भारतीय राष्ट्रीय मानक संस्थान
NATIONAL STANDARDS BODY OF INDIA

भारत सरकार
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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय
MINISTRY OF CONSUMER AFFAIRS,
FOOD & PUBLIC DISTRIBUTION
9, Bahadur Shah Zafar Marg, New Delhi 110001

व्यापक परिचालन मसौदा

हमारा संदर्भः सीईडी 48/टी-30 **20 जून 2025**

तकनीकी समिति: रॉक मैकेनिक्स विषय समिति**,** सीईडी 48

प्राप्तकर्ता:

क) सिविल इंजीनियरी विभाग परिषद्, सीईडीसी के सभी सदस्य
ख) सीईडी 48 के सभी सदस्य
ग) रूचि रखने वाले अन्य निकाय

प्रिय महोदय/महोदया,

निम्नलिखित भारतीय मानक का मसौदा संलग्न है:

प्रलेख संख्या	शीर्षक
सीईडी 48 (27737)WC	**शैल पर उथली नींव पर बने भवनों की संरचना सुरक्षा — रीति संहिता का भारतीय मानक मसौदा** [IS 13063 का *पहला पुनरीक्षण*] ICS 91.060.30

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

सम्मतियाँ भेजने की अंतिम तिथि : **21 जुलाई 2025**

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को उपरिलिखित पते पर संलग्न फोर्मेट में भेजें या manoj@bis.gov.in पर ईमेल कर दें ।

यदि कोई सम्मति प्राप्त नही 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 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 हैं।

धन्यवाद ।

भवदीय,

(द्वैपायन भद्र)
प्रमुख (सिविल इंजीनियरी)

संलग्नक : उपरिलिखित :

भारतीय राष्ट्रीय मानक संस्थान
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DRAFT IN WIDE CIRCULATION

Ref: CED 48/T-30 **20 June 2025**

TECHNICAL COMMITTEE: Rock Mechanics Sectional Committee, CED 48

ADDRESSED TO:

a) All Members of Civil Engineering Division Council, CEDC
b) All Members of CED 48
c) All others interests.

Dear Sir/Madam,

Please find enclosed the following document:

Doc No.	Title
CED 48 (27737)WC	**Draft Indian Standard** **Structural Safety of Buildings on Shallow Foundations on Rocks — Code of Practice** (*First Revision* of IS 13063) ICS 91.060.30

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

Last Date for comments**: 21 July 2025**

Comments if any, may please be made in the attached format and mailed to the undersigned at the above address or preferably through e-mail to manoj@bis.gov.in.

In case no comments are received or comments received are of editorial nature, you may 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,

(**Dwaipayan Bhadra**)
Head (Civil Engineering)

Encl: As above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A-4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/table/fig etc. be started on a fresh box. Information in column 3 should include reasons for the comments and suggestions for modified working 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 manoj@bis.gov.in)

Doc. No.: **CED 48 (27737) WC**

Title: **Draft Indian Standard Structural safety of Buildings on Shallow Foundations on Rocks — Code of Practice**
(*First Revision* of IS 13063) ICS 91.060.30

LAST DATE OF COMMENT: **21/07/2025**

NAME OF THE COMMENTATOR/ORGANIZATION: __________________________

Sl. No.	Clause/Para/Table/ Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY
(*Not to be reproduced without the permission of BIS or used as an Indian Standard*)

Draft Indian Standard

STRUCTURAL SAFETY OF BUILDINGS ON SHALLOW FOUNDATIONS ON ROCKS — CODE OF PRACTICE

(*First Revision* of IS 13063)
ICS 91.060.30

Rock Mechanics Sectional Committee, CED 48	Last date of comments: **21 July 2025**

FOREWORD

(*Formal clauses will be added later*)

Since most unweathered intact rocks are stronger and less compressible than concrete, the determination of allowable bearing pressure on such rocks may be unnecessary. However, Intact rock masses without weathered zones, joints or other discontinuities are encountered rarely in nature. The existence or location of specific discontinuities of foundation rocks often remain unknown until the rock mass is exposed by excavation. Thus, design engineers should be aware of dangers associated with the heterogeneity, anisotropy and unfavourable rock conditions. This is because overstressing a rock foundation may result in large differential settlements tilts or perhaps sudden failure.

This Indian standard was first published in 1991. The first revision of this Indian standard has been modified as a result of experience gained and to align the standard in line with present good practices being followed in the country and abroad. The principle modifications in this revision are as follows:

a) Electrical resistivity method for geophysical Investigations has been included;
b) seismic refraction method for geophysical investigations has been elaborated and align with IS 15681;
c) Laboratory testing methods are improved and align with their corresponding Indian Standards;
d) Guidelines for choice of method has been elaborated and ambiguities are clarified;
e) Wordings and sentences have been improved to avoid conflicting meanings.
f) Figures have been improved for better clarity; and
g) References have been aligned with latest Indian Standards.

In the formulation of this standard due weightage has been given to the standards and practices prevailing in different countries and that in our country.

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 : 2022 'Rules for rounding of numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

STRUCTURAL SAFETY OF BUILDINGS ON SHALLOW FOUNDATIONS ON ROCKS — CODE OF PRACTICE

(*First Revision*)

1 SCOPE

1.1 This standard lays down the general requirements for structural safety of buildings having shallow foundations on rock mass.

1.2 The provisions of this code does not cover the special requirements/conditions for foundations under tensile loads.

2 REFERENCES

The 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 were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 2809 and IS 1904 shall apply.

4 SITE INVESTIGATIONS AND OTHER GENERAL CONDITIONS

4.1 Objective of Site Investigation

The objective of any site investigation shall be for the determination of the followings:

a) The character of ground, identification of rock types together with their discontinuities, which tend to influence the behaviour of rock mass [*see* IS 11315 (Parts 1 to 11)];
b) Character of ground water, measurement of piezo metric pressures and location of the more permissible zones; and
c) Engineering properties of the rocks as determined by laboratory and field testing.

4.2 Existing Information

In areas which have already been developed, advantage should be taken of existing local knowledge, records of trial pits and bore holes, etc, in the vicinity and behaviour of existing structures, particularly those of a nature similar to that of the proposed structures. In such cases, exploration may be limited to checking that the existing ground conditions are similar as in neighborhood.

