भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

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व्यापक परिचालन मसौदा

हमारा संदर्भ : सीईडी43 /टी – 66 **22 मई 2019**

तकनीकी समिति :मृदा एवं नींव इंजीनियरी विषय समिति43 सीईडी ,

प्राप्तकर्ता :

1 सिविल इंजीनियरी विभाग परिषद् के रूचि रखने वाले सदस्य
2 सीईडी 43 के सभी सदस्य
3 रूचि रखने वाले अन्य निकाय

महोदय,(यों)

निम्नलिखित मसौदा संलग्न है :

प्रलेख संख्या	शीर्षक
सीईडी 43 (14121)WC	**प्रेषण लाइन टावरों एवं खम्भों की नींव की डिजाइन और निर्माण — रीति संहिता का भारतीय मानक मसौदा (IS 4091 का दूसरा पुनरीक्षण)** **आई सी एस संख्या: 29.240, 93.020**

कृपया इस मानक के मसौदे का अवलोकन करें और अपनी सम्मतियॉ यह बताते हुए भेजे कि यदि यह मानक के रूप में प्रकाशित हो तो इन पर अमल करने में आपके व्यवसाय अथवा कारोबार में क्या कठिनाइयॉ आ सकती हैं ।

सम्मतियाँ भेजने की अंतिम तिथि: **21 जून 2019**

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को उपरलिखित पते पर संलग्न फोर्मेट में भेजें।

यदि कोई सम्मति प्राप्त नहीं होती है अथवा सम्मति में केवल भाषा सम्बन्धी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दिया जाएगा । यदि सम्मित तकनीकी प्रकृति की हुई तो विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा ।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट **www.bis.gov.in** पर भी उपलब्ध है

धन्यवाद ।

भवदीय,
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प्रमुख (सिविल इंजीनियरी)

संलग्न : उपरिलखित

भारतीय मानक ब्यूरो
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DRAFT IN WIDE CIRCULATION

DOCUMENT DESPATCH ADVICE

Reference	Date
CED 43/T- 66	22 May 2019

TECHNICAL COMMITTEE:

Soil and Foundation Engineering Sectional Committee, CED 43

ADDRESSED TO :

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of CED 43
3. All other interests

Dear Sir(s),

Please find enclosed the following draft:

Doc No.	Title
CED43 (14121) WC	**Draft Indian Standard for Design and construction of foundations for transmission line towers and poles — Code of practice (second revision of IS 4091)** **ICS: 29.240, 93.020**

Kindly examine the draft revision and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as Amendment to National Standard.

Last Date for comments: 21 June 2019

Comments if any, may please be made in the format as given overleaf and mailed to the email id **madhurima@bis.gov.in**.

In case no comments are received or comments received are of editorial nature, you will kindly permit us to presume your approval for the above document as finalized. However, in case of comments of technical in nature are received then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website, **www.bis.gov.in**.

Thanking you,

Yours faithfully,

Sd/-

(Sanjay Pant)
Head (Civil Engg.)

Encl: as above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/subclause/table/fig etc. be started on a fresh box. Information in column 5 should include reasons for the comments, and those in column 4 should include suggestions for modified wording of the clauses when the existing text is found not acceptable. Adherence to this format facilitates Secretariat's work) {Please e-mail your comments to madhurima@bis.gov.in }

DOC. NO.	**Doc: CED 43 (14121)**
TITLE	**Draft Indian Standard for Design and construction of foundations for transmission line towers and poles — Code of practice (*second revision of* IS 4091)** **ICS: 29.240, 93.020**
LAST DATE OF COMMENTS	**21 June 2019**
NAME OF THE COMMENTATOR/ ORGANIZATION	_____

Sl. No. (1)	Clause/Sub-clause/Para No. (2)	Comments/Suggestions (3)	Modified Wording of the Clause (4)	Reasons/ Justifications for the Proposed Changes (5)

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Doc: CED 43(14121)
May 2019

BUREAU OF INDIAN STANDARDS

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Soil and Foundation Engineering Sectional Committee, CED 43	Last date for Comment: 21 June 2019

Draft Indian Standard

DESIGN AND CONSTRUCTION OF FOUNDATIONS FOR TRANSMISSION LINE TOWERS AND POLES — CODE OF PRACTICE

(*Second Revision* of IS 4091)

F 0 R E W 0 R D

(Formal clauses to be added later.)

