IS : 2911 (Part II) - 1980
(Reaffirmed 1995)

Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF PILE FOUNDATIONS

PART II TIMBER PILES

(First Revision)

Fifth Reprint MARCH 1999

UDC 624.154.2.04:006.76

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

Gr 4

August 1980

Indian Standard

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Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF PILE FOUNDATIONS

PART II TIMBER PILES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part II) (First Revision) was adopted by the Indian Standards Institution on 29 February 1980, after the draft finalized by the Foundation Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Piles find application in foundation to transfer loads from a structure to competent sub-surface strata having adequate load bearing capacity. The load transfer mechanism from a pile to the surrounding ground is complicated and could not yet be fully determined, although application of piled foundations is in practice over many decades. Broadly, piles transfer axial loads either substantially by friction along its shaft or by the end bearing or both. Piles are used where either of the above load transfer mechanism is possible depending upon the subsoil stratification at a particular site. Construction of pile foundations requires a careful choice of piling system depending upon the subsoil conditions, the load characteristics of a structure, the limitations of total settlement, differential settlement, and any other special requirement of a project. The installation of piles demands careful control on position, alignment and depth, and involves specialized skill and experience.

0.3 Timber piles find extensive use for compaction of soils and also for supporting as well as protecting water-front structures. The choice for using a timber pile shall be mainly governed by the site conditions, particularly the water-table conditions. Use of treated or untreated piles will depend upon the site conditions and upon whether the work is permanent or of temporary nature. They have the advantages of being comparatively light for their strength and are easily handled. However, they will not withstand as hard driving as steel or concrete piles. Timber has to be selected carefully and treated where necessary for use as piles,

as the durability and performance would considerably depend upon the quality of the material and relative freedom from natural defects. This standard is intended to provide the guidance with regard to the selection and use of timber piles in foundations. This standard was first published in 1965 and has now been revised to align its provisions with other Indian Standards on pile foundations.

0.4 The Sectional Committee responsible for the preparation of this standard has, while formulating this standard, given due consideration to the available experience in this country in pile construction and also the limitations regarding the availability of piling plant and equipment.

0.5 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*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers the design and construction of timber piles used either for load bearing or for the compaction of ground.

NOTE — Sawn timber piles, generally used in sheet piling, are not covered in this code.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 For general terms relating to timber, reference may be made to IS : 707 - 1976†.

2.2 Allowable Load — The load which may be applied to a pile after taking into account its ultimate load capacity, pile spacing, overall bearing capacity of the ground below the pile, the allowable settlement, negative skin friction and the loading conditions including reversal of loads, etc.

2.3 Batter Pile (or Raker Pile) — The pile which is installed at an angle to the vertical.

*Rules for rounding off numerical values (*revised*).

†Glossary of terms applicable to timber technology and utilization (*second revision*).

2.4 Bearing Pile — A pile formed in the ground for transmitting the load of a structure to the soil by the resistance developed at its tip or along its surface or both. It may be formed either vertically or at an inclination (batter pile) and may be required to take uplift.

2.5 Brooming — Separation of fibres at butt or tip of a timber pile, caused by excessive or improper driving or improper treatment or due to deceased timber.

2.6 Cut-Off Level — The level where the installed pile is cut off to support the pile caps or beams or any other structural components at that level.

2.7 Draft Bolt — A metal rod driven into a hole bored in timber, the hole being smaller in diameter than the rod.

2.8 Factor of Safety — The ratio of the ultimate load capacity of a pile, to the safe load of a pile.

2.9 Follower — A piece of timber or steel or some other material which is used following the main pile when adequate set is not obtained and it requires to be extended further. The diameter of the follower should be the same as the diameter of the pile.

2.10 Nett Displacement — Nett movement of the pile top after the pile has been subjected to a test load and subsequently released.

2.11 Pile Line — The rope used to lift a pile and hold it in place during the early stages of driving.

2.12 Pile Ring — A metal hoop used to bind the head of a timber pile during driving to prevent splitting and brooming.

2.13 Pile Shoe — A metal protection for the foot of a pile to prevent damage or to obtain greater penetration when driving through hard material.

