STRUCTURES DESIGN MANUAL
FOR HIGHWAYS AND RAILWAYS

2013 Edition

AMENDMENT NO. 1/2023

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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 2022, Highways Department conducted a regular review.

Following the review, amendments to Chapter 2, Chapter 3, Chapter 6, Chapter 10, Chapter 11, Chapter 12, Chapter 14, Chapter 15, Chapter 16, and Appendix F of the SDM are made.

AMENDMENT DETAILS

The following amendments are made:-

1. **CONTENTS**
   Pages 6 and 10 of the SDM are replaced by Replacement Sheets 1 to 2.

2. **CHAPTER 2**
   Page 25 of the SDM is replaced by Replacement Sheet 3.

3. **CHAPTER 3**
   Pages 42, 43, 65, 66 and 68 of the SDM are replaced by Replacement Sheets 4 to 8.

4. **CHAPTER 6**
   Pages 94, 95 and 96 of the SDM are replaced by Replacement Sheets 9 to 11.

5. **CHAPTER 10**
   Page 117 of the SDM is replaced by Replacement Sheet 12.

6. **CHAPTER 11**
   Pages 119, 120, 120A, 121, 122, 129 and 130 of the SDM are replaced by Replacement Sheets 13 to 19.

7. **CHAPTER 12**
   Pages 139, 144 and 150 of the SDM are replaced by Replacement Sheets 20 to 22.

8. **CHAPTER 14**
   Page 154 of the SDM is replaced by Replacement Sheet 23.

9. **CHAPTER 15**
   Page 171 of the SDM is replaced by Replacement Sheet 24.

10. **CHAPTER 16**
    Pages 211, 212 and 214 of the SDM are replaced by Replacement Sheets 25 to 27.

11. **Appendix F**
    Pages F2, F7, F9, F11, F12, F13, F14 and F15 of the SDM are replaced by Replacement Sheets 28 to 35.

    Page F16 of the SDM is deleted.

STRUCTURES DESIGN MANUAL

for Highways and Railways

2013 Edition

This electronic file is for reference only. When the content of this electronic file is inconsistent with the hard copy of the Structures Design Manual for Highways and Railways (SDM), 2013 Edition and the Amendments issued, the hard copy of the SDM, 2013 Edition and the Amendments shall prevail.

(This Version is Continuously Updated to include Amendments issued)

This Electronic File has incorporated the following Amendments:-

Rev	Issue Date	Amendment Incorporated
First Issue	May 2013	-
1	June 2018	Amendment No. 1/2018
2	April 2020	Amendment No. 1/2020
3	May 2021	Amendment No. 1/2021
4	January 2023	Amendment No. 1/2023

Highways Department

The Government of the Hong Kong
Special Administrative Region

AMD. 1/2023

AMD. 1/2018

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, sign gantries and noise barriers/enclosures 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, sign gantries and noise barriers/enclosures 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. 1/2023 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.

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, sign gantries and noise barriers/enclosures, 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. 1/2023 AMD. 1/2020

(4) For the design of sign gantries/noise barriers/enclosures mounted on bridges, the peak velocity pressure can be reduced by 20% as mentioned in Clause 3.4.2.1 (3). However, for the design of bridges supporting the sign gantries/noise barriers/enclosures, the peak velocity pressure acting on sign gantries/noise barriers/enclosures and bridges shall be obtained from Table 3.7 or Table 3.8 without reduction. AMD. 1/2023

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.

gives the most unfavourable effect on the structure. Provisions given in Clause 2.5.1(f) of PD 6688-1-7 shall not be used.

(3) If the risk ranking factor R_{de} is less than or equal to T_c = 2.4 and when L3 containment level barriers with full working width are provided to protect the bridge supports, the main and residual load components of the minimum forces for robustness should be adopted. When L3 containment level concrete rigid barriers with a minimum lateral clearance of 400 mm between the barrier and the support of foot/cycle track bridges are provided, the static design forces should be taken as either only a residual load component of $F_{dx} = F_{dy}$ = 85 kN or the main and residual load components of minimum forces for robustness, whichever gives the most unfavourable effect on the structure. Provisions given in Clause 2.5.1(f) of PD 6688-1-7 shall not be used.

3.6.2.2.4 Impact on gantry supports and noise barrier/enclosure supports

The equivalent static design forces due to vehicular impact on gantry supports and noise barrier/enclosure supports, and the associated adjustment factor F_a shall be determined in accordance with Table 3.26.

Table 3.26 – Equivalent Static Design Forces due to Vehicular Impact on Members Supporting Sign Gantries and Noise Barriers/Enclosures over or adjacent to Roads

	Force F_{dx} in the direction of normal travel (kN)	**Force F_{dy} perpendicular to the direction of normal travel (kN)**	**Point of application on support**
For gantries and noise barriers/enclosures over or adjacent to roads where speed limit ≥ 72kph			
Main load component	1650	825	At the most severe point between 0.75m and 1.5m above carriageway level
Residual load component	825	415	At the most severe point between 1m and 3m above carriageway level
Minimum forces for robustness			
Main load component	165	165	At the most severe point between 0.75m and 1.5m above carriageway level
Residual load component	85	85	At the most severe point between 1m and 3m above carriageway level

Notes: (1) The adjustment factor F_a shall be applied to all main and residual load components except for the minimum forces for robustness.

(2) The adjustment factor F_a shall be taken as 0.2 for gantries and noise barriers/enclosures with $R_{de} > 0.5$.

(3) The minimum forces for robustness shall be adopted for gantries and noise barriers/enclosures over or adjacent to roads where speed limit < 72kph or $R_{de} \leq 0.5$.

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3.6.2.3 Impact on Superstructures

(1) For road bridges, the equivalent static design forces due to vehicular impact on superstructures shall be determined in accordance with Table 3.27. The equivalent static design forces and the relevant heights for the reduction factor r_F given in Tables NA.9 to NA.10 and Clause NA.2.17 of the UK NA to BS EN 1991-1-7, shall not be used.

Table 3.27 – Equivalent Static Design Forces due to Vehicular Impact on Bridge Superstructures

Force F_{dx} in the direction of normal travel (kN)	Force F_{dy} perpendicular to the direction of normal travel (kN)	Point of application on superstructure
825	415	On vertical surface or underside surface of bridge deck in any direction between the horizontal and vertically upwards

Notes: (1) For foot/cycle track bridges over roads where speed limit ≤ 72kph, F_{dx} and F_{dy} shall be taken as 410 kN and 205 kN respectively.

(2) Reduction factor r_F shall be determined in accordance with Figure 4.2 of BS EN 1991-1-7 with the h_0 and h_1 taken as 5.7 m and 6.0 m respectively after compensation for vertical curvature and deflection. (The maximum deflection of the structure should be calculated at the SLS using the frequent combination of actions.)

(3) Notwithstanding the provision in Note (2), adequate restraint to the bridge deck should be provided to prevent the deck from being removed from the support under the action of the vehicle collision forces given in this table in all cases.

(2) For sign gantries and noise enclosures, consideration of vehicular impact on superstructures is not applicable and a minimum headroom of 5.5m shall be provided. AMD. 1/2023

(3) The force in the direction of normal travel F_{dx} shall be considered separately from the force perpendicular to the direction of normal travel F_{dy}.

