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

SECTION 2 **SPECIAL STRUCTURES**

PART 11

BD 83/01

DESIGN OF CCTV MASTS

SUMMARY

This Standard covers the use of The Institution of Lighting Engineers Technical Report Number 7, 2000 Edition (ILE TR7) for the design of closed circuit television (CCTV) masts made from steel. It provides particular requirements, which differ or are additional to those given in the Technical Report.

INSTRUCTIONS FOR USE

This is a new Standard to be incorporated in the Manual.

1. Insert BD 83/01 into Volume 2, Section 2, Part 11.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

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THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT

THE NATIONAL ASSEMBLY FOR WALES
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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

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Contents

Chapter

1. INTRODUCTION

Mandatory Sections

Sections of this document which form part of the standards of the Overseeing Organisations are highlighted by being contained in boxes. These are the sections with which the Design Organisations shall comply, or shall have agreed a suitable departure from standard with the relevant Overseeing Organisation. The remainder of the document contains advice and enlargement which is commended to Design Organisations for their consideration.

1.1 This Standard covers the use of The Institution of Lighting Engineers Technical Report Number 7, High Masts for Lighting and CCTV, 2000 Edition, Sections 1 and 2 (ILE TR7) for the design of closed circuit television (CCTV) masts made from steel. This Technical Report was originally developed for high mast lighting and has been revised to include CCTV masts as they have similar features. This Standard sets out the Overseeing Organisation's particular requirements where these differ from, or are additional to those given in the above Report.

Equivalence

1.2 Where CCTV masts are procured through a contract incorporating the Specification for Highway Works (MCHW 1), products conforming to equivalent standards or specifications of other member states of the European Economic Area will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these clauses must contain a suitable clause of mutual recognition having the same effect regarding which advice should be sought.

1.3 Where this Standard requires tests to be carried out the results of tests undertaken by a body or laboratory in a member state of the European Economic Area will be accepted provided that the body or laboratory offers suitable and satisfactory evidence of technical and professional competence and independence. This requirement will be satisfied if the body or laboratory is accredited in a member state of the European Economic Area in accordance with the relevant parts of the EN 45000 series of standards for the tests carried out.

Scope

1.4 This Standard sets out the design requirements for steel CCTV masts mounted on foundations in the ground for use on trunk roads including motorways. The requirements for lattice masts and breakaway masts are outside the scope of this Standard, as are the requirements for CCTV masts mounted on other structures eg gantries. Where attachments other than CCTV cameras are concerned see provisions in Chapter 5.

1.5 This Standard covers only steel masts. Where other materials are proposed, a departure shall be sought from the Technical Approval Authority (TAA), as defined in BD 2, DMRB 1.1.

Implementation

1.6 This Standard shall be used forthwith on all schemes for the construction and improvement of trunk roads, including motorways, currently being prepared, provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Organisations shall confirm its application to particular schemes with the Overseeing Organisation. Where contract documents are based on the Specification for Highway Works (MCHW 1) use of this Standard is mandatory. In Northern Ireland, the use of this Standard shall apply on roads designated by the Overseeing Organisation.

2. DIMENSIONAL LIMITATIONS

2.1 The nominal height of steel CCTV masts covered by this Standard shall be less than or equal to 25m. The nominal height is taken as the vertical distance between the bottom of the flange plate and the top of the mast.

Notes:

1. The nominal height excludes the height of camera, mounting etc.

2. ILE TR7 may be used in the design of CCTV masts less than 10m in height.

3. USE OF STANDARDS ISSUED BY THE OVERSEEING ORGANISATIONS AND OTHER TECHNICAL SPECIFICATIONS

3.1 The design, manufacture and installation of CCTV masts shall comply with the relevant requirements of ILE TR7 2000 Edition, as amended by this Standard and by the Specification for Highway Works (MCHW 1), hereinafter called the Specification.

3.2 The specific Overseeing Organisation's procedures for the Technical Approval of CCTV masts for use on motorways and other trunk roads shall be taken as that given in BD 2 (DMRB 1.1).

