

Highway parapets for bridges and other structures —

Part 1: Specification for vehicle containment parapets of metal construction

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/509 “Road equipment” to Subcommittee B/509/1 “Safety barriers”, upon which the following bodies were represented:

- Aluminium Federation
- Association of Consulting Engineers
- Association of County Councils
- British Cement Association
- British Railways Board
- British Steel Industry
- Convention of Scottish Local Authorities
- County Surveyors’ Society
- Department of Transport
- Fencing Industry Association
- Institution of British Engineers
- Institution of Highways and Transportation
- Royal Automobile Club
- Royal Society for the Prevention of Accidents

The following body was also represented in the drafting of the standard, through subcommittees and panels:

- Department of Transport (Transport and Road Research Laboratory)

This British Standard, having been prepared under the direction of Technical Committee B/509, was published under the authority of the Standards Board and comes into effect on 1 April 1992

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First published August 1987
Second edition March 1990
Third edition April 1992

The following BSI references relate to the work on this standard:
Committee reference B/509/1
Draft for comment 91/10849 DC

ISBN 0 580 20545 2

Amendments issued since publication

Amd. No.	Date of issue	Comments
8013	December 1993	
8629	July 1995	Indicated by a sideline in the margin

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Foreword

This Part of BS 6779 has been prepared under the direction of Technical Committee B/509 "Road equipment". This edition introduces technical changes but it does not reflect a full review or revision of the standard which will be undertaken in due course. It supersedes BS 6779-1:1989 which is withdrawn.

The other Part already published in the series is:

— *Part 2: Specification for vehicle containment parapets of concrete construction.*

The other Part so far planned in the series is:

— *Part 3: Specification for vehicle containment parapets of combined metal and concrete construction.*

The principal changes from the 1989 edition are as follows.

- a) The use of shock transmission units in joints for high containment parapets has been suspended.
- b) New requirements are included for notch ductility of steel.
- c) The overall title has been changed to show that the standard covers bridges and other structures such as retaining walls.

This Part of BS 6779 contains a number of appendices, the following of which form part of the specification:

Appendix E. Method for dynamic testing (see **26.1**)

Appendix F. Static testing of posts

Appendix G. Parapet designs exempted from the dynamic test requirements (see **0.6**)

The following appendices do not form part of the specification but are included for guidance and information only:

Appendix A. Guidance on levels of containment and derivation of theoretical design forces

Appendix B. Guidance on limit state design

Appendix C. Detailed design guidance recommendations for new designs based on tested configurations

Appendix D. Information to be provided by the supplier/purchaser

NOTE 1 The standard allows a number of options. The purchaser/supplier should indicate to the supplier/purchaser which of the options he requires. Appendix D forms a checklist of the items on which the purchaser/supplier should have made a decision.

Parapets are multi-purpose in that they have to serve the safety of errant vehicles and their occupants, pedestrians and other road users, and may be used to guard against possible initiation of a major incident in areas adjoining highways such as high-speed rail lines.

Parapets are generally required to have an acceptable appearance, and not to impose such weight or force on the edge of a bridge or structure as to add unduly to its structural requirements.

All or any of these requirements may be in conflict in any particular circumstance, and a judgement as to the solution providing the best overall balance of advantage and safety then has to be made.

The range of vehicles using the roads is vast and constantly developing and changes take place in design, axle loadings and other characteristics, and errant vehicles will produce impacts of differing severity over a range of angles, speeds and disposition of loaded weight. Open frame parapets may be required to have mesh, bar or solid infill for additional safety and for the protection of pedestrians, animals and rail users. Hence the range of variables and their combinations is virtually infinite.

Thus, specifying desirable characteristics for parapets, deciding upon levels of containment to be achieved, and specifying designs and/or tests to produce parapets which perform accordingly is fraught with difficulty. There are inevitably areas of imprecision: for example, for practical reasons ordinary production vehicles have to be used in testing parapets, and while these will comply with the specified parameters, they all may not have precisely the same effect upon a particular parapet.

A programme of full scale dynamic testing has been carried out on metal parapets for this Part of BS 6779 and is continuing for the other Part which follows. The results from these tests have been used to supplement and extend what was considered to be the best of current practice. Such tests are costly and resource consuming and the range of tests is necessarily limited for that reason. Some references will be found in the text to such problems and to the inclusion of established parapet designs.

Appendix A provides some background to the consideration of impact on parapets.

NOTE 2 Reference is made in the text to Department of Transport Standards which should be used until BS 5400 is superseded by European Standards, when an amendment to this standard will be issued.

NOTE 3 The changes implemented in this standard are indicated by a single vertical line in the margin.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 50, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

0.1 This Part of BS 6779 specifies requirements for parapets of metal construction which are designed to provide specified levels of vehicle containment on highways. These parapets are installed on bridges, retaining walls or other structures.

Parapets of concrete, or of composite concrete and masonry construction, or of combined concrete and metal construction are not covered in this Part of BS 6779.

0.2 Containment levels are related to defined vehicle impacts and normal, high and low levels of containment are specified. The normal level of containment is considered to offer a reasonable level of protection and to be the best compromise on safety considerations for all but the most exceptional circumstances. High level containment parapets may be required in extremely high risk situations. Low containment parapets with vertical infill are only to be used in 30 mile/h speed restricted areas. Other post and rail type low containment parapets may be used in areas where 80 km/h (50 mile/h) speed restrictions apply.

