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IS 1904 : 2021

मृदा में नींवों के डिजाइन और निर्माण के लिए सामान्य अपेक्षाएँ — रीति संहिता

(चौथा पुनरीक्षण)

General Requirements for Design and Construction of Foundations in Soils — Code of Practice

(Fourth Revision)

ICS 93.020

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FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Soil and Foundation Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

Series of Indian Standards on design and construction of various types of foundations (shallow, deep and special types) have been formulated covering their specific requirements. Many of the requirements for designing of such foundations are common for all types of foundations. In order that these general requirements are not repeated in each of such Indian Standards, this basic standard covering such general requirements has been formulated.

This Indian Standard was first published in 1961 and subsequently revised in 1966, 1978 and 1986. The standard till its third version covered requirements for shallow foundations. Considering that subsequent to its second revision, various new Indian Standards covering design and construction of various types of foundations had been formulated, the standard was again revised so as to cover the general requirements for design and construction not only for shallow foundation but also for all other types of foundations. Opportunity was utilized to transfer to this standard, the general requirements covered in IS 1080 : 1985 'Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) (*second revision*)', which was also revised simultaneously, so that it covers only the specific requirements applicable to design and construction of shallow foundations. This revision of the standard has been taken up to take into account changes that were required in view of recent advancements in the field. In this revision, following major modifications have been incorporated:

a) Combined foundation, referred as a type of deep foundation, has been deleted.

b) Suitable precautions to be taken in case of foundations in localities where considerable amount of soluble salts are contained in ground water and soil have been deleted and a reference to IS 456 : 2000 'Plain and reinforced concrete — Code of practice (*fourth revision*)' has been included for such provisions.

c) Minimum distance to be ensured between large size trees and foundation of buildings in case of clayey soil has been changed from 8 m to 6 m.

d) Common methods of site exploration suggested in the standard have been deleted, as it has to be suitably decided in accordance with IS 1892 : 2021 'Subsurface investigation for foundations — Code of practice (*second revision*)'.

e) Provisions for footings at different levels, loads on foundations and settlement of foundations have been modified for clarity. Reference to relevant Indian Standards for determination of various loads acting on the foundation has been made.

f) Need for liquefaction analysis in case of non-cohesive soils as per IS 1893 (Part 1) : 2016 'Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings (*sixth revision*)' has been added.

g) Provisions on backfilling of the excavation have been modified.

The design of the foundation, superstructure and the characteristics of the ground are inter-related. In order to obtain maximum economy, the supporting ground, foundation and superstructure should be studied as a whole. The design of a foundation involves both geotechnical aspects of supporting ground and the structural aspects of the foundation materials. The aim is to proportion the foundation (plan dimensions) in such a way that net loading intensity of pressure, called the net foundation pressure on the soil does not exceed the safe bearing capacity and that structural design which involves the determination of the thickness of elements so that maximum stress in concrete (plain or reinforced) and masonry is within permissible limits.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

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.

Indian Standard

GENERAL REQUIREMENTS FOR DESIGN AND CONSTRUCTION OF FOUNDATIONS IN SOILS — CODE OF PRACTICE

(Fourth Revision)

1 SCOPE

This standard covers the general requirements for design and construction of all types of foundations (shallow, deep and special types).

2 REFERENCES

The standards given 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 definition of terms given in IS 2809 shall apply.

4 TYPES OF FOUNDATIONS

4.1 Shallow Foundations

These cover such types of foundations in which load transference is primarily through shear resistance of the bearing strata.

4.1.1 The various types of shallow foundations are as under:

a) *Spread or pad foundation — See* IS 1080.
b) *Strip foundation — See* IS 1080.
c) *Raft foundation — See* IS 2950 (Part 1).
d) *Ring and shell foundation — See* IS 11089 and IS 9456.

4.2 Deep Foundations

These are foundations generally in the form of piles, caissons, diaphragm walls, well foundations used separately or in combination, to transmit the loads to deeper load bearing strata, when, no adequate bearing strata exists at shallow depths. The transfer of load to deeper strata may be through friction, end-bearing or a combination of both.

4.2.1 The various types of deep foundations are as under:

a) *Pile Foundations*
   1) *Driven cast in-situ — See* IS 2911 (Part 1/Sec 1).
   2) *Bored cast in-situ — See* IS 2911 (Part 1/Sec 2).
   3) *Driven precast — See* IS 2911 (Part 1/Sec 3).
   4) *Bored precast — See* IS 2911 (Part 1/Sec 4).
   5) *Timber — See* IS 2911 (Part 2).
   6) *Under-reamed pile — See* IS 2911 (Part 3).
b) *Caissons — See* IS 9527 (Part 1).
c) *Diaphragm walls — See* IS 9556.
d) *Well foundations* (a detail code on this subject is formulated by IRC).

4.3 Foundations for Special Structure

Foundations for certain structures and/or machineries require special design and detailing procedure taking into consideration the impact and vibration characteristics of the load and the soil properties under dynamic conditions.