4.3 Site Reconnaissance

4.3.1 If the existing information is not sufficient or is inconclusive, the site should be explored in detail so as to obtain a knowledge the of type, uniformity, consistence, thickness, sequence and dip of the strata and of the ground water conditions.

4.3.2 The site reconnaissance would help in deciding the future programme of field investigations, that is, to assess the need for preliminary or detailed investigations. This would also help in determining the scope of work, method of exploration to be adopted, field tests to be conducted and administrative arrangement required for the investigation. Where detailed published information on the geotechnical condition is not available, an inspection of site and study of topographical features are helpful in getting information about soil, rock and ground water conditions. Site reconnaissance includes a study of local topography, excavations, ravines, quarries, escarpments, evidence of erosion or landslides, behaviour of existing structures at or near the site, water marks, natural vegetation, drainage pattern, location of seeps, springs and swamps. Information on some of these may be obtained from topographical maps, geological maps, pedological and soil survey maps and aerial photographs.

4.4 Preliminary Exploration

The scope of preliminary exploration is restricted to the determination of depth, thickness, extent and composition of overlying soil strata, location of rock and ground water and also to obtain approximate information regarding strength and compressibility of various strata. During preliminary investigation, geophysical methods are useful guides.

4.4.1 *Geophysical Investigations*

Geophysical surveys make use of difference in, physical properties like elastic modulus, electrical conductivity, density and magnetic susceptibility of geological formations in the area to investigate the subsurface. Out of the four methods of geophysical surveys, namely, seismic, electrical, magnetic and gravity surveys, only seismic refraction and electrical resistivity method are widely used in geotechnical investigations.

4.4.1.1 *Seismic refraction method for survey*

The seismic refraction method for survey makes use of the variation of elastic properties of the strata, which affect the velocity of the shock waves travelling through them, thus providing the useful information about the subsurface formations. This method has the outstanding advantages of being relatively cheap and rapid to apply and influencing large volume of rock mass. For seismic refraction method IS 15681 may be referred. The following information in respect of the rock mass is obtained from these tests:

a) Location and configuration of bed-rock and geological structures in the subsurface; and
b) The effect of discontinuities in rock mass can be estimated by comparing the in-situ compressional wave velocity with laboratory sonic velocity of intact core obtained from the same rock mass.

$$\text{RQD percent} = \text{Velocity Ratio}$$
$$= (V_F/V_L)^2 \times 100$$

where

V_F = compressional wave velocity in rock mass; and

V_L = compressional wave velocity in intact rock core.

4.4.1.2 *Electrical resistivity method*

The purpose of electrical resistivity method for survey is to determine the subsurface resistivity distribution by making measurements on the ground surface. The ground resistivity is related to various geological parameters, such as, the mineral and fluid content, porosity and degree of water saturation in rock. For detailed guidance IS 15736 may be referred.

The measurements of electrical resistivity require that four electrodes be placed in contact with the surface material then a direct current, or a very low frequency alternating current, is passed into the ground through a pair of current electrodes, and the resulting potential drop is measured across a pair of potential electrodes.

The resistance is then derived as the ratio of the voltage measured across the potential electrodes and the current electrodes.

The apparent resistivity of subsurface materials is the resistance multiplied by a geometric factor determined by the geometry and spacing of the electrode array.

$$\rho_a = \text{k} \frac{\Delta V}{I}$$

where

ρ_a = Apparent resistivity;
k = geometric factor;
ΔV = potential drop; and
I = applied current.

4.5 Detailed Exploration

Detailed investigations follow preliminary investigation and should be planned on the basis of data obtained during reconnaissance and preliminary investigations. Detailed investigation includes the following:

a) Open pit trials;
b) Exploratory drilling;
c) Sampling;
d) Laboratory testing; and
e) Field testing.

4.5.1 *Open Pit Trials*

The method of exploring by open pit consists of excavating trial pits at site and thereby exposing the rock surface for visual inspection, geological mapping, in-situ field testing and for obtaining rock samples for laboratory testing. This method is generally used for small depths, fissures and zones of weak rocks, which would breakup in core barrel.

4.5.2 *Exploratory Drilling*

The purpose of a drilling investigation is to:

a) Confirm the geological interpretations;
b) Examine the cores and bore holes to determine the quality and characteristics of the rock mass;
c) Study the ground water condition; and
d) Provide cores for laboratory testing and petrographic analysis.

4.5.2.1 Various methods of the exploratory drilling have been described in IS 1892. Following methods are recommended for exploration in rock mass:

a) *Percussion drilling* — This method is more appropriate for boulderous and gravelly strata. However, since it does not even yield representative samples, it is not considered suitable for detailed investigations;

b) *Core drilling* — The objective of core drilling is to obtain rock cores for interpretation and testing. It is necessary to obtain 100 percent core recovery as far as possible. To ensure a successful drilling operation, the following aspects should be remembered:
   1) The drilling facilities permitting cores of at least NX size (54 mm diameter) and featuring split double tube core barrels to minimize drilling vibrations;
   2) It should also include for performing water pressure tests;
   3) Examination of bore hole walls by bore hole cameras should also be considered;
   4) Cores should be photographed as soon as possible and should be carefully marked, placed in protective wrappings in the core boxes and properly stored;
   5) A systematic method should be used for geotechnical logging of cores, which should include the history of drilling, for example, type of bit, rate of drilling and water test data, core recovery, RQD, weathering and description of rock;
   6) Each bore hole shall contain one piezometer set at the bottom of the bore hole so that once installed piezometers can be observed over an extended period; and
   7) If ground water contains harmful chemicals, its sulphate content and *p*H value shall be measured by chemical analysis of ground water.

c) *Shot drilling* — The system is used on large diameter holes, that is, over 150 mm. Due to necessity of maintaining the shots in adequate contact with the cutting bit and the formation, holes inclined over 5° to 6° cannot be drilled satisfactorily. The system is different from other types of core drillings because the coarser cuttings do not return to the surface but are accumulated in a chip cup immediately above the bit and here the chilled shot is used as an abrasive in place of the drill head.

4.6 Sampling

4.6.1 Rock samples commonly used in laboratory testing are lumped samples, block samples and core samples. IS 9179 should be referred to for methods of sample preparation.

