

Wall ties —

Part 2: Recommendations for design of wall ties

UDC 624.071.3

Confirmed December 2011

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The preparation of this Draft for Development was entrusted by the Civil Engineering and Building Structures Standards Committee (CSB/-) to Technical Committee CSB/52 upon which the following bodies were represented:

- Brick Development Association
- British Board of Agrément
- British Ceramic Research Association
- British Non-ferrous Metals Federation
- British Plastics Federation
- British Steel Industry
- British Woodworking Federation
- Constructional Steel Research and Development Organization
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Building Research Establishment, Princes Risborough Laboratory)
- Galvanizers' Association
- Greater London Council
- Institute of Building Control Officers
- Institution of Mechanical Engineers
- Institution of Structural Engineers
- Royal Institute of British Architects
- Stainless Steel Fabricators' Association of GB
- Timber Research and Development Association
- Zinc Development Association

The following were also represented in the drafting of the Draft for Development through subcommittees and panels:

Coopted members

This Draft for Development, having been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, was published under the authority of the Board of BSI and comes into effect on 27 February 1987

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The following BSI reference relates to the work on this Draft for Development: Committee reference CSB/52

ISBN 0 580 15654 0

Amendments issued since publication

Amd. No.	Date of issue	Comments
7971	March 1994	Indicated by a sideline in the margin

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Foreword

This Part of DD 140 has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee in response to requests from manufacturing industry and testing organizations for guidance on assessing new designs of wall tie not complying with BS 1243. It is based on the BRE publication “Performance Specifications for Wall Ties”¹⁾. However, the design loads in that document have been modified to suit the safety factors given in BS 5628-1. Further information is given in clause 0.

DD 140, despite its provisional status, has achieved significant use since its publication. It has not been possible to convert it to a full British Standard because that would contravene the CEN Standstill agreement. It is possible, however, to amend the DD. This particular amendment has been produced to meet industry’s needs and, at the same time, further align the text with the draft European Standard for wall ties scheduled for publication in 1995.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because further evidence is required before the performance criteria described can be incorporated into a British Standard.

It is recommended that it should be applied on this provisional basis so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication.

Notification of the start of the review period together with a request for the submission of comments from the users of this Draft for Development will be made in an announcement in the appropriate issue of *BSI News*. Observations which it is felt should receive attention before the official call for comments will be welcomed.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

The British Standards Institution requests that, because of the provisional nature of this publication, its reference number should not be marked on products.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

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

¹⁾ Obtainable from Building Research Establishment, Garston, Watford WD2 7JR.

0 Introduction

0.1 Basic philosophy

The philosophy adopted is broadly that given in the BRE publication "Performance Specifications for Wall Ties". However, in order to bring this Draft for Development into line with BS 5628-1, it has been necessary to modify the BRE approach as follows.

- a) The calculation of wind loads has been refined to take account of some of the factors which reduce the load on the wall in real situations. Also, recent experimental work on the interaction of brickwork and timber frame elements has been taken into account.
- b) A higher partial safety factor for materials of 3.0 has been adopted. As a consequence, the test methods given in DD 140-1 make no allowance for errors in construction which could reduce the performance e.g. laying off centre, incorrect cavity width, poor quality mortar, reduced tie density. Exceptionally, however, a check should be made to see whether the tie still performs satisfactorily if the actual cavity width exceeds the design width by 25 mm (see clause 7).

In addition the Committee decided to express the serviceability limit state as a minimum characteristic load to be achieved at a specified deformation. The characteristic loads are based on design wind forces and the deformations are based on variations in cavity widths observed in test walls and assessed by analysis when walls are subjected to the appropriate design forces.

0.2 Calculations

0.2.1 Wind loads. The wind loads have been taken from CP 3:Chapter V-2. The following S factors were used:

- $S_1 = 1$ (normal situation; extremes covered by safety factor)
- $S_2 =$ variable, but averaged between ground level and eaves for small buildings for both compression and tension, since there are no cases which envisage uniform negative pressures at the local pressure coefficient (C_p) level.
- $S_3 = 1$ (50 year return).

For dwellings it has been assumed that the ratio of height to width h/w is in the range 0.5 to 1.5. This will deal with typical detached houses, which tend to be approximately cube shaped, and most terraces and semi-detached dwellings, where the ratio of height to least lateral dimension will usually be in this range. Since the ratio of length to width l/w will tend to be within the range of 1 to 4, depending on the type of structure, it is simplest to assume the worst case for each wind condition. Thus the C_p value has been taken to be + 0.7. Since a positive internal pressure can only occur where there is an opening on the windward face and this opening would tend to relieve the external pressure on the face, the aggregate pressure coefficient has also been taken to be + 0.7. However in the case of suction the internal and external suction could occur together. Thus the values for external pressure coefficient C_{pe} and internal pressure coefficient C_{pi} have been taken to be – 0.7 and – 0.3 respectively.

For general purpose ties, the more onerous case should be used, i.e. h/w should be taken to be in the range 1.5 to 6, and C_p should be taken to be + 0.8 and – 1.1.

0.2.2 Transfer of wind loads to ties. The mechanism of the transfer of wind load to ties is complex and there are a number of uncertainties due to lack of data and variations in the design and construction of walls. For the purposes of this Part of DD 140 the following simplifications have been made.