3.6.3 Accidental Actions Caused by Derailed Rail Traffic under or adjacent to Structures

(1) The potential accidental actions from a derailed train colliding with the substructure of a bridge crossing a railway track is very large. To design a support capable of successfully withstanding such a loading may be very difficult. Nevertheless, because of the potentially disastrous consequences, consideration shall always be given to ways of alleviating the effects of such a collision. The appropriate railway authority shall be consulted for the design of bridge substructures across or adjacent to railway tracks.

3.7.2.2 Load Model 1

(1) The adjustment factors α_{qi} for the uniformly distributed load q_{ik} and α_{Qi} for the tandem system Q_{ik} of Load Model 1 (LM1) given in Clause 4.3.2 of BS EN 1991-2 shall be obtained from Table 3.28. The α_{qi} and α_{Qi} given in Table NA.1 of the UK NA to BS EN 1991-2 shall not be used.

Table 3.28 – Adjustment Factors α_{Qi} and α_{qi} for Load Model 1

Location	**α_{Qi} for tandem axle loads**	**α_{qi} for UDL loading**
Lane 1	$\alpha_{Q1} = 1.20$	$\alpha_{q1} = 0.53$
Lane 2	$\alpha_{Q2} = 1.00$	$\alpha_{q2} = 1.91$
Lane 3	$\alpha_{Q3} = 1.00$	$\alpha_{q3} = 1.91$
Other lanes	-	$\alpha_{qn} = 1.91$
Remaining area	-	$\alpha_{qr} = 1.91$
Where the loaded length is less than 60 m and N is greater than or equal to 6 then these should be modified to:		
Location	**α_{Qi} for tandem axle loads**	**α_{qi} for UDL loading**
Lane 1	$\alpha_{Q1} = 1.44$	$\alpha_{q1} = 0.64$
Lane 2	$\alpha_{Q2} = 1.20$	$\alpha_{q2} = 2.30$
Lane 3	$\alpha_{Q3} = 1.20$	$\alpha_{q3} = 2.30$
Other lanes	-	$\alpha_{qn} = 2.30$
Remaining area	-	$\alpha_{qr} = 2.30$

Notes: (1) α_{q1} shall be taken as 1.0 when determining the braking force.

(2) The value of N is to be taken as the total number of notional lanes on the bridge (this shall include all the lanes for dual carriageway roads) except that for a bridge carrying one way traffic only, the value of N shall be taken as twice the number of notional lanes on the bridges. AMD. 1/2023

(2) In general, the use of Load Model 1 defined in this Section is safe-sided for road bridges with loaded lengths over 200 m. Subject to the agreement of the Chief Highway Engineer/Bridges and Structures, project-specific load models may be used for loaded lengths over 200 m in individual project.

3.7.2.3 Load Model 2

The adjustment factor β_Q for the single axle load Q_{ak} of Load Model 2 (LM2) given in Clause 4.3.3 of BS EN 1991-2 shall be taken as 0.9. The β_Q given in Clause NA.2.14 of the UK NA to BS EN 1991-2 shall not be used.

CHAPTER 6 DESIGN OF STEEL BRIDGES

6.1 GENERAL

(1) Steel highway structures and railway bridges shall be designed in accordance with the requirements of BS EN 1993-1, BS EN 1993-2, the UK NAs to BS EN 1993-1 and BS EN 1993-2, PD6695-1-9, PD6695-1-10 and PD 6695-2, unless otherwise specified in this Manual. A detailed list of the relevant documents is included in Appendix A.

(2) The requirements for materials, products, execution and workmanship given in the General Specification for Civil Engineering Works of the Government of the Hong Kong Special Administrative Region shall be complied with. Reference to European Standards, European Technical Approvals and other standards for construction products and execution of works not specified in the General Specification for Civil Engineering Works, where considered necessary, shall be made only if the provisions therein are appropriate to Hong Kong conditions.

(3) Material and workmanship for structural steelwork shall comply with BS EN 1090-2 and Section 18 of General Specification for Civil Engineering Works. Where the requirements or conditions stipulated in BS EN 1090-2 differ from Hong Kong conditions, adjustments appropriate to Hong Kong shall be made as necessary. AMD. 1/2023

6.2 FATIGUE

(1) Special attention shall be given to fatigue assessment during the design of bridges which are particularly prone to fatigue and fracture damage, such as cable-stayed bridges or steel bridges that are frequently used by heavy vehicles.

(2) The provisions given in BS EN 1993-1-9, the UK NA to BS EN 1993-1-9 and PD 6695-1-9 for fatigue assessment shall be followed in so far as they are appropriate to Hong Kong conditions. Where the provisions therein differ from Hong Kong conditions, adjustments appropriate to Hong Kong shall be made as necessary.

6.3 HOT FORMED STRUCTURAL HOLLOW SECTIONS

(1) Hot formed hollow sections with steel properties and section sizes in accordance with BS EN 10210 Part 1 and Part 2 respectively shall be used for all structural steelworks.

(2) Designers shall check that the sections proposed will be available in the quantities required before finalising the design. The use of cold formed sections as an alternative shall not be permitted.

6.4 FABRICATION

(1) Structural steelwork shall be fabricated and erected by specialist contractors in the "Structural Steelwork" category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works.

(2) All structural steelworks shall be detailed so that they can be hot dip galvanized after fabrication, and also, they can be erected without damaging the galvanizing and without on site welding. For long span trusses and structures too large for hot dip galvanizing after fabrication, consideration shall be given to the application of sprayed metal coating after fabrication. If non-ferrous components are used with steel fixings, insulation must be provided to prevent galvanic corrosion.

(3) Removal of rust and mill scale from steelwork shall comply with Section 18 of General Specification for Civil Engineering Works. AMD. 1/2023

(4) When welding metal coated or zinc dust painted steel, the coating near the weld area shall first be removed, or the weld area be masked off before coating. After welding, scale and heat damaged coatings shall be removed by local blast cleaning and the areas renovated by re-applying the original coating. Damaged galvanized or metal sprayed surfaces shall be made good by :

(a) metal spraying;

(b) application of zinc rich paints to reinstate the original dry film thickness; or

(c) application of low melting point zinc alloy heated by torch to a pasty condition with the fluxes contained therein removed.

(5) The aforesaid guidelines may not be applicable to exceptionally massive steelwork, such as the steel deck of the Tsing Ma Bridge, Ting Kau Bridge, etc., where special corrosive protection system may be considered with regard to the particular project requirements. AMD. 1/2023

6.5 BLAST CLEANING

Blast cleaning of steelworks shall be carried out by specialist contractors in the "Class V: Hot dip galvanizing" of the "Specialized Operations for Highway Structures" category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works.

6.6 TESTING OF WELDS

(1) All structurally important welds of structural steelwork shall be subject to nondestructive testing in the form of magnetic particle, liquid penetrant, radiographic or ultrasonic inspection and interpretation by specialist contractors in the "Class IV: Non-destructive testing of welds" of the "Specialized Operations for Highway Structures" category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works. The extent of testing shall comply with the requirements given in

Section 18 of General Specification for Civil Engineering Works. Where necessary the designer shall specify the welds to be tested above this requirement. AMD. 1/2023

6.7 HOT DIP GALVANIZING

All hot dip galvanized steel components shall comply with BS EN ISO 1461 after fabrication by specialist contractors in the "Class V: Hot dip galvanizing" of the "Specialized Operations for Highway Structures" category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works. Steel hollow sections shall be sealed wherever this can be done without affecting the galvanizing process. If venting is necessary, the vents shall be carefully detailed and positioned so as to be inconspicuous, or be effectively sealed immediately after galvanizing.