Transmission line towers and poles are subjected to large horizontal forces at the top, thereby causing overturning and/or uplifting of foundation. The design of foundations for such structures involves special problems and this standard has been prepared with a view to providing guidance to the designer. Often well foundations are used in river beds for which the concerned IRC standard may be referred.

This standard was first published in 1967 and subsequently revised in 1979 to bring it in line with the then prevalent practices. This revision of the standard has been taken up to bring it line with the current practices. In this revision of the standard, following major modifications have been incorporated:

a) New terms and their definitions have been incorporated. Some of the existing definitions have also been modified;
b) The provisions on necessary information to be provided for design and construction of foundations for transmission line towers and poles have been modified;
c) Provisions on footings with and without under-cut have been modified. A 30° angle of cone assumption for determining soil resistance to uplift in case of footing has been specified for all soil types;
d) Use of raft foundations and precast concrete piles in prebored holes as per IS 2950 (Part 1):1981 'Code of practice for design and construction of raft foundations: Part 1 Design (*second revision*)' and IS 2911 (Part 1/Section 4):2010 ‘Part 1 Concrete piles: Section 4 Precast concrete piles in prebored holes (*first revision*)’ has been included;

e) Various provisions on materials have been modified in line with revised IS 456:2000 'Plain and reinforced concrete — Code of practice (*fourth revision*)';
f) Detailed provisions on design of under-reamed piles have been deleted and a reference to the concerned Indian Standard has been made for such aspects;
g) The table giving recommended type of foundation/class of footing depending upon type of load and type of soil reaction expected has been deleted; and
h) Existing provision for increasing permissible bearing pressure at the edges of the footing by 25 percent in certain cases has been deleted.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in this field in the country.

The composition of the Committee responsible for the formulation of this standards is given in Annex -----.

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 or analysis, 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.

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May 2019

BUREAU OF INDIAN STANDARDS

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Soil and Foundation Engineering Sectional Committee, CED 43	Last date for Comment: 21 June 2019

Draft Indian Standard

DESIGN AND CONSTRUCTION OF FOUNDATIONS FOR TRANSMISSION LINE TOWERS AND POLES — CODE OF PRACTICE

(*Second Revision* of IS 4091)

1 SCOPE

1.1 This standard covers the design and construction of concrete foundations including anchor bolts grouted into rock for transmission-line towers and poles.

1.2 Grillage, brick and masonry footings and anchor plates are not covered in this standard. The design and construction of pre-stressed concrete foundations are also not covered.

2 REFERENCES

The Indian Standards listed in Annex A contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated are valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

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

3.1 Loading Conditions

3.1.1 *Normal Condition (NC)* — This is a condition when the wires on either side of the transmission tower are intact.

3.1.2 *Broken Wire Conditions (BWC)* — This is a condition when one or more of the wires on one side or both sides of the tower or pole are broken causing an unbalanced pull or a twisting moment on the tower or pole.

3.2 Foundations — That part of the structure which is in direct contact with the ground and transmits the loads to the ground. The type of foundations covered in this standard are given in **3.2.1** to **3.2.3**.

3.2.1 *Footing* – A type of shallow foundation that are normally constructed by making open excavations, they may have enlarged base provided either in the open excavation or by under-cutting the soil by suitable devices for the purpose of distributing the load over a larger area of the ground. A spread footing (or isolated or pad) is provided to support an individual column. Sometimes, it is stepped or haunched to spread the load over a large area.

3.2.2 *Raft Foundation* – A substructure supporting an arrangement of columns or walls in a row or rows transmitting the loads to the soil by means of a continuous slab, with or without depressions or openings.

3.2.3 *Pile Foundation* — A particular type of precast or cast *in-situ* foundation normally provided by driving or boring, and having uniform, bulbed, tapered or corrugated section along its length.

3.3 Highest Flood Level (HFL) — Highest flood level of a river or stream is the level of the highest flood ever recorded or the calculated level for the highest possible flood.

3.4 Low Water Level (LWL) — Low water level of a river of stream is the level of the water surface obtained generally in the dry weather.

3.5 Rock — Foundation supporting material other than soil which is possible to excavate; in the case of soft rocks with pick axe and shovels, and in case of hard rocks by special methods like blasting.

3.6 Soil, Black Cotton Soil — Clayey soil, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement of ground. In deep deposits of these soil, generally there is no appreciable ground movement due to seasonal moisture changes beyond 3.5 m [*see* IS 2720 (Part 40)].