Definitions

3.3 The definitions given in ILE TR7, Section 1.4 shall be amended as follows:

i. HIGH MAST shall also refer to CCTV masts, meaning the support intended to hold one or more CCTV cameras with their mountings and housings. The design height of a CCTV mast shall be taken as the vertical distance between the bottom of the flange plate and the top of the CCTV mast or camera in its operating position, or other attachments, whichever is greater.

Note: The design height is different to "nominal height" and is required for wind loading calculations.

ii. The term LUMINAIRE shall be taken as including CCTV cameras, their mountings and housings.

Serviceability Limit States

3.4 Add at the end of ILE TR7 Section 2.3.2.3: "This calculation shall take full account of the actual weights of the CCTV mast, cameras, mountings, housings and any other attachments. The Overseeing Organisation may define more stringent rotation and deflection criteria if required."

Note: Using the terminology adopted by ILE TR7, at the serviceability limit state:

V_e (at 10m above ground level) = 22 m/s;

the corresponding dynamic wind pressure $q_{He} = 0.613V_e^2$; and

the peak equivalent static pressure: $E_{qH} = q_{He}.\delta.\beta$

where δ = size reduction factor; and

β = dynamic response factor.

Fatigue Criteria for Steel Masts

3.5 The stringent deflection requirements for the design of CCTV masts mean that stress ranges induced by dynamic response to wind loading are likely to be low. Thus fatigue is unlikely to be a critical design condition. However for masts sited in very exposed locations, fatigue shall be considered. Within the United Kingdom, very exposed locations are defined as:

i. sites at high altitude, above 250m;

ii. sites within 5km of the coast; and

iii. sites subject to significant local wind funnelling.

3.6 Fatigue damage is most likely to occur at or adjacent to welds or near sharp corners creating stress concentrations; particularly vulnerable positions are:

i. flange plates –
at the weld throat between the mast and flange
in the parent metal adjacent to the weld

ii. door openings –
at welded attachments
at poorly finished cut edges

iii. at any stiffening between the mast and the flange

iv. shoulder joints –
at the weld throat
in the parent metal adjacent to the weld

At such positions, fatigue prone details should be avoided.

3.7 Fatigue is critically dependent on geometrical configurations and fabrication. Stiffened and unstiffened door openings should comply with the constraints shown in Figure 1. In addition the following fabrication constraints should be met:

i. sharp irregularities at free edges due to the flame cutting process should be ground out;

ii. no welding should be closer than 10mm from the edge of the unstiffened door opening;

iii. longitudinal edge stiffeners should be continuous over their full extent.

Where shoulder joints are used, they should have an angle of inclination to the axis of the mast of between 12º and 35º.

3.8 Generally, when undertaking fatigue checks nominal stresses should be used based on nominal section properties. The stress concentrations inherent in the make-up of a welded joint (arising, for example, from the general joint geometry and the weld shape) are generally taken into account in the classification of the details. Otherwise the nominal stresses should be multiplied by stress concentration factors derived from stress analysis of the joint or from published data.

3.9 Classification may be derived by fatigue testing of a sample of typical full-scale details in an independent testing laboratory and covering an appropriate stress range to enable a fatigue life curve to be derived. Sufficient tests should be undertaken to provide a design curve representing mean minus 2 standard deviations.

Determination of Shape Coefficients

3.10 Where wind tunnel tests are necessary for the determination of shape coefficients for masts, brackets and CCTV cameras, their mountings and housings, the testing shall be carried out in accordance with ILE TR7 Section 2.6.5.

Protection against Corrosion

3.11 Surface preparation and paint protection of the steel CCTV mast shall comply with the relevant clauses of the 1900 series in the Specification for Highway Works (MCHW 1).

