BD 67/96

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Enclosure of Bridges

This Standard gives the requirements for evaluating and designing enclosures of bridges. It does not apply to the enclosure of any elements above deck level. The Standard applies whether the enclosure is designed for a new or an existing bridge.

VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS

SECTION 2 SPECIAL STRUCTURES

PART 7

BD 67/96

ENCLOSURE OF BRIDGES

SUMMARY

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INSTRUCTIONS FOR USE

This is a new document to be inserted into the Manual.

1. Insert BD 67/96 into Volume 2 Section 2.

2. Archive this sheet as appropriate.

Note: A quarterly Index with a full set of Volume Contents Pages is available separately from HMSO.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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PART 7

BD 67/96

ENCLOSURE OF BRIDGES

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1. INTRODUCTION

General

1.1 An enclosure around bridge deck support steelwork provides an additional method of protecting the steel against corrosion. It reduces the rate of breakdown of the protective coatings to the steel by providing an environment of low corrosivity and reducing direct contact with atmospheric pollutants, leading to a reduction in maintenance.

1.2 An enclosure shall also provide access for inspection and maintenance of the bridge. Where headroom and site constraints permit, this access is to be permanent.

Scope

1.3 This Standard gives the requirements for evaluating and designing enclosures of bridges. It applies when designing enclosures for the structural steel elements below deck level of any type of bridge, whether as a method of reducing future maintenance costs or of improving access, or both. The Standard applies whether the enclosure is designed for an existing bridge or for a new structure. It does not apply to the enclosure of any elements above deck level.

1.4 The requirements in the Standard are for enclosures acting non-compositely with the bridge superstructure. Composite action of the enclosure with the bridge superstructure is not within the scope of this document.

1.5 Advice Note BA 67 (DMRB 2.2.8) gives advice on the application and on the background of the requirements and should be read in conjunction with this Standard.

1.6 Where tests are carried out in other states of the European Economic Area these requirements shall be satisfied if the Test House is accredited in a state of the European Economic Area in accordance with the relevant part of EN 45000 series of standards for the tests carried out.

Implementation

1.7 This Standard should be used forthwith on all schemes for the construction, improvement, and maintenance of motorways or other trunk roads (in Northern Ireland those roads designated by the Overseeing Organisation). However in the case of schemes which are current at the time of issue of this Standard it need only be applied provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

Definitions

1.8 For the purpose of this Standard the following definitions apply:

i) Enclosure: An enclosure comprises all the structural elements which form a boundary around the primary steelwork of a bridge below deck level enclosing the steelwork in a protective environment.

ii) Enclosure Panels: The structural panels forming the outer shell of an enclosure.

iii) Support Members: A support member is a member to which the enclosure panel is affixed for support. Such members may be designed as separate items for individual installation or attached to the enclosure panel during manufacture.

iv) Fixings: Fixings are an assembly of fasteners, brackets and other items which are used to attach either an enclosure panel or support member to the structure or an enclosure panel to a support member.

v) Fasteners: The term fastener includes items such as bolts, nuts, washers, rivets, pins and screws.

2. EVALUATION

General

2.1 When an enclosure is being considered, the designer shall evaluate the cost-benefits of such a system during the design life of the bridge. During evaluation the following costs shall be identified.

A) With an enclosure

i) The cost of the enclosure itself and its maintenance.

ii) Any change in the cost of the bridge and associated works as a consequence of attaching the enclosure to it.

iii) Costs of permanent access provisions for inspection and/or maintenance. Where it is impractical to provide access facilities within an enclosure, a separate evaluation shall be carried out to include for the additional costs associated with the inspection and maintenance of the bridge and enclosure using temporary access facilities.

iv) Inspection and maintenance costs of the bridge.

v) Road user delay or rail possession costs during installation and during any future maintenance of the enclosure and the bridge, where appropriate.

