BRITISH STANDARD

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Incorporating Amendment No. 1

Methods of test for

Falsework equipment —

Part 1: Floor centres

Confirmed January 2010

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Cooperating organizations

The Builders' Plant and Equipment Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

British Mechanical Engineering Confederation
Concrete Society Limited*
Contractors' Plant Association
Department of the Environment, Building Research Station*
Federation of Civil Engineering Contractors
Federation of Manufacturers of Construction Equipment and Cranes
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Institution of Structural Engineers
Prefabricated Aluminium Scaffolding Manufacturers' Association

This British Standard, having been prepared under the direction of the Builders' Plant and Equipment Standards Committee, was published under the authority of the Executive Board on 31 August 1977

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Amendments issued since publication

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5360	May 1989	Indicated by a sideline in the margin

Contents

Foreword

The need to establish accurately the structural properties of equipment has become more important, and in consequence, the need to have satisfactory test methods. These should relate as closely to practice as possible and be completely reproducible. This British Standard, prepared under the direction of the Builders' Plant and Equipment Standards Committee, is the first of a series of test methods for common types of falsework equipment.

Floor centres are usually of lattice construction with each unit consisting of two or more sections telescoping one within another. There are many practical difficulties in assessing the strength and other related properties of these units by analytical approach alone and it has become customary for the users to rely on safe load tables and other information largely based on test results and published in the suppliers' literature.

At present in the UK there is no generally recognized method of conducting these tests or interpreting their results. It is hoped the tests described here will provide a common and verifiable basis for the determination of structural properties. Using appropriate safety factors, load/span tables can be prepared. These methods can also be used as a design tool when developing a new or modified type of floor centre, as an aid in quality control in production and for assessing the degree of serviceability of used floor centres.

Guidance on the application of test 1 to the last kind is given in Appendix A.

Guidance on which tests to use in particular circumstances is obtainable from Appendix B, which sets down the basis on which tests were formulated. Appendix C suggests how the test data may most usefully be interpreted for the user.

At least two tests of each type should normally be undertaken.

The material of which the samples tested are made will sometimes have significantly better properties than the minimum required by its specification. Thus the test results from such samples will give optimistic results for the equipment. Consideration was given to adjusting the results based on the relationship of minimum strength expected and that of the critical part of the centre. However, owing to the difficulty of setting down a precise and reliable method for local testing and adjustment of the properties it was not possible to include this proposal.

Successful use of this standard method will produce more meaningful data from fewer tests. It is hoped users will record problems so that if necessary improvements can be made in due course.

The test methods specified in this standard provide information for the great majority of requirements. Where other tests are needed the information given will be of direct use in formulating them.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

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

1 Scope

Four tests are specified for establishing the structural properties of floor centres in respect of bending strength, deflection, shear, strength at the overlap and the effect of propping from below. These can be used both for initial assessment, and to assess used equipment. Metallurgical examination is not considered.

2 Reference

The title of the publication referred to in this standard is shown on the inside back cover.

3 Principles

3.1 Symbols and subscripts. The following are the meanings of the main symbols and subscripts used in this standard.

Symbols

a	length of the horizontal part of the bearing tongue [see Figure 6(a)].
b	horizontal distance between the support face (at the root) of the bearing tongue and the centre of the end bearing [see Figure 6(a)].
c	clearance between a loading platform and the adjacent section (see Figure 3).
d	dimension of a loading platform along the centre line of the unit (see Figure 1, Figure 2 and Figure 3).
k	clear distance between the ends of two non-adjacent sections in a three section unit (see Figure 4).
l	overall length of the floor centre excluding the horizontal parts of the bearing tongues [see Figure 1, Figure 2, Figure 3 and Figure 6(a)].
P	test load applied through one loading platform or loading beam to two units (see Figure 1, Figure 2, Figure 3 and Figure 5).
δ	the deflection of the points specified in various tests, calculated or observed as appropriate.
δ_m	deflection of the top surface at the centre of the span in tests 1, 2 and 3 with reference to the ends.
δ_P	the deformation remaining, in test 4, when the load is removed.

Subscripts

max and min	refer to the maximum and minimum extension of the units.
i	initial reading.
m	at the centre.
P	permanent deformation.
1 to 4	refer to the tests of these numbers.
ult	the figure at failure.

The meanings of other symbols used are given in the text.