4.6.2 Rock lumps are obtained from exposed rock formations or pieces of block samples. However, core Samples may be used as lumped samples.

4.6.3 *Block Samples*

Such samples taken away from the rock formation shall be dressed to a size convenient for packing to about 100 mm × 75 mm × 75 mm. Many times a large blocks of size 300 mm × 300 mm × 300 mm are obtained from site and specimens of required sizes are prepared in the laboratory.

4.6.4 *Core Samples*

Core obtained from core drilling or shot drilling process are used as core samples.

4.7 Laboratory Testing

The strength of the rock material may be estimated by means of laboratory tests on intact rock specimens. Most frequently used laboratory tests are described in **4.7.1** to **4.7.6**

4.7.1 *Point Load Core Strength Index Test*

This test is very fast and cheap for estimating the point load strength index (D). The test may be conducted on core pieces of length more than 1.5 times the diameter. For detailed procedure IS 8764 may be referred.

4.7.2 *Point Load Lumped Strength Index Test*

This test is conducted on lump pieces of rock material. The depth of the specimen (D) between the points should be less than the width of the specimen but should be more than one third width of the specimen. For detailed procedure IS 8764 may be referred.

4.7.3 *Uniaxial Compressive Strength Test*

This test is conducted on the core samples or block samples having length about 2 times to 3 times the diameter/breadth of the sample on the universal compression testing machine. For carrying out this test and analysis of the test data provisions of IS 9143 should be referred.

4.7.4 *Brazilian Test*

It is an indirect method of estimating the tensile strength of rock material. In this, a cylindrical rock specimen lying on its sides is loaded diametrically with compression load so as to bring about a uniformly distributed tensile stress over the vertical, central and diametrical plane. For detailed procedure IS 10082 may be referred.

4.7.5 *Direct Shear Strength Tests*

These tests may be conducted without normal stress or with normal stress on shear planes. These tests are conducted for shearing through intact rock specimen as well as along the weak planes, for example, joints surfaces, bedding planes, etc. For detailed procedure IS 12634 may be referred.

4.7.6 *Ultra Sonic Interferometry Tests*

These tests are conducted on core sample to measure the time of travel of p-wave in rock material and then the p-wave velocity and elastic modulus of rock material is calculated. It is a quick and cheap test for determining the elastic modulus of intact rock material.

4.8 In-Situ Tests

In-situ rock strength tests are performed because rock mass may contain various discontinuities and plane of slippages which reduces its strength. Following in-situ tests on rock masses are recommended.

4.8.1 *Plate Load Test*

Plate load test shall be performed on the foundation rocks according to IS 1888 and a curve between pressure on plate versus its settlement is obtained. Using pressure-settlement curve the allowable bearing capacity corresponding to the permissible maximum settlement of foundation can be evaluated as per IS 12070. This curve is also used to calculate the settlement of the footing for the actual bearing pressure on them.

NOTE — Horizontal plate load test may be conducted, where vertical plate load test is not feasible.

4.8.2 *Block Shear Test*

Block shear test shall be conducted on the foundation rocks in-situ as per IS 7746 to evaluate the shear characteristics of the rock mass. These tests shall be carried out along the surface parallel to the base of the footing. In case of laminated/jointed rock mass, these tests shall also be conducted along the lamination planes or joint planes to assess the shearing characteristics along the planes. Concrete block shear test shall also be carried out on the in-situ foundation rocks to assess the shear characteristics of joint between the rock mass and the concrete.

4.8.3 *Pressure Meter Test*

Pressure meter test allows for a direct determination of the strength of rock mass including discontinuities and weathering for design of foundation on weak rocks.

4.8.4 Uniaxial Jacking Test as per IS 7317 may be conducted on the two opposite walls of a drift or gallery to determine the modulus of deformation of rock mass.

4.8.5 Seismic refractive surveys are conducted to delineate the rock profile and to measure the velocity of p-waves in rock mass.

4.9 Choice of Method

4.9.1 The choice of method of exploration and the tests depends upon the nature of ground, topography, importance and size of building and cost.

4.9.2 For lightly loaded foundations, such as wall footings for buildings up to three storeys high, the pressure that these foundations apply to the ground (up to 20 tonnes per square metre) is usually less than what even the weakest rock can safely support. Because the ground can already support more load than what is being applied, the foundation size doesn't need to be based on strength (bearing capacity) alone. Instead, other factors, like settlement or dimensions constraint will decide the foundation size. it would be adequate to ensure that any type of rock other than boulder exists at foundation level.

4.9.3 Where rock is exposed over large area of building prior to construction or will be exposed after excavation, visual inspection of the rock surface provides a very reliable assessment of the type and quality of rock and the discontinuities of rock mass can be mapped from the exposed surface. The number of drill holes and tests to be conducted will depend upon the nature and type of rocks exposed and the size and importance of the building.

4.9.3.1 *Number of drill holes*

a) In massive crystalline rocks, drilling may be omitted altogether, except in case of very large/important buildings in which case one hole for every 1 000 m^2 of area with a minimum of 3 holes shall be drilled;
b) In moderately jointed and foliated rocks, one drill hole for every 300 m^2 to 500 m^2 of area shall be drilled. A minimum of 5 drill holes shall be drilled in case of foundations for very large, heavy and important buildings; and
c) In heavily jointed, sheared and weathered rock mass, one drill hole for every 200 m^2 to 300 m^2 area shall be drilled.

4.9.3.2 *Depth of holes*

a) The depth of drill hole below the foundation level should be equal to half of effective width of the foundation system in case of massive and sound rocks;
b) In moderately jointed and foliated rocks, the depth of drill holes below the foundation level should be equal to the effective width of the foundation system;
c) In heavily jointed and weathered rocks the depth of drill holes below the foundation level should be equal to twice the effective width of the foundation system;
d) Drill holes shall extend inside the rock mass to a minimum depth of 3 m; and
e) In the case of solid rock below jointed rock the drill hole shall extend below the foundations as per (b) and (c) above as appropriate or half the effective width into solid rock whichever is shorter.

4.9.4 Where the rock is not exposed on the surface, one hole shall be drilled for every 300 m^2 to 500 m^2 of the area to know about the subsurface formations. If the depth of rock is irregularly varying with the adjacent holes, more holes shall be drilled to fairly estimate the rock profile. The criteria for depth of hole shall be same as **4.9.3.2**.

