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CODE OF PRACTICE FOR USE OF FIXING DEVICES IN WALLS, CEILINGS AND FLOORS OF SOLID CONSTRUCTION

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

CODE OF PRACTICE FOR USE OF FIXING DEVICES IN WALLS, CEILINGS AND FLOORS OF SOLID CONSTRUCTION

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CODE OF PRACTICE FOR USE OF FIXING DEVICES IN WALLS, CEILINGS AND FLOORS OF SOLID CONSTRUCTION

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 23 November 1961, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Building Division Council.

0.2 Fixing devices, such as expansion plugs, expansion bolts, etc. are of considerable usefulness in building work, but this is not so much appreciated in traditional methods of construction. Quite often it is found that wall plaster and other finishes are spoilt by subsequent operations for making fixtures by unscientific methods. Proper devices and tools will ensure a neat fixing work with minimum effort and little damage, and the fixtures will have adequate strength and durability. Special devices are also available for resisting dampness, chemical attack, thermal effects, etc. These features are bound to popularize, in course of time, the use of improved fixing devices in building work in this country. This standard attempts to provide the necessary guidance for their selection and fixing, giving also their essential dimensions and features, and situations of use.

0.3 In the case of masonry or concrete work wooden plugs are often employed for making fixtures, and these plugs are either embedded during construction or, when once the construction is over, they are inserted by cutting holes which are subsequently grouted. The practice of cutting large holes is detrimental to the completed masonry or concrete work and shall generally be avoided. Even embedded wooden block may not give permanent service since it would get dislodged from the masonry in course of time as a result of vibrations, disturbances, etc, in their vicinity. However, in view of its extensive use in present day practice, embedded wooden block is included in this standard as an accepted fixing device for the time being, and it is proposed to drop it when the building trade fully recognizes its shortcomings and prefers the use of better devices.

0.4 Another specification on fixing devices for use in cavity construction is under preparation.

0.5 Wherever a reference to any Indian Standard appears in this code, it shall be taken as a reference to the latest version of the standard.

0.6 Metric system has been adopted in India and all quantities and dimensions appearing in this standard have been given in this system.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS:2-1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.8 This code is intended chiefly to lay down requirements regarding design, quality of material and the manner of application of fixing devices, and it does not include all the necessary provisions of a contract.

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1. SCOPE

1.1 This standard lays down the essential features and methods of use of the following fixing devices suitable for use in walls and ceilings of solid construction:

a) Expansion wall plugs
b) Expansion shells
c) Caulked-in anchor devices
d) Built-in devices

1.2 This standard does not cover the use of fixing devices in hollow walls and cavity construction.

2. PRINCIPLES OF FIXING

2.1 Expansion wall plugs, expansion shells and caulked-in anchor devices are inserted in holes drilled in the masonry and, during fixing, they grip to the sides of the holes by lateral expansion. The force of grip developed depends essentially on the dimensional correspondence (or fit) of the fixing device and the hole in the direction of expansion and grip. As much *mechanical precision*, as is usual in the case of work on steel is, therefore, required in the drilling of holes for fixing purpose with regard to the lateral size or diameter. The size of the hole shall be equal to the overall diameter of the fixing device with only as much excess as is absolutely necessary for facility of insertion of the fixing device in the hole.

2.2 Built-in devices, as the name applies, are embedded in masonry at the time of construction and they may house a metallic thread for bolt fixtures or they may simply consist of a block of a relatively soft material for screw fixtures.

3. EXPANSION WALL PLUGS

3.1 Essential Features — Expansion wall plug is a hollow cylindrical plug inserted in a hole to which the fixture is made by means of a screw, or some times a nail, and it holds the fixture by expanding and gripping tightly to the sides of the hole in which it is housed.

3.2 Requirements

3.2.1 *General* — The expansion wall plug shall be sufficiently resilient to withstand the side compression to which it will be subjected in the hole when the fixture is made. It shall be termite-proof and reasonably damp-proof. It shall permit the tightening with manual force, and shall also facilitate the withdrawal and reinsertion of the screw when required. When used with the suitable screw and when fixed in accordance with the procedure specified in **3.6**, it shall develop the specified minimum strength as specified in **3.5.2** with a factor of safety of not less than four and without developing any crack or disturbance on the masonry into which the fixture is made.

3.2.2 *Materials and Construction* — Expansion wall plugs may be made of jute fibre, white bronze, lead alloy or any other suitable material depending upon the type of use it is required for.

3.2.2.1 Jute fibre plugs (*see* Fig. 1) shall have the jute threads so bonded with suitable bonding compound as to give them stiffness for insertion into the hole. The twisting of the threads shall be in such direction that the working of the screw while fixing does not untwist the fibres and break them.

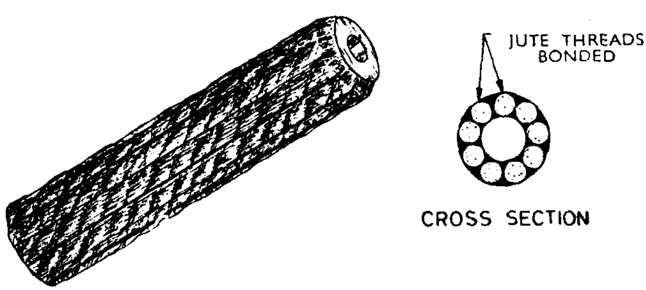


FIG. 1 JUTE FIBRE PLUG

3.2.2.2 White bronze plug shall have a flanged cross section as shown in Fig. 2 for facility of expansion and flexibility. It shall have exterior surface scoured or indented as shown in Fig. 2, to provide adequate anchorage against the sides of the hole when the screw is worked into the plug. One end of the plug may be coned to facilitate entry of the screw before tightening. The material and construction shall be such that the screw shall cut a perfect thread in the metal for facility of easy withdrawal, and at the same time expand the plug to the extent necessary for developing proper grip.