4.3.1 The various types of such foundations are as under:

a) *Machine foundations*
   1) *Reciprocating type — See* IS 2974 (Part 1).
   2) *Impact type — See* IS 2974 (Part 2).
   3) *Rotary type (medium and high frequency) — See* IS 2974 (Part 3).
   4) *Rotary type low frequency — See* IS 2974 (Part 4).
   5) *Impact type (other than hammer) — See* IS 2974 (Part 5).
b) *Tower foundations*
   1) *Transmission line towers and poles — See* IS 4091.
   2) *Radar antenna, microwave and TV tower — See* IS 11233.

5 GROUND

The natural geological deposits over base rock extending to the surface level of the earth should be examined.

6 SITE INVESTIGATION

6.1 The investigation of the site is an essential prerequisite to the construction of all civil engineering works with a view to assess the general suitability of the site for the proposed new works and to enable in preparing an adequate and economic design.

In particular, it is necessary to assess the impact during or after the construction of the structure due to the type of materials, methods of construction, etc which may adversely affect the safety of the structure or alter its performance or utility.

6.2 The subsurface investigation of the site shall be carried out in accordance with the principles set in IS 1892. As a preliminary, it is usually judicious to collect information relating to the site prior to commencing its exploration. The exploration of the site for a structure requires the exploration and sampling of all strata likely to be significantly affected by the structural load. The extent of this exploration will depend on the site and structure. Particular attention shall be paid to the ground water level, underground water courses, old drains, pits, wells, old foundation, etc, and presence of excessive sulphates, chlorides and/or other injurious compounds in the ground water and soil. The site should also be explored in detail, where necessary, to ascertain the type, consistency, thickness, sequence and dip of the strata.

6.3 Mass movements of the ground are liable to occur from causes independent of the loads imposed by the structure. These include mining subsidence, land slips, unstable slopes and creep on clay slopes. These factors shall be taken into account in the layout and design of the proposed works. However, if necessary, expert advice regarding the geological and hydrological characteristics of the site shall be sought.

6.3.1 Mining subsidence is liable to occur in mining areas. The magnitude of the movement and its distribution over the area and their vicinity can be roughly estimated. Where future subsidence is likely, care should be taken to design the superstructure and foundation sufficiently strong to cater for probable ground movements. Long continuous buildings should be avoided and large building should be divided into independent sections of suitable size, each with its own foundations. Expert advice from appropriate mining authority may be sought.

6.3.2 Cuttings, excavations or sloping ground near foundations may increase the possibility of shear failure in the ground supporting the foundations.

On sloping ground, there may be a tendency for the upper layers of soil to move downhill. The extent of such movement, however, depends on the type of soil, the angle of slope, ground water regime and climatic conditions. Instability may develop even after a long period of apparent stability, particularly in stiff, fissured and over consolidated clayey soil.

Uneven surface of a slope on natural ground, curved tree trunks, tilted fence posts, tilted boundary walls, etc, indicate the creep of the surface layers. Areas subject to land slip and unstable slopes shall therefore, be avoided.

6.3.3 Some clayey soils are susceptible to shrinkage and cracking in dry and hot weather, and swelling in wet weather. These conditions may also occur due to extraneous agencies like trees, boiler installations, furnaces, kilns, underground cables, services and refrigeration installations. These factors shall be considered carefully before designing any foundations. Shrinkage of clayey soils may be increased by the drying effect produced by nearby trees and shrubs. Swelling may occur, if they are cut down. No trees which may grow to a large size shall be planted within 6 m of foundations of buildings.

6.3.4 New constructions may interfere with drainage regime of the ground and affect the stability of existing structure. Adequate precautions should be taken to protect these. On the uphill side of a building on a sloping site, land drainage requires special consideration for diverting the natural flow of water away from the foundations. If excavation involves cutting through existing land drains, consideration should be given for diverting into the ground-drainage system.

6.3.5 Increase in moisture content results in substantial loss of bearing capacity in case of certain types of soils which may lead to differential settlement of foundations. On sites liable to be water logged in wet weather, it is desirable to determine the contour of the water-table surface in order to indicate the directions of the natural drainage and to obtain the basis of the design of intercepting drains to prevent the influx of ground water into the site from higher ground. The seasonal variation of the water table is of importance in some cases. In case of soils with low permeability, the water levels in boreholes or observation wells may take a considerable time to reach equilibrium with ground water. Spot readings of water level in boreholes may, therefore, give an erroneous impression of the true ground water level. It is generally determined by measuring the water level in the borehole after a suitable time lapse of 14 h or more, as the case may be. In soils with high permeability, such as sand and gravels, lesser time will usually be sufficient, unless the hole has been sealed with drilling mud. In such cases, it may be necessary to resort to indirect means to determine the water table. Where deep excavation is

required, the location of water bearing strata should be determined so that necessary precautions may be taken during excavation.