4.9.5 If the foundation rock happens to be lime stone and dolomite associated with ground water flow, there is a likely chance of solution cavities underneath. In such cases, drill holes shall be drilled up to depth of at least one and half time the effective width of the foundation below the foundation level.

4.9.6 If the foundation rock happens to be consolidated sand rock; silt stone or clay shale with likely chance of getting saturated, necessary exploration and testing shall be conducted assuming it to be the soil.

4.9.7 *Selection of Tests*

4.9.7.1 For foundations on massive rocks, subjected to mainly vertical loads, only the tests for point load strength index or uniaxial compressive strength may be required.

4.9.7.2 For foundations on massive rocks subjected to heavy horizontal loads, concrete block shear tests and in-situ shear test shall be conducted to check stability against sliding.

4.9.7.3 For foundations on moderately jointed rocks, the tests for point load strength index or uniaxial compression strength and in-situ shear test shall be carried out.

4.9.7.4 For foundations on very weak and weathered rocks, plate load test or pressure meter test and in-situ sheer test shall be carried out.

4.10 Presentation of Geological Data

4.10.1 In summary, the following geotechnical and geological information are considered important in the stability of the building foundations on rock mass:

a) Rock type and origin;
b) Orientation of discontinuities in the rock mass;
c) Spacing of discontinuities in the rock mass;
d) Condition of discontinuities including roughness separation, continuity, weathering and infilling (gauge);
e) Ground water conditions;
f) Major faults;
g) Properties of the rock material that is uniaxial compressive strength, point load lump strength index; and
h) Drill core quality (RQD).

For evaluation and presentation of the above data, IS 11315 (Parts 1 to 11) shall be referred.

4.10.2 Communication between the engineering geologist and the design engineer will be greatly enhanced, if the data is presented in standard format. The followings are recommended:

a) Bore hole should be presented in well executed geotechnical logs;
b) Mapping data should be presented as spherical projection or surface projections;
c) Longitudinal and cross-sections of structural geology at the site should form an integral part of a geological report;
d) For every important structures consideration should be given to constructing a geological model of the site; and

e) A summary of all the geotechnical and geological data including the ground water conditions should be entered in the input data sheet for rock mass classification purpose.

4.11 General Stability of Area

4.11.1 When slope instability occurs, there is limited scope to safeguard existing structures in the affected area. Therefore, area prone to land slips, mass movements, or unstable slopes shall be avoided.

4.11.2 If there happen to be an old slip zone near the site of the buildings, detailed stability analysis of the area shall be carried out and worst probable slip zone shall be demarcated. No buildings shall be constructed in the area which is 200 m or less from the boundary of the maximum probable slip zone.

4.11.3 If the area happens to be hilly terrain, before planning and approving a building complex on the slopes, detailed stability analysis of the slopes shall be carried out and maximum amount of the load that can be placed by way of buildings construction and their occupants on particular area shall be worked out and notified. Regulations shall be promulgated to effectively control construction in sensitive areas.

4.11.4 While carrying out the stability analysis of the zone where building complex is proposed, change in the subsurface water conditions due to development of township shall be accounted for.

4.11.5 Mass movements of the ground are liable to occur from causes independent of the presence of the building. These include excavation, saturation, mining subsidence, land slips on unstable slopes and creep on slopes. These factors shall be taken into account in the design and expert advice shall be sought, wherever required.

4.11.6 On uphill side of a building on a sloping site, drainage requires special considerations. The natural flow of water shall be diverted away from the foundation.

4.11.7 No trees which grow to a large size shall be planted within 8 m of the foundations of buildings.

5 GENERAL CONSIDERATIONS FOR DESIGN (SAFETY)

5.1 Loads on Foundation

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

a) Dead load, live load, earth pressure, water pressures/snow load in areas where it is encountered; and
b) Dead load, live load, earth pressure, water pressures/snow load where it is encountered with wind or seismic load.

5.1.2 Dead load also includes the mass of column/wall, footings, foundations, the overlying fill including frost, if encountered, ignoring the mass of soil displaced by foundation system.

NOTE — There are a number of states in India where snow will be encountered during winter or perennially over underlying bed rock on which the foundation system is intended to be constructed.

5.1.3 Live loads from the floors above, as specified in IS 875 (Part 2) shall be taken into account.

5.2 Allowable Bearing Pressures

5.2.1 Pressures coming on the rock due to building foundation shall not be more than the safe bearing capacity of rock-foundation system taking into account the effect of eccentricity. The effect of interference of different foundations should also be taken into account.

5.2.2 The total settlement of the foundation(s) shall not be more than permissible (recommended/allowable/tolerable) settlement (S_{per}) value.

5.2.3 Differential settlement (ΔS) and/or tilt of the building (T) or/and part of a building shall be not more than the recommended values ΔS_{per} and T_{per} respectively.

$$\Delta S \leq \Delta S_{\text{per}}$$
$$\text{and } T \leq \Delta T_{\text{per}}$$

where

ΔS = Calculated maximum value of differential settlement;
ΔS_{per} = Permissible value of differential settlement;
T = Estimated value of maximum tilt; and
T_{per} = Permissible value of tilt.

5.2.4 The recommended values of permissible settlements, differential settlements and angular distortion (tilt) are tabulated in Table 1. Higher values of maximum settlement can be adopted in case of highly weathered and disintegrated rock masses.

5.2.5 For satisfying the conditions of **5.2.1**, **5.2.2** and **5.2.3**, load combinations as described in **5.1.1** shall be considered.

5.2.6 For satisfying the conditions laid down in **5.2.1** and **5.2.2**, safe bearing pressures shall be estimated in accordance with IS 12070.

When wind loads or seismic loads are considered, the safe bearing pressure may be increased by 25 percent and 33 percent respectively. The safe bearing pressure shall not exceed the allowable pressures for the grade of concrete/masonry of foundation slab or grade of concrete laid over the rock surface, whichever is lower.

5.2.7 The allowable bearing pressure should, then, be determined by the following steps:

a) Proportion footing, making use of the safe bearing pressures value determined as per **5.2.5**;
b) Calculate differential settlements of footings;
c) Calculate angular distortions;
d) Compare the above values with those given in Table 1; and
e) If the comparison is not satisfactory, revise the allowable bearing pressure and repeat the steps (b), (c) and (d) until the comparison is satisfactory.