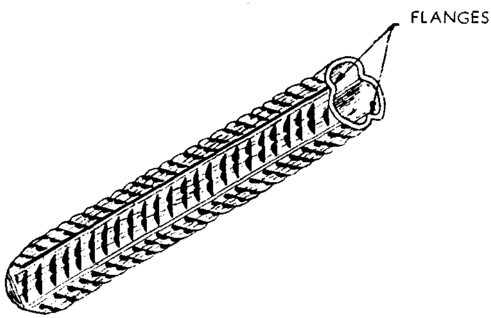


FIG. 2 WHITE BRONZE PLUG

3.2.2.3 Lead alloy plug shall be made of hard yet resilient alloy, ribbed externally to prevent rotation in the hole and coned and flanged at one end to facilitate the entry of the screw. They may preferably be grooved to assist expansion.

3.3 Screws for Expansion Wall Plug — Wood screws or coach screws conforming to IS : 451-1953 Specification for Wood Screws and IS : 1120-1957 Specification for Mild Steel Square or Hexagon Head Coach Screws with Gimlet Points respectively, shall be used with expansion plug. The size of screw suitable for each size of plug is given in Table I (*see* p. 6). Brass screws shall never be used with white bronze plugs. For best protection against corrosion, cadmium-plated screws may be used for white bronze plugs, and stainless steel screws for lead alloy plugs.

TABLE I SIZES AND LENGTHS OF EXPANSION WALL PLUG
(*Clauses* 3.3 *and* 3.5.1)

Nominal Size of Plug (Outside Diameter)	Length of Plug	Suitable Screw Sizes	
		Wood Screw Gauge No. (*see* IS : 451-1953)	Coach Screw Unthreaded Shank Dia (*see* IS : 1120-1957)
mm	mm		mm
3	10 to 25	3	—
4	10 ,, 25	6	—
5	10 ,, 50	8	—
6	15 ,, 50	12	—
7	15 ,, 50	14	—
8	25 ,, 65	16	6
9	25 ,, 65	18	6
10	25 ,, 65	20	8
12	35 ,, 75	—	10
16	50 ,, 90	—	12
20	65 ,, 100	—	16
25	75 ,, 100	—	20

3.4 Situations of Use

3.4.1 Jute fibre plugs may be used in most of the situations where resistance to vibrations, extremes of temperature and corrosive fumes of chemicals, is not important.

3.4.2 White bronze plugs will be specially suitable where there is vibration or where there are extremes of temperature.

3.4.3 Lead alloy plugs shall be used where acids and other corrosive chemicals or their fumes are likely to be present.

3.5 Selection of Size and Length

3.5.1 The sizes of plugs and the ranges of length in which they are used, are given in Table I. The size of the plug is referred to by its outside diameter.

3.5.2 In the case of steady constant loads applied, the safe minimum direct load for jute fibre expansion wall plug fixture in firm masonry (brick, concrete, etc) may be found approximately as follows:

$$p = 0{\cdot}35\, dl$$

where

p = maximum safe direct load in kg,
d = outside diameter of the plug in mm, and
l = length of plug bearing in the hole in mm.

The above formula allows normally for a factor of safety of five.

Where shock loads are likely to be encountered, the safe load shall be taken at half the value as for constant load.

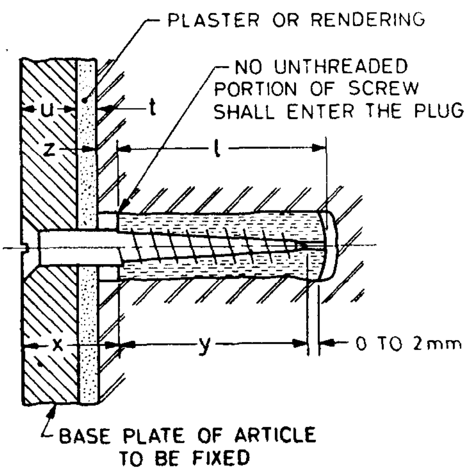
3.5.2.1 For being fully effective for strength development, the length of the plug shall be about 0 to 2 mm more than the threaded portion of the screw. Also the plug shall be housed entirely in the masonry of the wall and no part of it shall protrude into the plaster or rendering on the surface.

3.5.3 The appropriate size and length of the plug shall be selected giving due consideration to the load to be withstood by the fixture. Typical examples illustrating the selection of plug and screw are given in Appendix A.

3.5.4 The length of the plug (*see* l in Fig. 3) shall be about 2 mm more than the threaded portion of the screw (*see* y in Fig. 3). If in the available size of screw, a larger length of the threaded portion has to be accommodated, then the length of plug shall be correspondingly increased to satisfy **3.5.2.1**.

3.5.5 The unthreaded shank length of the screw (*see* x in Fig. 3) shall be equal to or greater than $t + u$, where t is the thickness of plaster or rendering over the wall and u is the length to be accommodated in the article to be fixed.