B) Without an enclosure

i) Costs of permanent or temporary access provisions for inspection and/or maintenance.

ii) Future inspection and maintenance costs of the bridge.

iii) Road user delay costs or railway possession during inspection and maintenance.

The costs shall be compared on the basis of their present value. If this comparison shows the costs to be similar or if those under A) are less than those under B) the provision of an enclosure shall be investigated further in detail.

Cost of the Enclosure Itself

2.2 Where a designer has previous experience of an enclosure of similar size and form, including information on the cost, this may be used to estimate the cost of the enclosure being considered. In other cases, an outline design shall be carried out to obtain an estimate of the cost. This estimate shall include all costs (including labour, plant and overheads) in material supply, fabrication and erection of the enclosure.

Changes in the Cost of the Bridge

2.3 If an enclosure is to be provided, the change in the cost of the bridge as a consequence of attaching the enclosure to it shall be quantified. In particular, the additional costs resulting from the following, where applicable, shall be evaluated.

i) Additional structural material in the bridge required to carry the additional loads (dead, superimposed dead, live and wind loads and transferred impact loads) associated with the enclosure.

ii) Any strengthening works to an existing bridge to carry the additional loads associated with the enclosure.

iii) Special details required for the attachment of the enclosure.

iv) Special measures needed to counter any adverse aerodynamic effect due to the enclosure.

v) All costs associated with raising the level of the bridge soffit in order to maintain adequate clearance below the enclosure (see also Clause 3.41).

The possible reductions in the cost of the bridge resulting from the following, where applicable, shall be evaluated.

vi) The application of fewer coats of paint or a less costly paint system applicable to internal surfaces.

vii) A reduction in concrete cover to the reinforcement and the omission of surface impregnation of the soffit of an enclosed concrete slab on a composite bridge.

viii) The benefits of reduced wind loads where the enclosure improves the aerodynamic characteristics of the bridge.

ix) Savings associated with the avoidance of the need for runway beams, gantry loadings or any other requirements for additional structural material in the bridge associated with alternative access.

x) Savings in formwork and falsework costs where the enclosure can be used to provide either support or access to enable simpler systems to be used.

Inspection and Maintenance Costs

2.4 Commuted inspection and maintenance costs shall be evaluated using the methods specified in BD 36 (DMRB 1.2.1) and illustrated by examples in BA 28 (DMRB 1.2.2). In carrying out these calculations the current Test Discount Rate shall be used. The costs shall include:

i) All temporary access and safety provisions.

ii) The cost of inspection and future maintenance of the enclosure itself, where provided.

Where access facilities are likely to be limited in the absence of an enclosure, inspections are likely to be less comprehensive than those carried out using access provided by enclosure. Account shall be taken of the consequences of limited inspections.

Road User Delay Costs

2.5 Road User Delay Costs shall be evaluated using the computer program QUADRO as described in Standard BD 36 (DMRB 1.2.1). Traffic delays as a result of lane or carriageway closures below overbridges whilst maintenance is carried out will normally arise when enclosures are not provided. Account shall be taken of any traffic delays due to plant on the bridge deck (eg a lorry mounted maintenance platform) or openings required in the bridge deck to provide access to the structure below. Traffic delays occurring during the installation of an enclosure shall be evaluated. Road User Delay Costs shall be discounted using the methods described in BD 36 (DMRB 1.2.1) and BA 28 (DMRB 1.2.2).

Railway/Waterway Possessions

2.6 The cost of railway or waterway possessions both for construction, inspection and maintenance of an unenclosed bridge and installation of enclosure shall be assessed by discussion with the operator. Additional costs associated with working in short possessions shall be evaluated.

Safety Boats

2.7 Costs and savings associated with the provision of safety boats when working over water shall be evaluated.

3. PERFORMANCE CRITERIA

Durability

3.1 The enclosure together with its fixings and fastenings shall be durable and substantially maintenance free and shall be designed as a permanent feature of the bridge structure. It shall have a design life of at least 40 years with a life to first maintenance of at least 20 years, unless otherwise agreed by the Technical Approval Authority (TAA). If any components, seals or other items have a service life shorter than the design life of the enclosure their use shall be subject to acceptance by the TAA. The cost-benefit analysis shall take full account of the cost of replacement of these items during the design life of the enclosure.