0.3 There is a vast and ever changing range in size, shape and configuration of vehicles and, inevitably, not all vehicles complying with the parameters for characteristic impacts would have precisely the same effect on any particular parapet.

There is therefore some imprecision in the specification of the vehicles and hence for characteristic impacts and levels of containment, but they are considered to be the best practically available.

Containment levels are further discussed in Appendix A.

0.4 The main objectives of the forms of parapets defined in this Part of BS 6779 are:

- a) to provide specified levels of containment to limit penetration by errant vehicles;
- b) to protect highway users and others in the vicinity by redirecting the errant vehicles with minimum deceleration forces on to a path as close as possible to the line of the parapet and to reduce the risk of the vehicle overturning.

0.5 The difficulty of predicting response to dynamic effects makes it impossible to give complete theoretical design criteria which could be guaranteed to produce satisfactory designs. In consequence, full-scale acceptance testing using a vehicle with appropriate impact characteristics is required for the approval of new designs. A method for acceptance testing is given in Appendix E.

0.6 Generally, parapets in the UK for the applications covered in this Part of BS 6779 have been designed to Department of Transport requirements. These requirements were determined for the same vehicle impacts specified in this Part of BS 6779 applied to the particular parapet configurations. For such configurations detailed design guidance was derived and this is given in Appendix C.

Those designs (listed in Appendix G), prototypes of which have been tested to the same or similar regimes as are required in **26.1** and which have produced results adjudged to be successful, are deemed to comply with the acceptance testing requirements of this Part of BS 6779 without further dynamic testing.

1 Scope

This Part of BS 6779 specifies requirements for the design, materials, construction (including storage, transportation and installation) and testing of metal parapets not less than 12 m long (see note 2). The parapets covered in this Part are mounted on plinths not greater than 100 mm high and are intended to provide specified levels of containment for vehicles on highways.

General information is provided in Appendix A, Appendix B and Appendix C for designers wishing to produce new designs, and to guide prospective purchasers as to acceptable designs and to indicate the principles on which existing designs are based.

NOTE 1 For barriers in and about buildings, see BS 6180. For pedestrian guard rails, see BS 3049. For safety fences and barriers for highways, see BS 6579.

NOTE 2 The containment characteristic of metal parapets is generally provided through absorption of the energy of the vehicle impact by progressive collapse of the support system over a length of parapet. A parapet of less than 12 m length may not provide the specified level of containment.

NOTE 3 The titles of the publications referred to in this standard are listed on page 50.

2 Definitions

For the purposes of this Part of BS 6779 the following definitions apply.

2.1

vehicle restraint system

installation to provide a level of containment for errant vehicles to limit damage or injury to users of the highway

2.2

highway parapet

a barrier at the edge of a bridge, or on top of a retaining wall or similar structure, associated with a highway

**2.3
safety fence**

an installation provided for the protection of users of the highway consisting of horizontal beams or wire ropes mounted on posts

**2.4
vehicle parapet**

highway parapet that acts as a vehicle restraint system

**2.5
vehicle pedestrian parapet**

vehicle parapet with additional safety provisions for pedestrians and animals

**2.6
front face of a parapet**

the face nearest to the traffic

**2.7
plinth**

a continuous upstand on the edge of a structure upon which the parapet is mounted

**2.8
main structure**

any part of the bridge, retaining wall or similar structure upon which the parapet is mounted, including the plinth

**2.9
adjoining paved surface**

the paved area on the traffic side of a parapet, immediately adjacent to the plinth or base of a parapet

**2.10
attachment system**

the system of attachment of the parapet to the anchorage, usually consisting of holding-down bolts

**2.11
anchorage**

that part contained within the main structure to which the parapet is directly fixed by means of the attachment system

NOTE For example, a cast-in anchorage cradle in a reinforced concrete edge beam and plinth.

**2.12
datum for height considerations**

the highest level of footway, verge, carriageway or any other part of the road construction within 1.5 m of, and on a line at right angles to, the traffic face

NOTE This will normally be the adjoining paved surface.

**2.13
effective longitudinal member**

those longitudinal members of a post-and-rail type parapet that become effective in restraining a vehicle in an impact

**2.14
non-effective longitudinal member**

an additional longitudinal member above the effective longitudinal members provided to give additional height to the parapet for the protection of pedestrians or animals or to support noise barriers

**2.15
traffic face of a parapet**

a vertical plane containing the front face of the main longitudinal member and the front face of the plinth

**2.16
infilling panel**

a non-structural panel used to cover the spaces between members on the front face of a parapet to safeguard pedestrians

NOTE Where required infilling panels may also be used as a protection against splash and/or noise.

**2.17
vertical infill bar**

infilling vertical members providing protection to pedestrians and animals by infilling between longitudinal members

**2.18
safety barriers**

an installation provided for the protection of users of the highway that is continuously in contact with its supporting foundation

**2.19
shock transmission unit (STU)**

a mechanism for transmitting vehicle impact forces across movement joints in steel high containment parapets

NOTE The use of a moving piston within a closed cylinder filled with silicone putty permits slower movements with negligible force transmission.