NOTE — Generally the unthreaded shank length is one-third and the threaded length two-thirds of the overall length of the screw.



l = Length of plug
u = Thickness of base plate of article
t = Thickness of plaster or rendering
x = Unthreaded length of screw
y = Threaded length of screw

$z = x - u - t$ = Depth up to which the end of plug should be sunk below the surface of hole

FIG. 3 DETAILS OF FIXING WITH EXPANSION PLUG

3.5.6 The depth of hole to be driven in the masonry exclusive of rendering shall be slightly more than $(l + x) - (u + t)$.

3.5.7 The sizes and lengths of expansion wall plugs suitable in building work are as follows:

a) Fixing of conduit saddles, cleats, wooden battens	4 to 5 mm size; 25 to 40 mm length
b) Fixing of electrical switches, switchboards, switchgears, light electrical fittings	3 to 10 mm size of suitable lengths
c) Light ceiling fittings	5 to 6 mm size; 25 to 40 mm length
d) Fixing of water-closets, wash basins, brackets, etc	7 to 8 mm size; 50 mm length
e) Light bath-room fixtures	4 to 5 mm size; 25 to 40 mm length
f) Fixing steel window frames	6 to 7 mm size; 50 mm length
g) Fixing door frames	7 to 8 mm size; 50 mm length
h) Fixing rain-water pipe	7 to 8 mm size; 30 mm length
i) Fixing roller shutters	9 to 10 mm size; 50 mm length

3.6 Method of Fixing — After the sizes and lengths of the expansion wall plug and screw are selected in accordance with **3.5**, the centres of holes shall be marked accurately either with reference to the article or fixture placed in position, or by measurements on it. The holes shall be drilled accurately with a suitable tool to a diameter equal to the size of the plug and the depth shall be as found in **3.5.6**. The plugs shall be inserted into the holes and thrust or even driven, if necessary, to the bottom. The article shall now be placed in position, and the fixture made by driving the screws into the plugs.

4. EXPANSION SHELLS

4.1 Essential Features — Expansion shell consists of an assembly of metallic segments forming a closed shell, which opens out when a bolt works through them and grips against the sides of the hole in which the device is inserted (*see* Fig. 4 and 5). It provides a heavy and reliable anchorage in any hard material, such as concrete, and grouting is unnecessary.