6.8 ADDITIONAL MODIFICATIONS TO BS EN 1993 AND THE UK NA TO BS EN 1993

In addition to those indicated in the preceding sections, the modifications to BS EN 1993-1, BS EN 1993-2, the UK NAs to BS EN 1993-1 and BS EN 1993-2 and PD 6695-2 as given in Table 6.1, shall be followed.

Table 6.1 – Additional Modifications to BS EN 1993-1, BS EN 1993-2, the UK NAs to BS EN 1993-1 and BS EN 1993-2 and PD 6695-2

Item	Clause of Eurocodes	Contents	Modifications
6.8.1	BS EN 1993-1-1 Clause 5.3.2	Imperfections for global analysis of frames	Second order analysis shall only be used with the agreement of the Chief Highway Engineer/Bridges and Structures.
6.8.2	BS EN 1993-1-1 Clause 5.3.3	Imperfection of bracing system	Second order analysis shall only be used with the agreement of the Chief Highway Engineer/Bridges and Structures. In the absence of second order analysis, Clauses 10 and 11 of PD 6695-2 shall be followed for the design of restraints at supports and intermediate restraints respectively.

(3) To ensure reasonable robustness, supports shall be designed to withstand, without collapse, a minimum static design force of 1650 kN in case of vehicular bridges, and 825 kN in case of footbridges, acting horizontally in any direction at a height of 1200 mm above the adjacent rail level in conjunction with permanent actions and other variable actions under the accidental design situation.

10.3 RAILWAY UNDERBRIDGE SUBSTRUCTURES

Railway underbridges shall be provided with ballast walls at approaches, high enough and long enough to prevent ballast from falling on to abutments and wing walls. The ends of wing walls will normally adjoin the boundary of the railway, where they shall be at least 2 m high above the adjoining pavement level.

10.4 HYDRAULIC EFFECTS ON BRIDGE SUBSTRUCTURES

10.4.1 Effects to be Considered

(1) Consideration shall be given to the effects of :

(a) pressure due to currents;

(b) hydrostatic pressure;

(c) scour;

(d) backwater; and

(e) waterborne traffic.

(2) Assessment of the above effects shall make reference to the provisions given in CD 356 – "Design of highway structures for hydraulic action", as far as they are applicable to Hong Kong conditions. AMD. 1/2023

(3) If a structure is exposed to the sea, the effects of wave action shall also be considered. Reference could be made to "Port Works Design Manual" (PWDM) published by the Civil Engineering and Development Department in assessing the effects of wave action. In addition, the recommended specification given in Appendix B of the PWDM Part 1 for reinforced concrete in marine environment should be adopted to address the corrosion concern.

10.4.2 Backwater Effects

(1) For a bridge crossing a river or stream, consideration shall be given to the backwater effects produced by the highway or railway crossing restricting the flow of water. Backwater can cause flooding upstream of the crossing and, in addition, the increased velocity of the stream, and its turbulence, can cause scour sufficient to endanger the bridge structure.

CHAPTER 11 PARAPETS

11.1 GENERAL

(1) A parapet is a structural component installed along the edge of a bridge or similar structure. Parapets are basically of three categories :

(a) vehicle parapets, designed to contain vehicles only on a structure;

(b) pedestrian parapets, designed to safeguard pedestrians but not to contain vehicles; and

(c) bicycle parapets, designed to safeguard cyclists but not to contain vehicles.

(2) Besides containing vehicles and safeguarding pedestrians and cyclists on a structure, parapets may have other purposes such as :

(a) to shield something below from view;

(b) to reduce noise pollution; and

(c) to prevent splash, from stormwater, or other missiles reaching the area below.

(3) In order to minimize maintenance problems arising from the proliferation of parapet designs, parapets shall as far as possible be of the standard designs having due regard to the appearance and functions of the structure. The outer, non-traffic, profile of standard concrete vehicle parapets may however be altered to suit the bridge architecture.

(4) The Chief Highway Engineer/Bridges and Structures shall be consulted at an early stage in the design of the structure for advice on the updated list of standard parapet designs. If special considerations suggest that the use of standard parapet designs appears to be inappropriate for any reason in a particular structure, the prior agreement of the relevant maintenance authorities and the Chief Highway Engineer/Bridges and Structures must be obtained for adopting non-standard designs.

11.2 VEHICLE PARAPET GROUPS

11.2.1 Containment Levels

(1) The range of possible vehicular impacts onto a parapet is extremely large in terms of vehicle type, approach angle, speed and other road conditions. For standardisation, the performance of a parapet is defined in terms of containment level based on a standardised impact configuration.

(2) Vehicle parapets are classified into four groups of performance classes of containment levels as given in Table 11.1. Vehicle characteristics are given in Table 11.2. AMD. 1/2023

11.2.2 Selection Guidance

(1) For newly constructed structures, vehicle parapets of containment level L3 or above should be provided. Guidance on the selection of containment level are given in Table 11.3B.

(2) For existing structures, guidance on the selection of containment level are given in Table 11.3A. The scoring system for containment level L3 on existing structures is detailed in Table 11.4. AMD. 1/2023

(3) Designers shall exercise judgment to consider the use of higher containment parapets where accidents risks are very high and the consequences of accidents are serious.

11.3 PARAPET HEIGHTS

(1) Height of parapet shall not be less than the dimensions given in Table 11.5. Height shall be measured from the adjoining paved surface to the top of the parapet. The "adjoining paved surface" is the paved area on the traffic side of a parapet, adjacent to the plinth or base of a parapet.

(2) Parapets higher than the dimensions given in Table 11.5 shall be provided wherever special circumstances require a greater height, in which case designers should note that extra working width may need to be allowed to cater for parapet deformation and vehicle movement during accident.

11.4 DESIGN DETAILS

11.4.1 Materials

Parapets may be constructed of steel, aluminium alloy, reinforced concrete or combinations of these materials.

11.4.2 Projections and Depressions

(1) Vehicle parapet shall have traffic face free of projections and depressions, except at joints in longitudinal members but all such projections or depressions shall not exceed 20 mm.

(2) Longitudinal rails shall be placed on the traffic side of their supporting posts, and present a smooth face to traffic free from sharp edges. The front faces of the longitudinal rails shall be in the plane of the traffic faces and, in no case, may depart from it by more than 25 mm.

11.4.3 Structures Not Exclusively Used as Vehicular Bridges

(1) For structures not exclusively used as vehicular bridges, vehicle parapets shall be positioned adjacent to the carriageway on the structure with pedestrian or bicycle parapets at the back of the footways or cycle tracks as appropriate.

(2) If space is limited and the traffic flow is light and slow, the vehicle parapets may be installed along the edges of the structure with the prior agreement of the Chief Highway Engineer/Bridges and Structures. In such case, only reinforced concrete vehicle parapets with minimum 800 mm high concrete plinth and metal top rail(s) minimum 1100 mm high above the adjoining paved surface may be used. The reinforced concrete vehicle parapets shall not be set back farther than 3500 mm from the edge of the carriageway in order to avoid the possibility of high angle impacts developing, the consequence of which can be particularly serious.

