

SAFETY FENCES, SAFETY BARRIERS AND PEDESTRIAN GUARDRAILS

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Safety Fences, Safety Barriers and Pedestrian Guardrails

401 Performance Criteria for Safety Fences and Safety Barriers

Safety

- 1 Safety fences and barriers shall comply with the following performance criteria:

Testing Criteria

- (i) On impact a safety fence or barrier shall contain and redirect a vehicle of 'A' kg mass travelling at a velocity of 'B' km/h at an angle of incidence of 'C' degrees to the fence or barrier.

Values of 'A', 'B' and 'C' shall be as follows:

- a) Normal level of vehicle containment:

'A' = 1500 ± 15 kg
'B' = 113 ± 5 km/h
'C' = 20 ± 1°

- b) Lower level of vehicle containment:

'A' = 1500 ± 15 kg
'B' = 80 ± 5 km/h
'C' = 20 ± 1°

- c) Higher level of vehicle containment:

'A' = 5000 ± 15 kg
'B' = 80 ± 5 km/h
'C' = 20 ± 1°

The centre of gravity of the 1500 kg test vehicle prior to impact shall be 500 ± 30 mm above the ground.

- (ii) After impact, defined in (i) above, the vehicle shall be contained by the fence or barrier and be redirected in a stable manner, onto a path adjacent to the line of the fence or barrier. The vehicle shall be redirected so that no part of the vehicle crosses the line drawn parallel with and 4.0 m from the original alignment of the traffic face of the fence or barrier within a distance of 10 m from the last point of initial impact with the fence or barrier, in the direction of adjacent traffic flow. The vehicle shall neither turn on its side nor roll over.
- (iii) The lateral deflection of each type of fence or barrier shall be established as part of the approval procedure.

Durability

- 2 Safety fences and barriers shall comply with the following durability criteria:

- (i) All components of a safety fence shall be designed to achieve a serviceable life of not less than 20 years and for concrete barriers, 50 years except for Temporary Vertical Concrete Safety Barriers where the nominal service life shall be not less than 10 years.

Approval

- 3 Only safety fences or safety barriers which have received approval by the NRA/Department of Environment shall be incorporated into the Works. The safety fences and barriers listed in Tables 4/1 and 4/2 and described in this Series and in the Safety Fence Details have been approved by the NRA/Department of Environment and are deemed to meet the performance criteria contained in this Clause. If the Contractor proposes to use a safety fence or barrier not listed in Tables 4/1 and 4/2 then he must first obtain approval from the NRA/Department of Environment.

402 Components for Safety Fences and Safety Barriers

General

- 1 Materials and fabrication of components and fittings shall be as described below, in the Safety Fence Details, and as particularly identified and described in Appendix 4/1.

Table 4/1: Performance Testing Criteria for Safety Fences

| Type of Safety Fence | Ref. Code | Single/Double Sided | Post Spacing m | Vehicle Mass kg | Vehicle Impact Speed km/h | Angle of Incidence Degrees |
|--|-----------|---------------------------------------|----------------|----------------------------|---------------------------|----------------------------|
| Tensioned Corrugated Beam (TCB) | TS1 | Single | 3.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Tensioned Corrugated Beam (TCB) | TS2 | Single | 1.6 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Tensioned Corrugated Beam (TCB) | TD1 | Double | 3.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Tensioned Corrugated Beam (TCB) | TD2 | Double | 1.6 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Untensioned Corrugated Beam (UCB) | US1 | Single | 3.2 | 1500 ± 15 | 80 ± 3 | 20 ± 1 |
| Untensioned Corrugated Beam (UCB) | US2 | Single | 1.6 | 1500 ± 15 | 80 ± 3 | 20 ± 1 |
| Open Box Beam (OBB) | BS1 | Single | 2.4 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Open Box Beam (OBB) | BS2 | Single | 1.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Open Box Beam (OBB) | BSB | Single on brackets fixed to structure | 1.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Open Box Beam (OBB) | BD1 | Double | 2.4 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Open Box Beam (OBB) | BD2 | Double | 1.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Open Box Beam (OBB) | BDS | Double with spacers and stiffeners | 2.4 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Double Rail Open Box Beam (DROBB) | DR1 | Single | 2.4 | (1500 ± 15) (5000 ± 15) | (113 ± 5) (80 ± 3) | (20 ± 1) (20 ± 1) |
| Wire Rope (WR) | WR | Single/Double | 2.4 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Tensioned Rectangular Hollow Section Beam (RHS) (100 x 100 mm) | RH1 | Double | 3.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Tensioned Rectangular Hollow Section Beam (RHS) (200 x 100 mm) | RH2 | Single or Double | 3.2 | 1500 ± 15 | 113 ± 5 | 20 ± 1 |