3.2 Definition. For the purposes of this Part of BS 5507 the following definition applies.

floor centre
an adjustable metal beam of two or more telescoping sections usually of lattice construction used to support soffit formwork. Its use is structural

3.3 Accuracy of readings and tolerances. test loads, deflections and spans should be measured within the following limits.

a) $\pm$ 0.04 P or $\pm$ 0.02 P_{ult} whichever is the more restrictive for the test load P;

b) $\pm$ 1 mm for the central deflection δ_m;

c) $\pm$ 0.2 mm for the local deformation δ_p;

d) $\pm$ 5 mm for the clear span l;

e) $\pm$ 2 mm for the dimension locating the bearer tongue support b.

3.4 Sampling. Before setting up the tests, the tester shall identify the specimens by comparing them with drawings and other documents supplied by the organization requesting the test and note complete agreement on points of discrepancy. The compliance shall be within specified or implied tolerance limits and include dimensions, weight, form and construction details. The purpose of this inspection is to ensure that the units tested are representative samples of the group and to allocate to them an appropriate identification reference.

3.5 Preparation of specimens. Units shall be tested with fixing components such as bolts, turnbuckles, pins and wedges in position and fully tightened up in accordance with instructions for use from the supplier so as to eliminate slackness at joints and thus achieving maximum camber.

4 Test arrangement and apparatus

4.1 General. Floor centres are generally used in assemblies of two (inner member and outer member) or three (two outers and one inner or two inners with the centre section an outer). These assemblies are usually free standing, i.e. simply supported at each end, but sometimes an intermediate support is used. Where such supports are used it is usual for the screw or wedge connector adjacent to the prop to be loosened so that the spans are simply supported on the prop.

If it is required to determine the ultimate bending strength of a floor centre assembly it may be necessary to consider the position of an overlap between members as this can be the most critical section of the assembly when subjected to bending. It is also important to consider the shear capacity of assembled floor centres, both at the ends where the lug supports occur and at any other positions including where intermediate supports may be positioned.

In all tests two floor centres shall be placed side by side 450 mm to 750 mm apart and parallel to each other. The load shall be applied to the centres distributed as uniformly as possible, and transmitted via loading beams spanning transversely between floor centres. Packing pieces may be used to ensure that the pressure on the top of the floor centre is uniform, e.g. under the horizontal loading beams in cases where two floor centres have slightly varying profiles. Loading beams used to transmit loads to the floor centres should be sufficiently stiff to prevent any torsion being induced in the floor centres.

It is important that any load spreading equipment should not give additional stiffness or strength to the floor centres being tested. Failure of the floor centres can occur in the vicinity of an overlapping joint; consequently, loading beams and any packing material should be kept clear of these areas.

To produce a loading simulating a UDL a number of loading beams, at least 4, should be positioned at equal centres of not more than 1 m and such that the distance from the supports to the nearest loading beam is half the distance between loading beams.

4.2 Details of supports. For tests 1, 2 and 3 the end details shall be generally in accordance with Figure 6(a) except that, if preferred, the 20 mm diameter roller may be replaced by a half-round ridge of 20 mm diameter and either securely fixed to the underside of the packing or forming an integral part of it. The packing piece shall be secured to the bearer tongue by screws, clamps, clips or similar means in such a manner as not to affect the strength or stiffness of the end attachment. The dimension b shall be equal to $a/2$ when $a > 40$ mm, and to 20 mm in all other cases. The packing piece (with the 120° locating groove) and the 20 mm roller bar should be of steel.

4.3 Load points and unit configuration

4.3.1 *Test 1. Bending moment and deflection.* [See Figure 1, Figure 5(a) and Figure 6.] This test procedure produces information on bending and deflection characteristics of floor centre assemblies spanning freely between end supports and where an overlapping joint does not occur near to the span centre. The maximum bending moment is therefore applied to a part of the structure other than at an overlap.

The number of loading points may vary with the span so that the load distribution on the centres follows closely a uniformly loaded condition, e.g. Figure 1 shows a satisfactory arrangement for a span of 5 m using 8 point loads.

Test 1 is suitable for both two and three member assemblies simply supported at the ends.

Unless otherwise required test 1 shall be carried out on fully extended floor centres when $l = l_{max}$.