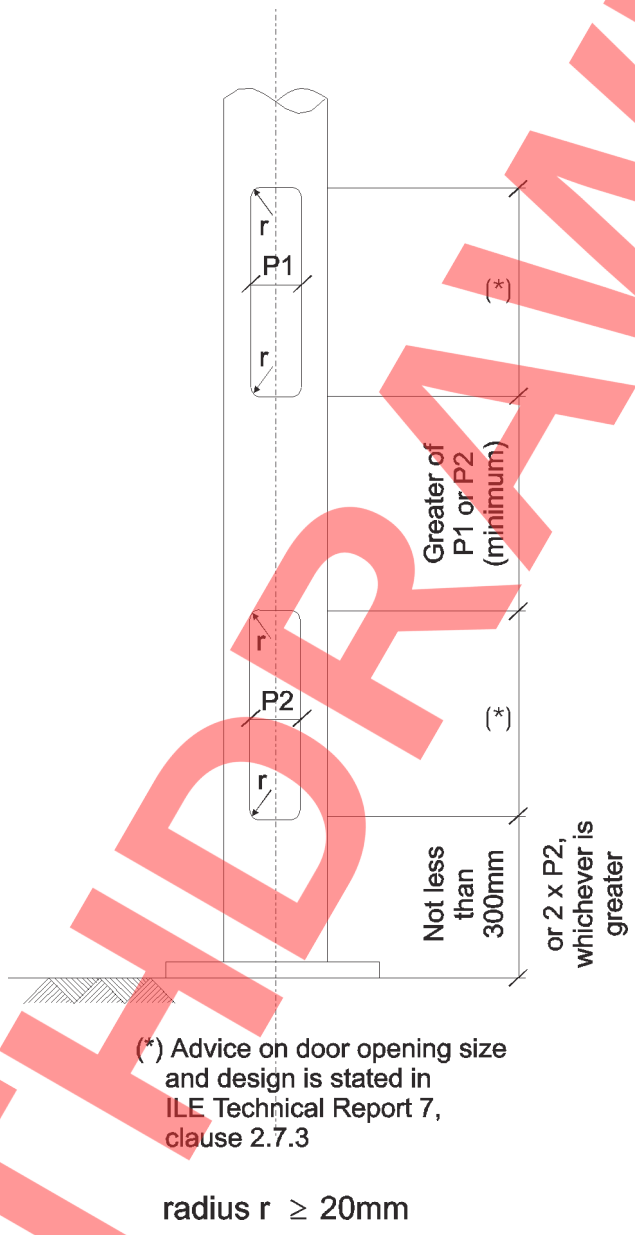

Figure 1: Door Opening

4. DOORS IN CCTV MASTS

4.1 In addition to ILE TR7, Section 2.7.3, the following requirements shall apply:

Where the section containing the door opening is circular or polygonal with eight or more sides, design strengths shall be calculated in accordance with BS 5649: Part 7, subject to the following amendments:

In clause 5.6.2.2, define

$$\phi_3 = \frac{t^2 E}{t^2 E + 0.07 R L f_Y} \text{ but} < \phi_1 \text{; and}$$

$$\phi_4 = \frac{t^2 E}{t^2 E + 0.035 R L f_Y} \text{ but} < \phi_2 .$$

In all other cases the design strength shall be calculated from first principles.

Alternatively, the design shall be based on the results of full-scale load tests.

4.2 Masts mounted in situations where there is a risk that a detached door could cause an accident if it fell on to the area below shall have their doors hinged or held captive by an approved metal chain which shall be sufficiently robust to support the door in severe gale conditions.

5. ATTACHMENTS TO CCTV MASTS

5.1 CCTV masts shall not be designed for attachments other than CCTV cameras and their associated equipment unless otherwise specified. Where attachments are specified they shall be incorporated into the design of the CCTV masts in accordance with the following provisions:

5.2 Where attachments are to be used, the mast shall be designed to resist the additional loading, which shall be described in Appendix 13 of the Notes for Guidance on the Specification (MCHW2). Where appropriate the additional dead and wind loads shall be calculated in accordance with ILE TR7.

5.3 Where attachments are required the CCTV pole and the attachments shall be designed such that the operation of the CCTV camera is not impeded. Similarly, access for installation, inspection or maintenance of an attachment shall not interfere with the operation of the CCTV camera. Where attachments are located below the operating position of the camera, they shall be designed as demountable to allow the CCTV mounting to be raised and lowered.