Expansion shells may be of loose-bolt type as shown in Fig. 4, where

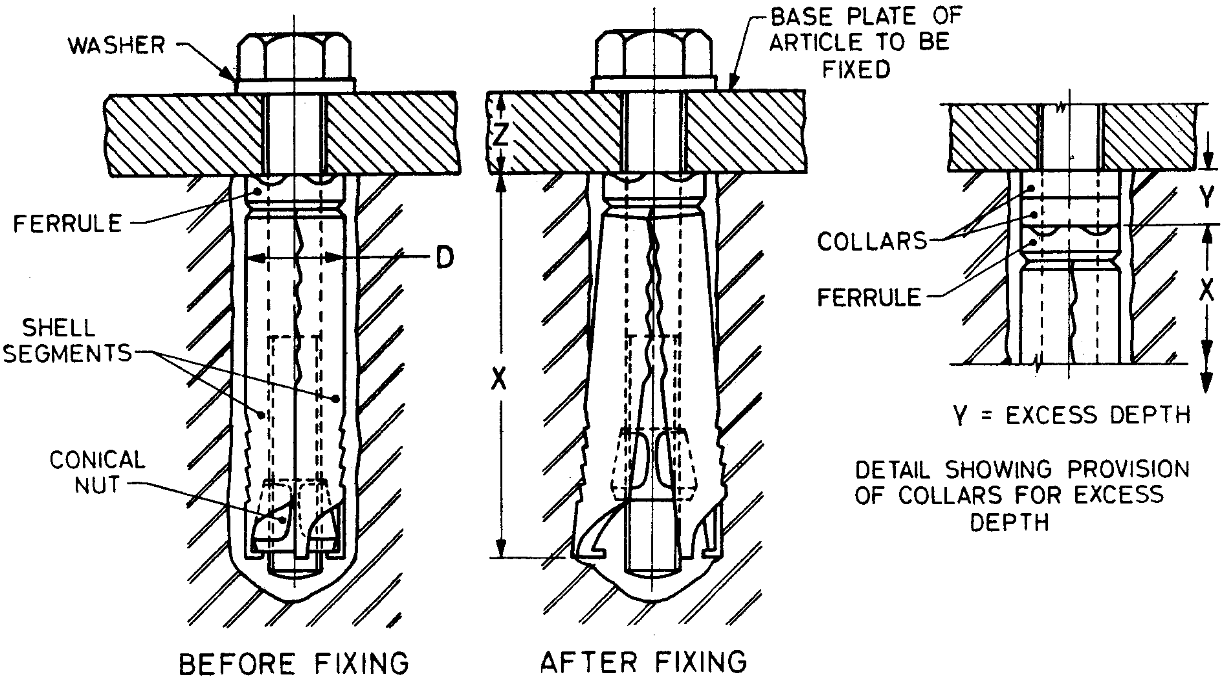


FIG. 4 EXPANSION SHELL—LOOSE-BOLT TYPE

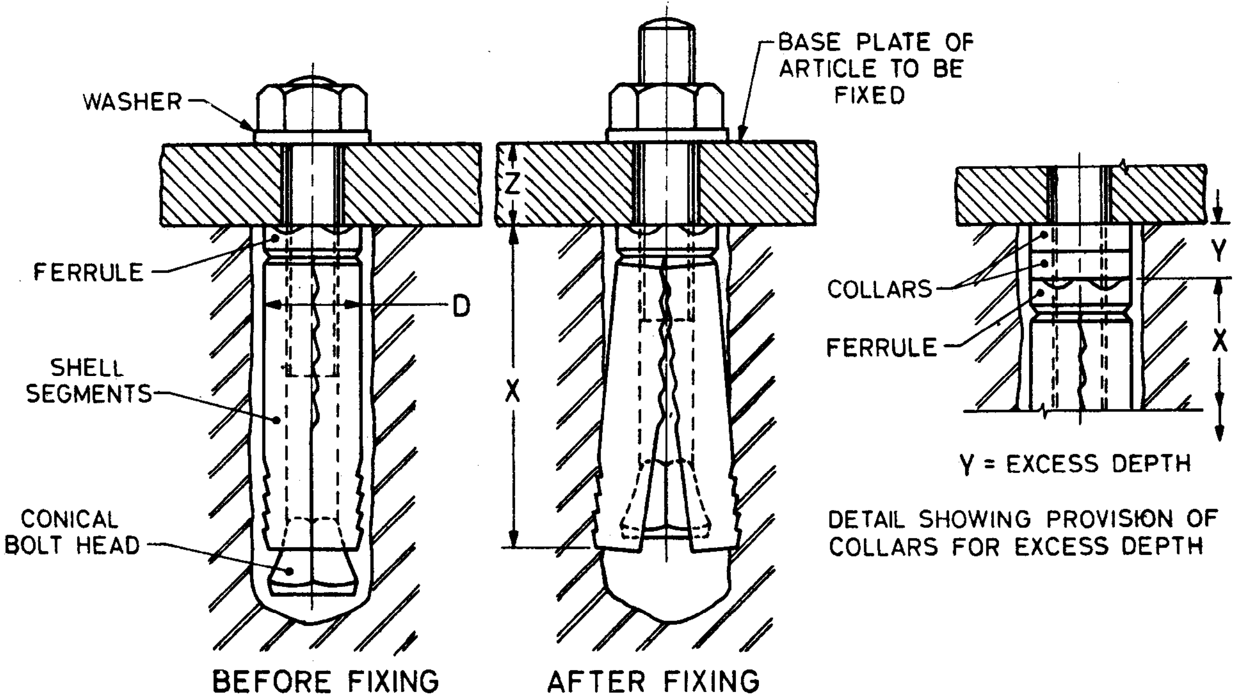


FIG. 5 EXPANSION SHELL—BOLT-PROJECTING TYPE

the bolt may be fitted independently at the time of fixture and worked with the bolt head at top, or of the bolt-projecting type as shown in Fig. 5, where the bolt is incorporated within the shell and its threaded end projects up to receive the nut at top.

The segments of the shell are held together by a ferrule at one end, and they open out by pivotal action. The bolt works through the centre of the ferrule. The nut within the shell negotiating the bolt-thread in the case of loose-bolt type and the bolt-head within the shell in the case of bolt-projecting type, are of special conical shape to ensure a smooth and even opening out of the segments when they travel up during tightening.

4.2 Requirements

4.2.1 *General* — The segments shall be generally four in number and shall open out uniformly. The design of the ferrule shall be such that during initial tightening at the time of fixture, it ensures that the shell does not have a longitudinal movement up the hole and cause the article to be fixed to rise above the surface. For facility of insertion and removal, the segments may be held together at the bottom by a spring ring; the spring will ensure uniform expansion and also positive collapse of the segments when the bolt is slackened. The segments shall have a serrated exterior at the area where they contact the sides of the hole for a positive grip. The design and construction shall be such as to develop a minimum anchorage strength as given in **4.5.5**.

4.2.2 *Materials and Construction* — The segments shall be made of malleable iron and the ferrule of mild steel. The segment ends shall be housed properly in the ferrule to ensure frictionless pivotal action and uniform opening out of the segments. The shape and workmanship of the conical piece (nut or bolt-head as the case may be) shall be such as to force open the segments evenly and freely as the piece travels up. The conical piece serving as nut shall have machined threads to negotiate the threads of the bolt it accommodates.

4.2.3 Expansion shells may also accommodate, instead of plain bolts, bolts fitted with hooks, eyes, pipe-clips, etc, for special situations of use.

4.2.4 When expansion shells are to be housed at more than ordinary depth for obtaining greater anchorage strength in the masonry, the gap between the top of the ferrule and the bottom plate of the article to be fixed should be filled with collars. Such collars shall be cylindrical rings of mild steel of suitable thickness with central hole to allow the bolt to pass through them. The collars shall have both faces parallel to each other and perpendicular to the axis of the bolt-hole.

4.3 Bolts for Use with Expansion Shells — The bolts for use in expansion bolt devices shall be made of mild steel and of standard sizes as specified in **4.5.1**. Each bolt shall have a nut of corresponding size (of conical or normal shape) to work with it smoothly.

4.4 Situation of Use — Expansion bolts are suitable for making heavy and positive fixtures as of ceiling fans, machinery, etc. The bolt-projecting type is convenient for making fixtures to walls and ceilings. The loose-bolt type is convenient for machinery fixture, as it facilitates movement without lifting machinery over the bolts.

4.5 Selection of Size and Length

4.5.1 The dimensions of expansion shell unit will depend upon the size of bolt it accommodates. The bolt sizes shall generally be in the following range:

6 mm, 8 mm, 10 mm, 12 mm, 16 mm, 20 mm, and 25 mm.