5.2.8 *Causes of Settlements*

For safety of building foundations, the engineer-in-charge should be well familiar with all causes of settlements. Foundations on rocks may settle due to combination of the following reasons:

a) Elastic compression of the foundation and the underlying bearing strata;
b) Ground movement on slopes due to erosion, creep or landslides;
c) Increase in ground water may soften the joint fill material, causing slippage along the joints;
d) Other causes such as adjacent excavation, mining, subsidence and underground erosion; and
e) Rocks such as schist, soft shale, and similar types tend to weather rapidly, which may lead to post-construction settlements during the structure's service life.

Table 1 Maximum and Differential Settlements of Buildings on Rock Mass
(*Clause* 5.2.4)

Sl No.	Type of Structure	Maximum Settlement mm	Differential Isolated Footing mm	Settlement Raft Foundation mm	Angular Isolated Footing	Distortion Raft Foundation
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	For steel structure	12	0.0033L	0.0033L	1/300	1/300
ii)	For reinforced concrete structures	12	0.0015L	0.002L	1/666	1/500
iii)	For plain bricks block walls in multistoried buildings					
	For L/H ≤ 3	12	0.00025L	—	1/400	—
	For L/H > 3	12	0.00033L	—	1/300	—
iv)	For water towers and silos	12	—	0.0025L	—	1/400

NOTE — The values given in the table may be taken only as a guide and the permissible settlement and differential settlement in each ease should be decided as per requirements of the designer depending upon importance of structure.
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.

5.2.9 *Causes of Differential Settlements*

Some of the causes of differential settlement are as follow:

a) Non-uniform pressure distribution from foundation to rock mass;
b) Overlap of stress distribution in rock mass due to loads of adjacent structures;
c) Geological and physical non-uniformity of rock mass under the foundation;
d) Slippage along the weaker planes of rock mass;
e) Water table fluctuations at construction site;
f) Non-uniform structural disruptions or disturbances of foundation rocks due to freezing and thawing;
g) Movement of the rock mass due to instability of general slopes;
h) In soluble rocks, solution cavities may become larger with time and may lead to differential settlements; and
j) Seepage of water in foundation of a part of a building.

5.2.10 The foundations shall normally be so proportioned that no tension is created at the foundation plane.

5.2.11 If tension is created under the foundation, the maximum tensile stress shall be less than three fourth of the 7 day modulus of rupture of foundation concrete or of concrete laid between the foundation and rock surface whichever is less. For this purpose, tensile strength of rock or cable anchors, if any, shall not be considered.

5.2.12 If tension is created under the base, the maximum bearing pressure shall be calculated on the modified base area which remain in compression only.

5.3 Stability Against Overturning and Sliding

Stability of foundation against overturning and sliding shall be checked and factors of safety shall conform to the requirements specified in **5.3.1** and **5.3.2**.

5.3.1 *Sliding*

5.3.1.1 The factor of safety against sliding of structures shall not be less than 1.5 when dead loads, live loads, earth pressures, water pressures and uplift pressures are considered together with wind load or seismic force. When only dead load, live load, earth pressure, water pressure

and uplift pressure are considered; the factor of safety against sliding shall be not less than 1.75.

5.3.1.2 For buildings founded on sloping rock surface, the factor of safety against sliding shall be calculated along the rock surface. The factor of safety against sliding may be improved by anchoring the foundation to the deeper strata of rock.

5.3.1.3 The adhesion and the coefficient of friction between the concrete and the rock mass under dry and submerged conditions and also of foundation rocks along weak shear zones and bedding planes shall be determined by in-situ block shear tests at site. For preliminary design the value given in Table 2 may be used.

Table 2 Values of Adhesion and Coefficient of Friction
(*Clause* 5.3.1.3)

Sl No.	**Material**	**Adhesion** kg/cm^2	**Coefficient of Friction**
(1)	(2)	(3)	(4)
i)	Massive and sound rock	5 to 10	0.80 to 1.0
ii)	Fractured, jointed rock	1 to 3	0.80

5.3.2 *Overturning*

The factor of safety against overturning shall be not less than 1.5 when dead loads, live loads, earth pressures and uplift are considered together with wind load or seismic forces. When only dead load, live load, earth pressures and uplift pressures are considered, the factor of safety shall be not less than 2.

5.4 Depth of Foundation

5.4.1 The minimum depth of foundation below the natural ground surface shall be 0.5 m.

5.4.2 In case of massive intact and unweathered rocks, the foundation can be laid over the rock surface after chipping off the top surface for preparation of a proper seat for the foundation.

5.4.3 In case of jointed, sheared and partially weathered rocks, the base of the foundation shall be kept at least 50 cm inside the rock surface, so that the upper portion of highly weathered rock miss is avoided. This would also take care of the error in judgement about the depth of rock surface.

5.4.4 In case of rock of very low strength, highly weathered rocks (for example, clay shales, sand rock and soft silt stone in Shivaliks), the depth of foundation shall be decided in accordance with provisions of IS 1904, considering the foundation material to be as soil.

5.4.5 A foundation on any type of rock mass shall be below the zone significantly weakened by root holes or cavities produced by barrowing animals or worms. The depth shall also be enough to prevent the rain water scouring below the footing.

5.4.6 Where there is excavation, ditch or sloping ground adjacent to the foundation which is likely to impair the stability of a building, either the foundation of such building shall be carried down to depth beyond the detrimental influence of such conditions or retaining walls (or similar works) shall be constructed for the purpose of shielding from their effects.

5.4.7 It is usually accepted to be safe that the foundation may be placed above the frost penetration limit (in areas where it is encountered) if the foundation is bearing on sound and massive rock. Any large or extensive seams, cracks, areas of disintegration in the rock should be cleaned and grouted up to the depth of maximum frost penetration by cement sand mortar (1 : 1). For other type of rocks, the base of foundation shall lie below the depth of maximum frost penetration.

6 GENERAL REQUIREMENTS

6.1 Concerning of Foundation

6.1.1 Wherever a foundation is embedded partially or fully in rock mass, the foundation concrete shall be laid from surface to surface of rock mass on sides. This will prevent any chance of rock mass movement due to loosening effect on the sides of foundation (*see* Fig. 1).