6. FOUNDATIONS

Foundations - General

6.1 Foundations shall consist of reinforced concrete blocks and shall be designed in accordance with paragraphs 6.1 to 6.6 as appropriate. The structural concrete shall be designed in accordance with BS 5400: Part 4 as implemented by BD 24, (DMRB 1.3.1). These requirements shall supersede the provisions of ILE TR7 section 2.9.

The approval of the TAA shall be obtained for any alternative form of foundation.

Foundations for Masts with Flange Plates

6.2 The design of the foundation shall be based on the design methods given in BS 8004: 1986 as implemented by BD 74 (DMRB 2.1.8), with the exception of clause 2.3.2.4.3 Wind loading, which shall be superseded by Clause 6.3.

6.3 Because of the difference in the dynamic behaviour of the CCTV mast and its foundation, in the absence of more accurate information, the following shall be assumed. The basic wind load transferred from the CCTV mast to the substructure at the top of the substructure reduces to 1/β of this value at the bottom of the substructure and foundation. β is the response factor given in ILE TR7, Figure 1.

6.4 Where Masts are positioned so that they are:

i. located more than 4.5 metres from the edge of the carriageway (the edge of the carriageway shall be as defined in BD 37 (DMRB 1.3)); or

ii. on a slope such that the underside of the flange plate is more than 2 metres vertically above the carriageway; or

iii. located behind a wire rope safety fence complying with the requirements of TD 32 (DMRB 2.2.3); or

iv. located behind a safety fence or barrier complying with the requirements of TD 19 (DMRB 2.2.8);

then the design loads for the foundation shall be the nominal loads and nominal wind loading applied by the mast when designed in accordance with ILE TR7.

6.5 Where a mast location does not fall within one of the categories given in Clause 6.4 above, approval of the TAA shall be obtained. As a minimum, the foundation shall be designed to resist the moment capacity of the actual mast at base level, M*, together with an equivalent ultimate shear force, F* (=2M*).
M* shall be calculated in accordance with ILE TR7, section 2.4 where:

$$M^* = M_p \frac{\left\{0.9241\left[\left(\frac{90\sigma_y D}{NEt}\right)^{-0.2858}\right] - 0.1266\right\}}{\gamma_m}$$

M_p, σ_y, D, N, E and t are as defined in ILE TR7. For the purpose of calculating foundation design loads alone, γ_m shall equal 1.00.

6.6 The foundation shall be designed with a factor of safety greater than 1.5 against overturning.

7. CONNECTION BETWEEN CCTV MAST AND SUBSTRUCTURE

General

7.1 The connection between the CCTV mast and its substructure shall be designed in accordance with paragraphs 7.1 to 7.13 as appropriate. These requirements shall supersede the provisions of ILE TR7 section 2.8.

7.2 A CCTV mast with flange plate shall be fixed to the foundation or bridge deck by an attachment system and anchorage which shall be capable of providing the required restraint. This will usually take the form of holding down bolts which connect with an anchorage. Anchorages of expanding type shall not be used. The attachment system shall allow the CCTV mast to be demounted.

7.3 The design resistance values of the holding down bolts and anchorages shall be determined in accordance with BS 5400: Part 3 as implemented by BD 13, (DMRB 1.3) and BS 5400: Part 4 as implemented by BD 24 (DMRB 1.3.1). They shall not be less than the design load effects due to ultimate loads. Due consideration of the capacity of the complete anchorage to resist the forces involved should also be made with regard to embedment and pull-out based on a 90° cone recommended in "Holding down systems for steel stanchions" CS/BCSA/Constrado, 1980.

7.4 Where masts are positioned in accordance with Clause 6.4, the flange plate shall be designed for the ultimate limit state using the loads and wind loads applied by the mast when designed in accordance with ILE TR7.