4.3.2 *Test 2. Interaction forces at lapped joint.* [See Figure 2, Figure 5(a) and Figure 6.] The intention of this test is to subject the minimum overlap length of two members to bending. The procedure will provide information on bending and deflection characteristics of an appropriate combination of two members spanning freely between end supports. The overlap joint should be positioned as near to the centre of the span as is possible when the floor centre is fully extended. This arrangement is designed to test the bending strength of the minimum overlap length.

Figure 2 shows a typical testing arrangement. The number of loading points may vary with the span with the intention of applying a maximum and constant bending moment in the vicinity of the lapped joint.

4.3.3 *Test 3. Shear and support forces.* [See Figure 3, Figure 5(a) and Figure 6.] This test produces information on shear at floor centre ends and bearing tongue strengths. The floor centre under test will consist of two members as far as possible, provided that there is at least 150 mm between the support under test and the end of the further member. Loads are to be applied close to the end under test and each type of end should be tested.

Figure 3 shows a typical testing arrangement.

4.3.4 *Test 4. Intermediate propping force.* [See Figure 4 and Figure 5(b).] This test produces information about propping a component and any deformation caused. For units with solid webs the load shall be placed at the centre line. In the case of lattice construction, it shall be placed under the node point nearest the centre line. Alternatively, it may be placed midway between the node points nearest the centre line. Exceptionally for this test, only a pair of single components is used.

In this test the load P shall be capable of being completely released at any stage by removing the loading beam so as to permit measuring the local deformation δ_P. For convenience, in this test only, the floor centres may be turned upside down and the test load, which represents a propping force, be applied downwards.

4.4 Instrumentation. Central deflection readings are obtained by subtracting the average vertical displacement of the bearing tongue from the gross value of the central deflection, both measured at the centre of the upper faces.

Provision shall be made in test 1 for recording deflection readings of the upper surface at the centre and directly above the supports.

The reference level for measuring the local deformation δ_P in test 4 shall be the average level, at the time of taking the reading, of two points on the bottom chord or flange, 300 mm apart, one on each side of the loading beam and equidistant from it. The instrumentation shall permit separate measurement of the deflections for each unit (in a pair of units).

5 Testing procedure

5.1 Initial loads. Before commencing the tests the expected value of the failure load, P_{ult}, shall be estimated (e.g. by approximate calculations or by interpretation of the known results of similar tests).

For tests 1, 2 and 3, in order to eliminate secondary effects such as slackness at joints, twist of units and unequal bearing at the supports, the following procedure should be adopted.

Initial loads P_i, not exceeding 10 % of the expected loads at failure, should be applied before taking the first (i.e. initial) deflection readings. The magnitude of P_i shall be recorded.

These loads shall not be removed or reduced until the test is completed.

One or more cycles of loading and unloading are desirable, provided that the maximum load does not exceed 40 % of the expected failure load P_{ult}. The self weight of the specimens shall not be included in the recorded force P.

5.2 Test loads. After applying the initial load, additional test loads shall be applied progressively. They should be sustained at a constant value for as long as the central deflection increases by more than 1 % (of total deflection) per minute.

The first test load increments should normally be between 5 % and 10 % of the estimated failure load. However, towards the end of the test when failure appears to be imminent smaller load increments may be more appropriate.

5.3 Failure loads. Each test shall continue until the maximum attainable load is reached, P_{ult}.

The following loads shall be recorded.

a) The load at which the central deflection δ_m exceeds *1*/80 from the horizontal (tests 1, 2 and 3).

b) The load at which the local permanent deformation δ_P exceeds 3 mm (test 4).

c) The load at which first signs of permanent damage are observed (e.g. inelastic deformation in bending or buckling, weld cracks, total failure of pins or other minor parts).

The magnitude of the failure load and the mode of failure shall also be recorded.

5.4 Permanent deformations. It is important to record the nature of all deformations and the loads at which they occur. When deformation or local damage is observed it may be necessary to reduce the loads so as to be able to inspect more thoroughly the parts affected. This procedure is necessary in any case in test 4.

5.5 Special requirements. If, additionally, experimental information on the central deflection at intermediate spans is needed, test 1 should be supplemented by appropriate complementary tests.

Test 3 is valid for the determination of the critical values of the shearing and reactive forces at one end of the unit only. If specimen details at the other end are different (or more generally when the unit is not symmetrical about its central line) the end to which the particular test refers shall be recorded.

