads and L-loads.

2) The sidewalk shall be loaded with a uniform load of 5.0 kN/m^2 as a sidewalk live load.

3) The railway shall be loaded with either the vehicle load on the railway or the T-load, whichever will cause the most adverse stress in the structural members to be designed. No limit shall be applied to the number of vehicles on the railway. Loading shall be applied in such a manner that the most disadvantageous stress will be developed in the design member. The occupied width and the load shall comply with the provisions specified for the relevant railway.

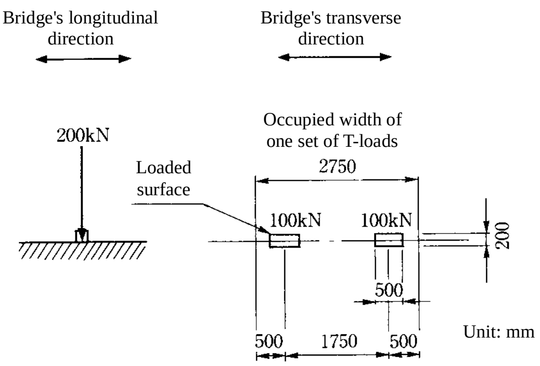


Figure 8.2.1 T-load

Table 8.2.1 Multiplying Factor for Designing a Floor System

Span length of the member *L*(m)	**L ≤ 4**	**4 < *L***
Factor	**1.0**	**L/32 + 7/8**

(5) Live load in designing main girders

When designing main girders, the live load shall be set as follows:

1) The roadway portion shall be loaded with the L-load consisting of two kinds of uniform load p_1 and p_2 shown in Figure 8.2.2 and Table 8.2.2. One set of loads p_1 shall be loaded per bridge. For the L-load, the uniform loads p_1 and p_2 (live load on main lanes) shall be loaded on a width of up to 5.5 m and its respective halves (live load on secondary lanes) to the remaining portion to cause the most adverse stress for the point or members to be designed.

For main girders or slab bridges with an especially short span, however, it shall be designed using either the T-load or L-load, whichever will cause the most adverse stress. In designing using T-load, T-loads no greater than two sets shall be loaded in the transverse direction to the bridge axis. For the third and later sets, the loading intensity shall be reduced to one-half. The factor shown in Table 8.2.1 shall be multiplied to the sectional forces calculated by loading the T-loads in designing bridges to which the B-live load should be applied. However, this factor shall not exceed 1.5.

For the suspended beams and cantilever arms of cantilever girders, L_1 and L_2 illustrated in Figure 8.2.3 shall be used for span length L in Table 8.2.2, respectively.

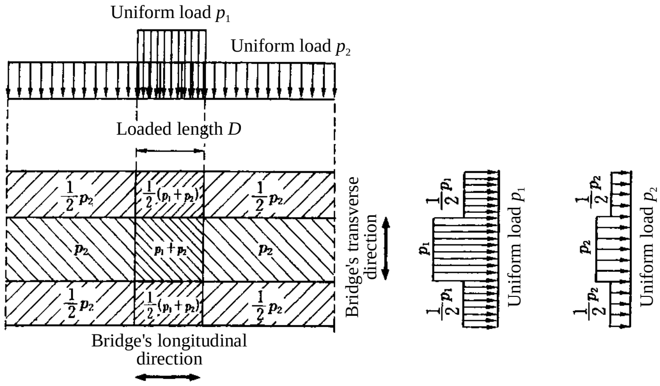


Figure 8.2.2 L-load

Table 8.2.2 L-load

Load	Live load on main lanes (width 5.5 m)						Live load on secondary lanes
	Uniform load p_1			Uniform load p_2			
	Loaded length D (m)	Load (kN/m^2)		Load (kN/m^2)			
		For calculation of bending moment	For calculation of shearing force	$L \leq 80$	$80 < L \leq 130$	$130 \leq L$	
A-live load	6	10	12	3.5	$4.3 - 0.01L$	3.0	50% of live load on main lanes
B-live load	10						

L: Span length (m)

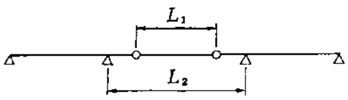


Figure 8.2.3 How to Take the Span Length *L* in a Gerber Girder

2) The sidewalk shall be loaded with the uniform load shown in Table 8.2.3 as a sidewalk live load.

Table 8.2.3 Uniform Load Imposed on Sidewalk

Span length L (m)	$L \leq 80$	$80 < L \leq 130$	$130 < L$
Uniform load (kN/m^2)	3.5	$4.3 - 0.01L$	3.0

3) The railway shall be loaded with either the vehicle load on the railway or the L-load, whichever will cause the most adverse stress in the structural members to be designed. The number of vehicles on the railway shall have no limitation, and the occupied width and the load of that railway shall be set according to the stipulations of the railway. If there is a railway roadway in which automobile traffic

is not allowed, this portion may be removed from the loaded width of the L-load.

(6) Live load in designing a substructure

In designing a substructure, the live load to be imposed on the superstructure shall be the load stipulated in (5) as a general rule.

8.3 Effects of Impact

(1) In loading a live load, the amount of response amplification due to dynamic effects shall be taken into account as the effects of impact, excepting for loading according to provisions (4) or (5).

(2) The characteristic value of the effects of impact shall appropriately be determined by considering the span length and structural properties of the bridge, the ratio of the live load to the dead load, traffic characteristics, and the vehicle axial load and the effects of its fluctuations.

(3) The effects of impact shall be taken into account as a value obtained by multiplying the live load by a factor.

(4) In designing uniform loads to be loaded on a sidewalk and the like and the main cable and stiffening girder of a suspension bridge, the effects of impact shall be excluded from consideration.

(5) Reaction force of a superstructure used for designing a substructure, the impact caused by a live load shall not be considered. For bearing supports, steel piers and concrete overhanging beams, and rigid-frame piers or lightweight building frames similar to rigid-frame piers, the effects of the impact of the live load shall be taken into account.

(6) When the effects of impact are considered by calculating the impact factor of a superstructure according to Table 8.3.2 from a span length given in Table 8.3.1, provisions (1) to (3) may be deemed to be satisfied.

Table 8.3.1 Span Length for Finding the Impact Factor

Type	Structural member	*L* (m)
Simple girder	Girder and bearing	Span length
Truss	Chord member, end column and bearing	Span length
	Hanging member of through truss	Span length of floor beam
	Post of deck truss	Span length of floor beam
	Diagonal and other similar members of subdivided panel	Span length of floor beam
	Other kinds of web	75% of span length

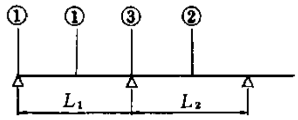
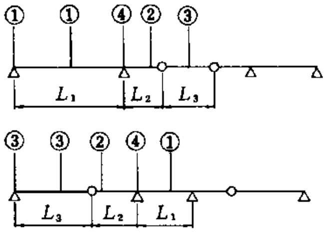
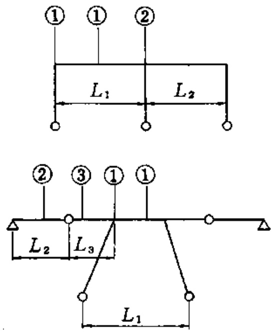
Continuous girder		L_1 for loaded at ① L_2 for loaded at ② $(L_1+L_2)/2$ for loaded at ③
Cantilever girder		L_1 for loaded at ① L_2+L_3 for loaded at ② For loaded at ③: L_3 for suspended girder L_2+L₃ for cantilever arm and anchor girder $(L_1+L_2+L_3)/2$ for loaded at ④
Rigid frame		L_1 for loaded at ① $(L_1+L_2)/2$ for loaded at ② L_1 for loaded at ① For loaded at ②: L_2 for suspended girder L_2+L_3 for cantilever arm and rigid frame For loaded at ③: L_1 for rigid frame L_2+L_3 for cantilever arm
Arch Arch with stiffening girder	Arch rib, chord member of arch, stiffening girder, chord member of stiffening truss, tie of bearing and tied arch	Span length
	Web member of arch and stiffening truss	75% of span length
	Post of deck arch	Span length of floor beam
	Hanging member of through arch	Span length of floor beam
Suspension bridge	Hanger	Span length of floor beam
Cable-stayed bridge	Main girder	Conforms to continuous girder
	Cable	Conforms to support of continuous girder

Table 8.3.2 Standards on the Effects of Impact

Bridge type	Impact factor i	Load Types
Steel bridge	$i = \frac{20}{50 + L}$	T-load/L-load
Reinforced concrete bridge	$i = \frac{20}{50 + L}$	T-load
	$i = \frac{7}{20 + L}$	L-load
Prestressed concrete bridge	$i = \frac{20}{50 + L}$	T-load
	$i = \frac{10}{25 + L}$	L-load

8.4 Prestress Force

(1) A prestress force to be applied to a structure shall appropriately be considered.