3.2 The enclosure shall be constructed of material from which graffiti may be removed without undue difficulty or damage to the material.

3.3 The enclosure materials shall be resistant to fungal attack, road de-icing salts and airborne chemical pollutants. Prolonged direct contact with contaminated drainage run-off from the bridge deck shall be prevented by the provision of adequate drainage pipes but the enclosure shall be designed to cater for short term leakages.

3.4 The enclosure materials shall not suffer from embrittlement or loss of strength through ageing, unless allowance is made in the design for such effects to ensure that the enclosure satisfies the design requirements for safety, structural performance, durability and appearance of the finished structure.

3.5 All holes, seams and cut edges shall be treated as appropriate to the material being used to ensure that the durability of the enclosure panel is not compromised.

3.6 For new steelwork the minimum corrosion protective system shall comprise:

Surface Preparation:	Blast clean with metallic abrasive to clean steel, 2nd Quality, Medium profile
Protective system:	Type 11 - Clause NG1900 of the Notes for Guidance (MCHW 2) - See also Clause 2.4iv in the Advice Note.

3.7 For exisiting steelwork, only where the condition of the protective treatment is Category IV as defined in SD7 (MCHW 5.2.2) shall remedial work to the protective system need to be considered.

Safety

3.8 The enclosure shall be designed to provide safe access for inspection and, where appropriate, maintenance of all parts of the bridge it encloses.

3.9 Points of entry and emergency exits from the enclosure shall be vandal resistant and fitted with locks which can be released from the inside without the use of a key. Access to the enclosure should preferably be from underneath the bridge. Entry points shall be placed in such positions as to give convenient access to all parts of the steelwork, and where their use would not cause interference to traffic. All entry points and access ways within the enclosure shall be suitably sized and designed to allow for the evacuation of a casualty, on a stretcher if necessary. Specific emergency routes and exits shall be indicated clearly by signs and provided with lighting (see BA 67/96 (DMRB 2.2.8), clauses 3.33 and 3.34).

3.10 Permanent access ladders and guardrails at changes in level within the enclosure shall be provided.

3.11 All walking surfaces shall be non-slip, shall avoid details which create a risk of tripping and shall be self draining. Emergency routes and exits requiring illumination shall be provided with emergency lighting of minimum intensity of 0.2 lux.

3.12 Warning notices and signs shall be provided to all mains power boards, valves etc where the operation may affect the safety of persons using the enclosure.

3.13 Notices shall be provided at all entrances stating the safe loads that can be imposed upon the enclosure.

3.14 Adequate ventilation and an approved method to extract dust or fumes during inspection and maintenance operations shall be provided.

3.15 Safety measures shall be designed into the enclosure system where panels have to be temporarily removed for inspection and maintenance operations and/or for ventilation purposes.

Fire Safety

3.16 The fire resistance of the enclosure shall comply with the following:

i) Classification of spread of flame - Test Class 2 when tested to BS 476: Part 7.

ii) Category A) or B) areas (defined in Clause 3.19) shall maintain their structural integrity at the point of fire source for at least 10 minutes when tested to BS 476: Part 21.

3.17 Drainage pipes which pass through the enclosure shall be able to contain burning liquids without leakage.

3.18 Not withstanding the above criteria, fire safety provisions shall ensure that personnel can reach a place of relative safety within 2.5 minutes, in the event of a fire occurring within the enclosure.

Design Loads

3.19 The enclosure shall be designed to carry live loading appropriate to the needs of inspection and, where appropriate maintenance, of the bridge structure. Areas shall be designated as follows:

Category A) - Areas designed for both inspection and maintenance operations.

Category B) - Areas designed for inspection only.