Table 4/2: Performance Testing Criteria for Safety Barriers

| Type of Safety Barrier | Ref. Code | Vehicle Mass kg | Vehicle Impact Speed km/h | Angle of Incidence Degrees |
|--|-----------|-----------------|---------------------------|----------------------------|
| Permanent Vertical Concrete Safety Barrier | VCB | 1500 ± 15 | 113 ± 5 | 20 ± 1 |
| Temporary Vertical Concrete Safety Barrier | TVCB | 1500 ± 15 | 80 ± 3 | 20 ± 1 |

Materials

2 Materials used shall be as given below unless otherwise shown on the Drawings.

(i) Steel Main Components.

| Component Type | Material |
|---|--|
| Corrugated and open box beams | BS EN 10 025 Grade Fe 430A |
| 'S' and 'Z' posts and plates | BS EN 10 025 Grade Fe 430A |
| 'S' and 'Z' posts and plates for Wire Rope Safety Fence | BS EN 10 025 Grade Fe 510A |
| Rolled hollow sections | BS 4360 Grade 43C or 50C, Section BS 4848 : Part 2 Note: Grade 50C for 100 mm x 100 mm beams in Rectangular Hollow Section (RHS) Safety Fence |
| Angles | BS EN 10 025 Grade Fe 430A, Section BS 4848 : Part 4 |
| Channels | BS EN 10 025 Grade Fe 430A, Section BS 4 : Part 1 |
| Reinforcement Bar | BS 4449 Grade 250 |
| Wire for component and tail ropes | BS EN 10 025 Grade Fe 430A |
| Wire for safety check ropes | BS 2763, 3 mm, Grade 1370 |
| | BS 2763, Grade 1770 |

Tolerances on stock thicknesses of steel plate shall be Class C to BS EN 10 029.

(ii) For 'S' and 'Z' posts, defects occurring during fabrication such as edge laminations and minor cracks shall be repaired by grinding, welding and dressing.

(iii) Fittings

- (a) Black bolts, screws and nuts shall, unless otherwise shown on the Drawings, comply with BS 4190 : 1967 amended as follows:

Clause 1.2, 2nd line, delete 'which may be produced by hot or cold forging, at the option of the manufacturer'

Clause 13.2, delete 5th, 6th and 7th lines and insert 'material strength grade shall be 4.8 or 6.9 as shown on the Drawings'.

Clause 18.1, 1st line, delete 'shall' and insert 'may, at the option of the manufacturer'; 6th line, delete 'shall also' and insert 'and the strength grade shall'.

- (b) Black washers shall comply with Section 2 of BS 4320. The steel used for the manufacture of washers shall be cold rolled carbon steel strip CS4 complying with BS 1449 : Part 1.
- (c) Stainless steel bolts, screws and nuts shall comply with BS 6105, Grade A4-80. The dimensions and tolerances of the bolts, screws and nuts shall comply with BS 4190 : 1967 as amended by (a) above.
- (d) Stainless steel washers shall comply with BS 4320 and be made from stainless steel strip type 304 or 316 to BS 1449 : Part 2.
- (e) For Wire Rope Safety Fences, threaded terminals, fork terminals, ordinary thimbles, rigging screws, pins, split pins, washers, locating hooks, locating pegs, nuts, post caps and excluders shall be as described in the approved manufacturer's drawings.
- (f) For Wire Rope Safety Fences, component ropes and tail ropes shall be 19 mm diameter 3 x 7 (6/1) coreless construction complying with BS 302 : Part 1. Safety check ropes shall be 8 mm diameter 6 x 19 (9/9/1) IWRC complying with BS 302 : Part 2.

(iv) Concrete

- (a) Concrete in foundations and anchor blocks shall comply with Clause 2602 and be of the grade described therein.

- (b) Concrete and reinforcement for the Vertical Concrete Safety Barriers shall comply with the Safety fence Details and with the 1700 Series.

Protective Finishes

- 3 All components except stainless steel items, reinforcing rings and reinforcing bars shall be galvanized as described in Clause 1911 unless otherwise described below:

- (i) For Wire Rope Safety Fences, threaded terminals shall be galvanized in compliance with Clause 1911.
- (ii) For Wire Rope Safety Fences, component and tail ropes shall be Class A finally zinc coated in compliance with BS 2763. Safety check ropes shall be Class A finally zinc coated or drawn zinc coated in compliance with BS 2763.
- (iii) Coating weight on items other than in (ii) above shall comply with the following:

| Items | Minimum average coating weight for any individual test area |
|--|---|
| Items of which all parts are 5.5 mm thick or over | 610 g/m ² |
| Items of which any part is less than 5.5 mm thick | 460 g/m ² |
| Bolts, screws, nuts, washers, rigging screws, fork terminals and thimbles. | 305 g/m ² |

- (iv) Black bolts, screws, nuts and washers shall be centrifuged. Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads shall be oiled. Small items such as connecting straps may be centrifuged but the coating weight shall comply with the minimum values specified in (iii) above.