2.14 Safe Load — The load derived by applying a factor of safety on the ultimate load capacity of the pile or as determined in the pile load test.

2.15 Spliced Pile — A pile composed of two or more lengths secured together, end to end, to form one pile.

2.16 Test Pile — A pile which is selected for load testing and which is subsequently loaded for that purpose. The test pile may form a working pile itself if subjected to routine load test with up to one-and-a half times the safe load.

2.17 Treated Pile — A timber pile impregnated with a preservative material which retards or prevents deterioration and destruction due to organism.

2.18 Trial Pile — One or more piles, which are not working piles, that may be installed initially to assess load-carrying capacity of the piles. These piles are tested either to their ultimate bearing capacity or to twice the estimated safe load.

2.19 Total Electric Displacement — This is the magnitude of the pile due to rebound caused at the top after removal of a given test load. This comprises the two components as follows:

a) Elastic displacement of the soil participating in load transfer, and

b) Elastic displacement of the pile shaft.

2.20 Total Displacement (Gross) — The total movement of the pile top under a given load.

2.21 Ultimate Load Capacity — The maximum load which a pile can carry before failure of ground (when the soil fails by shear as evidenced from the load settlement curves) or failure of pile materials.

2.22 Working Load — The load assigned to a pile according to design.

2.23 Working Pile — A pile forming part of foundation of a structural system.

3. NECESSARY INFORMATION

3.1 For the satisfactory design and construction of pile foundation, the following information is necessary:

a) Site investigation data as laid down in IS : 1892-1979* or any other relevant Indian Standard code. Sections of trial boring, supplemented where appropriate by penetration tests, should extend sufficiently below the anticipated level of founding of piles but this should generally be not less than 10 m unless bed rock or firm stratum has been encountered. The nature of soil both around and beneath the proposed piles should be tested for strength and compressibility. Ground water level and conditions (such as artesian conditions) should also be recorded and chemical tests to ascertain the sulphate, chloride and other deleterious chemical content of soil and water should be carried out. This is particularly required in a job when extensive piling is to be undertaken.

*Code of practice for sub-surface exploration for foundation (*first revision*).

b) The experience of driving piles in the area close to the proposed site and any boring report thereof for assessing the founding level of piles.

c) For piling work in water, as in the case of bridge construction, data on high flood levels/water level during the working season, maximum depth of scour, etc, and in the case of marine construction data on high and low tide level, corrosive action of chemical present and data regarding flow of water, etc.

d) The general layout of the structure showing the estimated loads, vertical and lateral, including moments and torques at the top of the pile caps, but excluding the weight of the pile caps and piles. The level of pile caps should also be indicated.

e) All transient loads due to seismic and wind conditions and force due to water should be indicated separately.

f) Sufficient information of structures existing nearby should be provided.

3.2 As far as possible, all information in **3.1** shall be made available to the agency responsible for the design and/or construction of piles and/or foundation work.

3.3 The design details of pile foundation shall indicate information necessary for setting out, the layout of each pile within a cap, cut off levels, finished cap levels, orientation of cap in the foundation plan, the safe capacity of each type of piles, etc.

4. EQUIPMENT AND ACCESSORIES

4.1 The equipment and accessories would depend upon the type of timber piles job by job and would be selected giving due consideration to the subsoil strata, ground-water conditions, type of founding material and the required penetration therein wherever applicable.

4.2 Among the commonly used plants, tools and accessories, there exist a large variety; suitability of which depends on the subsoil conditions, manner of operations, etc. Brief definitions of some commonly used equipments are given below:

Dolly — A cushion of hardwood or some suitable material placed on the top of casing to receive the blows of the hammer.

Drop Hammer (on Monkey) — Hammer, ram or monkey raised by a winch and allowed to fall under gravity.

Single or Double Acting Hammer — A hammer operated by steam, compressed air or internal combustion, the energy of its blows being derived mainly from the source of motive power and not from gravity alone.

Kentledge — Deadweight used for applying a test load to a pile.

Pile Frame (*or Pile Rig*) — A movable steel structure for driving piles in the correct position and alignment by means of a hammer operating in the guides or (leaders) of the frame.