NOTE — By bolt size is meant the diameter of the bolt shank.

4.5.2 The outer diameter D (*see* Fig. 4 and 5) of the shell assembly with segments in the folded position may be 1·7 to 1·8 times of the size of the bolt.

4.5.3 The overall length of the shell assembly including the ferrule may range from 2·5 D to 4·5 D.

4.5.4 The thickness of collars for use in expansion bolt assembly may range from 6·5 to 12·5 mm.

4.5.5 The safe direct load taken by expansion bolt fixture may be found by actual pull-out tests or from the data supplied by the manufacturer of these fixtures. A factor of safety of not less than five shall be allowed for the working load in the case of constant loads. The factor of safety shall be not less than ten in the case of shock loads.

4.5.6 The safe direct shear load may be taken as three-fourths of the safe direct load mentioned in **4.5.5**.

4.5.7 The appropriate size of the bolt shall be selected with due consideration to the load to be taken by the fixture.

4.5.8 The length of the shell shall be chosen in the range given in **4.5.3**, depending upon the type and condition of material (brick, concrete, etc) in which the fixture is made, and this is best done in accordance with the results of actual pull-out tests made, or the advice obtained from the manufacturer.

4.5.9 The depth of the hole for the fixture shall be to the extent where firm masonry is obtained for proper anchorage and may, if necessary, be more than what is required for accommodating the shell only, and the excess depth shall be filled up with collars as described in **4.6.1** and shown in Fig. 4.

4.5.10 The length of the bolt shall be sufficient to accommodate the following (*see also* Fig. 4 and 5):

a) the portion x to be engaged in the ferrule and the segments of the shell for expanding them and developing the grip on to the masonry,

b) any excess depth y provided in the hole for purpose of anchorage (*see* **4.5.9**), and

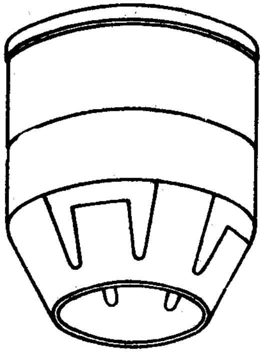
c) the length z required to negotiate in the article to be fixed.

4.6 Method of Fixing — After the selection of the size and length of the bolt in accordance with **4.5**, hole centres shall be marked accurately for the fixture. Holes shall be drilled to such finished diameter that the expansion shell just fits snugly into them (*see also* **2.1**). The depth of the hole shall be sufficient to accommodate the length of shell and ferrule completely, or in the case of weak masonry it shall be more for purpose of adequate anchorage. The shell shall be inserted into the hole with the bolt in the case of bolt-projecting type, and without the bolt in the case of loose-bolt type. Any excess depth of hole above the ferrule provided in the case of weak masonry shall be filled up with collars. The article shall then be fixed in position and the bolt (in the case of loose-bolt type) or the nut (in the case of bolt-projecting type) shall be fitted and tightened to obtain the anchorage.

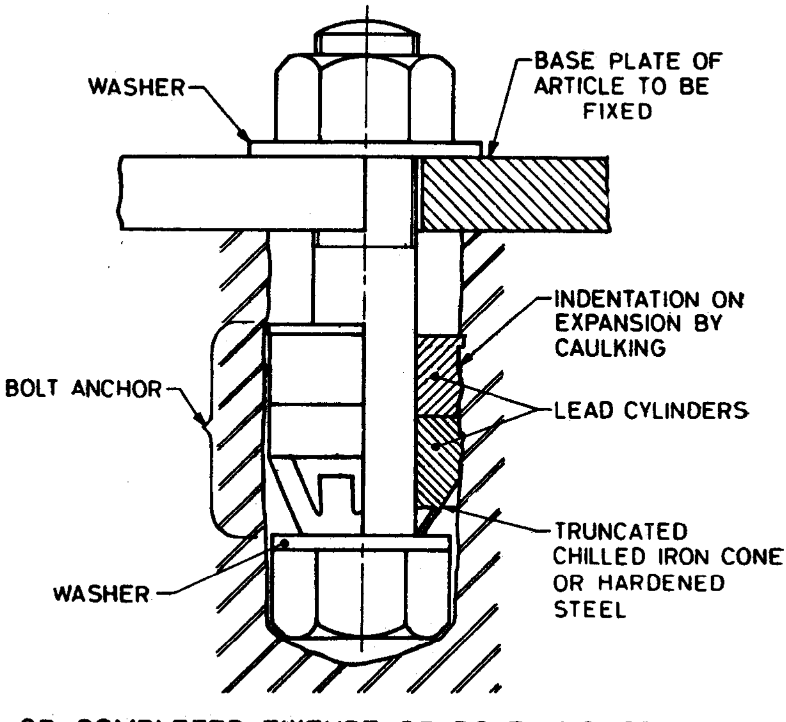
5. CAULKED-IN ANCHOR DEVICES

5.1 Essential Features — There are two types of caulked-in devices, namely, the bolt-anchor and the expansion tamp. Their design and construction shall be such as to obtain a minimum anchorage strength as given in **5.4.4**.

