

Code of practice for

Barriers in and about buildings

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- Association of Building Engineers
- Brick Development Association
- British Parking Association
- British Plastics Federation
- British Railways Board
- British Steel Industry
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- Department of the Environment (Building Research Establishment)
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- District Surveyors Association
- Flat Glass Manufacturers' Association
- Galvanizers Association
- Glass and Glazing Federation
- Health and Safety Executive
- Institution of Structural Engineers
- Royal Institute of British Architects

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Foreword

This revision of BS 6180 has been prepared under the direction of the Technical Sector Board for Building and Civil Engineering, B/-, and supersedes BS 6180:1982 which is withdrawn.

The changes incorporated in this revision reflect the current materials and practice used in the design, manufacture and installation of barriers, and are intended to provide some clarification on ways of applying the code.

In view of the variety of materials available for barrier construction and the wide range of possible uses for barriers, this code does not attempt to standardize methods of design but, following the last edition, refers instead to existing structural design codes. Clause 4 allows users freedom to choose materials and methods of design and construction not specifically mentioned, subject to the provision of research data and test results.

In this revision, loading data is provided in annexes. It is intended, however, that this information will be assimilated into BS 6399 in due course so as to provide one source only for the loading data.

The safety factors implicit in this code provide adequate levels of protection in the circumstances given. However, for example, in the case of multifunction buildings, the recommendations should be considered with reasoned judgement to provide a suitable design.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Attention is drawn to the fact that statutory legislation [1] may impose more stringent requirements in certain circumstances.

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 and ii, pages 1 to 30, 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.

1 Scope

This British Standard gives recommendations for the design and construction of temporary and permanent barriers to be provided in and about buildings and places of assembly, such barriers being positioned and designed to protect persons from various hazards and to restrict or control the movement of persons or vehicles. This British Standard is applicable to:

- a) barriers that indicate routes;
- b) barriers capable of stopping or diverting moving vehicles up to 2 500 kg within areas where vehicle speed is restricted to a maximum of 16 km/h (4.44 m/s, 10 mile/h);
- c) walls, glazing and other elements of buildings or structures where such elements act as protective barriers.

This British Standard does not apply to:

- 1) barriers for resisting impact from vehicles travelling at speeds greater than 16 km/h, for example, bridge parapets beyond the curtilage of a building, or highway safety barriers (see BS 6779);
- 2) barriers used in building operations and works of engineering construction.

2 References

2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 29. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 30, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 6100 apply, together with the following.

3.1 barrier

a protective barrier which is any element of building or structure, permanent or temporary, intended to prevent persons from falling and to retain, stop or guide persons or vehicles

3.2 datum

the finished level of the floor, roof, foundation slab, balcony, ramp, stage or pitch line of stairs, etc. (see Figure 1)

3.3 design level

the level at which the horizontal force on the barrier is assumed to act for the purposes of design (see Figure 1)

3.4 safety glass or safety plastics material

glass or plastics sheet material which remains unbroken or breaks safely under the test specified in BS 6206

3.5 handrail

a rail normally grasped by hand for guidance or support

4 Materials, components and methods of design and construction

Recommendations for the detailed design and construction of barriers using various materials, components and methods are given in clauses 7 to 13. Where materials, components and methods of design and construction are not covered by these clauses or by any other British Standard, this is not to be regarded as discouraging their use. The designer should satisfy himself that the materials and methods to be employed are such as to ensure durability, integrity and a level of performance at least equal to that recommended in this code.

Alternatively, a test assembly should be built to prove the material, component or method under consideration. The test assembly should be representative, as to materials, workmanship and details, of the design and construction for which approval is desired, and should be built under conditions truly representative of the conditions in the actual building construction or curtilage involved.