11.5 METAL PARAPETS AND TOP RAILS

11.5.1 Design Requirements

(1) Subject to the containment level and other requirements in this Manual, metal vehicle parapets shall be designed and fabricated in accordance with the requirements of BS 6779 Part 1 - Specification for Vehicle Containment Parapets of Metal Construction in so far as its recommendations are appropriate to Hong Kong conditions.

(2) Similarly, combined metal and concrete vehicle parapet shall be designed in accordance with the requirements of BS 6779 Part 3 - Specification for Vehicle Containment Parapets of Combined Metal and Concrete Construction in so far as its recommendations are appropriate to Hong Kong conditions.

(3) A vehicle parapet shall be demonstrated to achieve the required containment level with a full-scale impact test or a method agreed by the Chief Highway Engineer/Bridges and Structures. Impact tests and acceptance criteria shall follow BS EN 1317 – Road Restraint Systems, except the vehicle occupant impact severity assessment indices, and other requirements in this Manual.

(4) Metal pedestrian parapets shall be designed and fabricated in accordance with the requirements of BS 7818 - Specification for Pedestrian Restraint Systems in Metal in so far as its recommendations are appropriate to Hong Kong conditions.

(5) Metal bicycle parapets shall be designed and fabricated in accordance with the same requirements of metal pedestrian parapets in so far as they are applicable to metal bicycle parapets.

(6) Where Hong Kong specifications or conditions differ from the requirements or conditions described in the British Standards, adjustments appropriate to Hong Kong shall be made.

(7) The holding down and fixing arrangements of the parapets shall be fabricated from austenitic stainless steel and be of the base plate mounting type. Stainless steel, except those for fasteners, shall be Grade 1.4436 instead of Grade 1.4401 specified in the General Specifications for Civil Engineering Works.

11.5.2 Corrosion

(1) Steel parapets and top rails shall be detailed so that they can be hot dip galvanized properly after fabrication, and so that they can be erected without damaging the galvanizing and without on site welding. Special attention shall be given to details at joints to prevent water being trapped there.

(2) All steel components shall be hot dip galvanized in accordance with BS EN ISO 1461 to a minimum average mass coating of 600 g/m^2 after fabrication. Accidentally damaged galvanizing shall be made good by :

(a) metal spraying;

(b) application of zinc rich paints to reinstate the original dry film thickness; or

(c) application of low melting point zinc alloy heated by torch to a pasty condition with the fluxes contained therein removed.

(3) Steel hollow sections shall be sealed wherever this can be done without affecting the galvanizing process. If venting is necessary, the vents shall be carefully detailed and positioned so as to be inconspicuous, or be effectively sealed immediately after galvanizing.

(4) Non-ferrous components, particularly of aluminium alloy, do not normally corrode. If non-ferrous components are used with steel fixings, additional protective measures such as insulation must be provided to prevent bimetallic corrosion.

(5) To ensure a reasonable resistance to corrosion, the minimum section thickness of metal members for pedestrian and bicycle parapets shall be :

	Thickness
sealed steel hollow sections	4 mm
unsealed steel sections	5 mm
non-ferrous sections	3 mm

11.5.3 Plinth

(1) A reinforced concrete plinth, whose height at the traffic face (See Figure 11.1) shall be at least 50 mm but not more than 100 mm higher than the adjoining paved surface at any point on the cross section, shall always be provided under a metal parapet where the main structure is of concrete. The plinth shall be sufficiently strong to withstand moments and shears developed at post fixings.

(2) The bottom edge of a plinth shall lie in the plane of the traffic face. The front face shall be in this plane but may be inclined at up to 1 in 12 away from the traffic face up to a maximum of 25 mm. The top of the plinth shall fall toward the traffic face to avoid staining the outside face of the structure. The plinth shall be effectively sealed at the movement joints to prevent water leakage.

Table 11.3A – Selection Guideline for Existing Structures

Containment Level	Selection Guidelines
L1	For local access bridges on local distributors or rural feeder roads
L2	For bridges in general excluding those for which other containment levels are appropriate
L3	For bridges warranted by the scoring system in Table 11.4 or any special considerations deemed necessary by the designer and agreed by the Chief Highway Engineer/Bridges and Structures
L4	For railway overbridges, high risk locations or any special considerations deemed necessary by the designer and agreed by the Chief Highway Engineer/Bridges and Structures
Remark : Designers shall exercise judgment to consider the use of higher containment parapets where accidents risks are very high and the consequences of accidents are serious.	

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Table 11.3B – Selection Guideline for Newly Constructed Structures

Containment Level	Selection Guidelines
L3	For all bridges other than those to be installed with L4 high containment parapets
L4	For railway overbridges, high risk locations or any special considerations deemed necessary by the designer and agreed by the Chief Highway Engineer/Bridges and Structures
Remark : Designers shall exercise judgment to consider the use of higher containment parapets where accidents risks are very high and the consequences of accidents are serious.	

Table 11.4 – Scoring System for Selection of L3 Containment Level on Existing Bridge Parapets

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Road Characteristics	Criteria	Score
Speed limit	Speed limit ≥ 70 km/h	0.23
Height of road above ground or downhill slope	Height ≥ 20 m	0.19
Bus usage	Number of bus routes ≥ 10	0.19
Road geometry	Undesirable road geometry (See Note 3)	0.14
Traffic volume	Annual Average Daily Traffic (AADT) ≥ 30,000 (one-way)	0.07
Percentage of commercial vehicles	Percentage of commercial vehicles ≥ 20%	0.05
Features under road	Residents, schools, hospital or other similar occupants, or a water body, or expressways/ trunk roads exist in the vicinity.	0.08
Accident records	Frequent parapet impact accidents occurred (See Note 4)	0.05
	TOTAL	1

Note 1 : L3 containment level bridge parapets are warranted for a bridge section with a combined score of more than or equal to 0.70.

Note 2 : For individual assessment of score, a value of zero shall be adopted if the respective criterion is not satisfied.

Note 3 : Undesirable road geometry refers to a road section with radius less than 250 m for posted speed limit greater than or equal to 70 km/h, with radius less than 88 m for posted speed limit less than 70 km/h, with gradient greater than 8%, or at or within 20 m from junctions or interchanges.

Note 4 : Frequent parapet impact accidents refers to more than 10 accidents in 5 years. For new construction, accident records may be conservatively assumed to be frequent where the likelihood of such accident rate is high.

CHAPTER 12 FOOTBRIDGES AND SUBWAYS

12.1 GENERAL

(1) A footbridge or subway scheme is not likely to be successful unless it meets the basic directional movements of the potential users and a study shall be made of existing and future movements of pedestrians before deciding on the best practical layout of the footbridge or subway. Access to footbridges and pedestrian subways shall be as short and direct as possible avoiding long detours when using ramps or stairs. Ancillary fittings such as pillar box for pump house, lighting and other electrical and mechanical installations shall be of minimum size, unobstructive and be incorporated into abutments or walls wherever possible.