4 NECESSARY INFORMATION

4.1 For the design and construction of foundation, the following information shall be provided:

a) Route map showing the proposed layout of the towers with the general topography of the country and important towns, villages, temples, existing structures, existing transmission/ railways lines, highways etc, in the vicinity;

b) Sections of trial borings or pits showing soil profile at the site of work;

c) General layout of the towers, and towers schedule, etc;

d) The nature, direction and magnitude of loads applied to the tower and support reaction at the base of transmission tower both under normal condition and broken wire condition;

e) Special information, for example, prevailing wind direction, depth of frost penetration and earthquake [*see* IS 1893 (Part 1)]; and

f) A review of the performance of similar structures, if any, in the locality.

4.2 In the case of river crossings with towers or poles located in the river bed, the following additional information shall be given:

a) A site plan showing the details of the site selected for the crossing extending up to right of way upstream and downstream from the central line of the crossing. The plan should normally include the following:

1) The approximate outlines of the bank,
2) The direction of flow of water,
3) The alignment of the crossing and the location of the towers, and
4) The location of trial pits or borings taken in the river bed.

b) A cross section of the river at the site of the proposed crossing indicating the following:

1) The river bed up to the top of the banks and the ground line beyond the edges of the river, with levels at intervals sufficiently close to give a clear outline of marked features of the bed or ground, showing right and left bank and names of villages on each side;

2) The nature of the surface soil in bed and banks with trial pit or bore hole sections showing the levels and nature of the various strata down to the stratum suitable for founding the towers;

3) Low water level;

4) The highest flood level and years in which it occurred. State if the flood level is effected by back water or tidal effect and, if so, give details; and

5) The maximum depth of scour.

c) The maximum mean velocity of water current.

5 MATERIALS

5.1 Cement

The cement used shall be any of the following:

a) Ordinary Portland cement conforming to IS 269,
b) Rapid hardening Portland cement conforming to IS 8041,
c) Portland slag cement conforming to IS 455,
d) Portland pozzolana cement (fly ash based) conforming to IS 1489 (Part 1),
e) Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2), and
f) Super sulphated cement conforming to IS 6909.

5.2 Steel

Reinforcement steel shall be any of the following:

a) Mild steel and medium tensile steel bars conforming to IS 432 (Part 1), and
b) High strength deformed steel bars conforming to IS 1786.

5.3 Concrete

Materials, mixing and quality control for concrete shall in general be in accordance with IS 456.

6 DESIGN AND CONSTRUCTION

6.1 Normally the following load(s) are given at the plinth level:

a) Downward load,
b) Uplift load,
c) Horizontal thrust, and
d) Overturning moments.

Based on subsoil data obtained from site and the loading exerted by the structure, foundation design shall be carried out from bearing capacity considerations and settlement analysis.

6.2 General Design Criteria for Footings in Soils

6.2.1 Inclined loads shall be split up into vertical and lateral loads at the top of footings (lateral load is also sometimes called shear).

6.2.2 The uplift loads are assumed to be resisted by the weight of the footing plus the weight of an inverted frustum of a pyramid of earth on the footing pad with sides inclined at an angle of 30° with the vertical.

6.2.2.1 A footing with an under-cut generally develops higher uplift resistance that of an identical footing without an under-cut (*see* Fig. 1A, Fig. 1B and Fig. 1C). However, for design purpose, in a footing with under-cut, uplift resistance may be taken as 10-20 percent higher than a footing without under-cut.

6.2.2.2 A 30° angle of cone (*see* Fig. 1C) shall be considered.

6.2.2.3 For footings below water table, submerged weight of the soil shall be taken.

6.2.3 Alternative footing designs with or without under-cut should be provided where field investigations have not been made to determine the feasibility of under-cutting.

6.2.4 In enlarged footings without an under-cut where individual footing is not provided under each leg and where a combination of uplift loads with lateral loads occurs, the stability of the footing should be checked by the following criteria:

a) The resultant force acting vertically and laterally should act at a point in its base at a distance of one-sixth of its width from the toes;

b) The weight of the footing acting at the centre of the base; and

c) Mainly that part of the cone which stands over the heel causes a stabilizing moment. However, for design purposes, this may be taken equal to half the total weight of the cone of earth acting over the base. It shall be assumed to act through the tip of the heel.