Tolerances

- 4 (i) Fabrication tolerances shall be as shown on the Drawings. Components which are to be galvanized or metal coated shall be measured before galvanizing or metal coating.
- (ii) The tolerance on hole diameters shall be +1 mm, -0 mm.

Welding

- 5 (i) General. Arc welding of carbon manganese steels shall comply with BS 5135. Arc welding of aluminium alloys shall be in accordance with BS 3019 and BS 3571 as appropriate. Weld symbols shown on the Drawings are as described in BS 499: Part 2. Welding shall not be used except where detailed on the Drawings. Processes other than arc welding shall be to the approval of the Engineer.
- (ii) Procedures. Written welding procedures shall be used with testing to IS EN 288 : Part 3 for steel and Part 4 for aluminium alloys and shall apply to all production and repair procedures. These shall be subject to reapproval after a period of seven years. When applying IS EN 288: Part 3, the welding consumables and procedures used shall be such that the mechanical properties of deposited weld metal will not be less than the respective minimum specified values of the parent metal being welded. Approval shall be by an Independent Inspecting Authority using appropriately qualified Welding Engineers, Welding Quality Engineers or equivalent. Testing shall be by a laboratory appropriately accredited by ILAB for weld testing.
- (iii) Welder Qualification. All welders shall be approved to IS EN 287: Part 1 for steel and Part 2 for aluminium alloys. The tests shall include in addition an application test on transverse butt welds in beams. Welders carrying out fillet welds only may be approved to BS 4872: Part 1. Welders shall be subject to reapproval after two years. Approval shall be by an Independent Inspecting Authority using appropriately qualified Welding Engineers, Welding Quality Engineers or Welding Inspectors. Testing shall be by a laboratory appropriately accredited by ILAB for weld testing.
- (iv) Production Inspection and Testing. The manufacturer shall provide suitable personnel to carry out inspection of production welds as required in (a) to (c) below. Personnel conducting visual inspection shall have a nationally recognised certificate of competence appropriate to the type of welding being inspected. Personnel conducting non-destructive testing (NDT) shall be certified according to a nationally recognised certification scheme appropriate to the equipment used and the weld groups inspected. Evidence of training and qualification shall be retained and made available for examination when required. The results of all weld inspections shall be recorded.
- (a) Visual Inspection. All welded joints, except those on driven posts, shall be subject to visual inspection in accordance with BS 5289 prior to any NDT and galvanizing. Welded joints on driven posts shall be visually inspected at a rate of 1 post per 20. Weld surfaces shall be free of slag residues and sharp edges. All surfaces shall be free of traces of weld spatter, arc strikes and contaminants. The throat dimensions of butt welds and the leg length and apparent throat dimensions of fillet welds, as measured by a welding gauge, taking into account lack of fit, shall not be less than those specified, except that local shortfalls up to 1 mm may be accepted, provided the average over any 50 mm length is not less than the specified dimension. The toe angle shall not be less than 90°. The surface of all welds shall be free from cracks, lack of fusion including overlap, and slag. Isolated discontinuous porosity may be accepted provided it is not detrimental to the galvanizing process. Undercut shall not result in a section loss of more than 5% over any 50 mm length of joint, nor shall its depth exceed 0.5 mm or 10% of the thickness, whichever is the less.
- (b) Magnetic Particle Inspection (MPI) and Liquid Penetrant Inspection. MPI shall be applied in accordance with BS 6072 to joints selected in accordance with (d) below, where any of the material thickness exceeds 20 mm. Notwithstanding the requirements of (d) below, MPI or liquid penetrant inspection in accordance with BS 6443, shall be applied as appropriate where on visual inspection the presence of cracking or lack of fusion may be suspected. To aid inspection, the profile of the weld may be dressed by burr grinding provided that the specified throat size and leg length is still maintained. The surface of the weld shall be free of cracks, lack of fusion and slag.
- (c) Ultrasonic Testing. All butt joints in material 8 mm thick or greater selected in accordance with (d) below shall be ultrasonically tested in accordance with BS 3923. The weld shall be free of cracks. The height of

buried slag, lack of fusion or lack of penetration shall not exceed 3 mm and within 6 mm of the outer surface their individual lengths shall not exceed 10 mm. The resulting net throat area loss over any 50 mm length of weld shall not exceed 5% of the specified throat area.