(2) A prestress force shall be divided into the prestress force immediately after prestressing and effective prestress force, and each shall be considered appropriately.

(3) A statically indeterminate force occurring due to a prestress force shall appropriately be considered.

(4) When provisions (5) and (6) are complied with, provisions (1) and (2) may be deemed to be satisfied. When provision (7) is complied with, provision (3) may be deemed to be satisfied.

(5) The characteristic value of a prestress force immediately after prestressing shall appropriately be determined by considering the following effects on the tensile force applied to the tension end of the prestressing steel.

1) Elastic deformation of concrete

2) Friction between prestressing steel and sheath

3) Anchor set

(6) The characteristic value of an effective prestress force shall appropriately be determined by considering the following effects in addition to the effects that are listed in provision (5) as effects to be considered for the characteristic value of a prestress force immediately after prestressing.

1) Creep of concrete

2) Drying shrinkage of concrete

3) Relaxation of prestressing steel

(7) The statically indeterminate force caused by an effective prestress force shall be calculated multiplying the statically indeterminate force caused by the prestress force immediately after prestressing by the effective factor of prestressing steel tensile force averaged over the entire structural member.

8.5 Effects of Concrete Creep

(1) The effects of concrete creep shall be considered as creep strain.

(2) When provisions (3) and (4) are complied with, provision (1) may be deemed to be satisfied.

(3) The creep strain of concrete shall be calculated according to the provisions of Clause 4.2.3 of Part III.

(4) The statically indeterminate force occurring due to the effects of concrete creep shall be calculated according to the following provisions.

1) The structural system unchanged during construction

When the entire structure is constructed on staging at once with no change occurring between the structural system under construction and that after construction, the effects of concrete creep may generally be excluded from consideration.

2) The structural system changed during construction

When the entire structure is not constructed at once with some change occurring between the structural system under construction and that after construction, the statically indeterminate force due to the effects of concrete creep shall be calculated by using a value determined according to provision (3). The sustained loads to be considered in this case shall be the dead load, prestressing force, and the influence of drying shrinkage.

8.6 Effects of Drying Shrinkage of Concrete

(1) The effects of drying shrinkage of concrete shall be considered as strain due to drying shrinkage (drying shrinkage rate of concrete).

(2) When provisions (3) and (4) are complied with, provision (1) may be deemed to be satisfied.

(3) The drying shrinkage rate of concrete that is to be used for calculating the reduction in prestress shall be set according to Clause 4.2.3 of Part III.

(4) The statically indeterminate force occurring due to the effects of dry shrinkage of concrete shall be calculated according to provision 1) or 2).

1) The structural system unchanged during construction

When the entire structure is constructed on staging at once with no change occurring between the structural system under construction and that after construction, the dry shrinkage rate of concrete shall be set to 15×10^{-5}. When the amount of steel in the longitudinal direction is less than 0.5% of the concrete sectional-area of the structural member, the strain of drying shrinkage shall be 20×10^{-5}.

2) The structural system changed during construction

When the entire structure is not constructed at once with some change occurring between the structural system under construction and that after construction, the dry shrinkage rate of concrete shall not be determined according to the provisions of Clause 4.2.3(4) of Part III but separately taking into consideration the humidity around the member, the shape and dimensions of the cross section of the member, the material and age of the concrete under an acting load, and the like, and thereby, the statically indeterminate force shall be calculated. The sustained loads to be considered in this case shall be the dead load, prestressing force, and the influence of drying shrinkage.

8.7 Earth Pressure

(1) The earth pressure shall be set by appropriately considering the type of the structure, soil conditions, the displacement of the structure and the intensity of strain developed in soil, uncertainty in estimation of the mechanical properties of soil, and the like.

(2) The earth pressure during an earthquake shall be determined according to the provisions of Part V.

(3) The surface of action of earth pressure on an abutment shall generally be as follows.

1) For a gravity-type abutment, it lies at the back surface of the main body of concrete.

2) For a reversed T-type abutment, it lies at the back surface of the main body of concrete for sectional calculation of the wall and at the vertical imaginary back surface at the rear footing end for stability calculation.

(4) When provision (5) is complied with, provision (1) may be deemed to be satisfied.

(5) The earth pressure shall be the distributed load acting on the wall surface, and the characteristic value of the load intensity shall be as follows.

1) Active earth pressure and passive earth pressure

i) Sandy soil

$$p_A = K_A \cdot \gamma \cdot x + K_A \cdot q \quad \cdots\cdots (8.7.1)$$

$$p_p = K_p \cdot \gamma \cdot x + K_p \cdot q \quad \cdots\cdots (8.7.2)$$

ii) Cohesive soil

$$p_A = K_A \cdot \gamma \cdot x - 2 \cdot c \cdot \sqrt{K_A} + K_A \cdot q \quad \cdots\cdots (8.7.3)$$

Where $p_A \geq 0$

$$p_p = K_p \cdot \gamma \cdot x + 2 \cdot c \cdot \sqrt{K_P} + K_P \cdot q \quad \cdots\cdots (8.7.4)$$

where

$$K_A = \frac{\cos^2(\phi - \theta)}{\cos^2\theta \cos(\theta + \delta)\left\{1 + \sqrt{\dfrac{\sin(\phi + \delta)\sin(\phi - \alpha)}{\cos(\theta + \delta)\cos(\theta - \alpha)}}\right\}^2} \quad \cdots\cdots (8.7.5)$$

$$K_P = \frac{\cos^2(\phi+\theta)}{\cos^2\theta\cos(\theta+\delta)\left\{1-\sqrt{\dfrac{\sin(\phi-\delta)\sin(\phi+\alpha)}{\cos(\theta+\delta)\cos(\theta-\alpha)}}\right\}^2} \quad \cdots\cdots\cdots\cdots\cdots \text{(8.7.6)}$$

Take sin ($\phi \pm \alpha$) = 0 if $\phi \pm \alpha < 0$.

2) Earth pressure at rest

$$p_0 = K_0 \cdot \gamma \cdot x + K_0 \cdot q \quad \cdots\cdots\cdots\cdots\cdots \text{(8.7.7)}$$

where

γ : Unit weight of soil (kN/m^3)

p_A : Active earth pressure intensity at depth × (kN/m^2)

p_P : Passive earth pressure intensity at depth × (kN/m^2)

p_0 : Earth pressure intensity at rest at depth × (kN/m^2)

K_A : Coefficient of active earth pressure according to Coulomb's earth pressure theory

K_P : Coefficient of passive earth pressure according to Coulomb's earth pressure theory

K_0 : Coefficient of earth pressure at rest

x : Depth at which earth pressures p_A, p_P and p_0 act on the wall surface (m)

c : Cohesion of soil (kN/m^2)

q : Load imposed on the ground surface (kN/m^2)

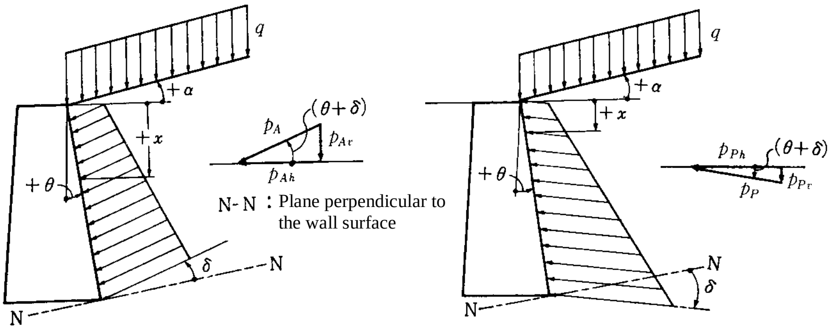
ϕ : Angle of shearing resistance of soil (degrees)

α : Angle formed between the ground surface and horizontal plane (degrees)

θ : Angle formed between the wall's rear surface and vertical plane (degrees)

δ : Angle of wall friction between the wall's rear surface and soil (degrees)

The normal direction of the above angles shall be the counter-clockwise direction.