5. DESIGN CONSIDERATIONS

5.1 General — Pile foundations shall be designed in such a way that the load from the structure it supports can be transmitted to the soil without causing any soil failure and without causing such settlement, differential or total, under permanent or transient loading as may result in structural damage or functional distress. The pile shaft should have adequate structural capacity to withstand all loads (vertical, axial or otherwise) and moments which are to be transmitted to the subsoil.

5.2 Adjacent Structures

5.2.1 When working near existing structures, care shall be taken to avoid any damage to such structures. Figure 1 of IS : 2974 (Part I)-1969* may be used as a guide for qualitatively studying the effect of vibration on persons and structures.

5.2.2 In case of deep excavations adjacent to piles, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil strata or releasing the confining soil stress.

5.3 Soil Resistance — The bearing capacity of a pile is dependent on the properties of the soil in which it is embedded. Axial load from a pile is normally transmitted to the soil through skin friction along the shaft and bearing at its tip. A horizontal load on a vertical pile is transmitted to the subsoil primarily by horizontal subgrade reaction generated in the upper part of the shaft. A single pile is normally designed to carry load along its axis. Transverse load-bearing capacity of a single pile depends on soil reaction developed and the structural capacity of the shaft under bending. In case the horizontal loads are of higher magnitude it is essential to investigate the phenomena using principles of horizontal subsoil reaction adopting appropriate values for horizontal modulus of the soil. Alternatively, piles may be installed in rake.

5.4 Structural Capacity — The pile shall have necessary structural strength to transmit the load imposed on it ultimately to the soil. Load tests shall be conducted on single and preferably on a group of piles. For

*Code of practice for design and construction of machine foundations : Part I Foundations for reciprocating type machines (*first revision*).

compaction piles, tests should be done on a group of piles with their cap resting on the ground [*see* IS : 2911 (Part IV)-1979*]. If such test data are not available, the load carried by the pile shall be determined by the Engineering News formula (*see* Note). Care shall be taken that while counting the number of blows, the head of the pile is not broomed or brushed and in case of interrupted driving counting shall be done after 30 cm of driving.

NOTE — For piles driven with drop hammer,

$$P = \frac{16\ WH}{s + 2{\cdot}5}$$

For piles driven with single-acting steam hammer,

$$P = \frac{16\ WH}{s + 0{\cdot}25}$$

where

P = safe load on pile in kg,

W = weight of monkey in kg,

H = free fall of monkey in m, and

s = penetration of pile in cm to be taken as the average of three blows.

5.5 Spacing of Piles — The centre to centre spacing of pile is considered from two aspects as follows:

a) Practical aspects of installing the piles, and

b) The nature of the load transfer to the soil and possible reduction in bearing capacity of group of piles thereby.

The choice of the spacing is normally made on semi-empirical approach.

5.5.1 In case of piles founded on a very hard stratum and deriving their capacity mainly from end bearing the spacing will be governed by the competency of the end bearing strata. The minimum spacing in such cases shall be 2·5 times the diameter of the shaft.

5.5.2 Piles deriving their bearing capacity mainly from friction shall be sufficiently apart to ensure that the zones of soil from which the piles derive their support do not overlap to such an extent that their bearing values are reduced. Generally, the spacing in such cases shall not be less than 3 times the diameter of the shaft.

*Code of practice for design and construction of pile foundations: Part IV Load test on piles.

5.5.3 In the case of loose sand or filling, closer spacing than in dense sand may be possible since displacement during the piling may be absorbed by vertical and horizontal compaction of the strata. Minimum spacing in such strata may be twice and half the diameter of the shaft.

NOTE — In the case of piles of non-circular cross section, diameter of the circumscribing circle shall be adopted.

5.6 Overloading — When a pile in a group, designed for a certain safe load is found, during or after execution, to fall just short of the load required to be carried by it, an overload of up to 10 percent of the pile capacity may be allowed on each pile. The total overloading on the group should not be more than 10 percent of the capacity of the group nor more than 40 percent of the allowable load on a single pile. This is subject to the increase of the load on any pile not exceeding 10 percent of its capacity.

