STRUCTURES DESIGN MANUAL FOR HIGHWAYS AND RAILWAYS

2013 Edition

AMENDMENT NO. 1/2020

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Highways Department
The Government of the Hong Kong Special Administrative Region

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INTRODUCTION

The "Structures Design Manual for Highways and Railways – 2013 Edition" (SDM) published by the Government of the Hong Kong Special Administrative Region sets out standards and provides guidance for the design of highway and railway structures in Hong Kong. In 2020, Highways Department conducted a review of the following:

i) The design working life and design wind pressure for walkway covers; and

ii) The requirements on external prestressing tendons in concrete bridges.

Following the review, amendments to Chapters 2, 3 and 5 of the SDM are made.

AMENDMENT DETAILS

The following amendments are made:-

1. **CONTENTS**
   Pages 5 and 8 of the SDM are replaced by Replacement Sheets 1 and 2.

2. **CHAPTER 2**
   Pages 25 to 30 of the SDM are replaced by Replacement Sheets 3 to 8 respectively.

3. **CHAPTER 3**
   Pages 42 and 43 of the SDM are replaced by Replacement Sheets 9 and 10 respectively.

4. **CHAPTER 5**
   Page 90 of the SDM is replaced by Replacement Sheets 11 to 12.

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2.2 DESIGN WORKING LIFE

(1) Unless otherwise stated, the design working life of highway structures and railway bridges shall be 120 years, i.e. design working life category 5 as defined in Clause NA.2.1.1 of the UK NA to BS EN 1990. AMD. 1/2020

(2) The design working life of walkway covers shall be 50 years, i.e. design working life category 4 as defined in Clause NA.2.1.1 of UK NA to BS EN 1990. The design of walkway covers shall follow this Manual in the same manner as other highway structures, except that the peak velocity pressure q_p determined under simplified procedure for calculation of wind actions shall be reduced in accordance with Clause 3.4.2.1(3) of this Manual. AMD. 1/2020

2.3 THE USE OF BS EN 1990 ANNEXES

(1) Annex A2 of BS EN 1990 and Clause NA.2.3 of the UK NA to BS EN 1990 shall be followed except as modified in Clause 3.2.

(2) Annexes B, C and D of BS EN 1990 and the corresponding clauses in the UK NA to BS EN 1990 shall not be used, unless otherwise agreed by the Chief Highway Engineer/Bridges and Structures.

2.4 DESIGN CHECKING

2.4.1 General

(1) This Section sets out the guidelines for carrying out independent checking on the design of new highway structures and the associated modification of existing highway structures by consultants or contractors employed by the government. The design checking stipulated below shall also apply to public highway structures which are designed by public organizations (other than the government), private organizations or their agents. These guidelines do not modify the contractual or legal responsibilities of any party for the work carried out, including without limitation the Designer and Checking Engineer as defined in Clause 1.3.

(2) The objective of the independent checking is to ensure :

(a) compliance of the design with the Project Office's requirements, relevant design standards and statutory requirements;

(b) validity of design concepts, methods and assumptions;

(c) applicability, accuracy and validity of the computer programs and models used in the design;

(d) accurate translation of the design into drawings and specifications; and

(e) practicality and adequacy of key details.

2.4.2 Classification of Highway Structures

(1) For design checking purpose, all highway structures shall be classified into Structure Categories I, II and III as shown in Table 2.2. This classification is not rigid and each case shall be decided on its merits having regard to the cost, complexity, safety, durability and consequences of failure. The Designer shall determine and agree with the Project Office the proposed Category for the highway structures being designed. If necessary, the Project Office or the Designer may approach the Chief Highway Engineer/Bridges and Structures for advice and/or decision on any matters relating to this classification.