**2.20
transition system**

an arrangement for connecting dissimilar and/or different capacity protective systems

**2.21
wheel penetration**

the maximum dynamic penetration of the lower outside face of any tyre or wheel measured perpendicular to the original traffic face of the parapet system

3 Symbols

The following is a list of the symbols used in this Part of BS 6779 to represent variables. Other symbols used for designation purposes are listed in Table 1.

a	Mean lateral deceleration (m/s ²)
b	Distance of the centre of gravity of the vehicle from the side (m)
c	Distance of the centre of gravity of the vehicle from the front (m)
D	Nominal bolt diameter (mm)
F	Mean impact force (kN)
f_k	Characteristic (or nominal) strength of the material
k_z	Ratio of the test strength to the theoretical strength
K_1	Factor k_z at critical stress condition
L	Distance between centreline of supports (m)
m	Vehicle mass (kg)
n	Number of effective longitudinal members
Q^*	Design load (kN)
Q_k	Nominal load (kN)
R^*	Design resistance
S^*	Design load effect
z	Sum of barrier deflection and depth of vehicle crumpling (m)
v	Approach velocity (m/s)
γ_{fl}	Partial load factor
γ_{f3}	Partial factor for load effect
γ_m	Material factor
σ_{vb}	Minimum ultimate tensile strength of bolt material (N/mm ²)
σ_{ya}	Minimum yield strength of anchorage material (N/mm ²)
θ	Angle of path of vehicle (degrees)

4 Designation of vehicle parapets

For the purposes of an abbreviated description, vehicle parapets shall be designated by three characters indicating:

- level of containment;
- height of parapet;
- type and height of infill.

Where appropriate, designations shall be supplemented by relevant information, e.g. materials, protection, infill treatment, anchorage type (see Appendix D). Designation details are set out in Table 1.

Table 1 — Designation of vehicle parapets

Item	Designation	Clause ref.
a)	Levels of containment N = normal level of containment L = low level of containment H = high level of containment	5 5.1 5.2 5.3
b)	Overall height of parapet 1.00 = 1 m height 1.25 = 1.25 m height 1.50 = 1.50 m height etc.	7 Figure 9, Figure 10, Figure 11, Figure 12 and Figure 13
c)	Infill for parapets not over railways O = no infill M = mesh infill to full height m = mesh infill to part height W = solid infill to full height w = solid infill to part height S = acoustic barrier V = vertical bar X = special design Infill for parapets over railways B = solid infill to full height b = solid infill to part height R = rail mesh to full height r = rail mesh to part height X = special design	16 16 b) 16 b) 16 d) 16 d) 16 e) 16 a) 16 16 d) 16 d) 16 c) 16 c)
NOTE Examples of designation:		
N/1.00/O	indicates a parapet of 1 m height above the datum, of normal level of containment to 5.1 and with no infill component.	
L/1.00/V	indicates a parapet of 1 m height above the datum, of low level of containment to 5.2 and with vertical bar infill to clause 16 a).	
N/1.25/r	indicates a parapet of 1.25 m height above the datum, of normal level of containment to 5.1 and with rail mesh infill to part height to clause 16 c).	
H/1.5/W	indicates a parapet of 1.50 m height above the datum, of high level of containment to 5.3 and with solid infilling panel to full height.	

Section 2. General design

5 Levels of containment

NOTE Appendix A gives guidance on the derivation of forces from these criteria. Appendix B gives guidance on the method of design for general purposes and Appendix C gives more detailed design guidance for new parapet designs based on tested configurations.

5.1 Normal level of containment

Normal level of containment shall be that required to resist penetration from the following vehicle impact characteristics:

Vehicle	Saloon car
Mass	1 500 kg
Height of centre of gravity	480 mm to 580 mm
Angle of impact	20°
Speed	113 km/h (70 mile/h)

NOTE The normal level of containment is that suitable for general use.

5.2 Low level of containment

Low level of containment shall be that required to resist penetration from the following vehicle impact characteristics:

Vehicle	Saloon car
Mass	1 500 kg
Height of centre of gravity	480 mm to 580 mm
Angle of impact	20°
Speed	80 km/h (50 mile/h)

NOTE 1 The low level of containment using vertical infill is only suitable for use in areas where speed restrictions up to 30 mile/h apply (see A.5).

NOTE 2 The low level of containment type of parapet, designed to redirect impacting vehicles using a post-and-horizontal rail type of parapet construction, is suitable for use in areas where speed restrictions up to 80 km/h (50 mile/h) apply.

NOTE 3 The 80 km/h (50 mile/h) speed adopted for the test is considered to provide the minimum acceptable level of containment.

5.3 High level of containment

High level of containment shall be that required to resist penetration from the following vehicle impact characteristics:

Vehicle	Four axle rigid tanker or equivalent
Mass	30 000 kg
Height of centre of gravity	1.65 m
Angle of impact	20°
Speed	64 km/h (40 mile/h)

NOTE The high level of containment is for use only in extremely high risk situations (see A.9).

6 Wind loading

Wind loading shall be derived from BS 5400-2 (see B.2.1).

Wind loading and vehicle impact forces shall not be considered coexistent.

NOTE Where large areas of solid sheeting (e.g. acoustic barriers) are fixed to or form part of a parapet, the effect of wind loading may be critical.

7 Minimum height

The height of parapets of normal and low levels of containment shall be not less than 1.00 m measured above datum. The height of parapets of high level of containment shall be not less than 1.50 m above datum.

NOTE Particular applications may require greater heights of parapet to be used (see section 4).

8 Minimum section thickness

The minimum thickness of section of all metal parts shall be in accordance with Table 2.

9 Freedom from projections and depressions

9.1 Metal rails and posts

9.1.1 Metal rails shall present smooth surfaces on the traffic face and on top and bottom faces and be free from sharp edges or corners on the front face. The minimum projected vertical depths shall be 50 mm for normal containment and 100 mm for high containment.