6.3 Raft Foundations

In case of raft foundation, the provisions of IS 2950 (Part 1) shall apply.

6.4 Pile Foundations

Different types of concrete pile foundations can be used depending upon the location, sub-surface condition and their suitability in the given condition. In case of pile foundations, the provisions of following Indian Standards shall apply:

a)	Driven cast in-*situ* concrete piles	IS 2911 (Part 1/Sec 1)
b)	Driven cast in-*situ* concrete piles	IS 2911 (Part 1/Sec 2)
c)	Driven precast concrete piles	IS 2911 (Part 1/Sec 3)
d)	Precast concrete piles in prebored holes	IS 2911 (Part 1/Sec 4)
e)	Under-reamed piles	IS 2911 (Part 3)

6.4.1 Bored piles with under-reaming is preferable in expansive type of soils, such as black cotton soils. They have to be carried down to deep layers of these soils to counter the effect of upthrust due to swelling pressure introduced in the soil. Independent spread footing at shallow depths may not be suitable in such soils. In case of heavy uplift forces and moments multiple under-reamed piles or anchors may be used. In case of loose to medium sandy soils, bored compaction under-reamed piles may be used. Under-reamed pile foundations shall be designed in accordance with IS 2911 (Part 3) The under-reamed piles in uplift should be designed by the usual considerations of the friction on stem and bearings on the annular projections. A factor of safety of 3 may be applied for safe uplift. In case of under-reamed piles resting on rock, the bearing component will be obtained by multiplying the safe capacity of rock with the bearing area of pile stem plus the bearing provided by the under-ream portion.

6.5 Allowable Bearing Pressure

The allowable bearing pressure of the foundation where the towers or poles are founded shall be based on adequate subsoil exploration and testing carried out in accordance with IS 1888, IS 1892 and IS 1904.

6.6 Permissible Stresses in Concrete and Reinforcement

Where stresses due to wind, temperature and shrinkage effects are combined with those due to dead, imposed and impact loads, permissible stresses specified in IS 456 for these conditions shall be used in the design.

6.7 Structural Safety

6.7.1 For the structural safety against sliding, overturning and for the footings at different levels, provisions laid down in IS 1904 shall apply.

6.7.2 The depth of foundation shall conform to the provisions laid down in the relevant Indian Standards depending on the type of foundation [*see* IS 1080, IS 1904, IS 2950 (Part 1), IS 2911 (Part 1/Sec 1), IS 2911 (Part 1/Sec 2), IS 2911 (Part 1/Sec 3), IS 2911 (Part 1/Sec 4) and IS 2911 (Part 3)].

6.8 Footing in Rock

6.8.1 A footing in rock, for uplift and horizontal loads, may be considered to develop strength by the dead load of concrete and the strength of bar anchorage (the pull-out

value of anchor bars grouted in drill holes or the failure strength of rock engaged by bars).

6.8.2 The depth of embedment of the bars below the bottom of the footing should not be less than the following:

$$D = 45d$$

Where,

D = the minimum depth of embedment in mm, and
d = diameter of anchor bar in mm.

6.8.3 The spacing of embedded bars should normally be one-half of the normal depth of embedment as given in **6.8.2**.

6.8.4 The size of the bar shall be governed by the criterion that combined stresses do not exceed the permissible limits.

6.9 Special Considerations

6.9.1 *Foundations in Seismic Zones*

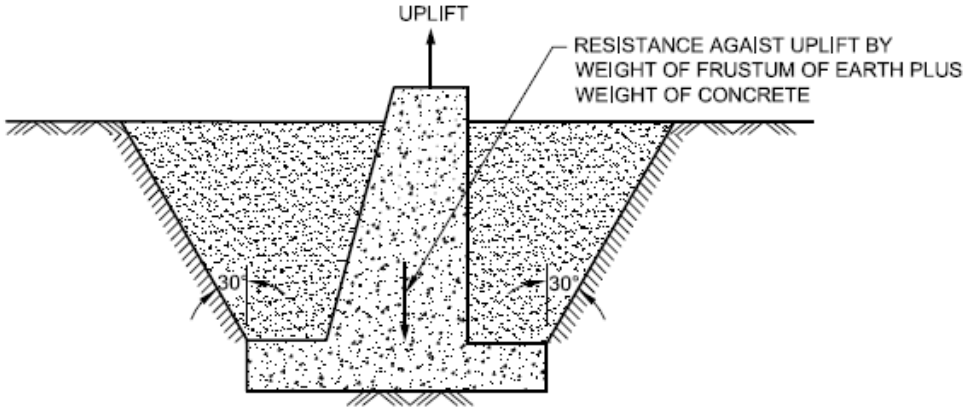
In designing foundations in seismic zones, the provisions of IS 1893 (Part 1) to evaluate the seismic forces shall also apply.