- (d) Frequency of NDT. Joints shall be selected as follows:

All joints of each type up to a batch size of 10 components and 10% of additional components thereafter. If non-conformances are found the scope of NDT shall be doubled. If further non-conformances are found, the whole batch shall be tested.

- (e) Reporting. Inspection records for production welds shall be retained by the manufacturer for three years and those covering the production periods relating to the components supplied shall be made available for examination.

Destructive Testing. Copies of certified reports of destructive tests on components supplied under earlier contracts with the National Roads Authority/Department of Environment shall be provided at the request of the Engineer.

The Contractor shall supply components or sample joints cut from components for destructive testing as selected by the Engineer. The basis of selection shall be as follows:

- (a) For batches of less than 100 beam assemblies with transverse butt welds, 1 sample joint shall be supplied unless an identical sample joint from the same works has been destructively tested within the previous four weeks. For batches exceeding 100 or more, 1 sample joint shall be supplied for each subsequent sampling lot not exceeding 100.
- (b) Welded adjuster brackets shall be supplied at the rate of 1 for each sampling lot not exceeding 300.
- (c) Each type of driven post shall be supplied at the rate of 1 post for each sampling lot not exceeding 1000.
- (d) Each type of surface mounted post shall be supplied at the rate of 1 post for each sampling lot not exceeding 100.

- (e) Each type of anchor frame, parapet connection and connection piece shall be supplied at an interval not exceeding 6 months for each manufacturer's works.

- (f) Other welded components shall be supplied at an interval not exceeding 12 months for each manufacturer's works.

The acceptance criteria shall be as specified in (iv) above, except that in (iv) (a) above the throat and leg dimension of the weld shall apply to the true rather than the apparent dimension.

In the event that there is a non-conformance arising from a serious deviation in materials, preparation, assembly or welding procedure, the batch concerned shall be rejected and further production of the components affected stopped until such time as the fault has been corrected. A minor non-compliance shall only be accepted on the basis that further sampling and testing shows that the fault is not repetitive and in the view of the Engineer will not in that instance impair structural integrity.

If the problem can be traced to a particular manufacturing period, operator, piece of equipment or batch of materials and if proper traceability to individual batches of components can be assured, only those batches affected may be subject to rejection.

The destructive test reports shall be retained by the manufacturer and recorded in a register for a period of three years. The destructive test samples shall be retained for a period of 18 months. These shall be made available for examination on future contracts with the National Roads Authority/Department of Environment.

- (vi) Remedial Work. Welds which do not comply with the Specification may be repaired to an approved procedure, as described in (ii) above.

Marking

- 6 (i) All components, including rope terminals and rigging screws but excluding fasteners, reinforcing rings and bars, shall be clearly and durably marked with the manufacturer's identification mark and digits indicating month and year of manufacture.

- (ii) In addition to the marking requirements of BS 4190: 1967, fasteners, except Items F18 and F19, shall be clearly marked with the following:
 - (a) fastener manufacturer's identification mark;
 - (b) safety fence manufacturer's identification mark;
 - (c) grade;
 - (d) fastener number.

Workmanship and Testing

- 7 (i) All components shall be manufactured so as to permit the construction of safety fences or barriers within the tolerances described in sub-Clauses 403.2, 403.5 and 408.4. During fabrication of components any necessary straightening or forming shall be carried out so as not to deface or weaken the material and they shall be assembled in such a manner that they are not bent, twisted or otherwise damaged.
- (ii) All fabrication of components except wire ropes and threaded terminals for Wire Rope Safety Fences shall be completed before galvanizing or metal coating.
- (iii) The Contractor shall provide the Engineer with evidence that the manufacturer of wire rope terminals has arranged for tensile tests to destruction to be carried out by a testing laboratory annually and whenever the production technique is changed. The test shall be carried out on a test piece of a Wire Rope Safety Fence consisting of a threaded terminal and a length of rope such that the minimum test length is 600 mm. The method of measuring the breaking load shall comply with BS 302 : Part 1. The minimum breaking load of component and tail ropes shall be 17.7 tonnes. The minimum breaking load of the rope fitted with the threaded terminal shall be 16.7 tonnes. For safety check ropes the minimum breaking loads shall be 4.1 tonnes and 3.9 tonnes respectively.
- (iv) The component ropes and tail ropes of Wire Rope Safety Fences shall be prestressed in the factory by applying a cyclic loading which shall be continued until all initial extension has been removed, eg. the lower limit of cyclic loading may be 1.7 tonnes and the upper limit 8.9 tonnes. The rope

shall exhibit a minimum modulus of elasticity of 8,300 kg/mm² (based on an area of 283 mm²) after prestressing.