(2) The provision of access for the disabled is a mandatory requirement. Apart from the requirements stated in this Manual, please also refer to the Volume 6 Chapter 8 of the Transport Planning and Design Manual (TPDM) published by the Transport Department. Access for the disabled shall therefore be included in highway crossing facilities where alternative access is unavailable. Ramps or lifts shall be provided in accordance with Transport Bureau Technical Circular No. 2/2000 issued by the then Transport Bureau. If in doubt, the advice of the Transport and Logistics Bureau (TLB) should be sought. AMD. 1/2023

(3) The planning and layout design of pedestrian crossing facilities are normally carried out by the Transport Department. The designer shall make reference to the TPDM for the layout design. The layout design requirements contained in this Chapter are largely extracted from the TPDM for easy reference. Should there be any inconsistent requirements between this Chapter and the TPDM, the requirements stated in the TPDM shall prevail. Close liaison with the Transport Department at detailed design stage will ensure that consistent standards of provision are maintained.

12.2 COVERS

(1) All new permanent footbridges, elevated walkways, pedestrian subways and their associated ramps and stairways in the urban area shall be covered. In rural areas, the provision of covers depends on the circumstances of the particular location. Detailed guidelines for the provision of covers are given in the TPDM issued by the Transport Department. Applications for permission to omit covers where normally they would be provided should be made to the TLB. AMD. 1/2023 Such applications shall contain appropriate justification, including background and reason for the request, and an account of the extent and result of any consultations with local interests, including the local District Officer. Also, a recommendation on provisions for future installation of covers should be made when submitting the application for omission of covers to the TLB. AMD. 1/2023

(2) When designing the roofs, consideration shall be given to avoid creating an uncomfortable environment during hot days. Measures shall be provided to prevent unauthorised access to the roof of footbridges for safety reasons. In a highly exposed and windy environment, due consideration shall also be given to minimising the effects of driving rains on pedestrians.

(9) A proper drainage system, involving the use of pumps where necessary, shall be provided to prevent flooding of the lift pit and lift machine room from groundwater or rainwater. A water level sensing device shall be installed at the lift pit sump chamber. In the event of flooding being detected, the lift homing operation shall be activated and a fault signal shall be transmitted through the telemetry system to the remote monitoring centre.

(10) Slope within a pedestrian subway catchment area must be properly protected and drained so as to avoid the possibility of a washout of silt. Sand traps and grilles shall be provided wherever water is discharged into the surface channels of paved areas or into stormwater pipes to avoid flooding caused by blockage of the subway pumping system. Planting within a pedestrian subway catchment area shall be of the evergreen broadleaf type to reduce the amount of fallen leaves which can easily block drains and cause flooding. Catchpits shall have desilting sumps not less than 250 mm deep. They shall be covered and grilles shall also be provided to all pipe inlets to prevent large pieces of rubbish from entering and causing blockage of the subway drainage system.

(11) Requirements of flood warning system for subways or underpasses should refer to Clause 14.6.

12.10 LIGHTING

(1) Lighting schemes for pedestrian structures shall comply with the requirements of the Public Lighting Design Manual and shall be approved by the Lighting Division of Highways Department. The maintenance authority i.e. the Lighting Division and/or the Electrical and Mechanical Services Department shall be consulted in preliminary design stage.

(2) Light fittings shall be as inaccessible to pedestrian as far as possible and compatible with maintenance requirements. Lighting conduits and junction boxes for newly constructed footbridge/subways shall not be surface-mounted except for steel structures. **AMD. 1/2023**

(3) Where footbridges or subways are located in prestigious area, decorative lights may be considered in order to enhance the harmony of the environment. The Lighting Division of Highways Department shall be consulted at the earliest possible time.

12.11 ESCALATORS

12.11.1 Provision of Escalators

(1) The criteria for provision of escalators at footbridges and elevated walkways are detailed in Transport Bureau Technical Circular No. 2/2000. The agreement of the TLB shall be obtained to the provision of escalators not complying with the foregoing criteria. **AMD. 1/2023**

12.15.2 Ventilation

(1) At locations where the lift shaft is exposed to direct sunlight for long periods, mechanical ventilation of the lift shaft will be required and the provision of shading elements to reduce heat load shall be considered. Ventilation fans fitted with weatherproof louvres shall be installed at high level at the lift shaft wall to remove the heated air from the lift shaft enclosure. Ventilation fans shall not be installed at the roof top to avoid water inflow into the lift shaft. Stainless steel inlet louvres fitted with removable filters to trap dust particles shall be installed at low level in the lift shaft to permit replacement air to flow into the shaft.

(2) In designing lift with mechanical ventilation, reference shall be made to the Highways Department Guidelines No. HQ/GN/19 "Guidelines on Lift Design with Mechanical Ventilation".

(3) Ventilation fans shall be installed at the lift car ceiling. If air-conditioning is provided where situation warrants, a mechanical or an electrical drain system shall be installed to drain the condensation from the air-conditioning system. **AMD. 1/2023**

12.15.3 Surveillance and Emergency Equipment

(1) A telemetry system shall be provided for transmitting lift fault signals automatically through the telephone network to a 24-hour manned remote monitoring centre, which shall contact the respective lift maintenance company to attend to the lift fault.

(2) An emergency alarm button, an intercom and a CCTV camera shall be provided in the lift car, which shall be connected to an intercom, a CCTV display monitor and an indication light placed at each of the lift entrances outside the lift. The emergency alarm button shall be connected to an alarm bell placed at the lift car top and an alarm bell placed at the ground floor lift entrance or lift pit.

(3) The intercom system shall comprise a 2-way speaker to allow people inside the lift car to communicate with people outside the lift at the landing call panel.

(4) A battery back-up system capable of maintaining a power supply to the emergency load for a minimum period of two hours shall be provided.

12.16 TACTILE WARNING STRIPS

Tactile warning strips for people with visual impairment shall be provided at the top, bottom and landings of ramps and staircases in accordance with TPDM Volume 6 Chapter 8 and also at lift entrances. They shall be made of durable and non-slippery materials and should contrast visually with the adjoining surfaces to provide clear indication of the routes to people with low vision.

CHAPTER 14 STORMWATER DRAINAGE

14.1 GENERAL

(1) Drainage design shall be in accordance with the Guidance Notes No. RD/GN/035A "Guidance Notes on Road Pavement Drainage Design" published by the Highways Department and the Stormwater Drainage Manual published by the Drainage Services Department. Requirements of drainage design for footbridges, subways and underpasses are detailed in Clause 12.9. AMD. 1/2023

(2) Stormwater drainage installations have often caused problems. The main reasons are :

(a) small diameter pipes, which have become blocked;

(b) changes of direction in pipe runs, which have become blocked;

(c) poor detailing of intakes and outlets resulting in frequent blockages;

(d) inadequate provision for clearing blockages; and

(e) thin-walled pipes broken by pressure of wet concrete, or incompletely sealed pipe joints through which cement grout has entered during construction, so that pipes have been blocked permanently before they have ever functioned.

14.2 PIPES AND PIPE LAYOUT

14.2.1 Minimum Diameter

Stormwater drainage pipes for vehicle and pedestrian/bicycle highway structures shall not be smaller than 150 mm and 100 mm in diameter respectively. Longitudinal carrier drains shall be provided with rodding eyes at interval not more than 20 m.

14.2.2 Material

(1) Drain pipes shall be of uPVC, unless some good reasons make the use of an alternative material desirable. uPVC drain pipes shall comply with BS 4660, JIS K-6741, or a comparable acceptable national standard, and have dimensions similar to those given in Table 14.1.

Table 14.1 – uPVC Drain Pipes

Standard	Nominal Size (mm)	Approximate Inside Diameter (mm)
BS 4660	110	103
	160	152
JIS K-6741	100	107
	150	154

towers of larger bridges. Figure 15.29 illustrates how lighting add aesthetic value to a highway structure.