6.9.2 *Foundations in Sulphate Bearing Clays*

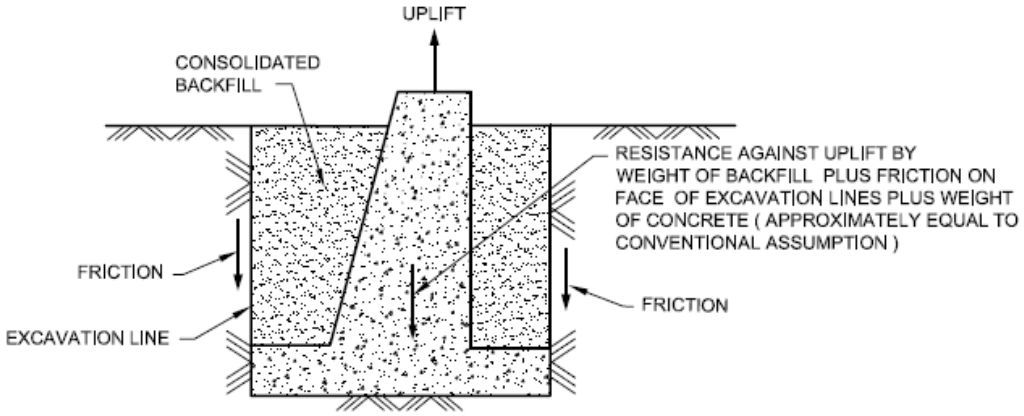
Suitable precautions' as laid down in IS 1904 shall be taken in the case of foundations in sulphate bearing clays.

6.9.3 In the case of river crossing, the horizontal pressure due to forces of water current shall be considered in the design.

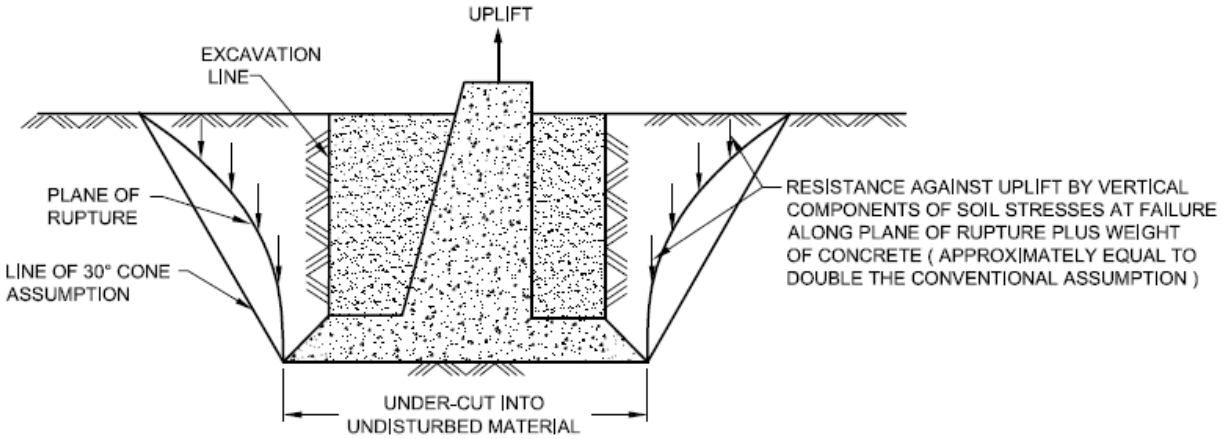
NOTE — Towers located in river are likely to be subjected to shock loads, due to floating debris. The towers should be suitably protected against such shocks.



1A CONVENTIONAL ASSUMPTION



1B ACTUAL ACTION WITHOUT UNDER-CUT



1C ACTUAL ACTION WITH UNDER-CUT

Fig. 1 Soil Resistance to Uplift

6.9.4 *Excavations, Drilling and Blasting*

These operations shall conform to IS 3764 and IS 4081.

6.9.5 In case the footings under the same tower structure happen to rest such that some of them are in soil and the rest on rock then the consideration shall be given for differential settlement and the structural safety.