(a) In the case of active earth pressure (b) In the case of passive earth pressure

Figure 8.7.1 Earth Pressure

8.8 Water Pressure

(1) The water pressure shall be set appropriately considering the water level variations, flow velocity, influence of scouring, and the shape and dimensions of the piers.

(2) The hydrodynamic pressure during an earthquake shall be determined according to the provisions of Part V.

(3) When provisions (4) and (5) are complied with, provision (1) may be deemed to be satisfied.

(4) The hydrostatic pressure shall be calculated by Equation 8.8.1. If it is obvious that the water pressure acting on the underground part of a structure will not reach this theoretical water pressure value, the water pressure may be reduced.

$$p_h = w_0 \cdot h \quad \cdots\cdots (8.8.1)$$

where

p_h : Hydrostatic pressure at depth h from water surface (kN/m^2)

h : Depth from water surface (m)

w_0 : Unit weight of water (kN/m^3)

(5) The flowing water pressure shall be the horizontal load acting on the vertical projected area of the pier in the flowing direction and shall be calculated by Equation 8.8.2. The point of action shall be 0.6*H* from the riverbed.

$$P = K \cdot v^2 \cdot A \quad \cdots\cdots (8.8.2)$$

where

P : Flowing water pressure (kN)

K : Factor determined from the shape of piers shown in Table 8.8.1

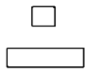
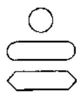
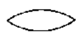
ν : Maximum flow velocity (m/s)

A : Vertical projected area of pier (m^2)

H : Water depth (m)

When there is the influence of scouring, the depth of scouring caused by the influence of the substructure and the general riverbed sinkage expected during the service of the bridge shall be added to the water depth (H). During a flood, the water depth shall be the water depth obtained above to which the water level rise during a flood and the scoured depth during a flood are added.

Table 8.8.1 Resistance Factor of Piers

Shape of pier at upstream and downstream ends	Coefficient
→ → 	0.7
→ → → 	0.4
→ 	0.2

8.9 Buoyancy or Uplift

(1) Buoyancy or uplift shall appropriately be determined by considering the presence of pore water and fluctuations in the water level.

(2) Buoyancy or uplift shall be regarded as a force acting in the vertical direction and shall be loaded in such a manner as to be the most disadvantageous to the structure.

8.10 Effect of Temperature Change

(1) The effects of temperature change shall be set by appropriately considering the type and structural conditions of the structure, environmental conditions at the bridging point, and the material and dimensions of the member.

(2) When provisions (3) to (6) are complied with, provision (1) may be deemed to be satisfied.

(3) The reference temperature used for design shall generally be +20°C. In cold regions, it shall generally be +10°C.

(4) The temperature range used for design shall be as follows, and the temperature difference in a structure shall be considered as the difference from the reference temperature.

1) Steel structures

The temperature range of a whole steel structure, shall be from -10°C to +50°C. In cold regions, it shall be from -30°C to +50°C.

2) Concrete structures

The temperature difference of a whole concrete structure shall be generally determined from the reference temperature considering the mean air temperature by the regions. In general cases, the temperature difference shall be 15 degrees. If the minimum dimension of the cross section is 700 mm or more, the above standard may be 10 degrees.

3) Bearing and expansion joint

In calculating the movement amount of bearings and the expansion-contraction length of expansion joints, one of the ranges shown in Table 8.10.1 shall be used as the temperature-change range in both cases 1) and 2).

Table 8.10.1 Temperature-Change Ranges to Be Used for Calculating the Movement Amount of Bearings and the Expansion-Contraction Length of Expansion Joints

Bridge type	Temperature range	
	Mild region	Cold region
Reinforced concrete bridge Prestressed concrete bridge	-5°C ~ +35°C	-15°C ~ +35°C
Steel bridge (deck bridge)	-10°C ~ +40°C	-20°C ~ +40°C

Steel bridge (through bridge and bridge with steel plate floor)	-10°C ~ +50°C	-20°C ~ +40°C

4) For the structure in the water or soil, temperature variations need not be considered.

(5) The coefficient of linear expansion used for design shall be as follows:

1) The coefficient of linear expansion of steel in a steel structure shall be 12×10^{-6}.

2) The coefficient of linear expansion of steel and concrete in a concrete structure shall be 10×10^{-6}.

3) When considering the composite action of a steel girder and concrete slab, the coefficient of linear expansion of steel and concrete shall be 12×10^{-6}.

(6) When the effects of temperature change is determined regardless provisions (3) to (5), in consideration of the type and structural conditions of the structure and the material and dimensions of the member, the characteristics value of the range of temperature change shall be retermined as a maximum value considering the statistical property of annual highest and lowet temperature in the area where the bridging point is located, corresponding to the design service life.

8.11 Effects of Temperature Difference

(1) The effects of the temperature difference between structural members shall be set by appropriately considering the structural conditions of the structure, environmental conditions at the bridging point, and the material and dimensions of the members.

(2) For steel structures, steel girders with concrete slabs, and concrete structures, when provisions (3) and (4) are complied with, provision (1) may be deemed to be satisfied.

(3) The following temperature differences shall be used for analyzing the effects of the temperature difference between structural members, and the effects shall be considered in such a manner that the most disadvantageous stress will be developed in the design members.

1) Steel structures

The relative temperature difference between members or between the portions of each member shall be set to 15 degrees.

2) Steel girders with concrete slabs

When the effects of the temperature difference between concrete slabs and steel girders need to be considered, the temperature difference shall be set to 10 degrees with the temperature distribution in the steel girders and that in the concrete slabs regarded as independently uniform.

3) Concrete structures

The relative temperature difference between slabs and members other than the slabs shall be set to 5 degrees with the temperature distribution in the slabs and that in the members regarded as independently uniform.

(4) The coefficient of linear expansion that is to be used in the design shall be determined according to the provisions of Clause 8.10(5).

8.12 Snow Load

(1) For areas for which the snow load needs to be considered, snowfall at the bridging point, and conditions for maintenance and management, such as snow removal, shall appropriately be considered as preconditions for design in setting the snow load.

(2) When provisions (3) to (5) are complied with, provision (1) may be deemed to be satisfied.

(3) For traffic of vehicles traveling on sufficiently compacted snow without any restrictions, a load of 1 kN/m^2 on the entire bridge surface in addition to the live load shall be considered.

(4) When a load due to automobile traffic is not loaded simultaneously with the snow load because snowfall is especially heavy, Equation 8.12.1 shall be considered.

$$SW = P \cdot Z_s \quad \text{(8.12.1)}$$

where

SW: Snow load (kN/m^2)

P: Average unit weight of snow (kN/m^3)

Z_S: Design snow depth (m), which shall appropriately be determined by considering the annual maximum snow depth corresponding to a recurrence interval of 10 years at the bridging point with consideration also given to previous records and the accumulation of snow on the bridge in ordinary cases

(5) When the snow load is not to be determined according to provision (3) or (4), conditions for maintenance and management, such as snow removal, shall appropriately

be considered as preconditions for design, and for the characteristic value of the snow load when automobile traffic is not taken into account, the annual maximum snow depth corresponding to a recurrence interval of 10 years at the bridging point may be considered in ordinary cases.