Handling and Storage

- 8 All components shall be protected from damage and handled and stacked in such a way that permanent damage is not caused, particularly to threaded components. Means shall be provided to avoid damage to galvanized coatings and any damage that does occur shall be made good in accordance with the recommendations of EN ISO 1461. Component ropes and tail ropes for Wire Rope Safety Fences shall be supplied on reels with a barrel diameter of not less than 450 mm. Ropes shall not be twisted or kinked. Transport and storage of galvanized articles shall comply with the recommendations of EN ISO 1461.

403 Installation of Safety Fences

Overall Requirements

General

- 1 Installation shall be as described in this Series, in the Safety Fence Details, and as particularly described in Appendix 4/1.

Layout

- 2 (i) The overall layout of safety fences and barriers shall be as described in Appendix 4/1.
- (ii) All safety fences and barriers shall be erected to present a flowing alignment and unless otherwise agreed by the Engineer in accordance with the following:
- (a) The overall alignment on plan of safety fences shall not depart from the prescribed alignment by more than ± 30 mm, nor deviate in any 10 m length from the straight or required radius by more than ± 15 mm.
 - (b) Beams and wire ropes shall be at the heights shown on drawings included in the Safety Fence Details.

Excavation for Concrete Foundations and Anchor Blocks

- 3 (i) Excavations for concrete foundations and anchor blocks shall have vertical sides.
- (ii) Where the side of excavations cannot be maintained vertical until concrete is placed, suitable permanent or temporary casings shall be used. The casings shall be installed immediately after excavation and any lateral overbreak of the excavation shall be filled with mix ST1 concrete where permanent casings are used. Temporary casings shall be withdrawn carefully to minimise disturbance to the surrounding material. The maximum taper on temporary casings to facilitate withdrawal shall be 2°.
- (iii) Impermeable plastic sheeting 125 microns thick shall be laid at the base of in situ concrete post foundations located in filter drains.
- (iv) Precast concrete post foundations shall be installed on a firm and level base. Any lateral overbreak of the excavation shall be filled with mix ST1 concrete.

Concrete in Foundations and Anchor Blocks

- 4 In addition to the requirements of Clause 2602 concrete shall be compacted by internal vibration, and the curing period shall be not less than 4 days.

Beams

- 5 Notwithstanding the manufacturing tolerances permitted for individual beams, the cumulative length tolerance shall be such that beams and posts can be positioned within 30 mm of their prescribed location and the requirements of sub-Clause 403.2 can be met. With the exception of any special closure pieces necessary to complete lengths of fencing, beam lengths shall not differ from those described in the Safety Fence Details.

Posts

- 6 Posts and foundations shall be of the types described in the Safety Fence Details, and as particularly described in Appendix 4/1 and shown on the Drawings. The radiused edge of all 'S' and 'Z' posts shall be presented to the adjacent traffic flow. Where posts are mounted in cast-in post sockets these shall be filled where described in Appendix 4/1, after erection, with a non-setting passive filler to prevent the collection of water.

Cutting of Components

- 7 (i) Unless otherwise approved by the Engineer:
- (a) No drilling, cutting (including flame cutting) or welding of beams and posts will be permitted after galvanizing.
- (b) Special closure pieces shall be fabricated before galvanizing.
- (ii) Damaged galvanizing and any areas of bare steel shall be made good in compliance with the recommendations of EN ISO 1461.

Assembly

- 8 Direct contact between dissimilar metals shall be avoided by interposing non-metallic sleeves, washers or coatings to prevent galvanic corrosion.

Anchorage and Attachment Systems for Surface Mounted Posts

- 9 (i) Unless otherwise described in Appendix 4/1, at least 4 weeks before installation, the Contractor shall submit to the Engineer well attested and documented evidence that proposed anchorages and attachment systems in drilled holes, are capable of resisting the ultimate design tensile loads given in Table 4/3. Anchorages of an expanding type, other than undercut anchorages, shall not be used.

Table 4/3: Design and Test Loads for Safety Fence Anchorage and Attachment Systems in Drilled Holes

| Nominal Post Section mm | Ultimate Design Tensile Load | | Anchorage Tensile Test Load kN |
|--|------------------------------|----------------------|--------------------------------|
| | Anchorage kN | Attachment System kN | |
| 100 x 32 x 6 (100 x 32 x 5) 110 x 49 x 5 | 65 | 55 | 40 |
| 125 x 90 x 6 | 125 | 100 | 75 |

Note : Loads are per bolt/stud.