6.3.6 In certain localities where considerable amount of soluble salts are contained in ground water and soil, cement concrete, especially thin members or buried metals are subjected to deterioration and corrosion. Certain soils have corrosive action on metals, particularly on cast iron, due to either chemical or bacteriological agency. In industrial areas, corrosive action may arise from industrial wastes that have been dumped on the site. Chemical analysis of samples of ground water or soil (or sometimes both) should be done to assess the necessity of special precautions (*see also* IS 456) and precautions as given in IS 456 shall be adopted.

7 DEPTH OF FOUNDATION

7.1 The depth of foundation depends upon the following principal factors:

a) Getting adequate allowable bearing capacity.
b) In the case of clayey soils, penetration below the zone where shrinkage and swelling due to seasonal weather changes, and due to trees and shrubs are likely to cause appreciable movements.
c) In fine sands and silts, penetration below the depth of frost penetration.
d) Maximum depth of scour, wherever relevant, should also be considered and the foundation should be located sufficiently below this depth.
e) Other factors, such as ground movements and heat transmitted from the building to the supporting ground may be important.

7.2 All foundations shall extend to a depth of at least 500 mm below natural ground level. On rock or such other weather resisting natural ground, removal of the top soil may be all that is required. In such cases, the surface shall be cleaned and, if necessary, stepped or otherwise prepared so as to provide a suitable bearing and thus prevent slipping or other unwanted movements.

7.3 Where there is excavation, ditch, pond, water course, filled-up ground or similar condition of the subsoil on which the structure is to be erected, the foundation of such structure shall either be carried down to a depth beyond the detrimental influence of such conditions, or retaining walls shall be provided for the purpose of shielding from the effects of such conditions.

7.4 A foundation in any type of soil shall be below the zone significantly weakened by root holes or cavities produced by burrowing animals or works. The depth shall also be enough to prevent the rainwater scouring below the footings.

7.5 Clayey soils, like black cotton soils, are seasonally affected by drying, shrinkage and cracking in dry and hot weather, and by swelling in the following wet weather to a depth which will vary according to the nature of the clay and the climatic condition of the region. It may be necessary in such soils, either to place the foundation on the strata where the effects of seasonal changes are not significant or to make the foundation capable of eliminating the undesirable effects of relative movement. Adequate load counteraction against swelling pressures also provides satisfactory foundations.

8 FOUNDATIONS AT DIFFERENT LEVELS

8.1 Where footings are adjacent to sloping ground or where the bottoms of the footings of a structure are at different levels or at levels different from those of the footings of adjoining structures, the depth of the footings shall be such that the difference in footing elevations shall be subject to the following limitations:

a) When the ground surface slopes downward adjacent to a footing, the sloping surface shall not intersect a frustum of bearing material under the footing having sides which make an angle of 30° with the horizontal for soil and horizontal distance from the lower edge of the footing to the sloping surface shall be at least 600 mm for rock and 900 mm for soil (*see* Fig. 1).
b) In the case of footings in granular soil, a line drawn between the lower adjacent edges of adjacent footings shall not have a slope steeper than one vertical to two horizontal (*see* Fig. 2).
c) In case of footing in clayey soils, a line drawn between the lower adjacent edge of the upper footing and the upper adjacent edge of lower footing shall not have a steeper slope than one vertical to two horizontal (*see* Fig. 3).

8.2 The requirement given in **8.1** shall not apply where adequate provision is made for the lateral support (such as with retaining walls) of the material supporting the higher footing.