Table 2.2 – Classification of Highway Structures for Design Checking

Structure Category	Description
I	**Simple Structures** Structures which contain no departures from or aspects not covered by current standards adopted by Highways Department, and which are either : a) Single simply supported span of less than 20m and having less than 25^{o} skew b) Buried concrete box type structures with less than 8m span c) Retaining walls with a retained height of less than 7m, or d) Noise barrier with a maximum height of 3m
II	**Intermediate Structures** Structures not within the parameters of Structure Categories I and III.
III	**Complex Structures** Structures requiring sophisticated analysis or with any one of the following features : a) High structural redundancy; b) Unconventional design aspects; c) Any span exceeding 80m; d) Skew exceeding 45^{o}; e) Continuous structure with spans exceeding 65m; f) Difficult foundation problems; or g) Difficult construction techniques/ problems.

(2) The Project Office shall arrange with the Designer the checking of a highway structure by a Checking Engineer appropriate to its Category. The Category shall be identified early. As the design evolves, the Designer shall ensure the structure is appropriately classified and seek the agreement of the Project Office to amend its Category and checking arrangements when necessary.

2.4.3 Checking Engineer

(1) The requirements of the Checking Engineer in each category of highway structures are outlined below :

(a) For Category I structures, an independent check shall be carried out by a qualified professional in the same organization as the Designer who may be from the same design team.

(b) For Category II structures, an independent check shall be carried out by a qualified professional or checking team in the same organization as the Designer but shall be independent of the design team.

(c) For Category III structures, an independent check shall be carried out by a checking team from a separate independent organization.

(2) For Categories II and III structures, the Checking Engineer shall be strictly excluded from having direct involvement in the design of the concerned project. In all cases, the Checking Engineer must have sufficient knowledge and experience relating to the type of structures to be checked. The Checking Engineer proposed or appointed by the Designer shall be approved by the Project Office in advance. The Checking Engineer shall exercise reasonable and professional skill, care and diligence at all times in the design checking and that the safety and integrity of the structures shall not be compromised in any way.

(3) Should the Project Office be dissatisfied with the performance of the Checking Engineer at any time, the Project Office may, having given reasonable notice of dissatisfaction, order the dismissal and replacement of the Checking Engineer.

2.4.4 Comment by the Chief Highway Engineer/Bridges and Structures

(1) For Category III structures, the Designer shall at the commencement of the design forward his design approach statement including design concept, design philosophy and outline of mathematical modelling of the structure to the Chief Highway Engineer/Bridges and Structures for comments and make a presentation if required. The Designer shall take account of the Chief Highway Engineer/Bridges and Structures' comments in his design.

(2) The comment by the Chief Highway Engineer/Bridges and Structures will be provided from the viewpoint of design standards and for public interest. It shall not relieve the responsibility of the Designer or the Checking Engineer in any way.

2.4.5 Checking Process

(1) Irrespective of the Category of structures, all design calculations, drawings and specifications shall first be self-checked by the Designer prior to the checking by the Checking Engineer. Also, any computer programs including those developed in-house and spreadsheet applications used in the structural analysis shall be verified and validated by an appropriate method, and the Designer shall be responsible for such verification and validation.

(2) It is a good practice to start the design checking as early as possible so that the design and checking can proceed together. Also, any disagreements or points of differences can be resolved earlier as the design progresses.

(3) Table 2.3 gives details of the design checking required for each Category of highway structures.

Table 2.3 – Scope of Design Checking

Category	Scope of Design Checking
I	a) Check compliance with design codes and standards. b) Carry out arithmetic check on the design calculations. c) Carry out spot checks on critical structural elements. Repetition of numerical calculations is not required if the Checking Engineer can validate the structural adequacy by alternative method or comparison with other similar completed structures. d) Ensure that the design is correctly translated into the drawings and specifications.
II	a) Carry out comprehensive check on drawings with reference to the design calculations. The check will include but not be limited to the design concept, the compliance with design code and standards, the derivation of loadings, method of analysis and design assumptions, the structural adequacy of individual structural elements, stability of the structures and sequence of construction. b) Check/Confirm the applicability, accuracy and validity of all computer programs used by the Designer. c) Check the numerical model, its applicability, input parameters and boundary conditions. d) Carry out separate analytical check on critical structural elements without reference to the design calculations. e) Ensure that the design is correctly translated into the drawings and specifications.