Category C) - Areas not intended for personnel access (including side panels).

All areas shall be clearly marked as to their appropriate category. Emergency access routes shall always be designed to Category A) or B).

3.20 Category A) areas shall be designed for a vertically downward live uniformly distributed load (UDL) of 2.5 kN/m² over a total area of 10 m² of any shape, which may be continuous or divided to give the most adverse effect, together with a UDL of 0.75 kN/m² elsewhere. Further, all surfaces (including side panels) of the enclosure shall be designed to withstand the effects of a single point load of nominal value 1.25 kN applied to an area 150 mm square in any direction in addition to other uniformly distributed live loads. Separately, Category A) areas shall be checked for two point loads of nominal value 2.5 kN at 0.7 metre centres applied to an area 150 mm square in conjunction with a UDL of 0.75 kN/m² elsewhere. Any part of the live load which causes a relieving effect on the element being assessed shall be omitted. Where heavy equipment will be used inside the enclosure and/or where the enclosure is required to temporarily support superstructure loads such as from the construction of the deck, these additional loads shall be allowed for explicitly.

3.21 Category B) areas shall be designed for a live load UDL of 1.5 kN/m² over a total area of 10 m² of any shape, which may be continuous or divided to give the most adverse effect, together with a UDL of 0.75 kN/m² elsewhere unless the depth of the structure is such that additional scaffolds and ladders are likely to be required to provide inspection access. In such cases these areas shall be detailed to support temporary staging capable of accepting the full Category A) loading.

3.22 Category C) areas shall be designed for a live load UDL of 1.0 kN on any 300 mm square area. Where areas provide permanent access for inspection and/or where areas are required to support temporary staging for inspections only, they shall be designed for Category B) loading. Areas required to support temporary staging for both inspection and maintenance operations shall be capable of supporting the full Category A) loading.

3.23 The enclosure shall be designed to resist loads resulting from the general and local effects of the wind and in the case of structures over roads and/or railways the effect of vehicle induced pressure waves in combination with all other live and dead loads.

Flexure of Enclosure Under Internal Live Loads

3.24 The surfaces of the enclosure subjected to working live loads shall be sufficiently stiff to instil confidence in the inspection and maintenance staff using it (see also Clause 5.18).

Construction Details

3.25 All construction details presented in these Clauses shall not only accommodate the requirements of the permanent structure but shall also be designed to facilitate a method of installation which will not overstress the components. Limitations on the forces and displacements of components shall be detailed.

3.26 The enclosure shall be connected to the bridge in such a way that it does not act compositely with the bridge and participate in carrying bridge loadings. Allowance shall be made in all fixings for any necessary relative movement between enclosure and structure.

3.27 The design of the enclosure shall take account of the strains due to deflection of the supporting superstructure. In particular, the hangars and their fixings shall take account of the loading induced by accelerations generated by oscillation of the bridge deck under live loading.

3.28 Fixings and joints shall be designed to allow for construction tolerances in both the bridge and the enclosure.

3.29 The detailing shall provide for substitute temporary support to facilitate replacement of hangars if necessary, with the bridge still in service. It shall also provide for a means of checking that the loading in all hangers is in accordance with the design value and provide a means of adjustment as necessary.

3.30 Where practical, the internal dimensions and constructional details of the enclosure shall provide sufficient clearances to allow access to expansion joints, bearings and all other parts of the bridge requiring inspection and maintenance without the removal of panels. It shall be possible to replace the bearings by working from inside the enclosure; the detailing should ensure that the enclosure would be free to rise with the bridge deck during jacking ie the jacking operation should not generate loading in the enclosure supports. Where this cannot be achieved, provision shall be made for the local removal of sections of the enclosure to facilitate these special maintenance procedures. Removable panels shall be provided with a safe means to prevent them falling during removal and replacement.