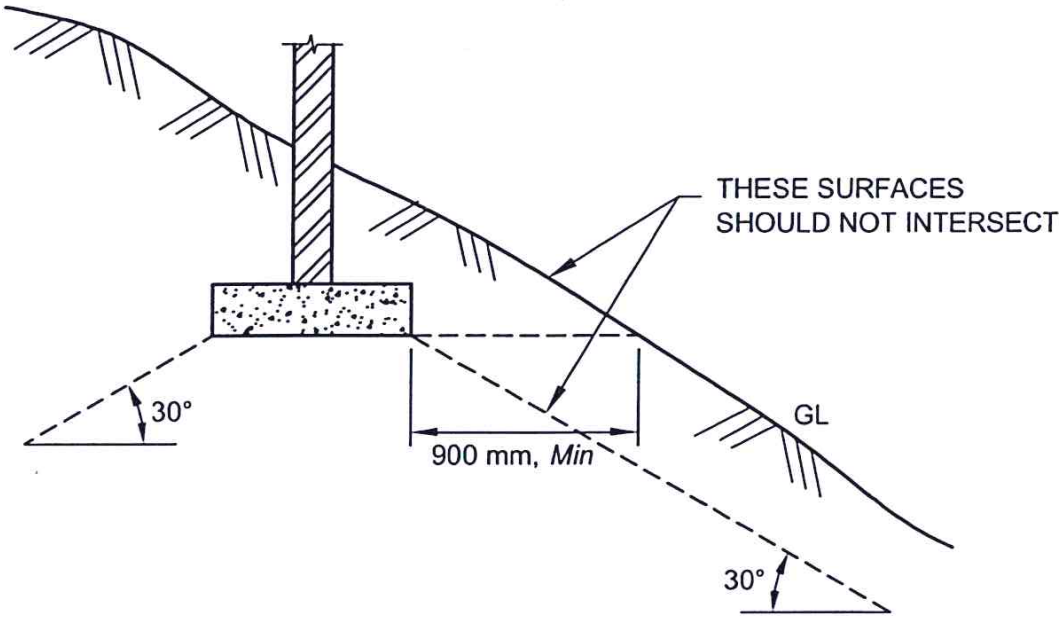

FIG. 1 FOOTING IN SLOPING GROUND

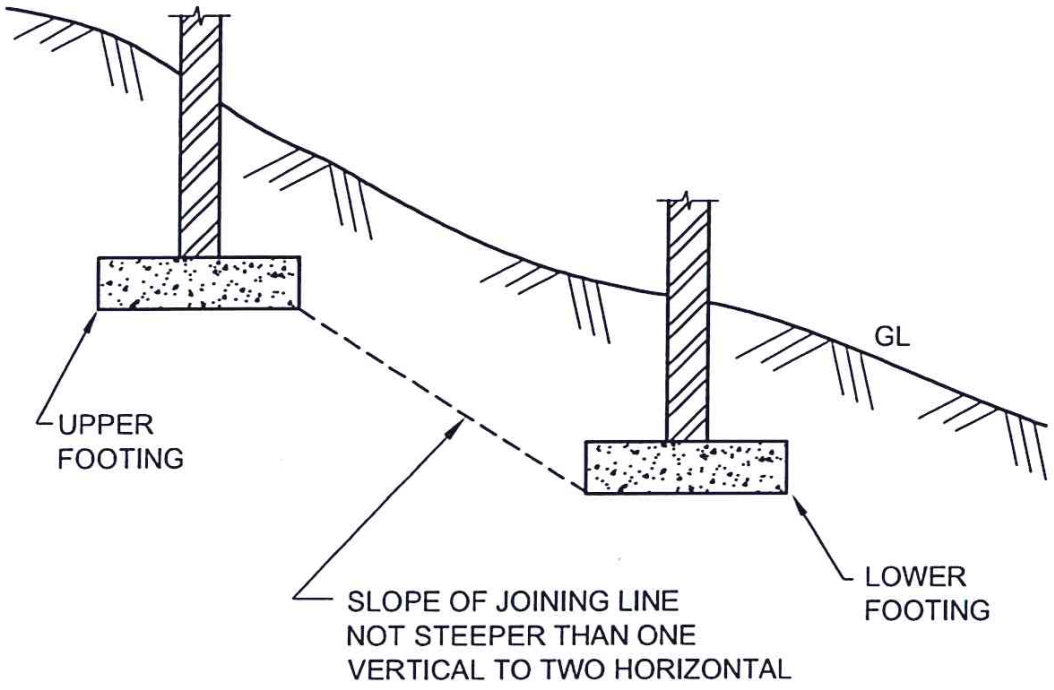

FIG. 2 FOOTING IN GRANULAR SOIL

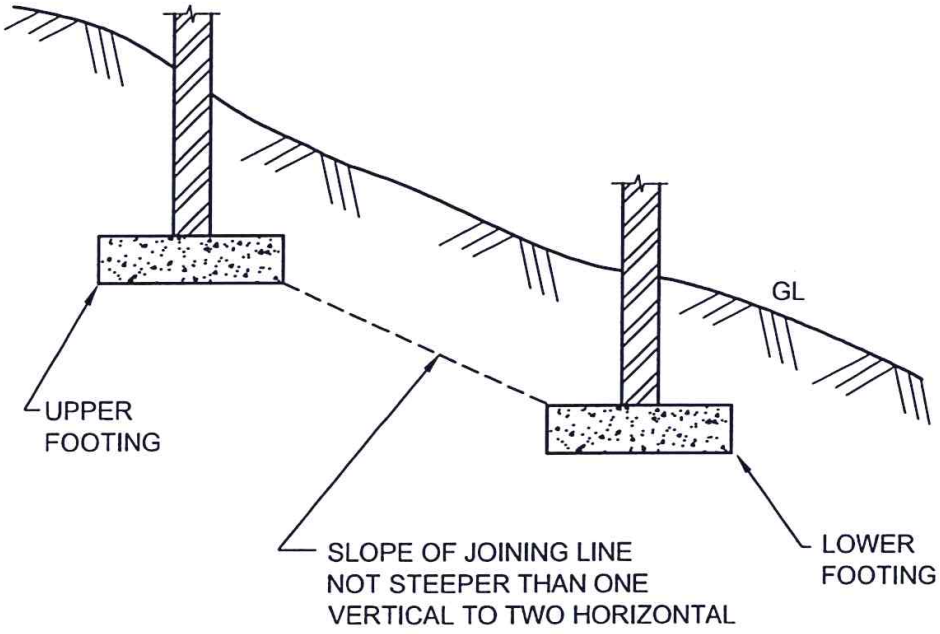

FIG. 3 FOOTING IN CLAYEY SOIL

9 EFFECT OF SEASONAL WEATHER CHANGES

During periods of hot, dry weather, a deficiency of water develops near the ground surface. In clayey soils, this may be associated with a decrease of volume or ground shrinkage and the development of cracks. The shrinkage of clay will be increased by drying effect produced by fast growing and water seeking trees. The range of influence depends on size and number of trees and it increases during dry periods. In general, it is desirable that there shall be a distance of at least 6 m between foundations of buildings and such trees. Boiler installations, furnaces, kilns, underground cables and refrigeration installations and other artificial sources of heat may also cause increased volume changes of clay by drying out the ground beneath them, the drying out can be to a substantial depth. Special precautions either in the form of insulation or otherwise should be taken. In periods of wet weather, clayey soils swell and the cracks tend to close, the water deficiency developed in the previous dry periods may be partially replenished and a subsurface zone or zones deficient in water may persist for many years. Leakage from water mains and underground sewers may also result in large volume changes. Therefore, special care shall be taken to prevent such leakages.

10 EFFECT OF MASS MOVEMENTS OF GROUND IN UNSTABLE AREAS

In certain areas, mass movements of the ground are liable to occur from causes independent of the loads applied by the foundations of structures. These include mining subsidence, landslips on unstable slopes and creep on clay slopes.

10.1 Mining Subsidence

In mining areas, subsidence of the ground beneath a building or any other structure is liable to occur. The magnitude of the movement and its distribution over the area are likely to be uncertain and attention shall, therefore, be directed to make the foundations and structures sufficiently rigid and strong to withstand the probable worst loading condition and probable ground movement. In this connection, reference should also be made to **6.3.1**.

10.2 Landslide Prone Areas

10.2.1 The construction of structures on slopes which are suspected of being unstable and are subject to landslip shall be avoided.

10.2.2 On sloping ground on clayey soils, there is always a tendency for the upper layers of soil to move downhill, depending on type of soil, the angle of slope, climatic conditions, etc. In some cases, the uneven surface of the ground will indicate that the area is subject to small land slips and, therefore, if used for foundation, will obviously necessitate special design consideration as specified in IS 14243 (Parts 1 and 2).

10.2.3 On sloping sites, spread foundations shall be on a horizontal bearing and stepped. At all changes of levels, they shall be lapped at the steps for a distance at least equal to the thickness of the foundation or twice the height of the step, whichever is greater. The steps