8.13 Effects of Ground Deformation

Where ground displacement is expected after completion of the substructure due to consolidation settlement of the ground or for other reasons, its effect shall be appropriately considered.

8.14 Effects of Support Displacement

(1) For statically indeterminate structures, the effects of the support displacement and rotation that are expected to occur during a prolonged period because of the consolidation settlement of the ground and the like shall appropriately be considered.

(2) When provision (3) is complied with, provision (1) may be deemed to be satisfied.

(3) As the sectional force brought about by the effects of support displacement, 50% of the sectional force corresponding to the final displacement estimated by elasticity calculation shall be used for design calculation for concrete bridges, and the sectional force corresponding to the final displacement estimated by elasticity calculation shall be used without modification for design calculation for steel bridges.

(4) The effects of support displacement due to an earthquake other than those specified in this Part shall be dealt with according to the provisions of Part V.

8.15 Centrifugal Load

(1) The centrifugal load shall be set appropriately considering the traffic of motor vehicles and track vehicles and the structural type of the bridge.

(2) When provision (3) is complied with, provision (1) may be deemed to be satisfied.

(3) Only when a curved track is present, 8% of the vehicle load on the track shall be applied as the centrifugal load at a height of 1.8 m above the rail surface in the lateral direction. For a very light bridge or other special cases, the centrifugal load of mortor vehicle shall also be considered.

8.16 Braking Load

(1) The braking load shall be set by appropriately considering the traffic of automobiles and railway vehicles and the structural type of the bridge.

(2) When provision (3) is complied with, provision (1) may be deemed to be satisfied.

(3) In the case of railway exists, the braking load acts on the direction of travel of the vehicle at a height of 1.8 m above the railway surface, with 10% of the total wheel load of the railway vehicle. In other cases, such as a very light bridge, the braking load of avehicle shall be 25 kN and act at a height of 1.8 m above the bridge surface in the direction of travel of the vehicle.

8.17 Wind Load

(1) The effects of wind shall be set by appropriately considering the position, topography, and ground-surface conditions of the bridging point and the structural properties and section shape of the bridge.

(2) In designing a bridge that easily develops deflection, such as a suspension bridge and a cable-stayed bridge, or a member that especially easily develops deformation, the dynamic effects of wind shall be considered.

(3) When provisions (4) and (5) are complied with, provision (1) may be deemed to be satisfied.

(4) The wind load that will act on superstructures shall be a horizontal load that is determined for a design reference wind speed of 40 m/s as a load acting in the transverse direction to the bridge axis, and shall be loaded on their effective projected areas in such a manner that the most disadvantageous stress will be developed in the design members. When a noise barrier is to be installed, the wind load may be reduced appropriately to the characteristics of wind and the structure of the noise barrier.

1) Steel girder

The wind load WS that will act on the steel girders of one bridge shall have the value shown in Table 8.17.1 per meter in the longitudinal direction to the bridge axis.

Table 8.17.1 Wind Load on Steel Girder (kN/m)

Section form	Wind load

$1 \leq B/D < 8$	$(V/40)^2 \cdot [4.0\text{-}0.2\ (B/D)] \cdot D \geq 6.0$
$8 \leq B/D$	$(V/40)^2 \cdot 2.4\ D \geq 6.0$

Here

- B : Total bridge width (m) (See Figure 8.17.1.)
- D : Total bridge height (m) (See Table 8.17.2.)
- V: Design reference wind speed (m/s)

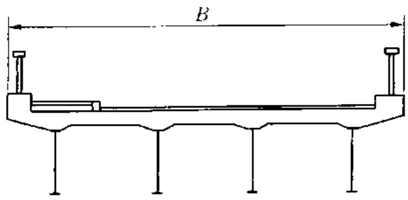
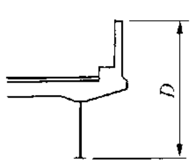
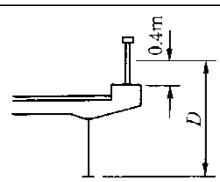


Figure 8.17.1 *B*: Total Bridge Width

Table 8.17.2 *D*: Total Bridge Height

Guard fence	Wall-type rigid guard fence	Others
D: Total bridge height		

2) Truss

The wind load WS that will act on a 2-main-truss structure shall have the value shown in Table 8.17.3 per square meter on its effective vertical projected area on the windward side. For standard 2-main-truss structures, however, the wind load per meter in the longitudinal direction to the bridge axis on chord members on the windward side may be determined according to Table 8.17.4. In this case, the wind load per meter shall be 6.0 kN/m or larger for loaded chords and 3.0 kN/m or larger for unloaded chords.

Table 8.17.3 Wind Load Acting on Double Main Structure Truss (kN/m^2)

Truss	$2.5(V/40)^2/\phi^{0.5}$
Bridge floor	$3.0(V/40)^2$

where $0.1 \leq \phi \leq 0.6$.

Here

- ϕ : Solidity factor of truss (ratio of projected truss area to the outer truss frame area)
- *V*: Design reference wind speed (m/s)

Table 8.17.4 Solidity Factor and Effective Vertical Projected Height of Standard Truss Structures (m)

Solidity factor of truss ϕ	Effective vertical projected height (m)
$4h/\lambda$	**Loaded chord and unloaded chord: 2*h* Bridge floor: *D***

where $7 \leq \lambda/d \leq 40$.

Here

- *D* : Total height of bridge floor (m). This excludes the height of the portion overlapping a chord member as seen from the perpendicular direction (see Figure 8.17.2).
- *h* : Height of chord member (m)
- λ : Main structure height from the center of bottom chord member to the center of top chord member (m)

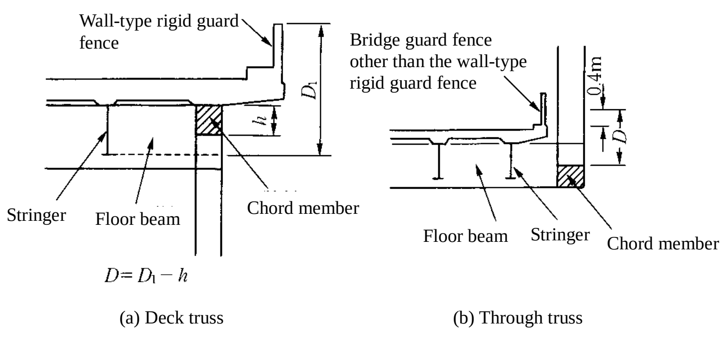


Figure 8.17.2 *D*: Total Height of the Bridge Floor

3) Wind load on bridges of other types

The wind load WS that will act on the girders of bridges of other types shall be determined by applying provision 1) or 2) according to their girder shapes.

The wind load acting on a structural member not stipulated in 1) or 2) shall be used given in Table 8.17.5 according to the section form.

Table 8.17.5
Wind Load Acting on a Structural Member of a Bridge Other than the Steel Girder or Truss (kN/m²)

Section form of member		Wind load	
		Member on windward side	Member on lee side
Circular	When no live load is applied	$1.5(V/40)^2$	$1.5(V/40)^2$
Rectangular	When no live load is applied	$3.0(V/40)^2$	$1.5(V/40)^2$

V: Design reference wind speed (m/s)

4) Parallel bridges

When steel girder bridges lie in parallel, the wind load in Table 8.17.1 shall be appropriately corrected considering the influence of the bridges on each other.

5) Wind load WL under the action of a live load

When a live load is to be loaded, a wind load WL of $3.0(V/40)^2$ (kN/m²) shall be applied at a point 1.5 m above the bridge surface under the action of the live load.

(5) The wind load WS that will directly act on a substructure shall be a horizontal load acting in the transverse direction to the bridge axis or that acting in the longitudinal direction to the bridge axis. Simultaneous loading in the two directions shall be excluded from consideration. The value of the wind load WS shall be the value shown in Table 8.17.6 for the effective vertical projected area in the wind direction.