It is particularly important in test 2 to keep under close observation the behaviour of the locking and clamping devices and other constructional details at the telescopic joint. (See also **5.3**.)

The determination of the permanent local deformation δ_P in test 4 may be largely a question of a trial and error approach, since it cannot be measured until the load is removed and there will be no permanent deformations until the load exceeds a certain value. It should be borne in mind, however, that failure in a different mode may take place before the deformation δ_P becomes measurable.

6 Interpretation

6.1 Units of measurement. Regardless of the system of units used in setting up the tests and taking readings, the test results (P, P_{ult}, δ_m, δ_P) and the derived properties (moments and shear forces) should be finally presented in the International System of units (SI). The number of significant digits in the final quantities should normally be one more or at most two more than the number required for the accuracy limits given in **3.2** and all the results should be rounded off accordingly.

6.2 *Text deleted.*

6.3 Deflections. After applying the initial load, as described in **5.1**, the initial camber is measured, by relating the positions of the top of the centre of the unit to the top at the ends. These points are used as the reference levels for measuring the central deflections δ_m. On completion of testing, these deflections shall be corrected by adding to each of them the constant quantity $\Delta = r \times P_i$, in which r is the average rate of change of deflection with load during the linearly elastic stage of behaviour and P_i is the initial load. Δ may also be obtained from a load/deflection diagram.

6.4 *Text deleted.*

7 Test report

7.1 Contents. The test report shall include the following information.

a) Adequate information by means of which the specimens tested can be reliably identified; this may be in the form of manufacturers' drawings, specially prepared sketches or extracts from trade catalogues. The type, the mark and, if known the year of manufacture of the units shall be given.

b) Sufficient information on the test set-up (including the magnitude of the initial camber and initial load P_i) and any special features of it to allow the test to be repeated in all its essentials solely on the basis of the information contained in the report and in this standard.

c) The test results, i.e. the quantities δ_m and δ_P for various test loads P, the ultimate loads P_{ult} and the basic derived properties given in **6.4**.

d) Other information relevant to the test, for example the organization commissioning the test, the testing laboratory, the date of the test and comments on the behaviour of the units under test loads, including a description of failure modes.

7.2 Presentation of test results. The test results shall be reported in a compact unambiguous manner, preferably in tabular form. The results which in the opinion of the testing laboratory may lie outside the accuracy limits stipulated in **3.2**, but are nevertheless included, shall be inserted in round brackets and the reason for suspecting larger than normal inaccuracies noted. Only the final quantities [listed under c) in **7.1**] need be given, without quoting the readings from which they were derived.

7.3 Test description. Without omitting any of the requirements given in **7.1**, the descriptive contents of the report should be as brief as practicable. Dimensioned sketches should be used in preference to purely verbal descriptions. A set of photographs may be included in an appendix to the report, together with other descriptive matter, while the main body of the report should contain the test results and the minimum information necessary to make it a self-contained document.

7.4 Authenticity of report. The test report shall be authenticated by a person in authority and his status and/or qualification given.

Appendix A Checking previously used floor centres

A.1 Purpose

Tests can provide information for assessing whether a group of used floor centres, all of which are in about the same state of wear and tear without being visibly damaged, are still suitable for normal usage. The tests may be done at site, at a maintenance workshop or at a storage depot. Data can be compared with that for new equipment.

A.2 Sampling

The pair which in the opinion of an experienced person are the weakest in any one group should be tested. Depending on the results, further testing may be required.

A.3 Testing

The selected units need be subjected to test 1 only. Generally, the same rules as given in the body of this standard should apply except that the site tests should not continue after the loads have reached 125 % of their safe working load. Alternatively the test may be continued to failure. The test report should contain only essential data and results and should be signed by the person in charge of the test.

A.4 Interpretation

Site testing should not be assumed to be a substitute for a thorough inspection and possible rejection of the floor centres in stock (either periodically or before each use) but should be viewed as being complementary to it. With this proviso the group may be considered as being satisfactory if both the following conditions are met.

a) None of the specimens tested suffers observable permanent deformation under a test load exceeding by 25 % the safe working load.

b) For deflection tests, the average central deflection of a pair of units should not exceed the corresponding average deflection of new units by more than 20 %. For failure tests, the average failure load of a pair of units should be not less than 80 % of the average ultimate load of unused units.