shall not be of greater height than the thickness of the foundation, unless special precautions are taken.

10.2.4 Cuttings, excavations or sloping ground near and below foundation level may increase the possibility of shear failure of the soil. The foundation shall be placed beyond the zone of such shear failure.

10.2.5 If the probable failure surface intersects a retaining wall or other revetment, the later shall be made strong enough to resist any unbalanced thrust. In case of doubt, as to the suitability of the natural slopes or cuttings, the structure shall be kept well away from the top of the slopes, or the slopes shall be stabilized.

10.2.6 Cuttings and excavations adjoining foundations reduce stability and increase the likelihood of differential settlement. Such an effect should be investigated when they exist or when made subsequently.

10.2.7 Where a structure is to be placed on sloping ground, additional complications are introduced. The ground itself may be subject to creep or other forms of instability, which may be enhanced if the strata dip in the same direction as the ground surface. If the slope of the ground is large, the overall stability of the slope and substructure may be affected. These aspects should be carefully investigated.

11 PRECAUTIONS FOR FOUNDATIONS ON INCLINED STRATA

In the case of inclined strata, if they dip towards a cutting or basement, it may be necessary to carry foundation below the possible slip planes. Land drainage also requires special consideration, particularly on the uphill side of a structure to divert the natural flow of water away from the foundations.

12 STRATA OF VARYING THICKNESS

Strata of varying thickness, even at appreciable depth, may increase differential settlement. Where necessary, calculations should be made of the estimated settlement from different thicknesses of strata and the structure should be designed accordingly. When there is large change of thickness of soft strata, the stability of foundation may be affected. Subsurface investigation of the site should, therefore, ensure detection of significant variations in strata thickness.

13 LAYERS OF SOFTER MATERIAL

Some soils and rocks have thin layers of softer material between layers of harder material, which may not be detected unless thorough investigation is carried out. The softer layers may undergo marked changes in properties if the loading on them is increased or decreased by the proposed construction or affected by related changes in ground water conditions. These should be taken into account.

14 SPACING BETWEEN EXISTING AND NEW FOUNDATION

The minimum horizontal clear spacing between the edges of the existing and new footings shall be equal to the width of the wider footing. While the adoption of such provision shall help minimizing damage to adjacent foundation, an analysis of bearing capacity and settlement shall be carried out to have an appreciation of the effect on the adjacent foundation. Suitable site-specific protection measures shall be adopted for the existing foundation, as required.