- (ii) Steel anchorages and attachment systems shall be used for securing surface mounted posts to a concrete or steel base. Attachment systems shall use M20 bolts or studs as appropriate.

- (iii) For anchorages in drilled holes, the hole location shall be checked to ensure that the hole will be clear of reinforcement before drilling is carried out.
- (iv) Before installation of anchorages in drilled holes, the hole shall be sound, clean and dry and the tolerance of the hole shall be within the values given by the anchorage manufacturer.
- (v) Where surface mounted posts are to be installed on bridge decks, the anchorages shall include an internally threaded component to receive the attachment system ie. holding down bolt or stud. All parts of anchorages on bridge decks (where the anchorage is within 80 mm of the upper surface of the supporting concrete or where the anchorage parts are threaded to receive the holding down bolt) shall be of stainless steel grade 316 S 31 or 316 S 33 to BS 970 : Part 1. Holding down bolts, studs and nuts on bridge decks shall be stainless steel grade A4-80 to BS 6105. Washers on bridge decks shall comply with BS 4320 and be made from stainless steel strip grade 316 S 31 or 316 S 33 to BS 1449 : Part 2.
- (vi) The threads of steel anchorages shall be lined with grease having a high resistance to creep and being suitable for hot or cold smearing. The grease shall provide protection to the threads for a minimum of either 18 months under cover or 6 months exposed on Site.
- (vii) Attachment systems shall be tightened to the appropriate torque and have the minimum thread engagement specified by the manufacturer of the system.
- (viii) Except where surface mounted posts are attached to a steel base they shall be bedded on mortar complying with Clause 2601. The bedding mortar shall have a minimum thickness of 10 mm and a maximum thickness of 30 mm.
- (ix) All voids in anchorages, attachment systems and base plates shall be filled with a non-setting passive filler to prevent the collection of water.

404 Site Testing

Anchorage in Drilled Holes

- 1 The Contractor shall carry out loading tests on anchorages in drilled holes. For the purpose of this sub-Clause the phrase "Type of fixings" as defined in sub-clause 1.2 of BS 5080 : Part 1 : 1974 (1982) shall include "anchorages". Where anchorages are tested they shall be loaded incrementally in tension in accordance with BS 5080 : Part 1 : 1974 (1982) except that they shall be capable of resisting the test load given in Table 4/3 in lieu of testing to failure. Incremental loads shall be held for not less than half a minute and the test load for not less than five minutes. Readings shall be taken immediately after applying load and at the end of the time intervals stated above.
- 2 The total movement of the anchorage shall not exceed 1.0 mm during the test. Any evidence of slip during loading up to the test load, as demonstrated by a significant change in the slope of the load/extension curve, shall constitute failure.
- 3 The Contractor shall test the anchorages selected by the Engineer and the testing frequency shall be in accordance with Appendix 1/5. In addition, testing shall comply with any special requirements given in Appendix 4/1.

Post Foundations

- 4 (i) Where stated in Appendix 4/1, the Contractor shall provide the test equipment and carry out loading tests on post foundations. Testing shall be carried out as described in the Safety Fence Details. Details of test equipment are also included in the Safety Fence Details. The tests shall be carried out and the results submitted to the Engineer at least one week prior to installation of the relevant lengths of fence, unless otherwise stated in Appendix 4/1.
- (ii) Where stated in Appendix 4/1, the Engineer will provide the test equipment and carry out loading tests on post foundations installed by the Contractor for that purpose. The Contractor shall make available a vehicle of not less than 5 tonnes for the Engineer's use while carrying out the tests.
- (iii) Unless otherwise agreed by the Engineer, the Contractor shall install test posts and foundations after completion of the finished ground.

- (iv) On completion of loading tests the Contractor shall remove the test posts and foundations and make good the finished ground.
- (v) Where appropriate, the Contractor shall establish and maintain traffic safety and management measures complying with Clause 117 during installation, loading and removal of the test posts and foundations.

alignment without signs of movement. Lock nuts shall be tightened to a torque of 140/160 Nm.

- (iv) All adjuster bolts and nuts shall be finger-tightened onto adjuster brackets.
- (v) Commencing at the adjuster assembly adjacent to one limit, adjuster nuts shall be tightened to a torque of 280/300 Nm. The nuts shall then be slackened and retightened to a torque appropriate to the ambient temperature as given in Table 4/4. Lock nuts shall be tightened to a torque of 140/160 Nm.