Appendix B Basic considerations

B.1 General

This appendix is mainly intended for the use of persons responsible for initiating a test programme, but may also be useful to those supervising the tests and writing up the test reports or who are concerned with interpreting the results. It elucidates the fundamental considerations forming the basis of the methods recommended by this standard.

B.2 Character of tests

Since the basic purpose of the tests is to provide results which would be of practical and, if necessary, immediate use, the test arrangements are more of a technical than a scientific nature. This consideration is reflected in the generous tolerance limits specified, in the neglecting of factors of secondary importance (e.g. frictional forces at supports) and in recommending method which require only simple and easily available test equipment. Although these simplifications may adversely affect the accuracy of the results, it is expected that only exceptionally will errors due to this source approach ± 10 %, which is acceptable for all practical purposes. Nevertheless, the test methods are sufficiently specific to make each type of test reproducible and the results comparable.

B.3 Critical parameters

Most types of failure of floor centres can be ascribed to the presence of either excessive bending moments or excessive shearing forces. In the case of failure of a telescopic joint the critical factor is the maximum value of one of the two coupling forces, whose magnitude depends on both the bending moment and the shearing force at the joint, i.e. on an interaction relation.

Good approximation of the bending moment distribution in floor centres, as normally used, is achieved in test 1. Although in this and other tests the imposed load intensity under the loading platforms is higher than it would be if the loads were distributed over the full span, such an arrangement reflects the possibility of the floor centres being subjected locally to higher than average loads. Since the central deflection depends predominantly on the bending moment distribution, test 1 is also valid for establishing load-deflection relations.

In test 2 the end shearing force and the support reaction are higher in relation to the maximum bending moment than they would be on a building site. The purpose of such an arrangement is to accentuate the effect of these forces and so make the interpretation of the test observations simpler and more reliable.

Test 3 is designed to investigate one critical factor, the coupling forces at telescopic joints. Their magnitude is obtained by dividing the bending moment M_3 (see **6.4**) by the minimum lever arm of the internal coupling forces. The test is concerned with assessing the effect of joint details on the behaviour of the specimen and with determining the failure value of the coupling forces.

Test 4 is intended for a single section only (not for a complete unit consisting of more than one section) and is concerned with the failure value of the propping force.

B.4 Factor of safety

The two most important stages in structural tests are the inception of inelastic behaviour and the final failure. The first stage may be due to such causes as local buckling, complete failure of minor parts or reaching the yield point of material in the major components. It leads inevitably to either a sudden total failure or large permanent changes in the overall geometry of the specimens. The second stage represents the ultimate load-carrying capacity. If the load interval between the two stages is small the failure may be classified as brittle; if it is large the failure is ductile. In the first case there is no or little warning of the impending total collapse and it is usual to apply to it a higher safety factor than that permitted for ductile failure. However, in the latter case it is still essential to ensure that there is an adequate margin against permanent local deformations occurring under working loads.

With floor centres being less amenable to purely analytical structural assessment than other load-carrying components used in construction it is especially important that the tests should not only determine the ultimate loads but also assess the mode and the nature of failure. The four tests described in this standard are intended to fulfil this requirement. With the aid of simple calculations they should suffice for the task of preparing a full set of safe load tables.

Appendix C Uses of test report

C.1 Presentation of results

Very often the user of floor centres will not be interested in all the technicalities of the tests, his main concern being whether the centres are safe for his intended use. The required information can be presented to him as a series of extracts giving the test results originally contained in several test reports, as a compilation of all the tests in a single document, or preferably (after suitable processing) as safe load tables. In the last case the assumed underlying criteria should be given.