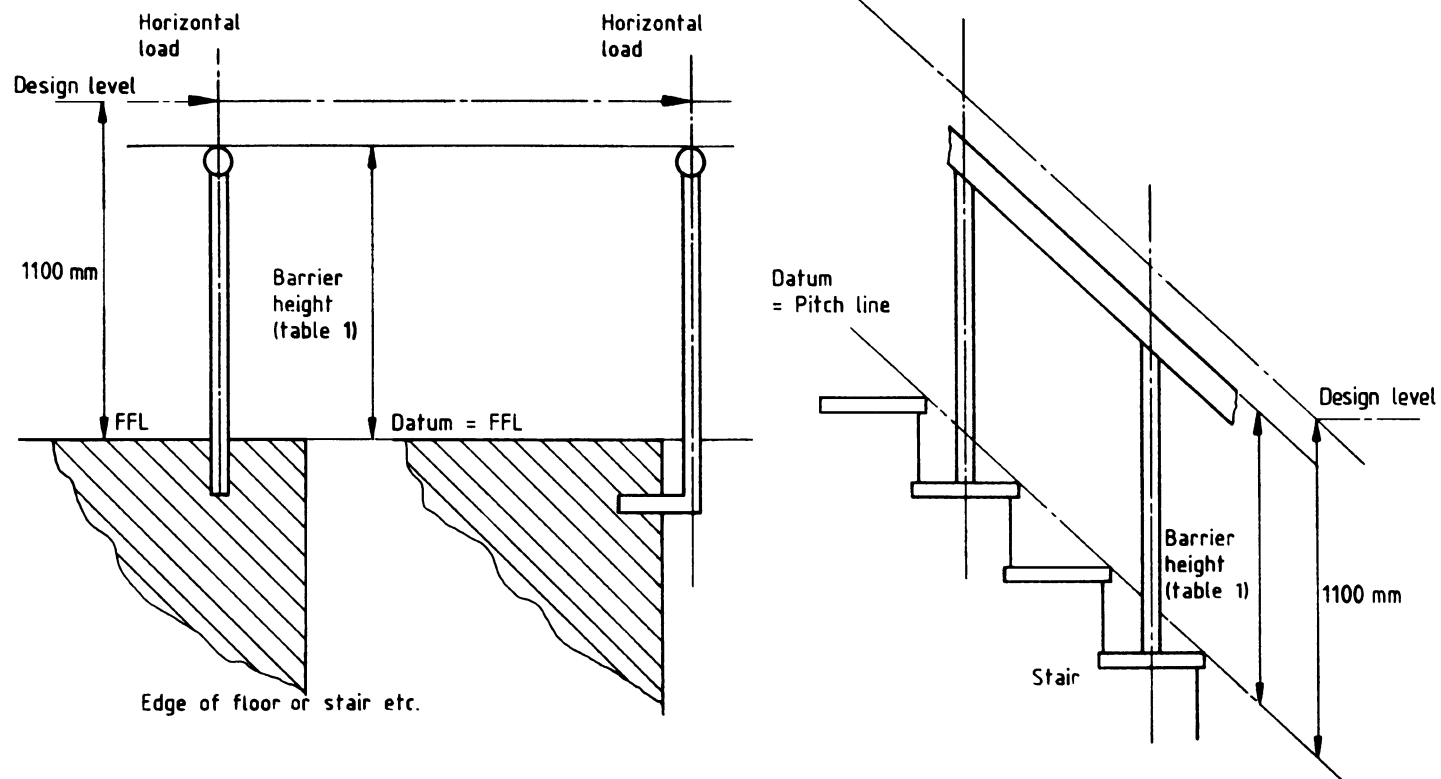


Figure 1 — Datum, barrier height and design height

5 Preliminary considerations

5.1 In the assessment of the need for a barrier and the type of barrier to be provided, the designer should give consideration to the building use and the risks to building users. Annex A sets out a table of building-use categories.

Where, in a building, more than one use of the building is anticipated, either the barrier design should be chosen to suit the worst case, or more than one type of barrier should be provided, as appropriate, to the location.

As a general rule, where there is a difference in adjacent levels greater than 600 mm, barriers should be installed to restrict or control the movement of persons and vehicles; however barriers may be required in certain circumstances where the difference in levels is less than 600 mm (e.g. if required by statutory legislation).