405 Tensioned Corrugated Beam Safety Fence (TCB)

Assembly

- 1 Beams shall be connected by lap joints using M16 screws, nuts and washers as described in the Safety Fence Details listed in Appendix 4/3. Longitudinal clearance between screws and slotted holes in the beams shall be removed by prising apart the beams using a tapered bar in the 20 mm diameter hole of one beam and the end of the other beam. The nuts shall be tightened to a torque of 60/80 Nm. Screws (Item F1) connecting beams to posts shall be only loosely assembled prior to tensioning.
- 2 On double sided safety fence installations the four lap screws and nuts (Items F7) securing connecting straps shall be left loose prior to tensioning.

Tensioning

- 3 Tensioning between any two limits shall not proceed until the Engineer is satisfied that each limit is anchored sufficiently securely to resist the load effects due to tensioning.
- 4 Tensioning shall be undertaken only when the ambient temperature is between 25°C and -5°C and shall proceed as follows:
 - (i) Lap screws and nuts at beam connections shall have been tightened as described in sub-Clauses 1 and 2 of this Clause and all longitudinal clearance between screws and slotted holes shall have been removed before tensioning is commenced.
 - (ii) Screws and nuts securing beams to posts and adjuster bolts and nuts shall be loosely assembled. Adjuster assemblies shall be located not more than 70.5 m apart and each installation shall incorporate at least one adjuster assembly.
 - (iii) Anchor bolts and nuts at both anchor positions shall be tightened until the adjacent posts just maintain their vertical

Table 4/4: Relationship Between Torque and Ambient Temperature

| Torque Nm | Ambient Temperature °C |
|------------------|------------------------|
| 0 (finger-tight) | 25 |
| 50 | 20 |
| 100 | 15 |
| 150 | 10 |
| 200 | 5 |
| 250 | 0 |
| 300 | -5 |

- Notes. 1. Interpolation between values is allowed.
2. Tolerance on torque to be $\pm 5\%$.

- (vi) The procedure shall be repeated at all adjuster assemblies sequentially along the length of the fence.
 - (vii) Screws and nuts securing beams to posts shall be tightened to a torque of 15/20 Nm.
 - (viii) On double sided installations the four lap screws and nuts securing the connecting straps shall be tightened to a torque of 60/80 Nm.
- 5 On completion of tensioning, the centre of each screw securing beams to posts shall be not closer than 25 mm \pm 2 mm to the end of the slotted hole in the beam.

406 Untensioned Corrugated Beam Safety Fence (UCB)

Assembly

- 1 Beams shall be connected by lap joints using M16 screws, nuts and washers as described in the Safety Fence Details listed in Appendix 4/3. Longitudinal clearance between screws and

slotted holes in the beams shall be removed by prising apart the beams using a tapered bar in the 20mm diameter hole of one beam against the end of the other beam. The nuts (Item F7) shall then be tightened to a torque of 60/80 Nm.

- 2 All nuts shall be tightened to the appropriate torque stated on the Safety Fence Detail listed in Appendix 4/3.

407 Open Box Beam Safety Fence (OBB)

Assembly

- 1 Beams shall be connected by butt joints using fish plates and M16 bolts, nuts and washers as described in the Safety Fence Details listed in Appendix 4/3.
- 2 Fences shall be as described in the Safety Fence Details listed in Appendix 4/3.
- 3 All nuts shall be tightened to the appropriate torque stated on the Safety Fence Detail listed in Appendix 4/3.
- 4 An expansion assembly (detailed on the Safety Fence Detail listed in Appendix 4/3) shall be provided at not more than 100 m spacing on all continuous lengths of open box beam fence exceeding 100 m overall length.

408 Double Rail Single Sided Open Box Beam Safety Fence (DROBB)

Assembly

- 1 Beams shall be connected by butt joints using fish plates and M16 bolts, nuts and washers as described in the Safety Fence Details listed in Appendix 4/3.
- 2 Fences shall be assembled in accordance with BS 7669: Part 3, Section 2.3.3.
- 3 All nuts shall be tightened to the appropriate torque stated on the Safety Fence Detail listed in Appendix 4/3.
- 4 An expansion assembly (detailed on the Safety Fence Detail listed in Appendix 4/3) shall be provided on each rail at not more than 100 m spacing on all continuous lengths of double rail single sided open box beam fence exceeding 100 m overall length.

- 5 Notwithstanding the manufacturing tolerance permitted for individual beams, and the tolerances described in sub-Clause 403.2 the cumulative length tolerance shall be such that the position of the upper beam joint is within ± 40 mm longitudinally of the lower beam joint.