Table 8.17.6 Wind Load Acting on Substructure (kN/m²)

Section form of main body	Wind load
Circular Oval	$1.5(V/40)^2$
Rectangular	$3.0(V/40)^2$

(6) When the design reference wind speed is not to be determined according to provision (4), it shall be set with consideration given to wind fluctuations at the bridging point and the statistical property so that the maximum value that may occur during the design

service life can be set.

8.18 Wave Pressure

(1) The wave pressure shall be set appropriately considering the water depth and wave properties where the structure is to be installed.

(2) When provisions (3) and (4) are complied with, provision (1) may be deemed to be satisfied.

(3) The wave pressure of breaking waves that will act on the vertical wall shall be calculated by using Equation 8.18.1 on the assumption that it uniformly distributes from a height of $1.25H_0$ above the still-water level to the seafloor.

$$p = 1.5 \cdot w \cdot H_0 \quad \cdots\cdots (8.18.1)$$

where p: Wave force of breaking waves (kN/m^2)

w: Unit weight of seawater (kN/m^3)

H_0: Offshore-wave height (m), for which a value that is equivalent to the expected recurrence value for the design service life shall be set on the basis of the distribution of the annual maximum values of the maximum wave pressure

(4) The wave pressure acting on a bridge pier in the stream may be generally neglected.

8.19 Effect of Earthquakes

(1) The effects of earthquakes, the following two types of earthquake ground motions shall appropriately be set as earthquake ground motions: the earthquake ground motion that is defined as a variable action specified in Clause 2.1, and that will often occur during the design service life of the bridge; the earthquake ground motion that is defined as an accidental action, and that will have immense impacts on the bridge once it occurs although its occurrence during the design service life of the bridge is extremely rare.

(2) The characteristic value of an earthquake ground motion that will act on the bridge shall be set by appropriately considering the effects of its displacement on the conditions of the seismic environment of its construction site, the effects of topography, geology, and ground of its construction site, and the like.

(3) When the effects of earthquakes considered according to provisions (1) and (2) are dealt

with according to Clause 2.3 of Part V, the effects of earthquakes may be regarded as appropriately considered for the bridge.

8.20 Collision Load

(1) If a motor vehicle, driftwood, a vessel, and the like, may collide with the bridge the effects of the collision shall appropriately be set.

(2) When provisions (3) to (5) are complied with, provision (1) may be deemed to be satisfied.

(3) Collision of motor vehicles

For building frames into which a motor vehicle may collide, a sufficient protective structure, such as a concrete wall, shall be installed. If such a protective structure cannot be installed, the frames shall be designed on the assumption that one of the following collision loads will horizontally act at a height of 1.8 m above the road surface.

1,000 kN in the roadway direction, 500 kN in the roadway's transverse direction.

(4) Collision of driftwood or the like

For the collision of driftwood or other driftage, the collision force calculated by using Equation 8.20.1 shall be applied at the water surface level.

$$p = 0.1 \cdot W \cdot v \quad \cdots\cdots (8.20.1)$$

where P: Collision force (kN)

W: Weight of rafted goods (kN)

v: Surface flow velocity (m/s)

(5) Collision of vessels

The collision load shall be set appropriately considering the size of plying vessels and the vessel velocity at the collision.

8.21 Erection Load

The erection load shall be set by performing the necessary examinations on the effects of the weight of the bridge, construction equipment, wind, and earthquakes, and the like in order to ensure safety for the construction of the bridge and performed in such a manner as to satisfy Clause 3.1(3) with appropriate consideration given to the construction method and the

structure under construction.

CHAPTER 9 MATERIALS

9.1 Steel Materials

(1) The steel materials shall have certain mechanical properties such as strength, elongation and toughness, chemical composition, limitations on harmful ingredients, geometrical dimensions such as thickness and warping, and quality.

(2) For steel materials listed in Table 9.1.1, the provision (1) may be deemed to be satisfied.

Table 9.1.1 Steel Materials (JIS)

Steel type	Standard		Steel material symbol
1) Steels for structural purpose	JIS G 3101	Rolled steels for general structure	SS400
	JIS G 3106	Rolled steels for welded structure	SM400, SM490, SM490Y SM520, SM570
	JIS G 3114	Hot-rolled atmospheric corrosion resisting steels for welded structure	SMA400W, SMA490W SMA570W
	JIS G 3140	Higher yield strength steel plates for bridges	SBHS400, SBHS400W SBHS500, SBHS500W
2) Steel pipes	JIS G 3444	Carbon steel tubes for general structure	STK400, STK490
	JIS A 5525	Steel pipe piles	SKK400, SKK490
	JIS A 5530	Steel pipe sheet piles	SKY400, SKY490
3) Steel fasteners	JIS B 1186	Sets of high strength hexagon bolt, hexagon nut and plain washers for friction grip joints	F8T, F10T
	JIS B 1180	Hexagon head bolts and hexagon head screws	Strength class 4.6, 8.8, 10.9
	JIS B 1181	Hexagon nuts and hexagon thin nuts	Strength class 5, 8, 10
4) Welding materials	JIS Z 3211	Covered electrodes for mild steel, high tensile strength steel and low temperature service steel	
	JIS Z 3214	Covered electrodes for atmospheric corrosion resisting steel	
	JIS Z 3312	Solid wires for MAG and MIG welding of mild steel, high strength steel and low temperature service steel	

	JIS Z 3313	Flux cored wires for gas shielded and self-shielded metal arc welding of mild steel, high strength steel and low temperature service steel	
	JIS Z 3315	Solid wires for MAG and MIG welding of atmospheric corrosion resisting steel	
	JIS Z 3320	Flux cored wires for gas shielded and self-shielded metal arc welding of atmospheric corrosion resisting steel	
	JIS Z 3351	Solid wires for submerged arc welding of carbon steel and low alloy steel	
	JIS Z 3352	Fluxes for submerged arc welding and electroslag welding	
5) Castings	JIS G 3201	Carbon steel forgings for General Use	SF490A, SF540A
	JIS G 5101	Carbon steel castings	SC450
	JIS G 5102	Steel castings for welded structure	SCW410, SCW480
	JIS G 5111	High tensile strength carbon steel castings and low alloy steel castings for structural purposes	SCMn1A, SCMn2A
	JIS G 4051	Carbon Steels for Machine Structural Use	S35CN, S45CN
	JIS G 5501	Grey iron castings	FC250
	JIS G 5502	Spheroidal graphite iron castings	FCD400, FCD450
6) Wire rods and secondary wire products	JIS G 3502	Piano wire rods	SWRS
	JIS G 3506	High carbon steel wire rods	SWRH
	JIS G 3536	Steel wires and strands for prestressed concrete	SWPR1, SWPD1, SWPR2, SWPD3, SWPR7, SWPR19
	JIS G 3549	Wire ropes for structure	
7) Steel bars	JIS G 3112	Steel bars for Concrete Reinforcement	SR235, SD295A, SD295B SD345, SD390, SD490
	JIS G 3109	Steel bars for prestressed concrete	SBPR785/1030 SBPR930/1080 SBPR930/1180
8) Others	JIS B 1198	Headed studs	Stud names 19 and 22

(3) For steel materials listed in Table 9.1.2, provision (1) may be deemed to be satisfied in addition to those listed in provision (2) when their characteristics and quality have been confirmed.

Table 9.1.2 Steel Materials (Other than JIS)

Steel type	Standard	Steel material symbol
Steel fasteners	Sets of a torshear type high strength bolt (S10T), hexagon nut and plain washers for friction grip joints	S10T
	Sets of a super-high-strength torque shear bolt (S14T), a hexagon nut, and plain washers for friction connection	S14T
	Sets of high strength reamer bolts (B8T, B10T), hexagon nuts, and plain washers for bearing connection	B10T, B8T
Secondary wire products	Parallel wire strands	
	Covered parallel wire strands	

9.2 Concrete

9.2.1 General

Concrete shall have certain strength, deformability, durability, workability for construction and other properties and quality. Therefore, appropriate consideration shall be given in each stage of material selection, mixing and construction.