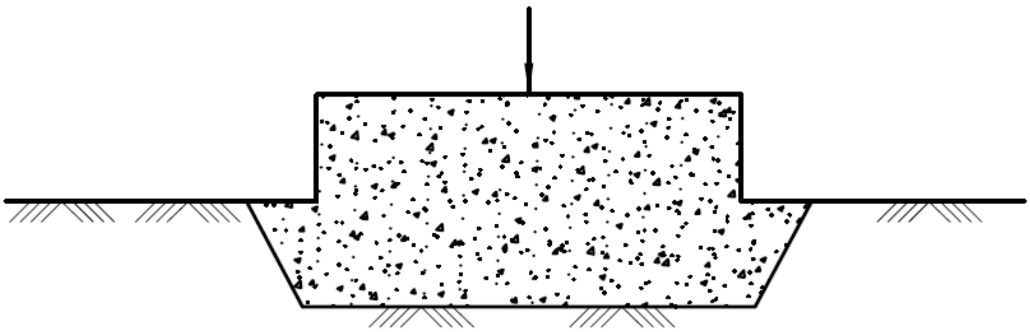

FIG. 1 EMBEDDED FOUNDATION

6.1.2 In case of presence of gypsum salt in the foundations, care be exercised to use sulphate resistant cement in the foundation.

6.2 Foundation Drainage

6.2.1 The surface drains in the building and around the building shall be so planned that water is drained away from the building.

6.2.2 All the surface drains, traversing jointed and weathered rocks in the built up area, shall be lined so as to prevent the entry of water to the foundation rocks.

6.2.3 If the springs/seepage of water is noticed on down slopes of a building complex, a suitable arrangement for free exit of water, provided with well-designed filter, shall be made so as to prevent the flow material along with water.

6.2.4 If the foundations are laid on the water bearing rock mass either the well-designed ground water drainage arrangement shall be provided so as to keep the ground water pressure well below the foundations or the foundation shall be designed for the water pressures and uplift pressures which will be exerted on the foundations.

6.2.5 If the bearing rocks are overlain by water bearing strata, suitable drainage arrangement shall be provided around the building foundations and the water pressures and uplift pressures shall be accounted for in design of foundations.

6.3 Foundation on Soluble Rocks

If the foundation rocks are dolomite or lime stone and there is a possibility of getting its joints charged with water, the joints shall be grouted with (1 : 1) cement sand mortar up to the depth equal to effective width of the foundation. For grouting of foundation rocks, IS 6066 may be referred.

6.4 Settlement Joints

It is recommended that settlement joints shall be provided on the buildings at places of abrupt change in the nature of foundation rock, superstructure or its layout in plan, for example, at the junction of the parts of a building with appreciably different number of storeys [*see* Fig. 2(A)] or where the outline of building in plan is sharply changed [*see* Fig. 2(B)] or where the compressibility of foundation strata abruptly changes [*see* Fig. 2(C)].