3.31 Unless otherwise agreed by the TAA, a clear gap of approximately 200 mm shall be maintained between the enclosure panel and the bridge steelwork soffit. A larger gap will be required between the enclosure panel and steelwork along the sides of the enclosure to enable personnel to inspect and maintain the edge girders.

3.32 All parts of the enclosure including individual panel units shall be replaceable in the event of damage. Unless otherwise agreed with the TAA, such replacement shall be made possible from within the enclosure with minimum use of external scaffolding, staging etc.

3.33 Panels shall be arranged in such a way that it will not involve the removal of large areas of the enclosure in order to get to the panels to be removed.

3.34 The enclosure and its attachment to the bridge shall be suitably sealed to prevent significant movement of air through the enclosed space.

3.35 Panels shall either overlap or butt together and be sealed at the joint in a way which complies with Clause 3.33 and 3.34. The joints between panels shall be detailed so as to prevent small objects from passing through them whilst still accommodating differential movements of adjacent panels. End laps shall be designed to accommodate relative thermal movement, where appropriate.

3.36 Suitable flashings and sealing at the corners between the sides and soffits of the enclosure and at joints between the enclosure and the primary bridge structure shall be designed to prevent the ingress of moisture and pollutants.

3.37 The surface finish of the panels shall be a non-reflective finish or a suitable patterned finish to minimise reflections.

3.38 Welding and bonding of panels and components shall be carried out by a process appropriate to the materials. No process shall be used which compromises the durability of the components being joined. Problems of replacing welded or bonded panels, the reduction in strength of a welded member and the possibility of panel distortions due to welding shall be considered.

3.39 Where materials of different electrochemical potential are connected together, either within the enclosure or in attaching the enclosure to the bridge, appropriate measures shall be taken to prevent bi-metallic corrosion.

Drainage

3.40 Provision shall be made for the drainage of any water collecting on the enclosure floor as a result of condensation or from defective deck joints, road drainage or any other cause.

Headroom and Accidental Damage

3.41 The minimum headroom to the soffit of an enclosure shall not be less than 5.30 metres for overbridges or less than 5.70 metres for footbridges.

Existing Bridges

3.42 Where the headroom to the soffit of the enclosure is equal to or greater than 5.70 metres, neither the bridge superstructure nor enclosure need be designed to withstand those effects of vehicle impact loads specified in BD 60 (DMRB 1.3.5).

3.43 Where the headroom to the soffit of the enclosure is less than 5.70 metres, the bridge superstructure shall be assessed only to withstand those effects of vehicle impact loads specified in BD 60 (DMRB 1.3.5) which are transferred from the enclosure. The bridge superstructure shall be modified or strengthened as appropriate to carry any additional loads.

New Bridges

3.44 Where the headroom to the soffit of the enclosure is equal to or greater than 5.70 metres, neither the bridge superstructure nor enclosure need be designed to withstand those effects of vehicle impact loads specified in BD 60 (DMRB 1.3.5).

3.45 Where the bridge superstructure has a headroom equal to or greater than 5.70 metres but the headroom to the soffit of the enclosure is less than 5.70 metres, the bridge shall be designed so that it can withstand those effects of vehicle impact loads specified in BD 60 (DMRB 1.3.5) which are transferred from the enclosure and which would not otherwise have occurred but for the addition of the enclosure.

3.46 Where the headroom to both the soffit of the enclosure and the superstructure is less than 5.70 metres, the superstructure shall be designed both to withstand those effects of direct vehicle impact loads specified in BD 60 (DMRB 1.3.5) and those which may be transferred from the enclosure.

3.47 In all cases where the soffit of the enclosure is less than 5.70 metres, the enclosure shall be designed such that:

i) there is no general loss of support due to lateral displacement of the enclosure under impact

ii) local damage destroying the means of support in one area does not precipitate disproportionate collapse

iii) damaged parts shall be localised and can be readily identified and replaced

3.48 The headroom provision shall be agreed with the relevant Highway, Railway and Waterway Authority concerned and with the Overseeing Organisation.