9.1.2 Projections and depressions on these faces and on tops of posts shall only be allowed at joints in rails, at connections to posts and at fixings to infilling and shall be within the following limits.

a) *Front, top and bottom faces within 15 mm of the front face*, a maximum of 15 mm including the heads of any fastenings which shall be of a well rounded shape.

b) *Top and bottom faces beyond 15 mm from the front face*, a maximum of 25 mm including the heads of any fastenings.

c) *Tops of posts*, including any caps or straps, shall not project above the level of the top of top rail by more than 16 mm and the heads of any fastenings to the top of the post shall not project above the top face of the top rail by more than 35 mm.

Table 2 — Minimum thickness of members, infill panels and other components

Material	Section	Minimum thickness			
		Primary load carrying members	Non-load carrying members and secondary elements of load carrying	Infilling panels, bars and mesh	Clips, covers fixings etc.
Steel	Hollow ^a sections, galvanized inside and outside or fully sealed	3	3	3	3
	All other sections	4	3	3	3
Aluminium alloy	All	3	1.2	3	1.2
Stainless steel	All	2	1	2	0.5

^a See 10.4.

9.2 Fixings to infilling

Where infilling is attached to the traffic face, fixings shall project not more than 15 mm beyond the front face of the infilling. Projecting bolt heads shall be well rounded. Plates which are welded to the longitudinal member to accept infill fixings shall be located on the lower face of the member, they shall project downward no more than 25 mm, and shall be 6 mm maximum thickness.

10 Durability and protection

10.1 Corrosion protection

10.1.1 Aluminium alloy parapets shall be constructed of the materials specified in clause 14.

NOTE The aluminium alloys specified in clause 14 are satisfactory for all the usual exposure conditions but undue corrosion has been found to occur where salt can accumulate and the normal cleansing effects of weather are absent. An example is a parapet on a multi-level junction shielded by a bridge structure. In such cases protective coatings should be considered.

10.1.2 Steel parapets shall be treated with a suitable protective system in accordance with the intended parapet environment and life requirement.

NOTE 1 Suitable systems are described in BS 5493, or may be obtained from the Department of Transport.

NOTE 2 The purchaser should state his requirements for the protective system to be used, as indicated in Appendix D.

NOTE 3 Roadside conditions may be highly corrosive. Where unsealed steel hollow sections are used (see 10.4) corrosion may take place internally. This has been found to affect a limited area around drainage holes, open ends etc., the extent being to some degree affected by exposure conditions. Where hollow sections are hot dip galvanized, the internal galvanizing will be sufficient protection against this. Table 2 calls for extra thickness of such members where they are not galvanized but, although this may give the desired life, the products of corrosion may be unsightly.

10.1.3 Corrosion protection of attachment systems and anchorages shall be as specified in clause 12.

10.2 Accessibility for maintenance

Adequate clearance or means of access shall be provided around all parts requiring maintenance.

10.3 Mixing different materials

Parts requiring maintenance against corrosion shall not be incorporated into a parapet which is constructed of corrosion-resistant materials. This requirement shall not preclude galvanized steel mesh being used on aluminium alloy parapets, nor the use of stainless steel bolts and washers with aluminium (but see 12.8 for holding-down bolts).

10.4 Sealing and drainage

Hollow sections shall either be drained to prevent corrosion and damage occurring due to the freezing of water which may accumulate inside them or be sealed by all joints being made with continuous welds of structural quality.

Holes for galvanizing and/or drainage shall have a diameter not greater than one-twelfth of the circumference of the member, with a minimum diameter of 8 mm prior to galvanizing or 6 mm if not galvanized, and a maximum diameter of 15 mm. Holes shall not be spaced closer than 700 mm if they are to be left open.

NOTE 1 Consideration should be given to the effect on the strength of members by the design, location and making of the holes.

NOTE 2 Moisture can collect in a section not open to direct penetration by condensation of water vapour drawn in by the breathing effect caused by changes in air temperature and pressure.

10.5 Vandalism

The need of the parapet to resist vandalism shall be taken into account in its design. It shall be ensured that fixings and fasteners are not so easily loosened as to allow parts of the parapet to be wilfully removed, simply and quickly using minimal tools, or to be damaged for example by blows [see Appendix D k)].

11 Requirements at joints and at ends of parapets

11.1 Post-and-rail type parapets

11.1.1 Joints for total movements 0 mm to 50 mm. Joints providing continuity between lengths of rails or across expansion or rotational joints where the total longitudinal movement at rail level is 50 mm or less shall comply with the following.

- a) *Rails in tension.* The joint shall be capable of transmitting 60 % of the tensile strength of the theoretical gross rail section.
- b) *Rails in bending.* The joint shall be capable of transmitting the full maximum design requirement of the rail in bending at any extension of the joint.

11.1.2 Joints for total movement greater than 50 mm. Joints across expansion or rotational joints where the total longitudinal movement at rail level is greater than 50 mm shall comply with the following.

- a) *General*
 - 1) *Rails in tension.* No requirement to transmit tension.
 - 2) *Rails in bending.* Joints shall be capable of transmitting the full maximum design requirement of the rail in bending at any extension up to the full design movement at the joint plus 100 mm.
- b) *Posts for low and normal containment.* Special end posts shall be provided at each side of the joint spaced as close together as practicable and not exceeding 1.5 m between centres (see 11.1.6).
- c) *For high containment.* Special end bays (see 11.1.7) shall be provided at each side of the joint. The end posts, either side of the joint, shall be spaced as close together as practicable and not exceeding 1.7 m between centres.