(4) For subway entrance, footbridge and walkway, efforts shall be made to provide a transparent or translucent roof cover. It will allow penetration of natural light, evoke a sense of openness and reduce lighting costs.

(5) With respect to the luminance level of functional lighting for highway structures, reference shall be made to the guidelines provided under HyD's *Public Lighting Design Manual*. During retrofitting, upgrading or major maintenance works to highway structures, due consideration shall be given to improving the standard of luminance levels in line with the recommendations under *Public Lighting Design Manual,* where appropriate, to facilitate the disabled and improve security to users.

15.6 EXTERNAL OR ANCILLARY FEATURES

15.6.1 Landscaping

(1) Landscape element is an integral part of the highway structure that needs to be considered in the initial stage of design process. A landscape section forming part of a design memorandum shall be developed in the project initiation stage, with specific landscape goals, assessment criteria to measure its effectiveness, and guidelines for landscape and surface treatments.

(2) Integration of the highway structure into its surrounding landscape is one of the most important consideration in aesthetic design. The creation of wastelands under overhead structures due to a lack of light, access preventative treatments or other inability to utilise these spaces has an adverse effect on the aesthetic quality of the structure and shall be minimised.

(3) Provision of soft landscape in form of "greening" is of increasing demand from the general public. Designers shall explore the opportunity for incorporating soft landscape and planting facilities onto structures and in its vicinity to enhance the visual and living quality of the whole environment. Regarding the provision of permanent planters and irrigation systems on future footbridges and flyovers, reference shall be made to Development Bureau Technical Circular (Works) No. 1/2018. AMD. 1/2023

(4) Soft landscaping, in particular tree and shrub planting, have the benefits to :

(a) anchor the structure on the ground plane;

(b) soften the scale and extent of hard surfaces;

(c) screen parts of structure;

(d) add amenity value to the local area;

(e) provide landscape focus to features;

(2) The volatile organic compounds (VOC) content for the paints shall be in compliance with the Air Pollution Control (Volatile Organic Compounds) Regulation (the Regulation), and shall not exceed the maximum limits of VOC content for the Regulated Architectural Paints as listed in the Regulation. As a general reference for highway works, paints classified as "Industrial Maintenance Coatings" with a VOC content limit of 250g/L under the Regulation are appropriate paint materials to be used for compliance.

(3) Direct application of paint to newly galvanized steelwork will result in premature failure of the paint system. Such failures are usually due to the formation of brittle zinc soaps at the paint/zinc interface with the resultant loss of adhesion and deterioration in the properties of the paint film. The pretreatment of the surface with a proprietary two pack etch primer prior to painting would prevent the failure of the paint system. Primers shall be applied in thin coats by continuous spraying and strictly in accordance with the manufacturer's instructions. Suitable one pack primers are also available, but care must be taken to ensure that they are formulated for use on galvanized steel.

(4) Weathering of galvanized surfaces until all bright zinc has changed to a dull surface by oxidation may aid adhesion of the paint, provided any loose particles have been removed from the surface. The deliberate use of weathering as a pretreatment for painting is not recommended as the minimum time needed for full weathering cannot easily be assessed. It may also be difficult to completely clean a weathered surface in preparation for painting.

(5) After galvanized or metal sprayed structures have been painted, subsequent maintenance will be of the paint system. The paint systems, and their required life to first maintenance of the paint system in very high corrosivity (C5) environment as defined in BS EN ISO 12944 Part 2, to be used for painting galvanized or metal sprayed steelworks shall be : AMD. 1/2023

(a) *Paint System I*

To be applied to : parapets, etc.

Life to first maintenance : 7 to 15 years, medium (M) durability as defined in BS EN ISO 12944 Part 1 AMD. 1/2023

Pretreatment : two-pack etch primer

Primer : two-pack epoxy primer, 80 µm minimum total dry-film thickness

Finish : two pack epoxy finish coat or polyurethane finish coat, 80 µm minimum total dry-film thickness

(b) *Paint System II*

To be applied to : structural steelworks

Life to first maintenance : 15 to 25 years, high (H) durability as defined in BS EN ISO 12944 Part 1 AMD. 1/2023

Pretreatment : two-pack etch primer

Primer : two-pack epoxy zinc phosphate primer, 80 μm minimum total dry-film thickness

Undercoat : two-pack micaceous iron oxide epoxy undercoat, 140 μm minimum total dry-film thickness

Finish : two-pack polyurethane finish coat, 100 μm minimum total dry-film thickness

(c) *Paint System III*

To be applied to : metal sprayed surfaces

Lift to first maintenance : 15 to 25 years, high (H) durability as defined in BS EN 1SO 12944 Part 1 AMD. 1/2023

Pretreatment : two-pack zinc tetroxychromate polyvinyl butyral pretreatment

Sealer : two-pack epoxy sealer applied by brush until absorption is complete

Primer : two-pack epoxy zinc phosphate primer, 80 μm minimum total dry-film thickness

Undercoat : two-pack micaceous iron oxide epoxy undercoat, 140 μm total minimum dry-film thickness

Finish : two-pack polyurethane finish coat, 100 μm minimum total dry-film thickness

(6) The aforesaid guidelines shall not be applicable to exceptionally massive steelwork, such as the steel deck of the Tsing Ma Bridge, Ting Kau Bridge, etc., where special corrosive protection system shall be considered with regard to the particular project requirements.

16.5 INCORPORATION OF UTILITY INSTALLATIONS IN HIGHWAY STRUCTURES

(1) In general no utility installations other than road lighting, emergency telephones and traffic surveillance equipment will be permitted on highway structures except in cases where there is no other viable routing available. Where other arrangements for a utility line to span an obstruction are not viable nor reasonably practical, the Highways Department may consider the accommodation of such line in a highway structure if the AMD. 1/2018

16.7 RUNNING SURFACES OF BRIDGE DECKS

(1) To achieve better riding quality and to allow greater flexibility in maintaining the running surfaces of highway bridge decks, the bridge deck surface shall be designed to be finished with bituminous materials in accordance with Highways Department Guidelines No. HQ/GN/25 "Running Surfaces of Bridge Decks". Due consideration shall also be given to the Guidance Notes No. RD/GN/033 "Guidance Notes on the Use of Waterproofing Membranes on Concrete Bridge Decks" published by the Highways Department in designing the bituminous surfacing. AMD. 1/2023

(2) A concrete running surface shall only be considered for sections where a short structure is located within a length of rigid carriageway.

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designed to be fit-for-purpose as noise mitigation structures while at the same time minimising their impacts on the immediate surroundings and the wider environment. Their extent and height shall be kept to a minimum in order to achieve economical design.

The spacing of structural frames shall be optimized. In general, utilization of the capacity of the structural frames would be maximized with larger spacing of the structural frames. On the other hand, the cost of sub-frames and thickness of panel materials would also increase due to the longer span between structural frames. Therefore, the Designer shall strike a balance between spacing of structural frame, sub-frame arrangement and panel material thickness with a view to achieving economical design. AMD 1/2018

For cantilever noise barriers and noise enclosures, haunches of beams at their connections with columns shall be considered in order to reduce the overall weight of the beams.