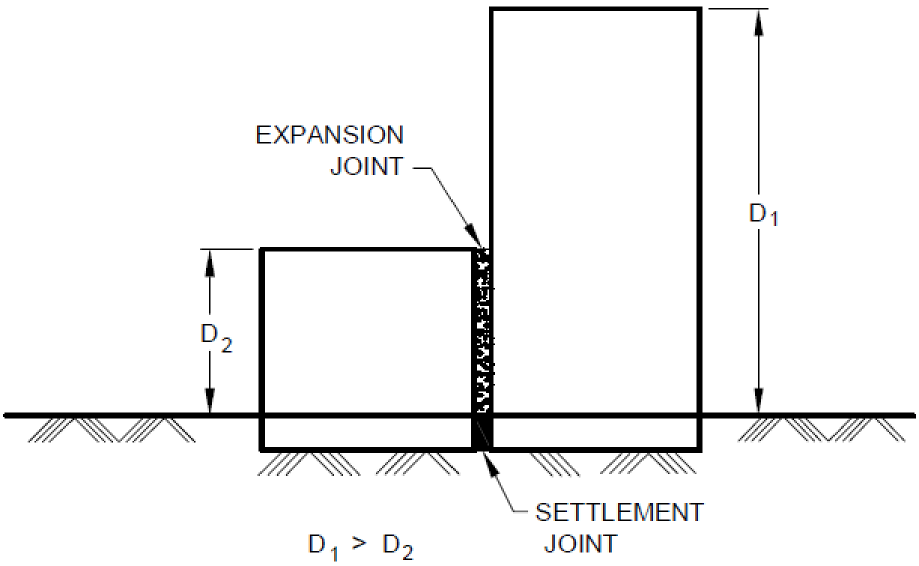

FIG. 2(A) ABRUPT CHANGE IN SUPERSTRUCTURE HEIGHT

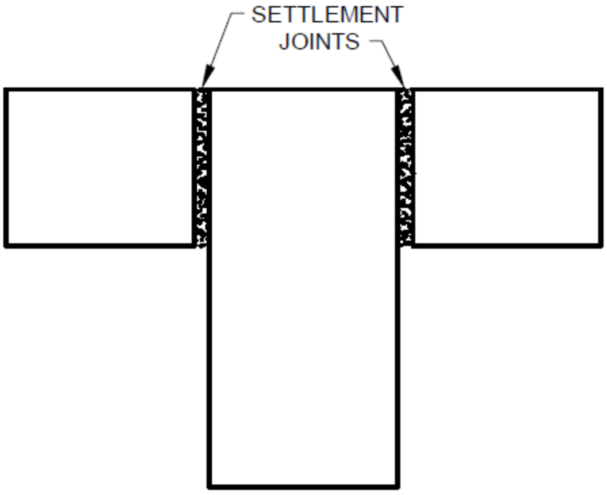

FIG. 2(B) ABRUPT CHANGE IN PLAN

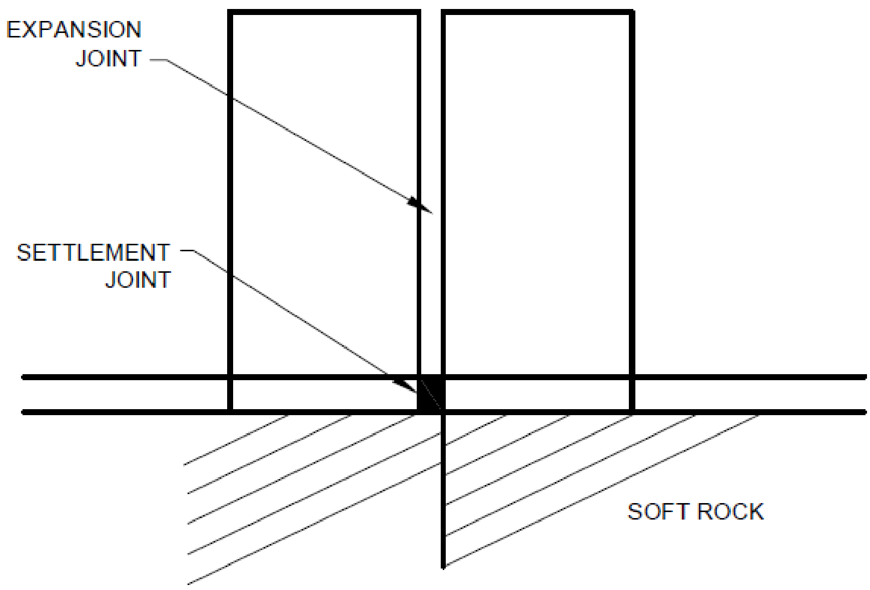

FIG. 2(C) FOUNDATION ON ROCK MASS OF TWO DIFFERENT COMPRESSIBILITIES

FIG. 2 TYPICAL CASES OF SETTLEMENT JOINTS

6.5 Foundations Adjacent to Sloping Ground

Where a foundation is to be constructed adjacent to the sloping ground, the following conditions shall be satisfied.

6.5.1 The frustum of bearing rock under the footing with sides, which make 60° with horizontal, shall remain within the sloping surface of rock [*see* Fig. 3(A)].

6.5.2 The minimum horizontal distance of lower edge of the footing shall be at least 60 cm away from the sloping surface [*see* Fig. 3(A)].

6.5.3 If the bedding or weak shear planes of the rock mass are dipping towards the slope, the footing should be so located that any weak plane through the base or the footing is not exposed on the sloping rock surface. To achieve this, either the foundation may be shifted away from the slopes or the depth of foundation may be increased [*see* Fig. 3(B)].

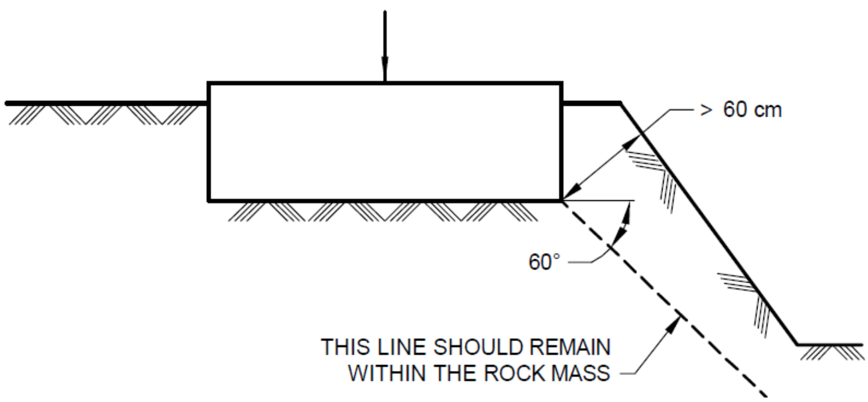

FIG. 3(A)

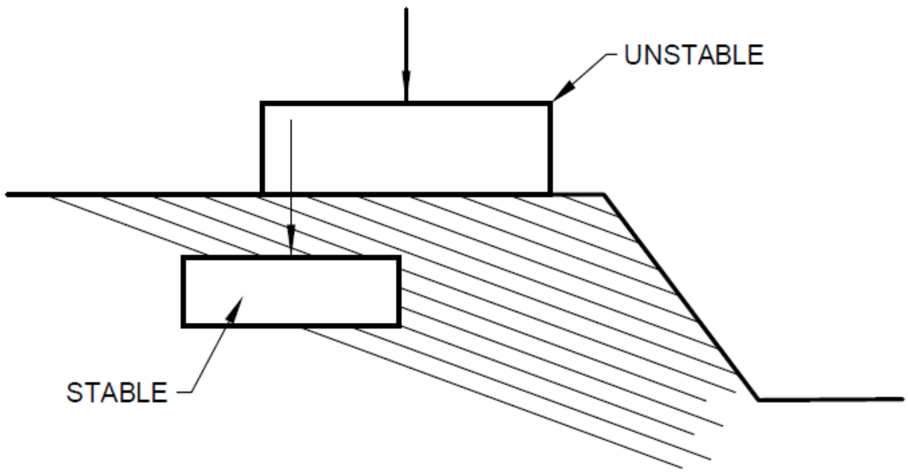

FIG. 3(B)

FIG. 3 FOUNDATION ADJACENT TO SLOPING GROUND

6.6 Foundation at Different Levels

Where foundations of the adjacent buildings are to be located at different levels, the following conditions shall be satisfied (*see* Fig. 4).

6.6.1 The minimum horizontal distance between the adjacent foundations shall be such that the loads from foundation at higher level are not transferred to the other foundation at lower level for which the lower foundation shall be outside the bearing frustum (making an angle of 60 with horizontal and also the weak planes crossing the base of higher foundation shall not cross the lower foundation.