NOTE A shock transmission unit solution has been considered but has been found to need further development.

11.1.3 Joints where complex movements take place. Joints where significant movement takes place in a vertical or transverse horizontal direction shall, where possible, comply with 11.1.1 and/or 11.1.2. Where compliance with 11.1.1 and/or 11.1.2 is not possible a discontinuity of the parapet is permissible. In such cases for low and normal containment, special end posts shall be provided at each side of the joint spaced as close together as is practicable and at centres not exceeding 1.5 m. For high containment, special end bays (see 11.1.7) shall be provided at each side of the joint. The end posts, either side of the joint, shall be spaced as close together as is practicable and not exceeding 1.7 m between centres. The gap between the ends of the rails shall not exceed the expected closing at the joint plus 25 mm.

NOTE It is emphasized that this discontinuity is only to be resorted to in extreme cases and it is most desirable that some form of bridging of the ends of the rails is devised to prevent, as far as is practicable, a vehicle which is in contact with a deflected length of parapet directly striking the end of an undeflected length.

When a bridging piece is used it shall be securely attached to the end of the rail on the approach side.

11.1.4 Ends of parapets for normal and low containment

11.1.4.1 Parapets with safety fences. Where a safety fence is provided at each end of a parapet it shall, except as provided for in the following, be made continuous with the parapet by a connection capable of resisting an ultimate tensile force of not less than 330 kN (see note 1).

Where such a connection is not practicable, a full height anchorage capable of resisting an ultimate tensile force of not less than 330 kN shall be provided to the safety fence, either close to the parapet or at the transition from a tensioned to an untensioned safety fence. A connection capable of resisting an ultimate tensile force of not less than 50 kN shall also be made with the parapet having sufficient overlap to maintain support for a movement of 100 mm. The final parapet post shall be a special end post complying with 11.1.6.

The end panel or panels of the parapet shall be strengthened, as necessary, to resist the minimum ultimate tensile force of 330 kN or 50 kN, as appropriate (see note 2).

Rails at the ends of parapets situated above the level of the safety fence, which could be struck by a vehicle, shall over-sail the final post of the parapet by not more than 600 mm and each shall be cranked back from the traffic face beyond the final post, or radiused, to give an angle of between 35° and 45° with the main axis of the rail so that the setback achieved is not less than 170 mm. The strength of the rail in bending shall be maintained to not less than 75 % of the normal rail strength.

NOTE 1 Safety fences provide protection to the end of the parapet and will normally be present on motorway or motorway type roads and on new major roads in rural areas.

NOTE 2 It will be necessary to have a special detail at the ends of the parapet where the safety fence is connected to it, to provide resistance to an ultimate tensile force of not less than 330 kN or 50 kN, as appropriate. This may give additional transverse stiffness, although there is no requirement for this. Ideally, the safety fence connection should transmit the force into the main structure over a short length of parapet. In the case of a post-and-rail parapet, a suitable system is to connect the first two (or last two) parapet posts, which may be strengthened and be at closer centres than elsewhere in the parapet; advantage may be taken of the bending strength of this end bay to transfer the force effects directly into the main structure.

Alternatively, a suitable detail may be designed to transfer the force effects into the main structure over a number of bays through end and/or intermediate parapet posts. Rail expansion joints catering for movements of greater than ± 10 mm should not be included in such a detail and special attention should be given to the rail-to-post connections.

On short span structures not exceeding 15 m (total span), connections that are capable of resisting a minimum ultimate tensile force of 330 kN or 50 kN, as appropriate, may be made to the main and lower effective longitudinal members on the approach and departure ends of the parapet, provided that any expansion joints in the rails are capable of resisting the residual force effects at these joints.

Details of approved connections between the types of safety fence covered by BS 6579-1, BS 6579-3, BS 6579-4, BS 6579-5, BS 6579-6 and BS 6579-7 and the existing post-and-rail parapet designs exempted from dynamic testing under 26.5 of this Part of BS 6779 are given in BS 6579. These details do not necessarily cover all the preceding requirements of this clause but are deemed to satisfy as they have successfully withstood dynamic testing and have been proved in service.

11.1.4.2 Parapets without safety fences. Where there is no safety fence at the end of a parapet the following shall apply.

- a) Such precautions as are practicable under the circumstances shall be taken to prevent errant vehicles colliding directly with the end of the parapet.
- b) The final post at each end of the parapet shall be a special end post complying with 11.1.6.

11.1.5 Ends of parapets for high containment

11.1.5.1 Parapets with safety fences

Where there is a safety fence present at the end of a parapet there shall be a suitable transition system to provide protection from impact to the end of the parapet.

NOTE 1 Details are obtainable from the Department of Transport.

NOTE 2 At some future date it is intended that a British Standard will be produced to cover the requirements for transition between safety fences and high containment parapets, but it will be some time before this will be available and no design parameters can be laid down at this time.

11.1.5.2 Parapets without safety fences. Where there is no safety fence at the end of a parapet the following shall apply.

- a) Such precautions as are practicable under the circumstances shall be taken to prevent errant vehicles colliding directly with the end of the parapet.
- b) The end bay of the parapet shall be a special end bay complying with 11.1.7.

11.1.6 Special end posts for normal and low containment. A special end post shall have a design strength in the longitudinal direction equal to the design strength of an intermediate post in the transverse direction.