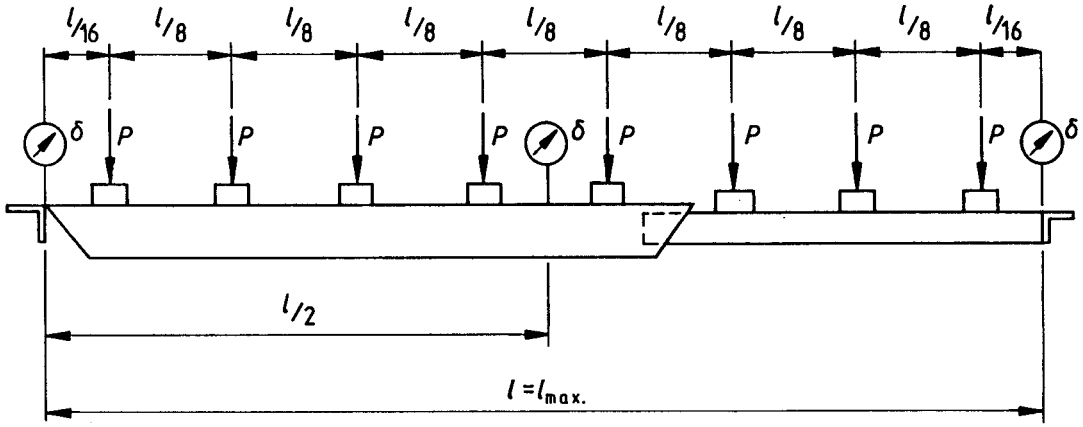


Figure 1 — Test 1 (for bending moment and deflection)

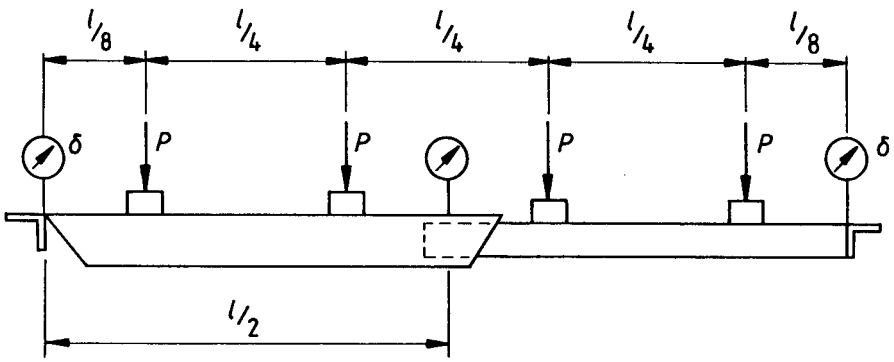


Figure 2 — Test 2 (for interaction forces at lapped joint)

C.2 Calculations

Normally the test results will have to be processed analytically before being used by a man on the job. The degree of analytical treatment may vary from merely dividing the failure load by a suitable safety factor in the case of an ad hoc test, to a sophisticated statistical analysis of the test results themselves, followed by an analytical treatment to obtain approximate values for intermediate data. Further extension of the result table may then be achieved by interpolation.

C.3 Supplementary tests

On rare occasions supplementary tests may be required to add to the information available from the four standard tests. Such a situation may occur when floor centres are modified in some minor detail or are used in a manner significantly different from normal.

An example of the first situation is the case when it is decided to use an end attachment different from that in the original test. In such a case only test 3 need be repeated and then only to the extent necessary to assess whether there is a significant reduction in the failing value of the bearing tongues.

The second group of supplementary tests, those necessitated by unusual loading conditions, may vary considerably in extent. Several additional tests may be required before it is decided whether a particular type of floor centre is suitable for the given dynamic, torsional and other unusual loads. The top flanges may also be in danger of collapsing owing to the absence of horizontal restraint normally provided by the formwork decking. On the other hand, a single test may be sufficient to confirm theoretical considerations in other cases, for example when centres support a trapezoidally distributed loading or, in addition to their normal function, are required to carry small loads attached to their bottom chords.

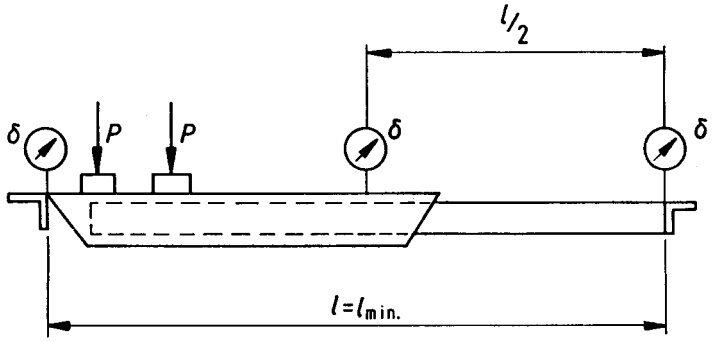
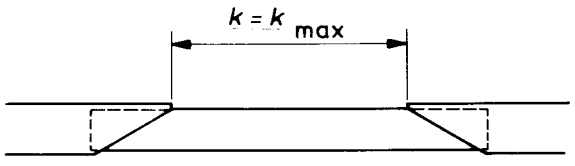
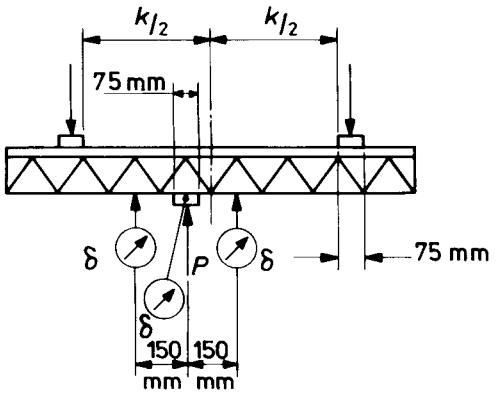