Table 2.3 – Scope of Design Checking (Cont'd)

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III	a) Derive all loading, design concept, criteria, assumptions and parameters, and sequence of construction from the design document i.e. drawings, design memorandum, specifications, site investigation records, etc. b) Check the compliance with design codes and standards, and limitations if any. c) Check the applicability, accuracy and validity of all computer programs used in design checking. d) Construct computer models, input boundary conditions and parameters and carry out independent structural analysis. e) Prepare an independent set of design check calculations. f) Ensure that the design is correctly translated into the drawings and specifications.

(4) The independent design checking for Category III structures shall be carried out without reference to the design calculations. It is incumbent upon the Checking Engineer to establish the validity of the design assumptions independently. The Checking Engineer would require documents including the design memorandum/manual, drawings, specifications, ground investigation results and other relevant design information for him to carry out the checking. The design memorandum shall contain sufficient information detailing the assumptions made in the design to enable the Checking Engineer to carry out his own independent analysis and assessment and to make direct comparison between his own results and the Designer's design. Major difference in design assumptions should be brought to the attention of the Designer. Although the methods of analysis need not be the same, the Designer and the Checking Engineer should consult with each other to ensure that their calculated results are comparable.

(5) In the event that the design checking reveals errors, omissions or ambiguities in the design, the Checking Engineer shall inform the Designer who shall in turn seek agreement with the Checking Engineer on the course of action required to rectify the design deficiency. The Designer shall make all necessary changes to the design and associated documents, and re-submit them to the Checking Engineer for further review and agreement.

(6) Should the Designer disagree with the Checking Engineer's view, he shall promptly refer the case to the Project Office. Where necessary, advice from an independent expert or the Chief Highway Engineer/Bridges and Structures may be sought.

(7) It must be emphasized that an independent check shall not in any way absolve the Designer from his responsibility and liability for the proper design of highway structures. The independent checking procedures stipulated herein are additional to any in-house design checking by the Designer.

2.4.6 Highway Structures Design and Check Certificate

(1) When the design checking has been completed and all necessary amendments to the design calculations, specifications and drawings have been made and checked by the

Checking Engineer, the Designer and the Checking Engineer shall sign the Highway Structures Design and Check Certificate as per the standard form appended in Table 2.4 or as per other form as agreed with the Chief Highway Engineer/Bridges and Structures. Unless there are justifiable reasons acceptable to the Project Office, the Designer shall exercise every effort to ensure that no drawings shall be issued for tendering or construction until the Highway Structures Design and Check Certificate has been accepted by the Project Office.

(2) For Category III structures, a full set of the design submissions and the Highway Structures Design and Check Certificate shall be submitted to the Chief Highway Engineer/Bridges and Structures for audit and record purpose before construction commences. Should the Designer or the Project Office have any difficulties to comply with this requirement under exceptional circumstances, they should seek the special agreement from the Chief Highway Engineer/Bridges and Structures.

(3) For all categories of structures, any amendments to the design deemed necessary which have structural implications following the issue of the Highway Structures Design and Check Certificate shall be checked and certified by an appropriate Checking Engineer. The Designer shall notify the Chief Highway Engineer/Bridges and Structures in case such amendments deviate significantly from the original design intent.

(4) An alternative design by a contractor shall also be subject to design checking if it is to be implemented.

for sheltered and exposed locations in Table 3.7. To aid designers in choosing suitable values, descriptions and examples of typical locations are given in Table 3.8.