15 LOADS ON FOUNDATIONS

15.1 Loads on a foundation are those forces imparted by the structure, it is supporting, in any of the form, (a) vertical either upwards or downwards, (b) horizontal or lateral, and (c) moment or couple.

15.2 Foundation shall be analyzed and designed for all the load combinations used for super-structure analysis and design. In the load combinations for analysis of foundations (for calculating bearing pressure or pile reaction), minimum load factor considered in design shall be unity.

15.3 The loads as in **15.3.1** to **15.3.7** shall be considered for design of foundations.

15.3.1 *Permanent Load*

This is the actual service load/sustained load consisting of dead loads and imposed loads of a structure which give rise to stresses and deformations in the soil below foundation causing its settlement.

15.3.2 *Transient Load*

This is a momentary or sudden load imparted to a structure due to wind or seismic vibrations. Due to its transitory nature, the stresses in the soil below the foundation carried by such loads are allowed certain percentage increase over the allowable safe values.

15.3.3 Foundations shall be proportioned for the following combination of loads:

a) Dead load + imposed load, and
b) Dead load + imposed load + wind load or seismic force.

Loads and forces shall be calculated in accordance with IS 875 (Parts 1, 2 and 3) and IS 1893 (Part 1).

15.3.4 Dead load also includes the weight of column/wall, footings, foundations and the overlying fill but excludes the weight of the displaced soil.

15.3.5 Imposed loads from the floors above as specified in IS 875 (Part 2) shall be taken in proportioning and designing the foundations.

15.3.6 Where wind or seismic load is less than 25 percent of that due to dead and imposed loads, it may be neglected in design.

15.3.7 Where wind or seismic load is more than 25 percent of that due to dead and imposed loads, foundations may be so proportioned that the pressure due to combination of load, that is, dead + imposed + wind load, does not exceed the safe bearing capacity by more than 25 percent. When seismic forces are considered, the safe bearing capacity shall be increased as specified in IS 1893 (Part 1) or IS 1893 (Part 4), as applicable. Analysis for liquefaction and the influence of earthquake shall also be made in accordance with IS 1893 (Part 1).

16 SETTLEMENT OF FOUNDATION

16.1 Uniform Settlement

The magnitude of the settlement that should occur, when foundation loads are applied to the ground, depends on the rigidity of substructure and compressibility of the underlying strata. In silts and clays, the settlement may continue for a long period after the construction of structure. Due allowance shall, therefore, need to be made for this consolidation settlement. In sand and gravels, the settlement is likely to be over by the end of the construction. In strata of organic soils, settlement may continue for a long time after construction. For the safety of foundations, the Engineer-in-Charge should be well familiar with all causes of settlement. Foundations may settle due to some combination of the following reasons:

a) Elastic compression of the foundation material and the underlying soil;

b) Consolidation including secondary compression;

c) *Ground water lowering* — Specially repeated lowering and raising of water level in cohesionless soils tend to compact the soil and cause settlement of the footings. Prolonged lowering of the water table in fine grained soils may introduce settlements because of the extrusion of water from the voids. Pumping water or draining water by wells or pipes from granular soils without adequate filter material as protection may, in a period of time, carry a sufficient amount of fine particles away from the soil and cause settlement;

d) Seasonal swelling and shrinkage of expansive clays;

e) Ground movement on earth slopes, for example, surface erosion, slow creep or landslides; and

f) Other causes, such as nearby excavation, mining subsidence and underground erosion by streams or floods.

16.2 Differential Settlements

The foundations of different elements of a structure may have unequal settlements and the difference between such settlements will cause differential settlement in the structure. Some of the causes of differential settlements are as follows:

a) Geological and physical non-uniformity or anomalies in type, structure, thickness, and density of the soil medium, an admixture of organic matter, peat, mud, etc;

b) Non-uniform pressure distribution from foundation to the soil due to non-uniform loading of the foundations;

c) Variation of ground water table;

d) Overstressing of soil at adjacent site by heavy structures built next to light ones;

e) Overlap of stress distribution in soil from adjoining structures;

f) Unequal expansion of the soil due to excavation for footing;

g) Non-uniform development of extrusion causing settlements; and

h) Non-uniform structural disruptions or disturbance of soil due to freezing and thawing, swelling, softening and drying of soils.

16.3 Criteria for Settlement Analysis for Shallow Foundation

16.3.1 For foundations resting on coarse grained soils, the settlements shall be estimated by considering the load mentioned in **15.3.3** (b). In such type of soils, settlements occur within a very short period of loading.

16.3.2 For fine grained soils, the settlements shall be estimated corresponding to the load mentioned in **15.3.3** (a).

16.3.3 It is possible to minimize differential settlement under an imposed load by providing appropriate foundations to keep the differential settlement of adjacent foundations within permissible limits. This may be done by the following procedure:

a) Determine the required bearing area for a column having the largest imposed load to dead load ratio. ln the conventional method of design, the area (A) is given by:

$$A = \frac{\text{Dead load} + \text{Imposed load}}{\text{Allowable bearing pressure}}$$

b) Compute for the same column, the design bearing value:

$$q_d = \frac{\text{Service load}}{A}$$

c) Determine the area for all other columns by the use of q_d, that is:

$$\text{Bearing area} = \frac{\text{Service load}}{q_d}$$

d) For calculation of settlement of foundations, IS 8009 (Part 1) may be referred.