9.2.2 Materials for Concrete Mixture

(1) The materials used in concrete mixture shall be as follows:

1) The cement shall have appropriate properties and quality, such as specific surface area, set time, compressive strength, limitations on harmful ingredients and so on.

2) The water shall not contain oil, acids, salts, organic matter or other harmful substances.

3) The fine aggregate shall be clean, hard and strong and have durability and an appropriate grading and shall not contain a harmful amount of dust, mud, organic impurities, chlorides.

4) The coarse aggregate shall be clean, hard and strong and have durability and an appropriate grading and shall not contain a harmful amount of thin or elongate

fraction, organic impurities, chlorides.

5) The chemical admixtures and mineral admixtures used in the concrete shall have a certain effect on improving the concrete properties and quality and shall have reliable properties and quality in themselves.

(2) The materials conforming to the standards or provisions given in Table 9.2.1 are deemed to satisfy the quality mentioned above.

Table 9.2.1 Standards or Stipulations of Materials for Concrete

Material type	Standard or stipulation		Remarks
1) Cement	JIS R 5210	Portland cement	Normal, High-early-strength
	JIS R 5211	Portland blast-furnace slag cement	
2) Water	JIS A 5308 Appendix C	Water used for kneading ready mixed concrete	
3) Aggregate	JIS A 5308 Appendix A	Aggregate for ready mixed concrete	
4) chemical admixture	JIS A 6204	Chemical admixtures for concrete	
5) Mineral admixture	JIS A 6201	Fly ash for use in concrete	
	JIS A 6206	Ground granulated blast-furnace slag for concrete	

(3) The total amount of chloride ions contained in the fresh concrete shall be 0.3 kg/m^3 or less.

9.2.3 Concrete Strength

Concrete to be used shall generally have higher strength than the minimum specified compressive strength shown in Table 9.2.2.

Table 9.2.2 Minimum Specified Compressive Strength of Concrete (N/mm^2)

Member type		Minimum specified compressive strength
Plain concrete member		18
Reinforced concrete member		21
Prestressed concrete member	Pretensionning method	36
	Post-tensionning method	30

9.3 Constants for Design Calculation

The values of constants for design calculation shall appropriately be determined by considering the characteristics and quality of the materials to be used.

CHAPTER 10 CONNECTION BETWEEN SUPERSTRUCTURE AND SUBSTRUCTURE

10.1 Bearing

10.1.1 General

(1) For bearings, appropriate type, structure and materials shall be selected to satisfy the following performance requirements:

1) A bearing support shall reliably receive a load from a superstructure and transfer it to a substructure.

2) A bearing support shall follow the expansion, contraction, and rotation of a superstructure due to live loads, temperature change, and the like and thereby absorb the relative displacement between the superstructure and the corresponding substructure.

(2) The seismic design of bearing supports shall be performed according to the provisions of Part V.

(3) In designing bearing supports, the effects of aging shall be considered.

(4) Factors in degradation, such as dust and stagnant water, shall be minimized, and durability and the reliability and ease of maintenance and management, shall be considered.

(5) In designing bearing supports, ensuring construction quality shall be considered.

(6) In designing the bearings, other members, and the like that compose bearing supports, examinations shall generally be performed on methods for inspecting and replacing the bearing supports and methods for dealing with damage to bearing supports during the design service life of the bridge, regardless of the design durability life that is set according to the provision of Clause 10.1.9(2). And the examination results shall generally be applied to the design of the bearing supports and the superstructures and substructures to which the bearing supports will be attached.

10.1.2 Design for the Load Carrying Performance of Bearing Supports

Design for the load carrying performance of bearing supports shall be performed according to the provisions of Clauses 10.1.3 to 10.1.8.

10.1.3 Action on a Bearing Support

(1) In designing the load carrying performance of bearing supports, action on the bearing supports shall be calculated for the combination of actions specified in Clause 3.3 with appropriate consideration given to the structural type of the bridge, the type of the bearings, and the like.

(2) When provisions (3) and (4) are complied with, provision (1) may be deemed to be satisfied.

(3) Vertical force acting on a bearing support shall be calculated considering the most disadvantageous conditions among the conbinations of actions specified in Clause 3.3. In a combination of actions in which a negative force may occur, disadvantageous value of negative force calculated by Equation 10.1.1 and 10.1.2 shall be considered as a vertical force acting on a bearing.

$$R_U = \alpha R_{L+I} + R_D \quad \cdots\cdots (10.1.1)$$

$$R_U = R_D + R_W \quad \cdots\cdots (10.1.2)$$

where
- R_U: Negative force at a support (kN)
- R_{L+I}: Maximum negative force due to live loads including impacts (kN)
- R_D: Force due to dead load (kN)
- R_W: Maximum negative force due to wind load (kN)
- α: Increase coefficient that corresponds to the maximum negative force due to live loads including impacts, and it shall be 1.65

(4) The horizontal action on the bearing support shall be calculated as follows:

1) When designing a movable bearing support, the frictional forces shall be considered and they shall be calculated using the coefficient of friction. The variation of coefficient of friction due to age deterioration which may differ depending on the bearing type and used materials, shall be considered.

2) When designing a fixed bearing support, a horizontal force due to the dynamic friction in the movable bearing supports of the same superstructure shall not be neglected.

10.1.4 Limit States of Bearing Supports

(1) Limit state 1 of a bearing support shall be a state in which any of the following is not satisfied.

1) State in which its behavior exhibits reversibility

2) State in which the displacement or vibration that is determined according to the function of the bearing support and that of the bridge does not take place

(2) Limit state 2 of a bearing support shall be a state in which although some portions of the bearing support suffer damage or develop material plasticity causing the bearing support to lose the reversibility of its behavior, it can ensure its load-carrying capacity within an assumed range.

(3) Limit state 3 of a bearing support shall be a state in which although some portions of the bearing support suffer damage or develop material plasticity causing the bearing support to lose the reversibility of its behavior, it does not completely lose its load-carrying capacity.

10.1.5 Characteristic Value of Resistance

The characteristic value of the resistance of each member and the like composing a bearing support shall be set as follows.

1) The characteristics of the resistance in limit states shall appropriately be considered.

2) A method based on appropriate knowledge, such as an approach with theoretical validity for appropriately evaluating the limit value or an approach that has been verified by an experiment, shall be used with consideration given to the purpose and method of verification.

10.1.6 Verification of the Load Carrying Performance of Bearing Supports

(1) When provisions 1) and 2) below are complied with, the bearing support may be regarded as having the required reliability in terms of Limit state 1 of the bearing support not being exceeded in the situation dominated by permanent action and the situation dominated by variable action.

1) For the situation dominated by permanent action and the situation dominated by variable action, verification shall be performed to confirm that the response of

each portion of the bearing support under the action of the force calculated according to Clause 10.1.3 does not exceed Limit state 1 of a steel member or a concrete member according to the provisions of Chapters 5 and 9 of Part II or those of Chapters 5 and 7 of Part III.

2) For the bearing support containing rubber members, Limit state 1 of the bearing support and a limit value representing it shall be set according to the provisions of Clauses 10.1.4 and 10.1.5. And verification shall be performed to confirm that with reliability equivalent to that of provision 1), the response of the bearing support under the action of the force calculated according to Clause 10.1.3 does not exceed the limit value in the situation dominated by permanent action and the situation dominated by variable action.

(2) When design is performed according to provisions 1) and 2) below, the bearing support may be regarded as having the required reliability in terms of Limit state 3 of the bearing support not being exceeded in the situation dominated by permanent action and the situation dominated by variable action.

1) For the situation dominated by permanent action and the situation dominated by variable action, verification shall be performed to confirm that the response of each portion of the bearing support under the action of the force calculated according to Clause 10.1.3 does not exceed Limit state 3 of a steel member or a concrete member according to the provisions of Chapters 5 and 9 of Part II or those of Chapters 5 and 7 of Part III.