Table 3.8 – Exposure to Wind – Simplified Procedure

Degree of Exposure	Description	Peak Velocity Pressure q_p (kN/m^2)	Example
1	Sheltered by surrounding buildings and /or topography	2.5	Kowloon Park Drive Flyover
2	Normal exposure	2.8	Castle Road Flyover
3	Elevated situation; not sheltered by buildings or topography	3.3	Tai Po Road Interchange
4	Exposed to north-easterly or south easterly winds across open sea	3.8	Ap Lei Chau Bridge

(3) In general, for the design of walkway covers, adoption of the simplified procedure to determine the peak velocity pressure q_p shall suffice. The peak velocity pressure q_p obtained from Table 3.7 or Table 3.8 shall be reduced by 20% (i.e. ranging from 2.0 kN/m^2 for sheltered location to 3.0 kN/m^2 for exposed location). If other methods are adopted, the designer shall consult the Chief Highway Engineer/Bridges and Structures for advice. AMD. 1/2020

3.4.2.2 Peak Velocity Pressure for Traffic Leading Combinations

(1) For road bridges, the probability of much traffic being present on a bridge at peak wind velocity exceeding 44 m/s is low and the corresponding peak velocity pressure of 1.2 kN/m^2 may be used in traffic leading combinations. Therefore, as discussed in BS EN 1991-1-4 Clause 8.1(4), the combination value $\psi_0 F_{wk}$ of the wind action on the bridge and on the vehicles travelling on the bridge, should be limited to a value F_W^* determined by taking q_p as 1.2 kN/m^2. Provision given in the UK NA to BS EN 1991-1-4 Clause NA.2.47 shall not be followed.

(2) For railway underbridges, the value of q_p for determining F_W^{**}, which is discussed in BS EN 1991-1-4 Clause 8.1(5), shall be agreed with the appropriate railway authority taking into account the possibility of the presence of railway traffic on the bridge at high wind velocity.

3.4.3 Full Procedure for Determining Peak Velocity Pressure

For bridges to be designed under the full procedure, due account shall be taken of the loaded length under consideration and the height of the structure above ground. Provisions given in this Section shall replace Clause NA.2.56 of the UK NA to BS EN 1991-1-4.

3.4.3.1 Peak Velocity Pressure for Wind Leading Combinations

The peak velocity pressure $q_p(z)$ shall be determined in accordance with Table 3.9.

3.4.3.2 Velocity Pressure on Relieving Areas for Wind Leading Combinations

Where wind on any part of a bridge or element gives relief to the member under consideration, the effective coexistent value of velocity pressure on the parts affording relief shall be determined from Table 3.9 as the appropriate hourly mean velocity pressure q'(z).

3.4.3.3 Peak Velocity Pressure for Traffic Leading Combinations

The peak velocity pressure $q_p(z)$ on those parts of the bridge or its elements on which the application of wind actions increases the effect being considered shall be taken as :

(1) For road bridges, $q_p(z)$ given in Table 3.9 shall be adopted, but the combination value $\psi_0 F_{wk}$ of the wind action on the bridge and on the vehicles travelling on the bridge, which is discussed in BS EN 1991-1-4 Clause 8.1(4), should be limited to a value F_W* determined by taking $q_p(z)$ as q'(z) given in Table 3.9. Provision given in the UK NA to BS EN 1991-1-4 Clause NA.2.47 shall not be followed.

(2) For railway underbridges, the value of $q_p(z)$ for determining F_W^{**}, which is discussed in BS EN 1991-1-4 Clause 8.1(5), shall be agreed with the appropriate railway authority taking into account the possibility of the presence of railway traffic on the bridge at high wind velocity.

3.4.3.4 Velocity Pressure on Relieving Area for Traffic Leading Combinations

Where wind on any part of a bridge or element gives relief to the member under consideration, the effective coexistent value of velocity pressure $q_L'(z)$ on the parts affording relief shall be taken as:

$$q_L'(z) = 1.2\, q'(z) / q_p(z)$$

where $q'(z)$ and $q_p(z)$ are obtained from Table 3.9 appropriate to the height of the bridge and the loaded length under consideration.