Vandalism

3.49 The enclosure shall be resistant to major damage from vandalism. Particular attention shall be given to areas that are easily accessible to the general public.

Aesthetics and Appearance

3.50 The overall appearance of the bridge with enclosure shall be subject to the approval of the TAA.

Inspection Requirements

3.51 The enclosure shall be inspected as an integral part of the structure during its design life in accordance with the requirements of BD 63 (DMRB 3.1.4) - Inspection of Highway Structures. All procedures required to ensure the safety of personnel during such inspections shall be contained in the operation and maintenance documentation.

4. CHOICE AND APPROVAL OF MATERIALS AND COMPONENTS

General

4.1 The materials selected for use in the design of the enclosure shall satisfy the design requirements for the safety, structural performance, durability and appearance of the finished structure, taking full account of the environment to which it will be subjected.

4.2 In selecting the materials to be used, account shall be taken of the construction process and the possible technical and cost benefits in using materials which are less familiar to the construction industry.

Materials

4.3 Regulation 8 of the Public Works Contracts Regulations 1991 sets down requirements for technical specifications in contract documents which the Design Organisation must follow. Where it is proposed to use materials and tests which do not conform to European Standards, European Technical Approvals or British Standards or materials which are not certified by the British Board of Agrément, the use of such materials and tests should be justified to the Overseeing Organisation in terms of the Regulations and their safety, suitability and fitness for purpose.

4.4 BD2 (DMRB 1.1) sets out the requirements for technical approval of structures. Materials supplied and installed shall comply with the specification on which technical approval was based.

4.5 The mechanical properties of materials shall be calculated on the basis of the proposed cross-section and specified minimum values carried out by an independent test house holding an acceptable level of accredition for such tests. Account shall be taken of the influence of age of the material and environmental factors which may affect the long term properties of the materials.

4.6 The strength of principal fixing, bonding and welding details shall be established by proof testing. Tests shall demonstrate the pull-out capacity, moment capacity and/or the shear capacity as appropriate to the connection detail.

4.7 The characteristic strength of material and fixings as assumed in the design shall be demonstrated by tests to have a probability of at least 95% of being achieved.

Fasteners

4.8 All fasteners shall be fit for purpose, including the need to resist the effects of vibration.

4.9 Where any metal part of a fixing is either external to the enclosure or within the enclosure where moisture or debris can collect, it shall be non-corroding and compatible with the panel material.

5. DESIGN OF STRUCTURAL ELEMENTS

General

5.1 The enclosure panels support members and fixings shall be designed using limit state principles in accordance with BD 15 (DMRB 1.3.2).

5.2 The ultimate limit state shall include yield or rupture, buckling, bending, global and punching shear, bond failure or any other condition likely to dictate the ultimate limit state for the material. Similarly the serviceability limit state shall take into account permissible strains, deflection and vibration of the element.

5.3 Where appropriate, the effects of shear lag shall be taken into account.

5.4 The design method shall also take into account fire, vibration, fatigue and environmental damage which could adversely affect the performance of the member(s) and support structure.

5.5 The identification of the appropriate limit states, the properties of materials and the selection of the particular form of construction shall be agreed with the TAA.

5.6 If the proposal is to add an enclosure to an existing bridge, the bridge shall be assessed to BD 21 (DMRB 3.4.3) taking into account the full effects of the enclosure.

Method of Analysis

5.7 The method of analysis shall be agreed with the TAA.

5.8 In general the global analysis shall be either by elastic methods (linear or non-linear) or plastic methods appropriate to the limit states and materials used. Plastic methods shall only be used for materials exhibiting ductile behaviour taking into account possible large deflections or strains.

Loads

Dead Load

5.9 The dead load shall comprise all enclosure panels, support members and fixings.

5.10 Nominal dead loads shall be based on the densities of the materials given in BS 648. For proprietary materials and products, values shall be obtained from the manufacturer.