5.1.1 *Bolt-Anchor* — By means of the bolt-anchor the head of the bolt can be held down in the hole so that the threaded end projects out and accommodates a nut for fixing the article (*see* Fig. 6). The bolt-anchor shall essentially consist of a truncated specially chilled iron or hardened steel cone with segments capable of opening out evenly on application of caulking pressure; the caulking is done on a cylindrical crown of lead attached to the cone. The segments shall have sharp edges which will dig and bite into the hole. The cone and the crown shall have central holes for the passage of the bolt. When the bolt-anchor is caulked into position the effect of caulking distends the lead crown and forms a seal against the walls of the hole, and at the same time the up-pointing iron segments of the cone opened out and the hardened points are forced into the masonry, thus giving a sealed and anchored fixing. Bolt-anchors may be



6A GENERAL APPEARANCE OF BOLT ANCHOR



6B COMPLETED FIXTURE OF BOLT ANCHOR

FIG. 6 DETAILS OF BOLT-ANCHOR

used in one or more numbers with a single bolt to develop the strength of anchorage required. Bolt-anchor will facilitate only the type of fixture where the bolt thread projects out.

5.1.2 *Expansion Tamp* — This device secures in the hole a metallic thread to which a fixture can be made by screwing down bolts (*see* Fig. 7). The expansion tamp shall consist of a threaded steel sleeve around which is cast a cylinder or lead alloy. The shape of the sleeve shall be such that the thread aligns itself centrally when the tamp is inserted in the hole and is not disturbed from the alignment by caulking operations. The tamp is inserted into the hole with the lead encasement at the top and pushed to the bottom, and when the lead encasement is caulked, it is distended to press against the sides of the hole and anchor the metallic thread in position. Expansion tamp will facilitate a loose-bolt type fixture.

5.2 Bolts for Use with Caulked-in Devices — Normal hexagonal or square headed bolts may be used, and their sizes shall correspond to the central hole of the bolt-anchor or the thread encased in the expansion tamp.

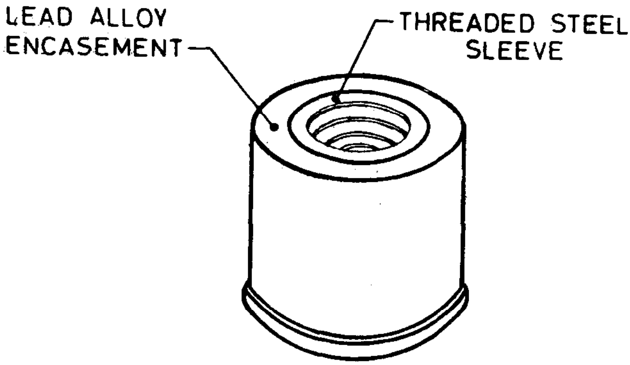
5.3 Situations of Use — Caulked-in devices give a sealed fixing without permitting access to solutions, water, etc, to collect in the sump of the hole. They are, therefore, suitable for use in dairies, breweries, collieries, dams, harbour and dock installations for fixing machinery and plant. Caulked-in devices are equally effective in vertical or horizontal holes, where they can be dropped in position. Bolt-anchor is bolt-projecting type of fixture, and expansion tamp is loose-bolt type. Relative advantages of bolt-projecting and loose-bolt types of fixtures are discussed in **4.4**. Expansion tamps are frequently used where it is necessary to have shallow fixtures in reinforced concrete, such as, where the reinforcement restricts the depth of hole that can be bored.

5.4 Selection of Size

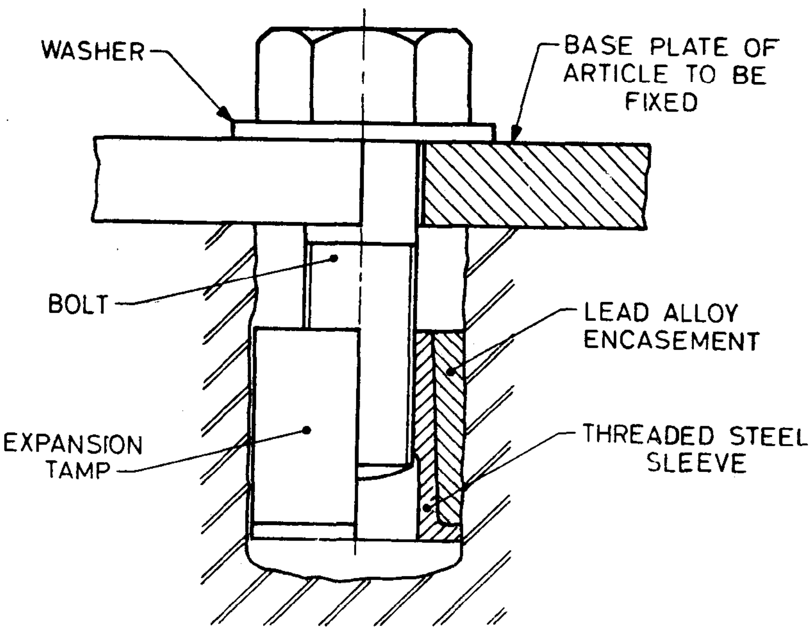
5.4.1 The dimensions of bolt-anchor or expansion tamp will vary with the sizes of the bolt they accommodate. The bolt sizes shall generally be as given in **4.5.1**.

5.4.2 The outside diameter *D*, of the bolt-anchor as well as the expansion tamp may be taken approximately as twice the size of shank of the bolt.

5.4.3 The length of the load portion that is caulked, namely, the crown of the bolt-anchor or the outer cylinder of the expansion tamp, may be taken as approximately equal to the outside diameter.