5.2 Where walls, glazing or other elements of buildings or structures perform the functions of barriers, the designer shall either:

- a) ensure that these elements satisfy the criteria given in this standard; or
- b) provide additional barriers designed in accordance with this standard.

5.3 The design of barrier adopted should be such as to minimize the risk of persons falling, rolling, sliding or slipping through gaps in the barrier. Except in areas not likely to be used by children, barriers should be designed so that the widest gap in the barrier does not permit a sphere of diameter 100 mm to pass through, making due allowance for deflection under load.

5.4 Designers should consider the use of barriers to protect critical structural elements abutting any road where vehicle impact could cause structural damage.

6 Design criteria

6.1 Introduction

Although the design loads tabulated in annex A are related to specific categories of buildings and parts of buildings, the design of barriers should be governed primarily by their location and the loads expected to be imposed on them in service rather than by the category of building in which they occur. Barriers should be designed to resist the most unfavourable likely imposed and wind loads without unacceptable deflections or distortions (see 6.4).

In some situations (e.g. sports grounds) the spacing of barriers may be critical. In the case of sports grounds, guidance may be obtained from a number of nationally recognized documents such as the HMSO *Guide to Safety at Sports Grounds* [2]. Table 1 gives minimum heights for each barrier location.

6.2 Design procedures

For barriers other than vehicle barriers, either permissible stress or limit state design procedures may be used, according to the recommended procedure given in the British Standard appropriate for the material to be used, treating the loads given in annex A as:

- a) working loads, for permissible stress design;
- b) characteristic loads, for limit state design.

When using limit state design, the partial safety factors for loads and materials should be those recommended by the appropriate British Standard for the relevant material. The strength of the barrier should be designed as Ultimate Limit State and the deflection as Serviceability Limit State.

In designing barriers to resist equivalent static loads, such as those due to vehicular impact (see 6.3.2 and 6.4.2), the permissible stress procedure is not appropriate. In such cases, it is essential to use a limit state approach based on the partial safety factors for load and materials appropriate to accidental damage or misuse. Where a code of practice makes no specific provision for design against impact loads, decisions should be made regarding the possible reduction of the overall factor of safety, according to the relative influence of dynamic loads compared with static loads on the properties of the material, the anticipated frequency of impacts and the failure mode or modes of the structure.

The designer should also be aware that the equivalent static force concept is related to an assumed mean deceleration. Validation tests on barriers constructed from the materials normally used in vehicle barriers such as steel, aluminium, or reinforced concrete show good correlation with calculated values. However, the performance of barriers constructed from other materials needs to be established in order to determine the equivalent static force against which they should be designed.

NOTE Information on the forces resulting from vehicle impact into yielding barriers is available from research papers published by the Transport Research Laboratory, Crowthorne, Berkshire RG11 6AU [3].

Table 1 — Barrier heights

Use		Position	Height mm
Single family dwelling	a)	Barriers in front of a window	800
	b)	Other positions	900
All other uses	c)	Stairs	900
	d)	Balconies and stands, etc. having fixed seating within 530 mm of the barrier	800
	e)	Other positions	1 100

NOTE The design level should be taken to be 1.1 m above datum level in all cases.
(This is the assumed height of the centre of the human body above datum level.)

6.3 Loading

6.3.1 General

The design loads should be chosen in accordance with the appropriate building-use category (see annex A) and the barrier location; that is:

- a) stairs, landings, ramps, edges of internal floors;
- b) external balconies (being part of or serving buildings or parts of buildings), edges of roofs, footways, pavements, and areas not less than 3 m wide, within the building curtilage and adjacent to access roads, basements or sunken areas (e.g. light wells);
- c) balconies and stands with fixed seating within 530 mm of the barrier.

Building-use categories and barrier loads are given in annex A. The design loads are applied horizontally at the design level (see Figure 1). Barriers should be designed to resist the more onerous loads arising from the separate consideration of the uniformly distributed and concentrated loads given in annex A. The concentrated loads are applied in the position which gives the most onerous requirements.