(c) shrinkage and creep of concrete;

(d) friction and wobble;

(e) draw-in,

where appropriate giving details of any assumption made, and also making clear whether allowance shall be made for anchorage and jack losses.

(4) Consideration must be given at the design stage to the practicability of fitting one or other of the acceptable proprietary post-tensioning systems into the work being designed, so that the post-tensioning specialists are not set an impossible task. End-block reinforcement depends on the type of anchorage used, and so shall not be detailed, but, again, consideration shall be given at the design stage to likely requirements. The proposals submitted by the main contractor must accordingly include end-block reinforcement details.

5.6.3 External Prestressing

(1) All highway structures and railway bridges adopting external prestressing shall be checked to ensure that the removal or failure either of any two external tendons or 25% of those at any one section, whichever has the more onerous effect, will not lead to collapse at the ultimate limit state under the design ultimate permanent actions.

(2) External tendons that are not located inside the closed cells of box-girder bridge deck can be susceptible to fire and mechanical damages. Project-specific requirements and provisions for the protection of the tendons shall be proposed for agreement by the Chief Highway Engineer/Bridges and Structures and the respective maintenance authorities.

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(3) All external tendons shall be replaceable and provisions shall be made in the design for the de-tensioning, removal and replacement of any external tendon. The use of prestressing components of the types that would facilitate the de-tensioning, removal and replacement of the tendons, such as sheaths/ducts of double casing type at deviators/anchor diaphragms and, where appropriate, tendons with independent strands with individual HDPE sheaths etc. should be considered.

(4) Where the detailing does not enable tendons to be removed and replaced without damage to either the tendons or the structure, a method statement defining in details how the tendons can be removed and replaced shall be provided. A method statement defining in details how the structure can be demolished shall also be provided.

(5) Where it is necessary to restrict traffic on the highway structure to replace the tendons, the extent of this restriction shall be agreed with the relevant authorities and defined in a method statement. It should be noted that traffic restrictions may not be appropriate for highly utilized structures with high delay costs.

(6) Provisions shall also be made in the design to facilitate routine inspection and maintenance of the tendons, particularly at the locations of deviators and anchor diaphragms where the tendons/anchors are encased in concrete. In particular, each tendon shall be provided with an identification tag showing the tendon reference number and anchorages shall be fabricated with inspection holes located to permit a probe or inspection by borescope of the upper part of the duct behind the anchor heads. The holes shall also facilitate the post-grouting inspection. Anchorage caps covering the inspection holes shall be designed to be removable as necessary for access to the inspection holes.

(7) A robust multiple barrier protection system shall be used to protect the external tendons from weathering and corrosion.

(8) For grouted tendons, consideration should be given to the use of vacuum-assisted grouting for improved quality of grouting especially for long horizontal tendons and for tendons without access/vents at the high points of the tendon profiles. **AMD. 1/2020**

(9) Length of tendons shall not exceed 200m, and length between grout injection point and the most distant grout vent/anchor head shall not exceed 100m, unless it can be demonstrated with grouting trials that complete filling of the tendon ducts, with the tendons completely surrounded with grout, can be satisfactorily achieved. Similarly for tendons to be injected with other flexible corrosion-inhibiting products.

(10) It is preferable to provide remote monitoring and warning system for the detection of tendon/strand/wire breakage. At locations where inspection of tendons is difficult, remote monitoring and warning system shall be provided. The need and details of the provision shall be agreed with the respective maintenance offices during the design stage.

5.6.4 Specialist Prestressing Contractors

(1) All prestressed concrete works for highway structures shall be carried out by specialist contractors in the Prestressed Concrete Works for Highway Structures Category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works.

(2) The Prestressed Concrete Works for Highway Structures Category consists of two classes:

Class I - Supply and Installation of Prestressing Systems; and

Class II - Supply of Prestressed Concrete Units.

(3) The supply and installation of on-site prestressing work shall be carried out by a contractor in Class I. Precast prestressed units manufactured off-site shall be supplied by a contractor in Class II.