16.3.3 The total settlement of the foundations caused by elastic and consolidation settlement of the soil shall be not more than permissible.

16.3.4 The permissible value of settlement for different types of structures are given in Table 1.

16.3.5 Differential settlement and/or tilt (angular distortion) of the structures shall not be more than the permissible values. The differential settlement shall be obtained by taking the difference between maximum and minimum settlement. Tilt shall be calculated by dividing the differential settlement by the distance between points of related maximum and minimum settlement.

16.4 Settlement Analysis for Deep Foundation

The permissible value of total settlement, differential settlement, and tilt (angular distortion) of the foundation shall be judiciously adopted by the designer considering the type of structure and functional requirements. The settlement shall be calculated according to IS 8009 (Part 2).

17 STABILITY AGAINST SLIDING AND OVERTURNING

17.1 The stability of the foundation against sliding and overturning shall be checked, and the factors of safety shall conform to the requirements specified in **17.1.1** and **17.1.2**.

17.1.1 *Sliding*

The factor of safety against sliding of structures which resist lateral forces (such as retaining walls) shall be not less than 1.5 when dead load, imposed load and earth pressures are considered together with wind load or seismic forces. When dead load, imposed load and earth pressure only are considered, the factor of safety shall be not less than 1.75.

NOTE — For structures founded on soils with low frictional coefficient (that is, slippery material), safety against sliding may be improved by providing anchor type cut-off walls or piles to take the excess load over that resisted by friction or an inclined underside of the base.

17.1.2 *Overturning*

The factor of safety for shallow foundation against overturning shall be not less than 1.5 when dead load, imposed load and earth pressures are considered together with wind load or seismic forces. When dead load, imposed load and earth pressures only are considered, the factor of safety shall be not less than 2. The factor of safety of other types of foundation is covered in relevant Indian Standards (*see* **4**).

18 BEARING CAPACITY

The net safe bearing capacity for shallow foundation shall be calculated in accordance with IS 6403. The method of computation of safe bearing capacity for other types of foundations has been specified in the relevant Indian Standards.

19 PRELIMINARY WORK FOR CONSTRUCTION

19.1 The construction of access roads, main sewers and drains should preferably be completed before commencing the work of foundations; alternatively, sufficient precautions shall be taken to protect the already constructed foundations during subsequent work.

19.2 Clearance of Site

Any obstacles, including the stump of trees, likely to interfere with the work shall be removed. Holes left by digging, such as those due to removal of old foundation, uprooted trees, burrowing by animals, etc, shall be back-filled with soil and well compacted.

19.3 Drainage

If the construction site is such that surface water drain towards the structure, the land may be dressed or drains laid to divert the water away from the structure.

19.4 Setting Out

Generally the site shall be levelled before the layout of foundations are set out. In case of sloping terrain, care shall be taken to ensure that the dimensions on plans are set out correctly in one or more horizontal planes.

19.5 The layout of foundations shall be set out in accordance with IS 11134. The setting out of walls shall be facilitated by permanent row of pillars, parallel to and at a suitable distance beyond the periphery of the building. The pillars shall be located at junctions of cross walls with the peripheral line of pillars. The centreline of the cross walls shall be extended to and permanently erected on the plastered tops of the corresponding sets of pillars. The datum lines parallel to and at the known fixed distance from the centreline of the external walls also be permanently worked on the corresponding rows of pillars to pillars to serve as checks on the accuracy of the work as it proceeds. The top of these pillars shall be at the same level and preferably at the plinth or floor level. The pillars shall be of sizes not less than 250 mm wide and shall be bedded sufficiently deep into ground so that they are not disturbed.

Table 1 Permissible Settlement, Differential Settlement and Tilt (Angular Distortion) for Shallow Foundation in Soils

(*Clause* 16.3.4)

Sl No.	Type of Structure	Isolated Foundations						Raft Foundations					
		Sand and Hard Clay			Plastic Clay			Sand and Hard Clay			Plastic Clay		
		Maximum settlement	Differential Settlement	Angular Distortion	Maximum settlement	Differential Settlement	Angular Distortion	Maximum settlement	Differential Settlement	Angular Distortion	Maximum settlement	Differential Settlement	Angular Distortion
		mm	mm		mm	mm		mm	mm		mm	mm	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	For steel structure	50	.003 3L	1/300	50	.003 3L	1/300	75	.003 3L	1/300	100	.003 3L	1/300
ii)	For reinforced concrete structures	50	.001 5L	1/666	75	.001 5L	1/666	75	.002 1L	1/500	125	.002L	1/500
iii)	For multi-storeyed buildings:												
	a) RC or steel framed buildings with panel walls	60	.002L	1/500	75	.002L	1/500	75	0.002 5L	1/400	125	0.003 3L	1/300
	b) For load bearing walls												
	1) $L/H = 2$[1)]	60	.000 2L	1/5 000	60	.000 2L	1/5 000	← Not likely to be encountered →					
	2) $L/H = 7$[1)]	60	.000 4L	1/2 500	60	.000 4L	1/2 500						
iv)	For water towers and silos	50	.001 5L	1/666	75	.001 5L	1/666	100	.002 5L	1/400	125	0.002 5L	1/400

[1)] For intermediate ratios of L/H, the values can be interpolated.