6.3.2 Imposed loading due to vehicles

When designing barriers to resist vehicular impact, an estimate of the characteristic mass m of the vehicle should be made. Ideally, this should be determined statistically; if this is not possible, the characteristic mass should be taken to be equal to the maximum mass anticipated.

Annex B can be used to estimate the equivalent static force F for a given characteristic mass and displacement.

Simplified design recommendations for car parks are given in BS 6399-1:1984. Loadings can be calculated in accordance with clause 10 of that code, which allows for a characteristic mass of 1.5 t to be taken for car parks designed for vehicles not exceeding 2.5 t in mass.

A graphic interpretation derived from these recommendations is given in annex B.

Further information to enable designers to derive equivalent static forces for cases where different parameters apply is given in annex B.

The anticipated area and position of contact should be used in calculating the ultimate strength of the barrier if the pattern of vehicle or barrier deformation can be reliably predicted.

The assumed distribution of the impact force and the design level at which it is applied should be related to the likely area and position of initial contact.

Angular impacts may give rise to additional forces directed along the line of the barrier. Where the construction of the barrier is such that frictional contact between it and the vehicle is likely to be high, or such that projections may restrain the vehicle, these additional forces can reach three times the lateral applied forces. Annex B provides data for vehicles impacting at 20° to a barrier.

6.3.3 Wind load

External barriers should be designed to resist the wind loads given in BS 6399-2.

6.3.4 Infill panels and balusters

Infill panels should be designed as recommended in 5.3 and 6.3. Where the infill consists of successive balusters, each baluster should be designed to resist half the concentrated load given in annex A, applied at mid-height.

6.4 Deflection

6.4.1 Barriers for the protection of people

A barrier for the protection of people that is structurally safe should not possess sufficient flexibility to alarm the building users when subjected to normal service.

The horizontal displacement of any part of the barrier should not exceed 25 mm.

Glass barriers should also conform to 8.1.2.

Where the infill panel is a plastics material, as given in 11.4, then the horizontal displacement of any point of the infill panel should not exceed $L/80$ (where L is the clear span of the infill panel between supports) or 25 mm, whichever is the lesser.

This recommendation is in addition to any recommendations for limiting deflection under full load given in the appropriate structural codes for the material to be used, in which event the most onerous limit is to be applied.

6.4.2 Vehicle barriers

Barriers designed to resist vehicular impacts may be distorted by such impacts but should remain substantially in place thereafter.

6.5 Fixings

Care should be taken to ensure that the strength of the fixing is adequate for the loading to which the barrier will be subjected. All joints should be designed to provide the full strength of the members being joined.

Wherever a single fixing or support is essential to prevent the collapse or failure of a barrier, or of a critical part of a barrier, the design should avoid reliance wholly on the pull-out strength of the fixing. It is essential that fixing design takes particular account of the material into which the fixing is placed, the spacing between fixings, the edge distance, and the position of reinforcement in the concrete.

When designing fixings, connections, supporting brackets and other supports, the design loads for the components should be multiplied by an additional nominal factor of 1.5.

6.6 Safety details

6.6.1 General

The finished barrier should have no sharp edges or projections that may cause injury to persons or damage to clothing.

Infill panels and balusters are intended to provide support and protection to the user, and should be designed to restrain people without causing additional injury from sharp edges, thin sections, projecting details, etc.

The ends of barriers on unlit access roads should be provided with reflectors or reflective markings.

6.6.2 Vehicle barriers

The designer should wherever possible avoid introducing projections on the vehicular face of the barrier and should also consider ways of redirecting vehicles in such a way as to cause minimum damage after impact.

6.7 Support from adjacent construction

Designers should ensure that any construction or structure acting as support for barriers is of adequate strength and stability to sustain all applied loads safely without excessive stress, deflection or distortion.

6.8 Maintenance

Designers are alerted to the need to provide for the safe maintenance of barriers. Consideration should be given to the possibility of tampering or vandalism.