6. CLASSIFICATION

6.1 Depending upon the use, that is, type of structure and the size, piles shall be classified as Class A and Class B.

6.1.1 *Class A* — Piles for railway and highway bridges, trestles, docks and wharves. The butt diameter or sides of square shall be not less than 30 cm.

6.1.2 *Class B* — Piles for foundation work other than those specified in **6.1.1** and temporary work. Piles used for the compaction of ground shall be not less than 10 cm in diameter or side in case of square piles.

7. TIMBER SPECIES

7.1 The species of timber and their specification shall conform to IS : 3629-1966*. The length of the individual pile shall be the specified length ± 30 cm for piles less than 12 m long, and the specified length ± 60 cm for piles of length 12 m or above. In case of round piles, the ratio of heartwood diameter to the pile butt diameter shall be not less than 0·8. Both the ends will be sawn at right angles to the length of pile and the surface shall be made flush by trimming the knots and limbs.

8. PRESERVATIVE TREATMENT

8.1 The timber shall be treated in accordance with IS : 401-1967† specially where conditions are not favourable.

*Specification for structural timber in building.

†Code of practice for preservation of timber (*second revision*).

9. WORKING AND DRIVING STRESSES

9.1 The working stresses shall be as given in IS : 883-1970*. These may be exceeded by not more than 100 percent during driving.

10. DESIGN OF PILE CAP (RCC)

10.1 The method of stresses and allowable stresses should be in accordance with IS : 456-1978†.

10.2 Pile cap shall be deep enough to allow for necessary anchorage of the column and pile reinforcement.

10.3 The pile cap should normally be rigid enough so that the imposed load could be distributed on the piles in a group equitably.

10.4 The clear overhang of the pile cap beyond the outermost pile in the group shall normally be 100 to 150 mm, depending upon the pile size.

10.5 The cap is generally cast over 75 mm thick levelling course of concrete. The clear cover for main reinforcement in the cap slab shall not be less than 75 mm.

10.6 The pile should project 40 mm into the cap concrete.

11. CUTOFFS AND THEIR TREATMENT

11.1 After driving, pile tops shall be cut off to a true plane and shall show a solid head at the plane of cutoff. After cutoff the pile tops shall be treated with a preservative (*see* IS : 401-1967‡). If metal top-covers are specified these shall be placed immediately after the treatment. Any holes and cuts if required for framing shall be suitably treated.

11.2 Capping — Capping shall be done when the piles are in correct position.

12. CONTROL OF PILE DRIVING

12.1 The piles in each bent of a pile trestle shall be selected for uniformity of size to facilitate placing of brace timbers.

12.2 The pile tip shall be pointed (unless the driving is wholly in soft strata) in the form of truncated cone or a pramid having the end 25 cm^2 to 40 cm^2 in area and the length shall b one-and-a-half to two times the diameter or side of square.

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*Code of practice for design of structural timber in building (*third revision*).

†Code of practice for plain and reinforced concrete (*third revision*).

‡Code of practice for preservation of timber (*second revision*).

12.2.1 If the driving is to be done through hard material as stiff clay, gravels, etc, metal shoes of approved design shall be attached to the tip.

12.3 To prevent splitting and reduce brooming, the head of the pile should be hooped with a suitable ring or wrapped with wires.

12.3.1 The heads of the piles shall be further protected by the provision of cushion blocks.

12.3.2 Use of followers shall be avoided as far as possible.

12.4 If the piles are required to be formed from two or more lengths, the butting surfaces should be cut square to ensure contact over the whole cross section of the pile. A thin steel plate placed between the butting surfaces will reduce the tendency to brooming. The pieces should also be secured with steel tube or steel flats. Splices near the middle of the pile should be avoided. If it is necessary to obtain increase in size and length of pile by building up piles from several timber sections, the joint should be staggered and timber members connected by means of bolts or coach screws.

12.5 Control of Alignment — Piles shall be installed as accurately as possible according to the designs and drawings either vertically or to the specified batter. Greater care should be exercised in respect of installation of single piles or piles in two-pile groups. As a guide, for vertical piles a deviation of 1·5 percent and for raker piles a deviation of 4 percent should not normally be exceeded although in special cases a closer tolerance may be necessary. Piles should not deviate more than 75 mm from their designed positions at the working level of the piling rig. In the case of a single pile in a column positional tolerance should not be more than 50 mm. Greater tolerance may be prescribed for piles driven over water and for raking piles. For piles to be cutoff at a substantial depth, the design should provide for the worst combination of the above tolerances in position and inclination. In case of piles deviating beyond these limits and to such an extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap or pile ties, the piles should be replaced or supplemented by one or more additional piles.