L denotes the length of deflected part of wall/raft or centre-to-centre distance between columns.

H denotes the height of wall from foundation footing.

NOTES — The values given in the table may be taken only as a guide and the permissible total settlement/different settlement and tilt (angular distortion) in each case should be decided as per the requirements of the designer. L denotes the length of deflected part of wall/raft or centre-to-centre distance between columns. H denotes the height of wall from foundation footing.

20 PROTECTION OF EXCAVATION

20.1 The protection of excavation during construction and dewatering operations, where necessary, shall be done in accordance with IS 3764.

20.2 After excavation, the bottom of the excavation shall be cleared of all loose soil and rubbish and shall be levelled, where necessary. The bed shall be wetted and compacted by heavy rammers to an even surface.

20.3 Excavation in clayey or other soils that are liable to be effected by exposure to atmosphere shall be concreted as soon as they are dug. The bottom of excavation shall be protected immediately by laying at least 80 mm thick layer of cement concrete not leaner than mix 1 : 5 : 10 over which shall come the foundation concrete, or in order to obtain a dry hard bottom, the last excavation of about 100 mm shall be removed only before concreting.

20.4 The backfilling of the excavation shall he done with care so as not to disturb the constructed foundation, and shall be compacted in layers not exceeding 150 mm compacted thickness, with sprinkling of minimum quantity of water necessary for proper compaction.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
456 : 2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
875	Code of practice for design loads (other than earthquake) for buildings and structures
(Part 1) : 1987	Dead loads — Unit weights of building materials and stored materials (*second revision*)
(Part 2) : 1987	Imposed loads (*second revision*)
(Part 3) : 2015	Wind loads (*third revision*)
1080 : 1985	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) (*second revision*)
1892 : 2021	Subsurface investigation for foundations — Code of practice (*second revision*)
1893	Criteria for earthquake resistant design of structures
(Part 1) : 2016	General provisions and buildings (*sixth revision*)
(Part 4) : 2015	Industrial structures including stack-like structures (*first revision*)
2809 : 1972	Glossary of terms and symbols relating to soil engineering (*first revision*)
2911	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*)
(Part 2) : 2021	Timber piles (*second revision*)
(Part 3) : 2021	Under-reamed piles (*second revision*)
2950 (Part 1) : 1981	Code of practice for design and construction of raft foundations: Part 1 Design (*second revision*)
2974	Code of practice for design and construction of machine foundations
(Part 1) : 1982	Foundation for reciprocating type machines (*second revision*)
(Part 2) : 1980	Foundations for impact type machines (hammer foundations) (*first revision*)
(Part 3) : 1992	Foundations for rotary type machines (medium and high frequency) (*second revision*)
(Part 4) : 1979	Foundations for rotary type machines of low frequency (*first revision*)
(Part 5) : 1987	Foundations for impact machines other than hammer (forging and stamping press, pig breaker, drop crusher and jolter) (*first revision*)
3764 : 1992	Excavation work — Code of safety (*first revision*)
4091 : 1979	Code of practice for design and construction of foundations for transmission line towers and poles (*first revision*)
6403 : 1981	Code of practice for determination of breaking capacity of shallow foundations (*first revision*)
8009	Code of practice for calculation of settlements of foundations
(Part 1) : 1976	Shallow foundations subjected to symmetrical static vertical loads
(Part 2) : 1980	Deep foundations subjected to symmetrical static vertical loading
9456 : 1980	Code of practice for design and construction of conical and hyperbolic paraboloidal types of shell foundations
9527 (Part 1) : 1981	Code of practice for design and construction of port and harbour structures: Part I Concrete monoliths
9556 : 1980	Code of practice for design and construction of diaphragm walls

IS No.	*Title*	*IS No.*	*Title*
11089 : 1984	Code of practice for design and construction of ring foundation	14243	Selection and development of site for building in hill areas — Guidelines
11134 : 1984	Code of practice for setting out of buildings	(Part 1) : 1995	Microzonation of urban centres
11233 : 1985	Code of practice for design and construction of radar antenna, microwave and TV tower foundations	(Part 2) : 1995	Selection and development

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Soil and Foundation Engineering Sectional Committee, CED 43

Organization	*Representative(s)*
In Personal Capacity (*Flat No. 202/395, Jodhpur Park, Kolkata 700068*)	Dr N. Som (***Chairman***)
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