6.9.6 In case of deviations in the alignment of the line, modifications should be made in the design of foundations for towers. No special provisions may be necessary for deviations up to 2°.

6.10 Concreting

Concreting shall be done in accordance with the relevant requirements given in IS 456.

7 STAY SETS

7.1 The stay set may be provided by burying a 300 mm x 300 mm and 5 mm thick mild steel plate having a 18 mm dia hole in the centre through which a 16 mm diameter bolt passes.

7.2 As an alternative to the steel plate in **7.1**, cleats formed by two 300 mm long pieces of angle iron of size 50 mm x 50 mm x 6 mm buried in a concrete pad of 150 mm can also be provided.

8 POLES

8.1 The foundation for poles is provided by a certain length of the pole buried into the ground. The bearing capacity in compression is mainly derived by the skin friction on the surface of the poles and to a smaller extent by the base area. Under the action of wind, the lateral loading introduces moments and lateral thrust on the foundation.

8.2 Depth of embedment of the pole for the purpose of foundation should not be less than one-sixth of the total length of the pole above ground level.

8.3 A protective collar providing a concrete cover of not less than 100 mm around the pole shall be provided. The depth of the concrete collar below the ground level should not be less than 450 mm and it should be at least 150 mm above the ground level.

ANNEX A
(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
269:2015	Ordinary Portland cement — Specification (*sixth revision*)
432 (Part 1):1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 1 Mild steel and medium tensile steel bars (*third revision*)
455:2015	Portland slag cement— Specification (*fifth revision*)
456:2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
1080:1985	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) (*second revision*)
1489	Portland pozzolana cement — Specification
(Part 1):2015	Fly ash based (*fourth revision*)
(Part 2):2015	Calcined clay based (*fourth revision*)
1786:2008	High strength deformed steel bars and wires for concrete reinforcement — Specification (*fourth revision*)
1888:1982	Method of load test on soils (*second revision*)
1892:1979	Code of practice for subsurface investigation for foundations (*first revision*)
1893 (Part 1):2016	Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings (*sixth revision*)
1904:1986	Code of practice for design and construction of foundations in soils: General requirements (*third revision*)
2062:2011	Hot rolled medium and high tensile structural steel — Specification (*sixth revision*)
2131:1981	Method for standard penetration test for soils (*first revision*)
2720 (Part 40):1977	Methods of test for soils: Part 40 Determination of free swell index of soils
IS 2911:2010	Design and construction of pile foundations — Code of practice
(Part 1/Sec 1):2010	Part 1 Concrete piles: Section 1 Driven cast in-situ concrete piles (*second revision*)
(Part 1/Sec 2):2010	Part 1 Concrete piles: Section 2 Bored cast in-situ concrete piles (*second revision*)
(Part 1/Sec 3):2010	Part 1 Concrete piles: Section 3 Driven precast concrete piles (*second revision*)
(Part 1/Sec 4):2010	Part 1 Concrete piles: Section 4 Precast concrete piles in prebored holes (*first revision*)
2911 (Part 3):****	Design and construction of pile foundations — Code of practice:

	Part 3 Under-reamed piles (*second revision*) (*under preparation*)
2911 (Part 4):2013	Design and construction of pile foundations — Code of practice: Part 4 Load test on piles (*second revision*)
2950 (Part 1):1981	Code of practice for design and construction of raft foundations: Part 1 Design (*second revision*)
2974 (Part 1):1982	Code of practice for design and construction of machine foundations: Part 1 Foundation for reciprocating type machines (*second revision*)
3764:1992	Excavation work — Code of safety (*first revision*)
4081:2013	Blasting and related drilling operations — Code of safety
4968	Method for sub-surface sounding for soils
(Part 1):1976	Dynamic method using 50 mm cone without bentonite slurry (*first revision*)
(Part 2):1976	Dynamic method using cone and bentonite slurry (*first revision*)
(Part 3):1976	Static cone penetration test (*first revision*)
6403:1981	Code of practice for determination of breaking capacity of shallow foundations (*first revision*)
6909:1990	Supersulphated cement — Specification (*first revision*)
8041:1990	Rapid hardening portland cement — Specification (*second revision*)
8043:1991	Hydrophobic portland cement — Specification (*second revision*)
12330:1988	Specification for sulphate resisting Portland cement
12600:1989	Portland cement, low heat — Specification