2) For the bearing support containing rubber members, Limit state 3 of the bearing support and a characteristic value representing it shall be set according to the provisions of Clauses 10.1.4 and 10.1.5. And verification shall be performed to confirm that with reliability equivalent to that of provision 1), the response of the bearing support under the action of the force calculated according to Clause 10.1.3 does not exceed the characteristic value in the situation dominated by permanent action and the situation dominated by variable action.

10.1.7 Design of the Connections between Bearings and Superstructures or Substructures

(1) The connection between the bearing and the superstructure or substructure shall have a structure that can firmly transmit the force acting on the bearing support.

(2) When provisions (3) to (5) are complied with, provision (1) may be deemed to be

satisfied.

(3) The steel plate used to connect the bearing to the superstructure or substructure (i.e., sole plate or base plate) shall have a thickness of 22 mm or over.

(4) When anchor bolts are to be used to secure a bearing to a substructure, provisions 1) to 3) below shall be satisfied.

1) The anchor bolts shall be arranged in such a manner that the force acting from the bearing will be distributed among them evenly to the extent possible.

2) In designing a connection to a substructure consisting of concrete members by using anchor bolts, the provisions of Clause 7.5 of Part III shall be satisfied.

3) The minimum diameter shall be 25 mm, and a fixed length of 10 times of the diameter or more inside the substructure shall be ensured so as to obtain sufficient bond strength to resist upward force.

(5) Superstructures and substructures to which a bearing support will be attached shall be appropriately reinforced so that they will not develop local deformation or damage due to load concentration.

10.1.8 Amount of Bearing Movement

(1) The amount of design bearing movement shall be decided considering the bridge deck temperature variations, concrete creep and shrinkage, elastic deformation due to prestress, the amount of superstructure movement due to the deflection caused by live loads, and the allowance for construction error.

(2) When provisions (3) to (6) are complied with, provision (1) may be deemed to be satisfied.

(3) The amount of movement due to temperature variations shall be decided according to Equation 10.1.3.

$$\Delta l_t = \Delta T \cdot \alpha \cdot l \quad \cdots\cdots (10.1.3)$$

where Δl_t: Amount of movement due to temperature variations (mm)

ΔT: Range of temperature variations given in Table 8.10.1

α: Coefficient of linear expansion stipulated in 8.10 (5)

l : Girder expansion length (mm)

(4) The amount of movement due to drying shrinkage and creep of concrete shall be decided according to Equation 10.1.4 and 10.1.5 as a standard value.

$$\Delta l_s = \varepsilon_{cs} \cdot l \quad \cdots\cdots (10.1.4)$$

$$\Delta l_c = \frac{P_t}{E_c \cdot A_c} \cdot \varphi \cdot l \quad \cdots\cdots (10.1.5)$$

where Δl_s: Amount of movement due to drying shrinkage of concrete (mm)

Δl_c: Amount of movement due to creep of concrete (mm)

ε_{cs}: Drying shrinkage rate described in Clause 4.2.3 of Part III

P_t: Tensile force acting on PC strand immediately after prestressing (N)

A_c: Cross-sectional area of concrete (mm^2)

E_c: Young's modulus of concrete described in Clause 4.2.3 of Part III (N/mm^2)

φ: Creep coefficient of concrete described in Clause 4.2.3 of Part III

l : Girder expansion length (mm)

(5) The amount of movement due to elastic deformation caused by concrete prestress shall be decided according to Equation 10.1.6

$$\Delta l_p = \frac{P_t}{E_c \cdot A_c} \cdot l \quad \cdots\cdots (10.1.6)$$

where Δl_p: Amount of movement due to elastic deformation caused by concrete prestress (mm)

P_t: Tensile force acting on PC strand immediately after prestressing (N)

A_c: Cross-sectional area of concrete (mm^2)

E_c: Young's modulus of concrete described in Clause 4.2.3 of Part III (N/mm^2)

l : Girder expansion length (mm)

(6) A value determined by a structural analysis shall be used as the amount of movement of a superstructure due to girder deflection caused by live load.

10.1.9 Design for the Durability Performance of Bearing Supports

(1) Design for the durability performance of a bearing support shall be performed according to the provisions of Chapter 6.

(2) For the material and structure of a bearing support, measures shall be taken, to minimize functional degradation due to aging of materials, such as, corrosion of steels and degradation of rubber and the like, in addition to complying with provision (1).

(3) To satisfy the provision (2) , at least provisions (4) to (7) shall be complied with.

(4) The bodies of steel bearings and other steel members shall have appropriate rust prevention and corrosion prevention function. For the bodies of rubber bearings, covering rubber with a thickness of 5 mm or more with durability equal to or better than that of the inner rubber shall be attached to their surfaces exposed to ambient air.

(5) Appropriate rust prevention and corrosion prevention shall be applied around the connection surfaces between the bodies of rubber bearings and upper and lower steel plates to prevent relative displacement from occurring between them.

(6) The bearing seat surface on which a bearing is installed shall have a good drainage to prevent rust and corrosion of the bearing.

(7) The main members of steel bearing shall have a thickness of 25 mm or more.

10.1.10 Construction of Bearing Supports

(1) For the manufacture and installation of bearing supports, manuals on manufacturing methods and procedures, inspection methods, and the like shall be established so that it can be confirmed that construction is performed in such a manner that the preconditions of design, matters determined in the design stage, and the like are satisfied.

(2) Inspection items shall appropriately be set considering the degree of construction difficulty, the types of materials. The inspections shall be performed to confirm if the construction is performed by a determined method.

(3) The provisions relevant to construction that are specified in Parts II to V shall be satisfied.

10.1.11 Mesnager Hinge Bearing

When a Mesnager hinge bearing is to be used, the structure shall satisfy both the provisions of Chapter 7 of Part III and the below provisions 1) to 4) at least.

1) The structure shall transfer only shearing force and axial force in response to action force and not allow bending moment to be developed.

2) Intersecting reinforcements shall be arranged with a sufficient anchorage length ensured so that axial force and shearing force from members will reliably be transferred. To bear the stress from intersecting reinforcements, intersecting-reinforcement filling concrete shall have a structure that satisfies the provisions of Clause 5.7 of Part III.

3) The anchorage zones structure of intersecting reinforcements shall be reinforced with lateral reinforcements so that cracking will not continuously progress due to the adhesion in their in response to the repeated response of the bearing.

4) Corrosion prevention for intersecting reinforcements shall be applied in such a manner that their material quality will not be changed. When a reinforcement is to be subjected to bending after the application of corrosion prevention, the bending shall be performed in such a manner as not to cause degradation in its material quality and the performance of the corrosion prevention.

10.2 Joint Gaps

(1) The joint gap between the ends of neighboring two superstructures in the longitudinal direction to the bridge axis or the one between a substructure and the end of the superstructure shall generally be formed in such a manner that these structures will not collide with each other due to relative horizontal displacement.

(2) In design situations in which the effects of earthquakes are not considered, when a joint gap larger than or equal to a value calculated according to the provisions of Clause 10.1.8 is ensured, provision (1) may be deemed to be satisfied for the joint gap.

(3) When the effects of earthquakes are considered, joint gaps shall be determined according to the provisions of Clause 13.2.1 of Part V.

10.3 Expansion Joint

10.3.1 General

(1) For expansion joints, appropriate structures and materials shall be selected to satisfy the following performance so that the purpose of use of the bridge and its conformity will

be satisfied.

1) In the situation dominated by variable action specified in provision 2.1(1)2), the surface smoothness, continuity, and strength of the road surface that allow vehicles to travel without any problems shall be ensured.

2) Durability shall be ensured against vehicular traffic.

3) Water-tightness shall be ensured against intrusion of rainwater or the like.

4) Structure shall be considered for reduction of noise and vibration by vehicular traffic.

5) The skid resistance of the road surface shall be higher than or equal to a level that is appropriately set.