6.9 Sight lines

It is essential to consider sight lines as well as safety aspects when designing barriers in theatres, cinemas and concert halls. This applies particularly to barriers protecting balconies or parts of balconies having fixed seating within 530 mm of the barrier. The relationship between the height and width of a barrier affects both sight lines and safety. A lower, wider barrier may provide the same degree of protection as a higher, narrower barrier. The height for a narrow barrier given in annex A is 800 mm; however this height may be reduced to a minimum of 750 mm provided the sum of the barrier width and the barrier height is greater than 975 mm (see Figure 2).

It should be noted that where the barrier is not in front of fixed seating (e.g. at the end of the gangway) the normal design criteria apply.

7 Concrete

All concrete used in the construction of barriers should be designed and constructed using the design criteria in clause 6 and in accordance with the recommendations of BS 8110-1 and BS 8110-2.

When concrete is used to form the external face of barriers, it is essential that the designer takes into account the mode or modes of failure that any envisaged overload would cause and provide appropriate reinforcement so as to prevent the spread of debris to a dangerous extent. The use of fibres in the concrete may be helpful in this respect.

Special consideration should be given to the ultimate strength and strain behaviour of the fixings for precast concrete elements in protective barriers. The designer may choose to design the barrier so that restraints in one zone fail before those in another. In such a case, it is essential that the restraints designed to fail last are capable of resisting the residual forces after applying the partial safety factors given in 6.2.

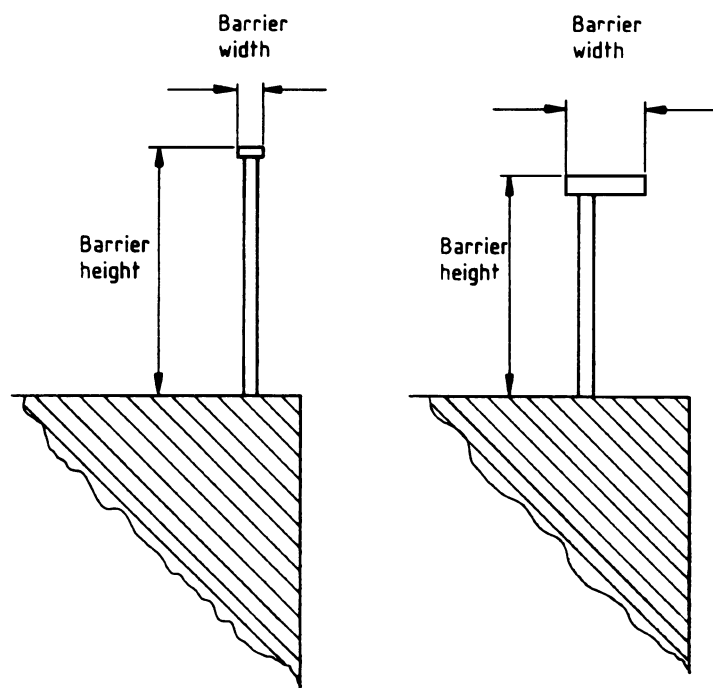


Figure 2 — Height and width of barriers in front of fixed seating

8 Glass

8.1 Application

8.1.1 General

Glass is not suitable for vehicle protection barriers. There are certain situations, particularly under some lighting conditions, where the presence of transparent glass may not be readily evident. Suitable manifestation should be provided in accordance with BS 6262-4.

NOTE Glass totally above the barrier height is outside the scope of this British Standard.

8.1.2 Classification of glass usage

There are three common types of barrier that use glass.

a) *Full height barrier.* Full height barriers formed partially or wholly from glass (e.g. storey-height windows) should be designed in accordance with this standard, unless another barrier (designed in accordance with this standard) is provided in front of the full height barrier to protect the building user.

Where the barrier is or contains an opening window, the barrier should also be in accordance with this British Standard when the window is in the open position. When there is an unrestricted opening below the level of 800 mm a barrier or rail should be provided not less than 800 mm from the floor.

b) *Barrier with glass infill panels.* In this type of barrier, the main frame of the barrier (i.e. handrail and baluster) is designed to withstand the loads applied to the handrail and the glass is used to form the infill panels. The glass in no way provides any support to the main frame.

c) *Free-standing glass protective barrier.* In this type of barrier, the glass is designed to withstand all the design loads. Each glass plate is clamped to the structure along its bottom edge, the handrail is attached to the top edge of the glass and there are no balusters.