Superimposed Dead Load

5.11 The superimposed dead load shall include access provisions to the enclosure and all permanent non-structural elements and items such as cabling, service pipes (including contents), lighting and ventilation plant.

5.12 Nominal superimposed dead loads shall be based on the densities of the materials given in BS 648. For proprietary products values shall be obtained from the manufacturer.

Live Load

5.13 The internal surfaces of the enclosure shall be designed to support uniformly distributed live loads appropriate to the category of use as described in Clauses 3.19 -3.23 above.

Wind Load

5.14 The wind loading on the enclosure and enclosure panels shall be evaluated using BS 6399: Part 2. The overall wind force on the bridge shall be derived using the rules given in BD 37 (DMRB 1.3), using the bridge cross section as modified by the enclosure.

Temperature

5.15 Unless a more detailed assessment is carried out the maximum and minimum effective bridge temperatures specified in BD 37 (DMRB 1.3) shall be used unaltered by the presence of an enclosure.

5.16 The maximum and minimum temperatures of the enclosure material shall be taken to be the same as the maximum and minimum effective bridge temperatures. Where dark coloured enclosure is used consideration shall be given to the use of a higher maximum temperature in the enclosure material.

5.17 The effects of a temperature difference between the enclosure panels, the support members and the bridge structure shall be taken into account. In this respect and in the absence of a more accurate assessment, the design shall allow for the temperature of the enclosure panels being 15°C greater than or 5°C less than the bridge structure, with the support members being at the same temperature of either the enclosure panels or the bridge structure, whichever gives the more onerous conditions.

Deflection Criteria

5.18 The serviceability requirements for deflection shall be deemed to be satisfied for Category A) and B) areas if the deflection under a single point load of 1.25 kN applied over an area 150 mm square anywhere on the enclosure in any direction does not exceed 15 mm. In addition, the deflection of the enclosure panel under the uniformly distributed loads given in Clauses 3.20 - 3.22 shall not exceed 1/100 times the span between support members or 50 mm whichever is the lesser. For Category C) areas the deflection under the patch load specified in Clause 3.22 may exceed these requirements provided other geometric restrictions such as headroom below the structure are not compromised.

5.19 The elastic strain at the surface of the enclosure panel shall be limited to that which has been demonstrated by testing not to affect the durability of the materials being used.

Aerodynamic Effects

5.20 Unless excluded in BD 37 (DMRB 1.3) an investigation shall be undertaken to determine how the presence of an enclosure affects the aerodynamic stability of the bridge and performance of the structure in terms of safety, bridge life or user comfort.

Partial Load Factor γ_{fL}

5.21 The nominal dead loads for the enclosure components shall be multiplied by a partial load factor, γ_{fL}. The values given in BD 37 (DMRB 1.3) shall be used where applicable. Where γ_{fL} for dead loads for a particular material is not given in that Standard, the appropriate γ_{fL} shall be derived so that the same level of safety and reliability is achieved as for steel. The derivation of the partial load factor shall be approved by the TAA.

5.22 The values of γ_{fL} for dead loads shall be derived taking into account the expected variability of the material and dimensional tolerances. This shall be correlated with the specification.

5.23 For checking the effects of the enclosure on the bridge structure, the same partial load factors as for checking the enclosure components shall be used.

5.24 For live loads, $\gamma_{fL} = 1.0$ shall be used at the serviceability limit state (SLS) and of $\gamma_{fL} = 1.5$ at the ultimate limit state (ULS) for all load combinations considered.

5.25 For wind, γ_{fL}, shall be as given in BD 37 (DMRB 1.3).

5.26 For temperature effects, γ_{fL}, shall be as given in BD 37 (DMRB 1.3).

5.27 Load combinations 1, 2 and 3 as defined in BD 37 (DMRB 1.3) shall be considered.

Material factors γ_m

5.28 Where relevant British Standards exist partial material factors shall be taken from these as approved by the TAA.

5.29 Where such standards do not exist, partial factors shall be derived from the statistical analysis of test results on representative materials, taking into account environmental effects. Separate partial factors for strength and stiffness at tensile, compressive, bending, shear and buckling limits shall be derived as appropriate to the material and its application. The derivation of partial material factors shall be subject to the approval of the TAA.