7A GENERAL APPEARANCE OF EXPANSION TAMP



7B COMPLETED FIXTURE OF EXPANSION TAMP

Fig. 7 Details of Expansion Tamp

5.4.4 The ultimate direct load taken by the bolt-anchor properly fixed in standard quality concrete, shall be at least equal to the tensile breaking load of the bolt.

This shall be verified by actual pull-out tests, unless detailed data is available from the manufacturers of these devices. The safe direct pull load may be taken as one-fifth of the ultimate load, in the case of uniformly applied loads and one-tenth of the ultimate load in the case of shock loads.

Where masonry is weak, additional holding power with bolt-anchors may be obtained by drilling deeper than normal and applying more than one anchor to the bolt.

5.4.5 The size of bolt-anchor caulked-in devices shall be selected with due consideration to the strength of the masonry.

5.4.6 Expansion tamp being essentially shallow fixtures, a depth of hole that is equal to four to six times the diameter of the holding bolt will be sufficient for it in masonry of standard quality.

5.4.7 The length of the bolt shall be sufficient to engage in the fixing device in its position of anchorage, and also to provide necessary fixing length for the article.

5.5 Method of Fixing

5.5.1 After selection of the size of the caulked-in device in accordance with **5.4**, hole centres shall be marked accurately for the fixture. Holes shall be drilled to such finished diameter that the fixing devices snugly fit into them (*see also* **2.1**), and the depth of hole shall be as specified in **5.4.6**. The fixing shall then be made as in **5.5.2** or **5.5.3** as may apply.

5.5.2 *Fixing with Bolt-Anchor* — The bolt shall be dropped into the hole so as to lodge well at the bottom with its hole in vertical alignment. A steel washer shall then be dropped on the head of the bolt followed by the bolt-anchor with its cone downwards. The anchor hall be caulked in position with a proper caulking tool or tubing giving sharp blows with a heavy hammer until the job feels solid. The caulking tool shall be withdrawn and, if the bolt used is more than 12 mm size, a second lead cylinder shall be placed over the bolt-anchor and caulked once more as before. The anchor is now ready for fixture, and the article shall be placed in position against the projecting ends of bolts and fixed by means of nuts. The completed fixture is as shown in Fig. 6B.

5.5.3 *Fixing with Expansion Tamp* — The expansion tamp shall be dropped in position so as to lodge well at the bottom with its hole in vertical alignment. The tamp shall then be caulked as explained in **5.5.2**, till the lead cylinder expands and anchors the threaded sleeve well into the hole. The anchor is ready for fixing and the article shall be placed in position against the holes and fixed by means of bolts. The completed fixture is as shown in Fig. 7B.

6. BUILT-IN DEVICES

6.1 Essential Features — These devices are built in during construction of the masonry or concrete work and may be in the form of a metallic socket incorporating a thread for making a bolt fixture, or may be a wedge-shaped wooden plug to which the fixture can be made by means of nails or screws.

6.1.1 The metallic socket (*see* Fig. 8) may preferably be of malleable iron. It shall be tapped centrally to take bolts of standard sizes as specified in **4.5.1**. The socket may be provided with an enlarged base flange, fins, etc, for positive anchorage by bearing. The design and construction of the socket shall be such as to develop the anchorage strength not less than the tensile strength of the bolt.

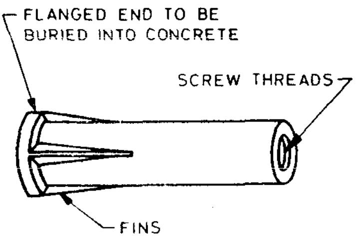


FIG. 8 METALLIC SOCKET

6.1.2 Wooden plugs shall be made of teakwood or other hardwood, and shall be wedge-shaped as shown in Fig. 9. The size shall be 20 mm square at one end, 25 mm square at the other end and 50 mm long.

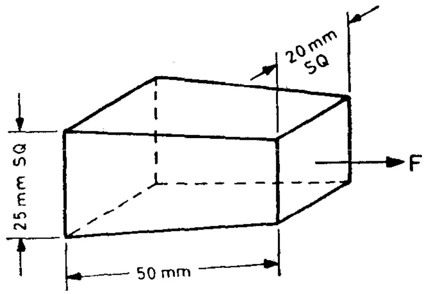


FIG. 9 WOODEN PLUG

6.2 Situations of Use — Metallic sockets with threads are useful only in locations where fixing points can be accurately determined at the time of construction of masonry or concrete, as later adjustments are not possible. They facilitate loose-bolt type fixtures with corresponding advantages as mentioned in **4.4**.

6.2.1 Wooden plugs shall be used only for light fixtures. They will not serve the purpose adequately if used in larger sizes than mentioned in **6.1.2**, in order to take heavy loads. Normally they may be used for light electrical fittings, picture hanging, etc.

6.3 Selection of Size

6.3.1 The size of the socket to be used would depend on the bolt it has to accommodate as already mentioned in **6.1.1**. The outer diameter of the socket may be between 1·5 to 1·8 times and the length of socket 5 to 7 times the size of the bolt shank.

6.3.2 For wooden plugs the complete size is already specified in **6.1.2**, and larger sizes are not useful for fixing purposes because of the limitations explained in **0.3**.

6.3.3 The ultimate direct load taken by metallic socket fixtures will be not less than the breaking load of the bolt, and the safe direct load may be taken as one-fifth of the ultimate load in the case of constantly applied loads, and one-tenth of the ultimate load in the case of shock loads. The safe shear load may be taken as three-fourths of the safe direct strength. For design purposes the safe load may be calculated in the same manner as in **4.5.5**.