Figure 3 — Test 3 (for shear and support forces)



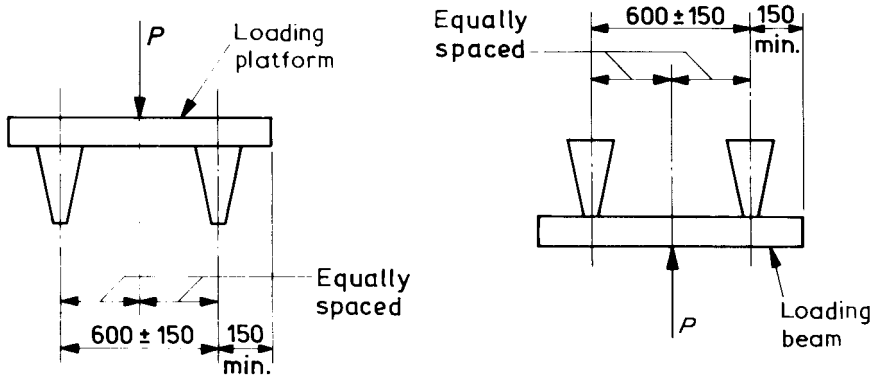
(a) Middle section at maximum extension



(b) Middle section under test

NOTE Intermediate propping of the bottom chord should preferably be at a node point. If another position is selected (as shown) this needs to be recorded.

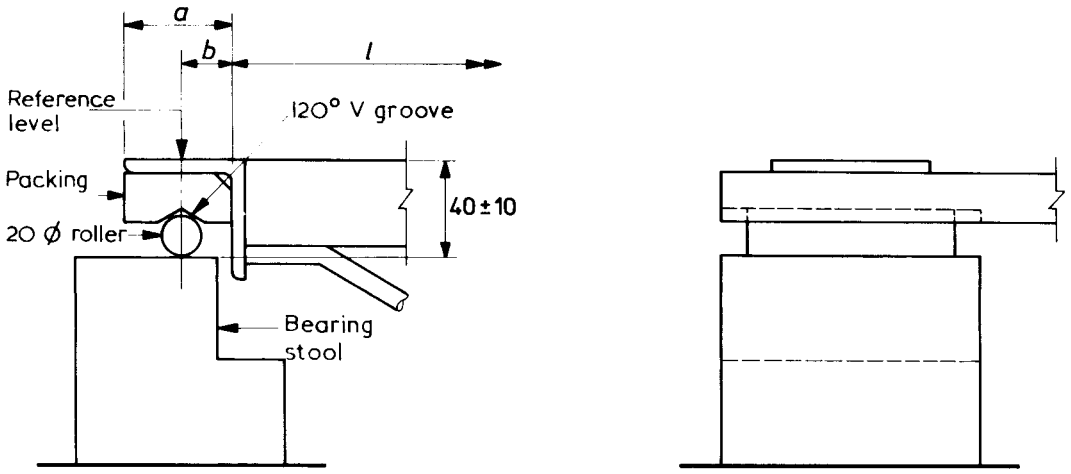
Figure 4 — Test 4 (for intermediate propping force)



(a) Tests 1, 2 and 3 (b) Test 4

All dimensions are in millimetres.

Figure 5 — Cross sections at loading points



(a) Section (b) End view

All dimensions are in millimetres.

Figure 6 — Support details in tests 1, 2 and 3

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Publication referred to

BS 2846, *Guide to statistical interpretation of data.*

BSI — British Standards Institution

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