Additional Factor γ_{f3}

5.30 Moments, shears, total loads and other effects of the design loads shall be multiplied by an additional factor, γ_{f3} to obtain the design load effects.

5.31 The additional factor, γ_{f3} takes into account inaccurate assessment of the effects of loading, unforeseen stress distribution in the structure, variation in dimensional accuracy achieved in construction and the importance of the limit state being considered.

5.32 The appropriate additional factor γ_{f3} shall be derived in relation to the load factor γ_{fL} and the level of understanding of the particular behaviour of the material under consideration. The derivation of the additional factors shall be subject to the approval of the TAA.

Strength of Enclosure Panel - By Testing

5.33 As an alternative to calculation based on material strength, the design strength of any enclosure system may be determined from the results of adequate tests, as agreed with the TAA.

Strength of Fixings

5.34 The design strength of any fixing, other than that of bolts or pins acting as fasteners in direct shear or tension, shall be determined from the results of independent tests on the actual connection details. Hanger supports and other critical support fixings such be the subject of full scale prototype testing of their integrity in addition to theoretical calculations.

5.35 The fixings shall be designed to resist the forces and moments derived from the analysis of the enclosure system at ultimate limit state. Account shall be taken of the load-deformation characteristics of all the components of the connection, asymmetrical effects and load distribution in the fixings.

6. REFERENCES

1. Manual of Contract Documents for Highway Works (HMSO)

Volume 5: Contract documents for Specialist Activities

2. Design Manual for Roads and Bridges (HMSO)

Volume 1: Section 2: Other Procedural Documents

BD 36 Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures (DMRB 1.2.1)

BA 28 Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures (DMRB 1.2.2)

Section 3: General Design

BD 15 General Principles for the Design and Construction of Bridges. Use of BS 5400: Part 1: 1988 (DMRB 1.3.2)

BD 60 The Design of Highway Bridges for Vehicle Collision Loads (DMRB 1.3.5)

BD 37 Loads for Highway Bridges (DMRB 1.3)

Volume 2: Section 2: Highway Structures: Design (Substructures and Special Structures), Materials

BA 67 Enclosure of Bridges (DMRB 2.2.8)

Volume 3: Section 1: Inspection

BD 63 Inspection of Highway Structures (DMRB 3.1.4)

Section 4: Assessment

BD 21 The Assessment of Highway Bridges and Structures (DMRB 3.4.3)

Volume 6: Section 1: Links

TD 27 Cross Sections and Headroom (DMRB 6.1.2)
(TD 27/96 supersedes TD 27/86 and SH 2)

SH 2 Technical Memorandum - Road Cross Sections and Headroom, for use in Scotland only (DMRB 6.1)

3. British Standards (BSI)

BS 476: Part 7: 1987: Fire Tests on Building Materials and Structural Method for Classification of the Surface Spread of Flame of Products

BS 476: Part 21: 1987: Methods for Determination of the Fire Resistance of Loadbearing Elements of Construction

BS 648: 1964 - Schedule of Weights of Building Materials

BS 5400: Part 1: 1988: Steel, concrete and composite bridges, general statement

4. British Standards Codes of Practice (BSI)

BS 6399: Part 2: 1995: Code of Practice for Wind Loads

5. Legislation

Health and Safety at Work etc Act 1974 (HMSO)

Factories Act 1961 (HMSO)

Control of Substances Hazardous to Health Regulations 1994 (HSE)

The Construction (Design and Management) Regulations 1994 (HSE)

6. Other Documents

Departmental Publication QUADRO 3 Manual (DOT)

Note: In Northern Ireland the equivalent legislation to the references in 5 applies.