(2) The performance of expansion joints other than the performance under the effects of earthquakes, that is specified in this Part, shall comply with the provisions of Part V.

(3) For expansion joints, examinations shall generally be performed on methods of inspection and replacement and methods to deal with damage during the design service life of the bridge, regardless of the design durability life that is set according to the provision of Clause 10.3.4(1), and the examination results shall generally be applied to the design of the expansion joints and the structures to which the expansion joints will be attached.

10.3.2 Forces Acting on Expansion Joint

(1) Forces that will act on an expansion joint shall be set by appropriately considering acting loads, the types of the expansion joint, and the like.

(2) In calculating the vertical load that will be used for design, the T-load specified in Clause 8.2 shall basically be used with appropriate consideration given to the effects of impacts.

(3) For expansion joints to be installed in portions corresponding to sidewalks and the like, the vertical load appropriate to conditions for use may be considered.

(4) When the vertical load that to be used for designing an expansion joint except for a portion corresponding to a sidewalk and the like is determined according to provisions (5) and (6), provision (2) may be deemed to be satisfied.

(5) For each of the members and the like that receive a wheel load, a vertical load of 100 kN shall be assumed. In this case, the effects of its impact shall be considered according to provision (6).

(6) As the stress developed as an effect of the impact, 75% of the live-load stress shall be considered for expansion joints consisting of rubber material and steel material, and 150% for finger joints with a steel member having an overhang on its surface, and the like.

10.3.3 Design Movement for Expansion Joint

(1) The design expansion-contraction of an expansion joint shall be set considering girder temperature variations, concrete creep and drying shrinkage, amount of movement of the superstructure due to the deflection caused by live loads, and the amount of allowance for construction error.

(2) When the design expansion-contraction is calculated according to the provisions of Clause 10.1.8, provision (1) may be deemed to be satisfied.

10.3.4 Examinations on the Durability Performance of Expansion Joints

(1) Examinations on the durability of expansion joints shall be performed according to the provisions of Chapter 6.

(2) In examining the durability performance of an expansion joint, abrasion of members and the like due to vehicular traffic shall also be considered.

10.3.5 Construction of Expansion Joints

(1) For the manufacture and installation of expansion joints, manuals on manufacturing methods and procedures, inspection methods, and the like shall be established so that it can be confirmed that construction is performed in such a manner that the preconditions of design, matters determined at the design stage, and the like are satisfied.

(2) Inspection items shall appropriately be set by taking into account the degree of construction difficulty, the types of materials, and the like. Inspections shall be performed to verify if the construction is performed by a determined method.

(3) Not only provisions of Clause 1.10 but also the provisions relevant to construction that are specified in Parts II to V shall be satisfied.

10.4 Fail-safe

(1) Appropriate measures shall generally be taken to prevent the superstructure from easily falling in response to the occurrence of excessive relative displacement between the superstructure and a structure supporting it for a connection between a superstructure and a substructure established with a bearing or a like.

(2) The measures shall be implemented by an appropriate method with consideration given to the structural characteristics of the bridge, bridge site conditions, and the like.

(3) The measures shall be implemented in such a manner that a fatal situation caused by a fall of the superstructure or some other event can be avoided because of an unexpected malfunction of the connection between the superstructure and the substructure, at least from the viewpoint of seismic design.

(4) When measures to prevent the superstructure from easily falling are examined and implemented according to the provision of Clause 2.1(3) of Part V, provisions (1) to (3) may be deemed to be satisfied.

(5) Examinations on fail-safe durability shall be performed according to the provisions of Chapter 6.

CHAPTER 11 ACCESSORIES AND OTHERS

11.1 Bridge Guard Fence

11.1.1 General

For installation of a bridge guard fence, the "Standard for Guard Fences" (Official Notice of Director-General of the Road Bureau) shall apply.

11.1.2 Effect of Bridge Guard Fence on Deck Slab

(1) A pedestrian and bicycle guard fence shall be designed not to damage the bridge deck slabs when subjected to the combination of thrust acting on the fence top and uniformly distributed load on sidewalk.

(2) When a vehicle guard fence is to be installed, the bridge portion equipped with deck slabs shall be designed with consideration given to the external force exerted on the vehicle guard fence by the collision of a vehicle.

(3) When provisions (4) and (5) are complied with, provision (2) may be deemed to be satisfied.

(4) For installation of a guardrail or other posted vehicle guard fence on the curb, slab deck shall be designed as the moment of resistance of a post at the cross section at the lower-most end of the post divided by the post spacing should act on the deck slab uniformly as an end moment. In designs using reinforced concrete wall, the moment of action used for designing the lower end of the wall shall be applied to the deck slab as edge moment without modification.

If the post is directly anchored in the deck slab, employ a structure in which the working moment due to a collision is dispersed in, and acts on, the deck slab. In this case, the working moment on the deck slab may be taken to be equal to the case where installed in the curb.

(5) For steel superstructures, verification specified in Clause 11.12 of Part II shall be satisfied; for concrete superstructures, verification specified in Clause 9.6 of Part III shall be satisfied.

11.2 Drainage

(1) The structure shall be designed to be capable of quickly eliminating water from the bridge surface with consideration given to safety for running vehicles and the like.

(2) Each structural part shall be designed to drain water surely considering the bridge durability. Quick drainage on the top surface of the deck slab shall be considered.

(3) Drainage facilities shall be designed to have a structure and durability consistent with the maintenance and management plan so that their functions will reliably be maintained during the design service life of the bridge.

11.3 Bridge Pavement

(1) For the bridge pavement structure, the "Technical Standard for Pavement Structure"

(Official Notice of Director-General of the Road Bureau and Director-General of the City and Regional Development Bureau) shall apply.

(2) A cement concrete pavement shall be constructed to form an integral structure with the deck slab concrete.

(3) For an asphalt pavement, a waterproofing layer shall be provided to prevent rainwater from permeating the deck slab.

11.4 Inspection Facilities

When an inspection facility and the like are to be installed, considerations shall be made to minimize its influence on the load carrying performance and durability performance of the body of the bridge.

11.5 Accessory Facilities

When an accessory facility, such as lighting, a sign board, and a noise barrier, is to be installed, necessary measures shall be taken with consideration given to its influence on the bridge.

Selection of a location for installing the accessory facility shall be made so as to minimize its influence on the load carrying performance and durability performance of the body of the bridge with consideration given to the reliability and ease of the maintenance and management of the accessory facility.

11.6 Affixed Articles

When a water pipe and the like are to be laid, necessary measures shall be taken with consideration given to its influence on the bridge.

Selection of a laying location and designing of a laying structure shall be made so as to minimize influence on the performance of the body of the bridge with consideration also given to the reliability and ease of the maintenance and management of the accessory.

11.7 Others

For security of the bridge facilities if necessary measures shall be considered to ensure that no third party can enter the bridge facilities.

CHAPTER 12 RECORDS

12.1 Bridge Ledger

The bridge length, width, design load, specifications for highway bridges (the fiscal year of their edition), design seismic coefficient, the type and embedment depth of the foundation, ground conditions, structural drawings of major parts, completion date, and other matters necessary for future maintenance and management work on the bridge shall be recorded in a bridge ledger, and the bridge ledger shall be in safekeeping.

12.2 Bridge Nameplate

A bridge nameplate shall generally be attached to the bridge to indicate at least matters necessary for future maintenance and management work, such as bridge name, completion date, specifications for highway bridges (the fiscal year of their edition), live load, steel materials used, project implementing body, and companies responsible for designing, manufacturing, and construction.

12.3 Matters Concerning Design and Construction

After the completion of the bridge, at least the following records of design and construction shall be kept available for maintenance and management during its service life.

(1) Records concerning investigation stipulated in Section 1.6

(2) Records concerning planning stipulated in Section 1.7

(3) Records concerning design methods stipulated in Section 1.8.2

(4) Records concerning structural design-related considerations stipulated in Section 1.8.3

(5) Design drawings, etc. stipulated in Section 1.9

(6) Records concerning construction stipulated in Section 1.10