NOTE This may be achieved by the combination of two intermediate posts spaced as close together as is practicable and not exceeding 1 m.

11.1.7 Special end bays for high containment where no transition is used. A special end bay shall be designed for the ends of high containment parapets capable of resisting and transmitting to the main structure 500 kN applied longitudinally at a level 200 mm below the top of the parapet.

NOTE The 500 kN figure was derived from dynamic testing.

11.2 Other parapet configurations

11.2.1 General. When parapet designs of configurations other than post-and-rail are being considered the general principles embodied in 11.1 shall be followed, together with the requirements given in 11.2.2 and 11.2.3.

11.2.2 Joints. Joints shall comply with the following.

- a) *Joints for total movement 0 mm to 50 mm.* Adequate continuity shall be provided in tension and bending.
- b) *Joints for total movement greater than 50 mm.* Adequate continuity of bending shall be provided and the need for additional vertical stiffness assessed and provided if necessary. For high containment adequate anchorage or continuity shall be provided to resist tension.
- c) *Joints where complex movements occur.* Discontinuity is permitted but the need for additional vertical stiffness and tension anchorage shall be assessed and provided if necessary.

NOTE It is most desirable to provide some form of bridging (see 11.1.3).

11.2.3 Ends of parapets for normal and low containment with safety fences. Where a safety fence is provided at the ends of a parapet it shall, except as provided for in the following, be made continuous with the parapet by a connection capable of resisting an ultimate tensile force of at least 330 kN.

Where such a connection is not practicable, a full height anchorage capable of resisting an ultimate tensile force of at least 330 kN shall be provided to the safety fence, either close to the parapet or at the transition from a tensioned to an untensioned safety fence. A connection capable of resisting an ultimate tensile force of not less than 50 kN shall also be made with the parapet having sufficient overlap to maintain support for a movement of not less than 100 mm.

Any part of the parapet that projects above the safety fence shall be cranked back from the traffic face to give an angle of between 35° and 45° with the main axis of the parapet, so that the setback achieved is not less than 170 mm, so as to avoid the possibility of an errant vehicle impacting directly with the end of the parapet. Adequate strength in bending shall be maintained to assist in deflecting an errant vehicle.

11.2.4 Ends of parapets with safety fences for high containment. In the case where safety fences are present the best practicable adaption of the system transition (see 11.1.5) shall be used where protection of the end of the parapet is required.

11.2.5 Ends of parapets without safety fences. Such precautions as are practicable under the circumstances shall be taken to prevent errant vehicles colliding directly with the end of the parapet and suitable tension anchorage arrangements made in the ends of the parapet.

12 Main structure, anchorages, attachment systems, bedding and plinths

12.1 General

The anchorages, attachment system and the main structure, including the plinth, shall be designed to resist without damage all loads which the parapet is theoretically capable of transmitting, up to and including failure, in any mode that may be induced by vehicular impact.

NOTE Appendix B gives guidance on limit state design and suitable partial factors to cover these requirements in normal circumstances.

The design of parapet attachment systems and anchorages shall be such that removal and replacement of damaged sections of parapet may be readily achieved.

12.2 Main structure

The local and global effects of vehicular collision with the parapets to be considered in the design of the elements of the main structure and on the superstructure, bearings and substructure shall be as specified in Department of Transport Standard BD 37/88.

12.3 Fixings using base plates

Parapets that use base plates, such as post-and-rail systems, shall be fixed to the main structure via the base plates by stainless steel holding-down bolts engaging with an anchorage.

12.4 Engagement of holding-down bolts

NOTE 1 See also note 1 to 24.4.

Each holding-down bolt shall have a length of engagement into the anchorage of not less than that given by the following expression:

$$0.7 \times \frac{\sigma_{vb}}{\sigma_{ya}} \times D$$

where

σ_{vb} is the minimum ultimate tensile strength of bolt material (N/mm²);

σ_{ya} is the minimum yield strength of the anchorage material (N/mm²);

D is the nominal bolt diameter (mm).

NOTE 2 This is to ensure that bolt failure occurs prior to anchorage thread failure.

NOTE 3 If the type of holding-down bolt used requires an initial torque to be effective, this torque should be specified.

12.5 Anchorages in concrete main structures

Anchorages in concrete shall be either cast-in cradle anchorages, or cast-in or drilled individual bolt anchorages that are of purpose design or of proprietary manufacture. It shall be ensured that they will provide the necessary resistance taking into account the effect of possible overlap of stress cones from individual bolts and any bursting forces from expanding type anchorages.

NOTE 1 The concrete of the main structure may need additional local reinforcement to resist without damage the forces that may be transmitted from the parapet.

NOTE 2 Static testing of the proposed assembly may be considered advisable if other evidence is not available covering the particular application.

NOTE 3 It is good practice to fill any voids in anchorages, such as those around bolts in holes drilled for individual anchorages, with a non-setting passive filler to prevent the collection of water which may freeze and engender bursting stresses.

NOTE 4 It is good practice to grease internal threads of anchorages with a grease having a high resistance to flow/creep to assist with any need for renewal.

12.6 Bedding

Any bedding used, e.g. between base plates and plinth, shall be capable of permanently transmitting the loads involved, safely and without undue deformation. The finished bedding shall not contain voids and shall be resistant to penetration by water. It shall have a minimum thickness of 10 mm and a maximum thickness of 30 mm plus allowance for falls on the top of the plinth (see clause 24 and note 1 to 24.4). Due regard shall be given to the bearing stresses developed in any bedding or in the concrete plinth.