- a) When the wind blows on one leaf of a cavity wall or a cladding panel, some of the pressure may be transferred directly to the backing structure by pressure equalization in the cavity resulting from air leakage. The extent of leakage will vary with design (e.g. weep-holes), quality of construction (e.g. how well joints are filled) and condition of the wall (e.g. pores filled with water). Because it is not possible to foresee the state of a wall, the conservative assumption is made that there is no pressure equalization.

b) When the structure is a box structure (e.g. masonry cavity walls with both leaves returned at their ends to flank walls or buttresses, or timber frame construction with the inner leaf returned in a similar way) and the stiffness of the two leaves is similar, the horizontal spanning action of the loaded leaf should reduce the forces transferred to the ties. The precise extent is difficult to quantify and the forces will vary with the position of the tie in relation to the returns and other features such as openings. For small box structures it has been assumed that half the wind force will be borne by spanning. The masonry in large structures or those with leaves of significantly different stiffness should be assumed to act as cladding unless horizontal spanning action can be demonstrated by calculation or experiment.

c) For buildings where the masonry is in the form of cladding principally supported by the ties, it has been assumed that there is no horizontal spanning action. This will apply to most multi-storey frame or slab structures and most commercial/industrial structures where the horizontal spanning will be prevented by movement joints. Walls of buildings greater than 15 m long in any plan dimension are likely to have such joints. Terraced housing may, however, be treated as a box structure, provided that any movement joints are placed at party wall junctions and that additional ties are provided on either side of such joints [see 0.2.2 e)].

d) Under test, structures of one and two storeys with a gable indicate that a significant degree of vertical spanning action occurs, with the wall behaving like a simply supported vertical cantilever with a falling prop. The complexity of the spanning action makes it impossible to model accurately by calculation because all the factors (wind pressure versus height, prop action versus height and element stiffness, stiffness of ties versus deformation) tend to vary non-linearly. On the basis of recent research a conservative assumption is made that the overall force on the ties is reduced by 25 %.

e) In any structure consisting of a single panel of masonry spanning vertically from a base support, the assumption is made that the wind force transferred to the ties may be taken to be the mean of the forces at the top and at the base. For houses the base will normally be the foundation level and the top the roof peak. For other structures the base may be an intermediate support at a floor and the top may be a movement joint at the panel head.

f) Simple calculations make the assumption that the forces in the ties are uniformly distributed or that any local high stresses may be redistributed by elastic or plastic deformation of the ties. In fact, research has shown that the forces in the ties are very unevenly distributed and can be locally very high or even of opposite sign to the incident load. Since the distribution is controlled by the detailed form of the structure, it is not possible to anticipate peak loads in a simple design. However, it should be borne in mind that peak loads are to be expected only on rare occasions and therefore it would be reasonable to allow some redistribution of stress by plastic yield under compressive loads. Under tensile loads the possibilities for plastic deformation are usually less and the consequences of failure are more serious, but the peak loads occur near unreturned edges where they can be dealt with by specifying a greater tie density.

0.3 Transfer of load to support structure

In buildings of three storeys or more where the cavity between the leaves of a panel wall continues past a floor, beam or column or intersecting wall which is assumed to act as a supporting structure for a panel, the designer should consider the need to install ties along the line of this structure to transfer to it the transverse lateral load to be carried by the outer leaf. In dwellings with conventional masonry cavity walls having leaves of comparable stiffness it will normally be unnecessary to provide additional tying at floor lines unless the lateral resistance of the wall is critically dependent on the division into small panels.

1 Scope

This Part of DD 140 gives recommendations for the design of wall ties, including remedial ties, manufactured from materials listed in clause 4 and intended for use in masonry and timber frame construction anywhere in the UK.

NOTE 1 Appendix B gives an example calculation.

NOTE 2 The titles of the publications referred to in this Part of DD 140 are listed on the inside back cover.

2 Definitions

The definitions given in BS 5628-3 apply.

3 Classification

Ties should be classified according to the intended end use as shown in Table 1.

4 Materials

The tie should be made from one or more of the following materials:

- a) galvanized low carbon steel in accordance with **3.2** or **3.3** of BS 1243:1978;
- b) plastics coated zinc coated mild steel in accordance with **3.3** and **5.3** of BS 1243:1978;
- c) austenitic stainless steel wire in accordance with **3.6** of BS 1243:1978;
- d) austenitic stainless steel strip in accordance with **3.7** of BS 1243:1978;
- e) copper in accordance with **3.4** of BS 1243:1978;
- f) copper alloys in accordance with **3.5** of BS 1243:1978;
- g) injection moulded polypropylene as described in Appendix A (type 4 ties only).

All parts of the tie and the associated fixings should be made either from the same material or from materials compatible with each other, i.e. not be liable to any deleterious chemical or electrochemical interaction. Shot-firing nails will normally be incompatible with any of the specified body metals and should only be used where special coatings and grommets are provided to isolate the nail electrically from the tie. If protected in this way, the tie may be structurally suitable for tying back to concrete or steel frames or slabs at the discretion of the designer.

NOTE The recommended materials have an estimated minimum service life of 60 years when embedded in the outer leaf of masonry.

5 Functional sections

The tie should consist of three functional sections, namely:

- a) an inner leaf connection;
- b) a cavity spanning section;
- c) an outer leaf connection.

The requirements for these sections should be as given in Table 2 and Figure 1 for the appropriate type of tie.