The Designer shall also consider to adopt high productivity construction method such as off-site prefabrication, multi-trade integration and module maximization, alternative structural forms and advanced materials at the early design stage with a view to reducing erection time and cost. The Designer shall also ensure that sufficient structural capacity and stability are provided against accidental actions. AMD 1/2023

Figures F5 to F8 show some examples of noise barriers/enclosures used in Hong Kong.

Figure F5 – Vertical noise barrier at Kwun Tong Bypass (Transparent panels)

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Figure F8 – Noise semi-enclosure at Lai Chi Kok viaduct (Route 8)
(Vertical part: Transparent panels; Roof: absorptive panels and transparent panels)

AMD 1/2018

F.4 MATERIALS

The materials used for acoustic panels can largely be categorized as reflective and absorptive. A reflective type panel is either transparent or non-transparent. An absorptive panel is typically made up of a perforated cover sheet enclosing noise absorptive material (mineral wool or fiberglass inside and wrapped up with polyester film). In choosing a suitable material, the Designer may have his own set of considerations to suit an individual case. The "Guidelines on Design of Noise Barrier" has briefly explained the advantages and disadvantages of different materials which could be used as general guidance. The use of materials with long-term maintenance issues shall be avoided. The maintenance authority shall be consulted in this regard.

The use of lightweight materials generally reduces the costs of the structures and their foundations. The Designer should ensure maximum cost effectiveness in the choice of materials. The elements to be considered should include but not limited to the capital cost, life cycle cost (life time maintenance and replacement) and associated costs such as loading imposed on supporting frames, bridges and foundations.

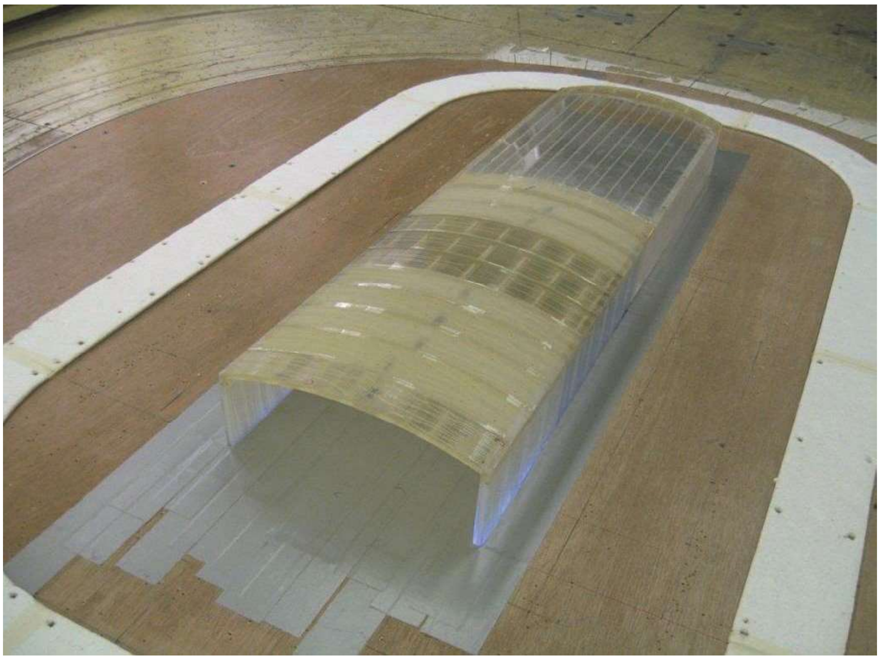
For the structural frames, reinforced concrete and structural steel have been adopted. While the two materials have their own merits, in general, a reinforced concrete structure is bulkier and heavier when compared with structural steel. The use of reinforced concrete frames as structural support for noise barriers/enclosures will increase the construction time and costs and should be adopted only with justifications. The use of high strength material could be considered to enhance cost-effectiveness. The Designer may make reference to the "Guidelines on Design of Noise Barriers" for details.

AMD 1/2023

The Designer shall assess the wind loading accurately taking into account the different pressure coefficients in different zones in order to achieve economical design of a structure. The edge zones would experience larger wind drag compared to the middle zones. Structural member sizes and framing shall be designed to cater for larger wind loading in the edge zones and smaller wind loading in the middle zones. The design for edge zones shall not be adopted as a typical design.

As the configurations of noise enclosures vary widely, the pressure coefficients given in BS EN 1991-1-4 may not be applicable. In this connection, reference shall be made to established standards and published data or aerodynamic analysis shall be conducted to obtain the appropriate pressure coefficients. For noise enclosures of significant scale and/or of non-typical configurations, wind tunnel tests shall be considered to determine suitable pressure coefficients in order to achieve economical design. Figure F9 shows a wind tunnel test conducted for a noise enclosure to determine the wind pressure coefficients. When wind tunnel tests are performed, the provisions given in Clause A.5 of PD 6688-1-4 and the further guidance given in Appendix E of this Manual shall be followed. AMD 1/2018

Figure F9 – Wind tunnel test conducted for a noise enclosure



F.6 SUPERIMPOSED DEAD LOAD AND LIVE LOAD

Chapter 3 of this Manual and the following provisions shall be followed in respect of superimposed dead load and live load to be considered for the design of noise barriers/enclosures.

The adoption of greening measures shall follow the "Guidelines on Greening of Noise Barriers". AMD 1/2023
Due consideration shall be given to adoption of greening measures as the additional heavy loading induced by landscaped decks and vegetation would increase the construction cost as well as the maintenance cost. AMD 1/2018

The Designer shall consult the maintenance authority in respect of the imposed loads on noise enclosure roofs for normal maintenance and repair works. In any case, the imposed loads shall not be less than the values given in Clause 3.7.3.4 of this Manual. AMD 1/2018

Where the panel material can absorb water, the wet weight should be considered. Structural frames shall be designed to support the wet weight of the panel material.

The adoption of Photo-Voltaic (PV) system shall follow the requirements stipulated in DEVB Technical Circular No. 2/2015 and the "Guidelines on Design of Noise Barriers". The Designer shall take into consideration the weight of PV system in the structural design of noise barriers/enclosures. The imposed loads for normal maintenance and repair works shall also be considered. AMD 1/2023

F.7 ACCIDENTAL ACTIONS CAUSED BY ROAD VEHICLES

In general, noise barriers/enclosures shall be set back sufficiently and protected by vehicle restraint systems of the appropriate containment level with full working width or supported on concrete rigid barriers of the appropriate containment level with full working width to reduce the vehicular impact actions. AMD 1/2018

In the design of noise barriers/enclosures against vehicular impact, the Designer shall formulate the strategy for the structure against accidental actions. The principles given in Clause 3.6.1 of this Manual and Clause 3.3 of BS EN 1991-1-7 shall be followed. The scenarios of both during and after the accidents shall be assessed. In essence, a noise barrier/enclosure structure should be designed and constructed so that it is inherently robust and not unreasonably susceptible to the effects of accidents or misuse, and disproportionate collapse. The overall structural integrity of the structure shall be maintained following impact from vehicular impact, but local damage to a part of the support posts or other structural members can be accepted. AMD 1/2023

To improve the performance of noise barrier/enclosure structures against vehicular impact in the direction of normal travel, the support posts should be tied by one to two rows of structural members located at the top and near the mid-height of the support posts. This would increase the redundancy of the structure and reduce the resultant forces transferred to the base of the support posts. As a result, the member sizes of the support posts would be reduced, especially for universal beam and universal column sections where the orientation of minor axis is usually perpendicular to the direction of normal travel. AMD 1/2018

F.8 DIRECTIONAL SIGNS

The provision and design of directional signs would affect the height of a noise enclosure. Figures F10 to F12 show some examples of designs of noise enclosures and directional signs. In Figure F10, the noise enclosure has been designed to enclose a sign gantry resulting in excessive height of the noise enclosure. Such design would result in bulkiness of the structure and shall be avoided. The design of directional signs shall comply with the requirements given in the Transport Planning and Design Manual (TPDM). AMD 1/2023

Figure F10 – Noise enclosure designed to enclose a sign gantry

AMD 1/2023

AMD 1/2018

To reduce the height of noise enclosure, sign gantries shall not be placed within a noise enclosure. If feasible, they shall be placed outside noise enclosures as shown in Figure F11.