12.7 Plinth

Where the main structure is of concrete, the parapet shall be mounted on a plinth having an upstand above datum of not less than 50 mm at the traffic face and not more than 100 mm at any point on the cross section and having its front edge in line with the traffic face of the parapet. The width of the plinth shall be a minimum of 450 mm.

12.8 Resistance to corrosion

The following requirements shall be observed in addition to the general requirements of this Part of BS 6779.

- a) Aluminium which is to be in contact with concrete or mortar shall be coated with at least two applications of bituminous coating solution in accordance with BS 3416 or with hot-dip bitumen, applied to a clean, degreased surface.
- b) Metal-to-metal contact between dissimilar materials shall be avoided by the use of non-metallic sleeves, washers or coatings to prevent galvanic corrosion.

- c) Parts of anchorages within 50 mm of the surface of the plinth shall be suitably protected against corrosion.

NOTE The use of corrosion-resistant materials or of steel galvanized in accordance with BS 729 is suitable.

13 Parapets of open-framed design

Parapets of open-framed design, such as post-and-rail, shall comply with the following.

- a) The effective longitudinal members shall not be so narrow or so shaped as to cause undue damage to an impacting vehicle.

NOTE 1 A 50 mm overall depth with a blunt profile to the traffic face has been found satisfactory in existing designs for low and normal containment. A 100 mm overall depth has been found satisfactory for high containment design.

- b) Effective longitudinal members shall not be so widely spaced as to allow undue penetration by parts of impacting vehicles and the supporting members shall be set far enough back from the traffic face to avoid direct impact from parts of vehicles that do penetrate between longitudinal members.

NOTE 2 A combination of a maximum gap between effective longitudinal members of 300 mm and a minimum setback of 150 mm between the traffic face and the front face of the post at the base of the posts has been found satisfactory for low and normal containment parapets.

- c) The top rail of a three rail system shall be of the same section as the other two rails.

Section 3. Materials

14 Materials of construction

14.1 Steel parapets, fixings, anchorages and attachment systems

14.1.1 Steel used for parapets, fixings, anchorages and attachment systems shall comply with the appropriate British Standard listed in Table 3.

14.1.2 Steel used for all structural parts of parapets and anchorages shall have adequate notch toughness. This requirement shall be deemed to be satisfied provided the steel thickness complies with **6.5.4** of BS 5400-3:1982 (using $U = -10\text{ }^{\circ}\text{C}$) as modified by Department of Transport Standard BD 13/90.

Table 3 — Materials of construction for steel parapets

Form of material	Specification	
	BS number	Requirements specified
Hot rolled sections	BS 4-1	Dimensions and sectional properties (see BS 4360 for other relevant requirements)
Hot rolled hollow sections	BS 4848-2	
Equal and unequal angle sections	BS 4848-4	
Weldable structural steels (includes appropriate requirements for items above)	BS 4360 (see note 2) BS EN 10025	Physical properties, chemical composition, and dimensional tolerances
Plate, sheet and strip		Physical properties, chemical composition, material condition and dimensional tolerances
carbon steel	BS 1449-1	
stainless steel	BS 1449-2	
Bars, rods	BS 970-1	Physical properties, chemical composition and dimensional tolerances
Welded wire mesh	BS 4483	General requirements
Expanded metal		Properties, chemical compositions, material condition and dimensional tolerances
carbon steel	BS 1449-1	
stainless steel	BS 1449-2	
Fasteners (see note)		Dimensions, sizes, physical properties, chemical compositions, grades, tolerances and marking
ISO metric black hexagon bolts, screws and nuts	BS 4190	
ISO metric precision hexagon bolts, screws and nuts	BS 3692	
Washers	BS 1449-2 (see note 3)	
Spring washers	BS 4464	
Corrosion-resistant stainless steel fasteners	BS 6105	
High strength friction grip bolts	BS 4395-1	
NOTE 1 The standards listed in this table relating to the form of fasteners do not cover special bolts, nuts, screws, etc. which may be used for particular fixings where it is not possible to incorporate bolts, screws, etc. of standard dimensions or where special fixings are required to resist vandalism (see 10.5).		
NOTE 2 The scope of BS 4360 has been reduced by the introduction of BS EN 10025 and the scope of BS 4360 will be progressively reduced by the introduction of further European Standards for structural steels, e.g. EN 10113, EN 10155 and EN 10210.		
NOTE 3 The material for stainless steel washers, when used, shall comply with the compositions in BS 1449-2 which fall within the limits defined in BS 6105 for grades A4 and A2.		

14.2 Aluminium alloy parapets and fixings

Aluminium alloys used for parapets shall comply with the appropriate British Standards listed in Table 4.