NOTE — In case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile.

12.6 Sequence of Piling

12.6.1 In a pile group the sequence of installation of piles shall normally be from the centre to the periphery of the group or from one side to the other.

12.6.2 Consideration should be given to the possibility of doing harm to a pile recently formed by driving the pile nearby. The danger of doing harm is greater in compact soils than in loose soils.

12.6.3 *Driving a Group of Friction Piles* — Driving piles in loose sand tends to compact the sand which in turn increases the skin friction. Therefore, the order of installing of such a pile in group should avoid creating a compacting block of ground into which further piles cannot be driven.

In case where stiff clay or compact sand layers have to be penetrated, similar precautions need be taken. This may be overcome by driving the piles from the centre outwards or by beginning at a selected edge or working across the group. However, in the case of very soft soils, the driving may have to proceed from outside to inside so that the soil is restrained from flowing out during operations.

12.7 Jetting — Jetting of casing by means of water shall be carried out if required in such a manner as not to impair the bearing capacity of piles already in place, the stability of the soil or the safety of any adjoining buildings.

12.8 Defective Pile — In case defective piles, they shall be removed or left in place, whichever is convenient, without affecting performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as necessary.

12.9 Amount of Driving — Care shall be taken not to damage the piles by over-driving. Any sudden change in the rate of penetration which cannot be ascribed to the nature of the ground shall be noted and its cause ascertained, if possible, before driving is continued.

13. RECORDING OF DATA

13.1 A competent inspector shall be maintained at site to record necessary information during installation of piles and the data to be recorded shall include the following:

a) Sequence of installation of piles in a group;

b) Dimensions of the pile, including the reinforcement, details and mark of the pile;

c) Depth driven;

d) Time taken for driving and for concreting;

e) Cut-off level/working level; and

f) Any other important observation.

14. STORING AND HANDLING

14.1 For storing purpose, provisions of IS : 883-1970* may be referred to.

14.2 Handling

14.2.1 Care shall be taken that the piles are supported at a sufficient number of points, properly located to prevent damage due to excessive bending.

14.2.2 Treated piles shall be handled with hemp or manila rope slings or other means of support that will not damage the surface of the wood.

14.2.3 Dropping, bruising, breaking of fibres and penetrating the surface shall be avoided.

14.2.4 Sharp pointed tools shall not be used for handling or turning them in leads.

14.2.5 Minor abrasions of the surface of treated piles below cut-off level in the portions which are to remain permanently under water shall be permitted.

14.2.6 Surface of the treated piles below cut-off shall not be disturbed by boring holes or driving nails to support temporary material or stagging.

*Code of practice for design of structural timber in building (*third revision*).

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Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 1 JULY 1989

TO

IS : 2911 (Part 2)- 1980 CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF PILE FOUNDATIONS

PART 2 TIMBER PILES

(First Revision)

(*Page* 6, *clause* **2.19**, *line* 1) — Substitute the word ' Elastic ' *for* ' Electric '.

(*Page* 9, *clause* **5.4**) — Substitute ' IS : 2911 (Part 4) - 1985* ' *for* ' IS : 2911 (Part IV) - 1979* '.

(*Page* 9, *foot-note*) — Insert ' (*first revision*) ' in the end.

(*Page* 10, *clause* **8.1** *and page* 11, *clause* **11.1**) — Substitute ' IS : 401-1982 ' *for* ' IS : 401-1967 '.

(*Pages* 10 *and* 11, *foot-notes*) — Substitute ' *third* ' *for* ' *second* '.

[*Page* 13, *clause* **13.1**(b)] — Delete the words ' including the reinforcement, details '.

[*Page* 13, *clause* **13.1**(d)] — Delete the words ' and for concreting '.

(BDC 43)

Reprography Unit, BIS, New Delhi, India