AMD 1/2023

Figure F11 – Sign gantry located outside a noise enclosure

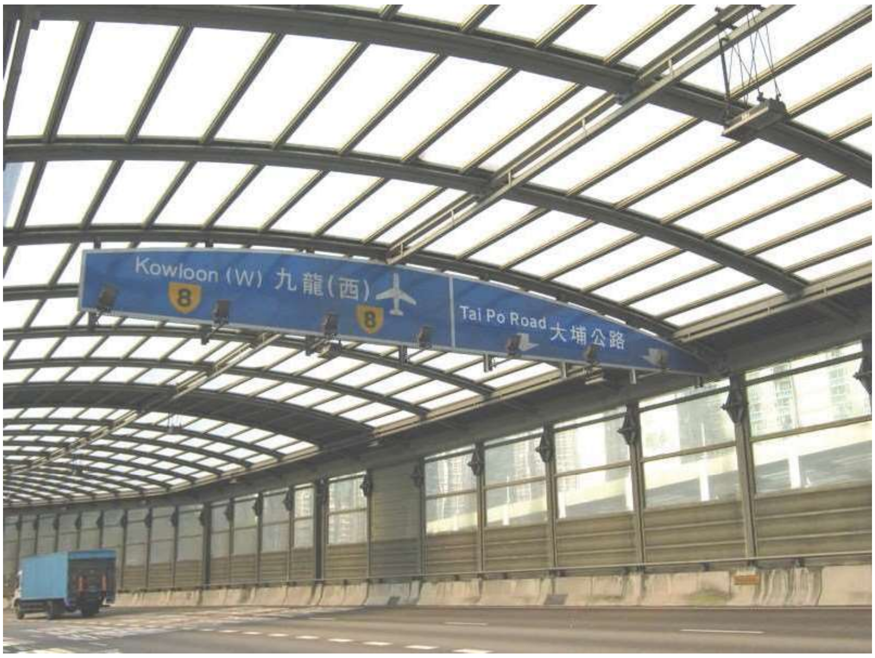
AMD 1/2018

For a directional sign to be placed within a noise enclosure, its shape shall be tailor-made to suit the roof profile of the noise enclosure and its dimensions shall be minimized to reduce the overall height of the noise enclosure. The directional sign shall be fixed to the roof structural members if practicable. Figure F12 shows an example of a directional sign designed to suit the profile of the noise enclosure roof and mounted to the roof structural members. The Transport Department shall be consulted on locations and dimensions of directional signs.

AMD 1/2023

AMD 1/2018

Figure F12 – Directional signs designed to suit the profile of the noise enclosure roof AMD 1/2023



AMD 1/2018

F.9 AESTHETIC AND OTHER DESIGN CONSIDERATIONS

Similar to other forms of highway structures, the aesthetic appreciation of noise barriers/enclosures can be made from either the static viewpoint of observers away from the structures, or the dynamic viewpoint of motorists/users along the roadway. From the perspective of static appearance, the noise barriers/enclosures shall properly fit into the surroundings. The overall appearance of the structure shall not adversely affect the visual envelope of the spatial environment. From the motorists' perspective, the noise barriers/enclosures shall not elicit a feeling of confinement, leading to driver discomfort. The guidelines given in "Guidelines on Design of Noise Barriers" and Clause 15.6.5 of this Manual shall be followed. The guidance given in "Guidelines on Greening of Noise Barriers" shall also be followed for the greening design of noise barriers/enclosures. AMD 1/2023

F.10 FIRE RESISTANCE AND EMERGENCY ACCESS

The guidelines on fire resistance and emergency access given in "Guidelines on Design of Noise Barriers" shall be followed. If transparent panels are used, the guidelines given in "Noise Barriers with Transparent Panels" shall also be followed.

AMD 1/2018

F.11 HOLDING DEVICES AND CATCHING CONTRIVANCES

The risk associated with panels of noise barriers/enclosures falling onto vehicle/pedestrian paths upon impact by vehicles should be considered in the design. Holding devices shall be provided to prevent panels from falling off noise barrier/enclosures. Such devices shall be in form of wire ropes holding the four corners of each panel. If drilling on the panels is considered not appropriate (e.g. glass panels), the wires shall hold the sub-frames instead. In that case, the panels shall be properly glued to the sub-frames by sealant. For transparent panels, catching contrivances should be provided to prevent spread of panel fragments that could cause hazard to road users. The guidelines given in "Noise Barriers with Transparent Panels" shall be followed.

F.12 BIRD COLLISION

There were reported cases where birds collided onto noise barriers/enclosures with transparent panels causing bird mortality. As transparent panels appear invisible to birds or are reflective that mirror the facing landscape, birds are unable to recognize them as physical barriers. The Agriculture, Fisheries and Conservation Department recommends that transparent panels should be avoided as far as possible in the design of noise barriers/enclosures in areas with high bird density or for roads that cut across rural areas.

To alleviate the bird collision problem, the Designer should consider bird collision measures during the design stage. The guidelines given in "Noise Barriers with Transparent Panels" shall be followed. AMD 1/2018

F.13 GLARE

Noise barriers/enclosures with metallic and transparent materials can produce "glare" effects at certain incident angles of sunlight, causing nuisance to road users and nearby residents. Under some situations, the reflection of sunlight from slanting or horizontal panels would also cause nuisance to nearby residents. The Designer shall ensure that noise barriers/enclosures do not reflect light in such a way as to cause nuisance to road users and nearby residents, and the top surface of roof panels shall be non-glaring. If transparent panels are used, the guidelines given in "Noise Barriers with Transparent Panels" shall be followed.

The guidelines on lighting inside noise enclosures to avoid glare effects given in "Guidelines on Design of Noise Barriers" shall also be followed.

F.14 MAINTENANCE CONSIDERATIONS

The Designer should consider the need to stipulate in the contract that the supplier should specify the method and procedures for the future replacement of panels and/or cleansing of noise barrier/enclosure panels for agreement by the maintenance authority. Consideration shall be given at the early design stage to the provision of means of access to all locations and components, including greening provisions, if any, of noise barriers/enclosures for inspection and maintenance. Such means of access may include walkways, working platforms, maintenance access openings, as appropriate. Management and maintenance matrix shall also be agreed before implementation. The guidelines given in "Guidelines on Design of Noise Barriers" and Chapter 16 of this Manual shall be followed. The maintenance authority shall also be consulted in this regard. AMD 1/2023 AMD 1/2018