Table 4 — Materials of construction for aluminium alloys parapets

Form of material (see note 1)	Specification	
	BS number and designation	Requirements specified
Extruded sections	BS 1474, alloys 6061, 6063 and 6082	Chemical composition, properties and tolerances
Drawn tube	BS 1471, alloys 6061, 6063 and 6082	Chemical composition, properties and tolerances
Seam welded tube	BS 4300-1, alloy 5251	Tolerances, properties and mechanical tests
Plate and sheet	<i>Aluminium alloy</i> BS 1470, alloys 1200, 3103, 3105, 5083, 5251 and 6082 <i>Stainless steel</i> BS 1449-2	Chemical composition, properties and tolerances
Rivets	BS 1473, alloys 5154A and 6082 BS 1474, alloy 5065A	Chemical composition, properties and tolerances
Castings	BS 1490, alloys LM6 and LM25	Chemical composition, properties and chemical tests
Welding filler rods and wire	BS 2901-4	Chemical composition, properties, diameters and tolerances
Welded wire mesh	BS 4483	General requirements
Expanded metal aluminium alloy carbon steel stainless steel	BS 1470 BS 1449-1 BS 1449-2	Properties, chemical composition, material condition and dimensional tolerances
Fasteners (see note 2): ISO metric black hexagon bolts, screws and nuts ISO metric precision hexagon bolts, screws and nuts Washers Spring washers Corrosion-resistant stainless steel fasteners High strength friction grip bolts	BS 4190 BS 3692 BS 1449-2 (see note 3) BS 4464 BS 6105 BS 4395-1	Dimensions, sizes and tolerances Chemical composition and physical properties

NOTE 1 The physical properties of aluminium alloys may be modified by welding. A method of dealing with this effect for design purposes is given in **B.2.3**.

NOTE 2 The standards listed in this table relating to the form of fasteners do not cover special bolts, screws, etc. which may be used for particular fixings where it is not possible to incorporate bolts, screws, etc. of standard dimensions or where special fixings are required to resist vandalism (see **10.5**).

NOTE 3 The material for stainless steel washers shall comply with the compositions in BS 1449-2 which fall within the limits defined in BS 6105 for grades A4 and A2.

Section 4. Additional design requirements for parapets for particular applications

NOTE This section deals with those applications that call for requirements such as pedestrian protection in addition to vehicular containment. The usual need is to fill gaps in open parapets, such as post-and-rail types.

Because cladding made to parapets for the purpose of meeting those requirements could affect performance in respect of vehicle containment, appropriate standard treatments are given for the most common requirements. These are considered to be satisfactory for the situations described and care should be taken if there are any departures to ensure that additional hazards are not created.

15 General requirements for infilling and additional members

Infilling or additional members for particular applications shall comply with the following.

- a) There shall be no footholds or projections exceeding those permitted in **9** on the traffic face where pedestrians have access.
- b) All cladding shall be securely fixed and shall not be easily detachable (see **10.5** and **C.3.7**).
- c) No reflective surfaces shall be used that might create a hazard for users of any road or railway.

16 Requirements for particular types of infilling

Infilling used for the protection of pedestrians and/or livestock and acoustic barriers shall be one of the following (see note 2).

- a) *Vertical bars*. Vertical bar infilling spanning between effective longitudinal members shall comply with the following and be in accordance with Figure 11. This method of infilling shall be used for low level of containment parapets only.

The product of the nominal yield stress, or 0.2 % proof stress, and the plastic modulus of the vertical bars forming the infilling shall be not less than the moment induced by a design point load Q^* of 10 kN applied in any direction.

Each end connection to the longitudinal members shall develop at least half the strength of the infilling bar in bending and tension acting simultaneously and the strength of the bar in shear acting separately. The longitudinal member at the connection shall not fail by local buckling due to forces applied by the infilling.

- b) *Wire mesh and expanded metal for applications not over or adjacent to railways*. Wire mesh and expanded metal shall have apertures with a perimeter not exceeding 200 mm. The minimum metal thickness shall be in accordance with Table 2 and the maximum metal thickness shall not exceed the required minimum thickness by more than 1.5 mm.

Expanded metal shall be supplied in a deburred and pressure roll flattened condition so that the strands are in the same plane as the sheet.

- c) *Wire mesh and expanded metal for railway applications*. Wire mesh and expanded metal sheet shall have a minimum metal thickness in accordance with Table 2 and the maximum metal thickness shall not exceed the required minimum thickness by more than 1.5 mm.

Wire mesh infill shall have apertures not exceeding 25 mm × 25 mm.

Expanded metal sheet infill shall have openings not exceeding 45 mm × 20 mm and shall be fixed vertically with the long dimension horizontal. It shall be supplied in a deburred and flattened condition so that the strands are in the same plane as the sheet.

- d) *Solid panels*. Solid infill panels shall present a smooth surface to the traffic face. Joint gaps shall not exceed 3 mm. The minimum metal thickness shall be in accordance with Table 2. The maximum metal thickness shall not exceed the required minimum thickness by more than 1 mm generally and 2 mm in the case of acoustic barriers and high containment cladding in aluminium (see notes 2, 3, 4 and 5).

NOTE 1 In the case of high containment parapets the cladding panels may be lapped in the direction of the adjacent traffic flow and the consequent outstand accepted.

- e) *Acoustic barriers*. On occasions it will be necessary to combine a noise barrier with a vehicle parapet with or without pedestrian access. The noise attenuation requirements may give variable heights and thicknesses of infill and each case shall be considered on its merits observing the general requirements of this section.

NOTE 2 A grit blasted finish or a patterned surface with maximum depth of 1 mm may be used on solid panels to offset the risk of dazzle (see note 4).

NOTE 3 Solid infill may also be used for anti-splash or anti-dazzle purposes.

NOTE 4 Deeply corrugated infill panels can present a hazard on vehicle impact. They should not be located on the traffic face.

NOTE 5 Wind loading should be considered where solid infill is used (see Appendix B).

17 Applications not over or adjacent to railways

17.1 The following requirements shall be observed.

- a) *Pedestrian protection*. Mesh or solid infill shall extend from not more than 25 mm above the plinth at the traffic face to the full height of the parapet with the exception that vertical bar infill may be used for low containment parapets.