7.5 Where a mast location does not fall within one of the categories given in Clause 7.4 above, then approval of the TAA shall be obtained. As a minimum, the following criteria shall apply:

i. The flange plate shall be capable of developing a moment of resistance about each axis, taken at the underside of the flange plate, at least 1.2 times the theoretical ultimate moment capacity, M*, of the actual CCTV mast, calculated at base level in accordance with ILE TR7 sections 2.4 and 2.5.

ii. The connection between the CCTV mast and the flange plate shall be capable of developing the theoretical ultimate moment capacity of the actual CCTV mast, M*, calculated at the base level in accordance with ILE TR7 sections 2.4 and 2.5, and an equivalent ultimate shear force, F* (=2M*).

7.6 The method of design for the flange plate shall be appropriate for the actual fabrication details. Full account shall be taken of the shear stresses around the holding down bolts, and bending strength within the flange by means of yield line analysis, or other suitable method. Alternatively, the design may be based upon the results of full-scale load tests, subject to the agreement of the TAA.

7.7 The diameter of the flange plate shall not be less than the pitch circle diameter of the holding down bolts plus 2.5 times the diameter of the bolts.

7.8 The holding down bolts shall be installed with a lower location plate and an upper template to ensure correct vertical and horizontal bolt alignment.

7.9 The space between the top of the substructure and the underside of the flange plate shall either be filled with an impervious material after provision of an adequate drainage hole or left open. The cable entry duct shall not be obstructed.

7.10 When the weight of the CCTV mast is to be carried by nuts beneath the flange plate, the holding down bolts shall be designed to resist all additional stresses arising from this construction detail, and protected against corrosion. When the weight of the mast is supported directly through

the flange plate to the substructure, the space should be packed with a suitable bedding mortar.

7.11 The bearing stresses in any bedding mortar under the flange plates shall not exceed 20 N/mm^2. The maximum bearing stresses on the concrete under a flange plate shall be in accordance with the requirements of BS 5400: Part 4 as implemented by BD 24 (DMRB 1.3.1).

7.12 The substructure shall be designed to resist the anchorage loads without damage. The tensile strength of the concrete should be ignored in the calculations. The concrete in the foundation or bridge component to which a mast is fixed shall be reinforced against bursting associated with any internal forces generated by the holding down bolts/anchorage system.

7.13 Where masts are located within 4.5 metres of the edge of the carriageway or within the central reserve, the design of attachment systems and anchorages shall be such that removal and replacement of damaged masts can be readily achieved to the satisfaction of the TAA. This shall be achieved by providing internally threaded components in the anchorage to receive the holding down bolts.

8. REFERENCES

8.1 British Standards Institution

BSEN40: Lighting Columns

Part 1: - Definitions and terms

BS 5649: Lighting Columns

Part 2: - Dimensions and tolerances; AMD 3136

Part 7: - Method for verification of structural design by calculation

BS 6399: Part 2: Loading for buildings, code of practice for wind loads.

BS 8004: Code of Practice for Foundations

BS 5400: Steel, Concrete and Composite Bridges

Part 3: - Code of Practice for design of steel bridges

Part 4: - Code of Practice for design of concrete bridges

8.2 Design Manual for Roads and Bridges (DMRB)

Volume 1: Section 1: Approval Procedures

BD 2 – Technical Approval of Highway Structures on Motorways and other Trunk Roads

Volume 1: Section 3: General Design

BD 13 – Design of Steel Bridges : Use of BS 5400: Part 3: 1982 (DMRB 1.3)

BD 24 – The Design of Concrete Highway Bridges and Structures – Use of BS 5400: Part 4: 1990

BD 37 - Loads for Highway Bridges

Volume 2: Section 2: Special Structures

TD 19: Safety Fences and Barriers

TD 32: Wire Rope Safety Fence

8.3 Manual of Contract Documents for Highway works (MCHW)

Volume 1: Specification for Highway Works (MCHW 1)

Volume 2: Notes for Guidance on the Specification for Highway Works (MCHW 2)

8.4 Other Technical Specifications

The Institution of Lighting Engineers Technical Report Number 7 – High Masts for Lighting and CCTV, 2000 Edition (ILE TR7).

Holding down systems for steel stanchions, published by the Concrete Society, The British Constructional Steelwork Association and the Constructional Steel Research and Development Organisation, October 1980.

9. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

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