6.3.4 The safe direct load for wooden plug of the dimensions given in **6.1.2** may be taken as 50 kg, and the safe shear load as 25 kg. For larger loads, recourse shall be made to other types of fixing devices.

NOTE—The value 50 kg is arrived at as follows (*see* Fig. 9):

Mortar area sheared $= 25 \times 50$ mm
$= 12{\cdot}5\ cm^2$

Taking the safe shear strength as $1{\cdot}5\ kg/cm^2$,
the total strength $F = 4 \times 12{\cdot}5 \times 1{\cdot}5$
$= 75$ kg, *or* to be on safer side 50 kg.

6.4 Method of Fixing

6.4.1 Metallic sockets shall be placed in position and fixed during construction of masonry or concrete, and grouting may be used if necessary. The threaded hole in the socket may be protected with a wooden plug or a wad of paper to prevent entry of mortar during fixing.

6.4.2 Wooden plugs shall be fixed with grout around them if necessary, at the time of construction generally. If they are fixed later, a neat chase shall be made of a size slightly larger than the size of the plug, and the plug shall be fixed in the hole and the surrounding space grouted with neat cement mortar. In the fixture, the side with the larger cross section shall be inserted to be inside the wall.

APPENDIX A

(*Clause* 3.5.3)

EXAMPLES ILLUSTRATING THE SELECTION OF EXPANSION PLUG AND SCREW

A-1. EXAMPLE 1

A-1.1 Assume a single bracket with distributed load as given in Fig. 10A.

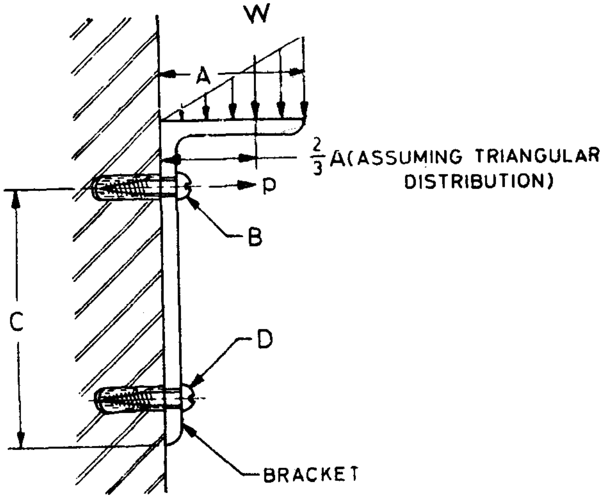
A-1.2 Then the pull p (kg) on screw B will be $\frac{A \times 2/3 \times W}{C}$ or $\frac{2AW}{3C}$, where W is the applied weight.

Let $A = 15$ cm, $C = 22$ cm, and $W = 66$ kg.

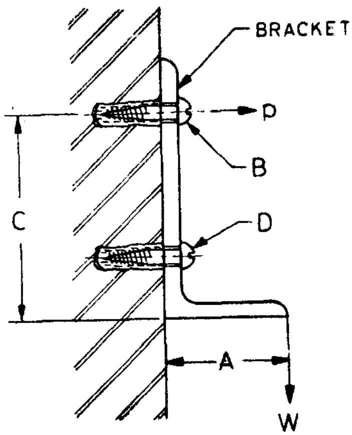
Then $p = \frac{2 \times 15 \times 66}{3 \times 22} = 30$ kg, which is the direct pull on screw B.

For practical purposes, the load in screw D may be ignored.

A-1.3 Referring to the formula given in **3.5.2**, namely, $p = 0{\cdot}35\ dl$, and substituting the value of p obtained in **A-1.2** in the above formula, we get $30 = 0{\cdot}35\ dl$; or $dl = 86$.



10A SINGLE BRACKET WITH DISTRIBUTED LOAD-EXAMPLE I



10B SINGLE BRACKET WITH CONCENTRATED LOAD-EXAMPLE II

FIG. 10 EXAMPLES ILLUSTRATING THE SELECTION OF EXPANSION PLUG AND SCREW

Plug diameters d are in established sizes, for example, 5 mm, 6 mm, 7 mm, etc, so that, if 5 mm size is chosen, the plug length required will be $l = \frac{86}{5} = 17{\cdot}2$ mm.

The nearest standard length available will be 20 mm; so the correct plug size for fixing will be 5 mm dia x 20 mm.

A-2. EXAMPLE 2

A-2.1 Another form of loading commonly met with is as shown in Fig. 10B.

A-2.2 The calculated pull p in fixing unit B in this case will be $\frac{A \times W}{C}$

Let A = 12 cm, C = 6 cm, and W = 60 kg.

Then $p = \frac{12 \times 60}{6} = 120$ kg.

This is the pull on screw B; again for practical purposes the load on screw D may be ignored.

A-2.3 Referring to the formula given in **3.5.2**, and substituting the value of p as above, we obtain $dl = 343$.

A-2.4 If, again the diameter of plug d, is chosen as 5 mm, then length l will be 68·6 mm, which will be rather long.

The plug length l should generally be limited to 50 mm so that d would then be $\frac{343}{50} = 6{\cdot}85$ mm.

The nearest size plug to this is the 7 mm diameter.

Therefore a plug of 7mm dia × 50 mm would be the correct size for use in this case.

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