409 Wire Rope Safety Fence (WR)

Assembly

- 1 Wire Rope Safety Fence shall be installed in accordance with BS 7669: Part 3, Section 2.5. Driven line posts shall be installed to the prescribed levels without damage to the slot in the top of the post.

Ropes

- 2 The ropes shall be installed to the layouts as shown in the approved manufacturer's drawings, to the layouts in Appendix 4/1 and to the following requirements:
 - (i) The two lower line ropes shall be placed on the locating hooks or pegs of each deflection post, interwoven between successive line posts and finally positioned on the locating hooks or pegs of each line post.
 - (ii) The two upper line ropes shall be placed in the slot of each post.
 - (iii) Ropes shall be joined by rigging screws with a thread engagement of not less than 25 mm.
 - (iv) One end of each tail rope shall be connected to the anchor frame in the anchor block and shall be fitted with a safety check rope which shall be connected to the attachment plate.
 - (v) The length of line rope between any two adjacent anchors shall be not greater than 627 m.
 - (vi) Two ropes, one upper and one lower, shall be terminated at each intermediate anchor.

Tensioning

- 3 Tensioning between any two limits shall not proceed until the Engineer is satisfied that each limit is anchored sufficiently securely to resist the load effects due to tensioning.
- 4 Tensioning shall be undertaken only when the ambient temperature is between 30°C and -10°C.
- 5 All rigging screws on each line rope shall be adjusted equally to achieve the tension given in Table 4/5 appropriate to the ambient temperature

which shall be agreed with the Engineer and measured using a tension indicating device approved by the Engineer.

- 6 Before putting the safety fence into service the tension in each rope shall be checked and it shall be retensioned if necessary to comply with the requirements of Table 4/5.

Table 4/5: Relationship Between Rope Tension and Ambient Temperature

| Rope Tension kN | Ambient Temperature °C |
|--------------------|---------------------------|
| 14.0 | 30 |
| 16.75 | 25 |
| 19.5 | 20 |
| 22.25 | 15 |
| 25.0 | 10 |
| 27.75 | 5 |
| 30.5 | 0 |
| 33.25 | -5 |
| 36.0 | -10 |

Note. Interpolation between values is allowed.

410 Tensioned Rectangular Hollow Section Safety Fences (RHS)

Beams

- 1 Beams shall be either 200 mm x 100 mm section mounted either on top of posts or on the side of posts or 100 mm x 100 mm section mounted on top of posts, as detailed on the Drawings. They shall be connected using internal steel plates, bolts and washers as detailed in the Safety Fence Details.

Assembly and Tensioning

- 2 (i) The installation shall be as detailed in the Safety Fence Details.
- (ii) Tensioning between any two limits shall not proceed until the Engineer is satisfied that each limit is anchored sufficiently securely to resist the load effects due to tensioning and that the safety fence has been completely assembled and connected to the anchorages.
- (iii) Tensioning shall be undertaken only when the ambient temperature is between 10°C and 20°C and shall proceed as follows:
- All beam to beam connector screws shall be tightened.
 - Shear bolts, strap bolts, anchorage

bolts and the tensioner assemblies shall be loosely assembled. Tensioner assemblies shall be located not more than 70.5 m apart and each installation shall incorporate at least one tensioner assembly.

- The covers at the tensioner assemblies shall be slid back to expose the turnbuckles.
- Anchorage bolts at each anchor position shall be tightened until the adjacent intermediate post connected to the anchorage beam just maintains its vertical alignment without signs of movement.
- The turnbuckles at the tensioner assemblies shall be hand tightened.
- Starting from one anchor position, all the residual slack in the safety fence installation shall be removed by applying a torque of 700Nm to the turnbuckles at the tensioner assemblies sequentially along the length of the safety fence.
- The shear bolts and the strap bolts shall be tightened to a torque of 18/20 Nm.
- The covers at the tensioner assemblies shall be slid over the turnbuckles.

411 Concrete Safety Barriers

- The Permanent Vertical Concrete Safety Barrier (VCB) shall comply with the Safety Fence Detail listed in Appendix 4/3.
- The Temporary Vertical Concrete Safety Barrier (TVCB) shall comply with the Safety Fence Detail listed in Appendix 4/3.

Where required in Appendix 4/1 the Contractor shall provide, and on completion of the Works remove to the location stated therein, the Temporary Vertical Concrete Safety Barrier.

Where the Temporary Vertical Concrete Safety Barrier is to be provided by the Road Authority the Contractor shall remove the barrier units from, and return on completion of the Works to, the location stated in Appendix 4/1.

412 Pedestrian Guardrails

- Pedestrian guardrails shall comply with BS 3049 and with any other requirements described in Appendix 4/2.