8.1.3 Deflection limits

When the glass components of barriers are subjected to half the imposed loads given in annex A, the horizontal displacement of any point of the glass component, relative to its fixings, should not exceed the smaller of 12.5 mm or $L/125$, where L is as given in 8.3, 8.4 or 8.5.

8.2 Materials

8.2.1 *Glass types*

The type of glass should be chosen to suit the design of protective barrier.

NOTE Glass types are defined in BS 952-1.

Where glass is used in the building façade, or in other full height barriers which fill the whole of an opening from floor to ceiling (see 8.1.1 a)), the glass should be of a type in accordance with the appropriate recommendations given in BS 6262.

Where glass is used in a protective barrier which does not fill the whole of an opening, the glass should be a safety glass (see 3.4) and should conform to the appropriate impact test requirements of BS 6206, as recommended in 8.6.

Laminated glass is a safety glass suitable for all barriers where the glass is used fully framed.

Toughened glass is a safety glass suitable for all barriers where the glass is fully or partially framed or is free-standing (see 8.1.1 c)).

Wired glass which is in accordance with BS 6206 is not suitable for use in the types of barrier described in 8.1.1 b) and 8.1.1 c), but can be used in full height barriers where the glass is used fully framed. The manufacturer should be consulted.

8.2.2 *Working of glass*

The size, position and shape of holes and notches in toughened glass, and the production of shapes other than rectangles, should be decided after consultation with the manufacturer.

8.2.3 *Fixing of glass*

Contact between glass and any other hard material (including other glass parts) should be prevented. Rubber gaskets or other glazing materials should be used with frame sections. The frame section should give a minimum of 15 mm edge cover to the glass. Where bolted connections are used, it is essential to surround bolts through holes in the glass with incompressible bushes 2 mm to 3 mm thick, and 1 mm thick incompressible fibre gaskets should be used under clamping plates.

The frame and/or fastenings should be designed so that they do not tend to distort the glass panel. This is more important with bolted connections, which can exert considerable forces on the glass, where particular attention should be paid to the alignment and position of the fasteners in order to avoid unnecessary stresses being developed.

The glass, framing system and connections of barriers and infill panels should be capable of sustaining and safely transmitting the design loads to the supporting structure.

Where appropriate, the method of glazing should be in accordance with the recommendations given in BS 6262.

8.3 Design of glass in full height protective barriers

8.3.1 *General*

The method of designing the glass depends on its relation to the barrier height as given in Table 1.

8.3.2 *Glass partly or totally below the barrier height*

Glass in this position should be designed to satisfy the appropriate design criteria given in clause 6. Any part of a glass pane below the barrier height should sustain the infill loads. Where the barrier height is coincident with the glass, the glass should also sustain the line load applied at the appropriate height.

The deflection of the glass should be as recommended in 8.1.3, taking L as the longest dimension of the glass.

Table 2 indicates sizes of glass panes for different types and thicknesses of glass which, when used with a glazing method which fully supports the glass along all edges, will withstand the design criteria given in clause 6. Significantly larger sizes than those shown in Table 2 may be possible, depending on the shape of the glass pane and whether it is in a double glazing unit. Glazing methods which do not support the glass on all four edges may require smaller sizes or thicker glass.

NOTE Glass totally above the barrier height is outside the scope of this British Standard.

8.4 Design of infill panels

8.4.1 *Design criteria*

Infill panels should be designed to satisfy the appropriate design criteria given in clause 6.

8.4.2 *Fully framed infill panels*

The deflection of the glass should be as recommended in 8.1.3, taking L as the longest dimension of the glass.

8.4.3 *Two-edge framed infill panels*

The deflection of the glass should be as recommended in 8.1.3, taking L as the span between the supporting frames.