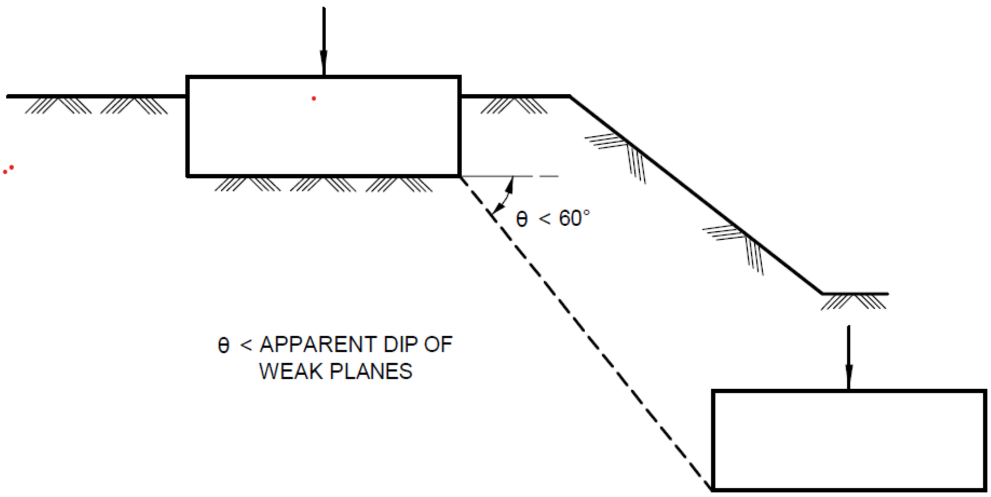

FIG. 4 FOUNDATION AT DIFFERENT LEVELS

6.6.2 If condition of **6.6.1** cannot be complied with, the lower foundations shall be designed for the additional loads (horizontal and vertical) transferred from higher foundation and the construction of the lower foundation shall be done prior to construction of higher foundation.

NOTE — In hills, there is bad practice to construct the walls of a building directly over the retaining walls which are constructed in dry random rubble masonry. Since the deformability of dry random rubble masonry is very high in comparison to that of the wall masonry as well as the foundation rock mass, they normally give way leading to cracking of the houses and sometimes results in total collapse of the building. Such practice should be discontinued.

6.7 Detailing of Reinforcement

6.7.1 The requirement of IS 456 shall be complied with.

6.7.2 In case of strip footings, the main reinforcement is provided along the width of footings. Some longitudinal reinforcement in the footing is desirable to assist in bridging over soft spots associated with heterogeneous conditions in rock masses. The longitudinal reinforcement in strip footing shall be not less than maximum of:

a) 0.15 percent (in case of mild steel) or 0.12 percent (when high steel deformed bars or welded wire fabric are used) of the total cross-sectional area on each face (top and bottom) of the RCC footing; and
b) 25 percent of the main reinforcement.

7 TREATMENT OF ROCK DEFECTS

7.1 Open Vertical Joints

7.1.1 More or less vertical joints from one to several centimeters are sometimes encountered even in unweathered rocks. These joints may either be open or clay filled. Such joints shall be cleaned out to a depth of four to five times their width and filled with cement grout, a mixture of one part of cement and one part of sand with enough water to permit pouring of grout into the joints [*see* Fig. 5(A)]. Large spaces, wider at top are commonly filled with dental concrete or high performance concrete.

7.1.2 If the foundation rocks comprises of nearly vertical joints so wide that they constitute an appreciable fraction of area (more than 20 percent), the excavation is usually deepened until the joints are no longer within the base or they narrow down to acceptable limits (within 20 percent of base area).

7.2 Open Horizontal Joints

Many rocks contain nearly horizontal joints which gets opened up due to relief in vertical stress. If such open joints are located beneath the foundations as shown in [Fig. 5(B)], the rock mass above the open joints shall be removed, if economically feasible, otherwise, the open space of the joints shall be filled with cement sand grout.

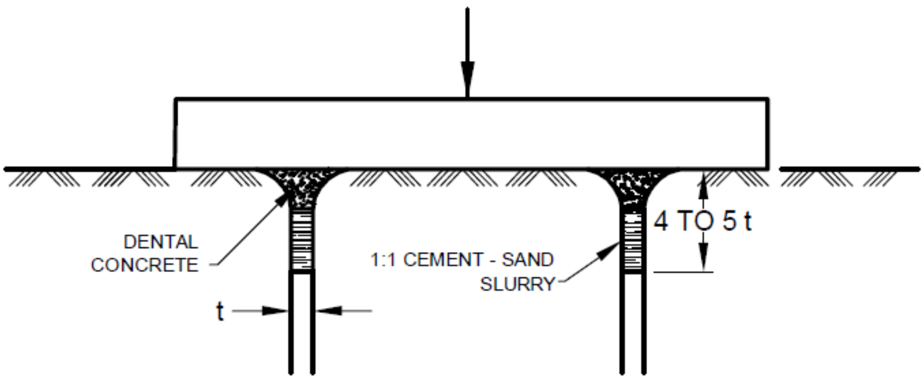

FIG. 5(A) STEEPLY DIPPING OPEN JOINTS

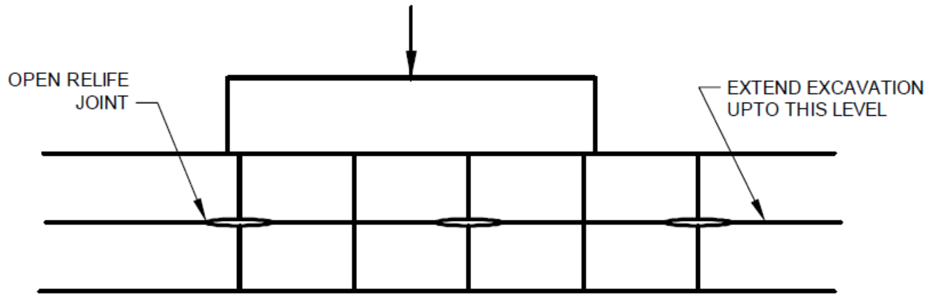

FIG. 5(B) OPEN HORIZONTAL JOINTS

FIG. 5 TREATMENT OF ROCK JOINTS

7.3 Solution Cavities

Solution cavities require detailed attention. In bedded lime stone, cavities are more likely to occur in some horizons than in others. Exploration shall be carried out to locate the horizon where unfavourable conditions exist. If the area of cavities is less than 20 percent of the base area of foundation, the safe bearing pressure shall be reduced as prescribed in IS 12070.

8 SPECIAL TREATMENTS

8.1 Weak Seams Under the Foundation

8.1.1 When inclined seams filled with soft material are located on the excavated rock surface under the foundation base covering less than 20 percent of the total area, the joint shall be washed and cleaned for depth equal to 2 to 3 times the width of the joint and shall be filled up with the cement sand grout (1 : 1) (*see* Fig. 6).

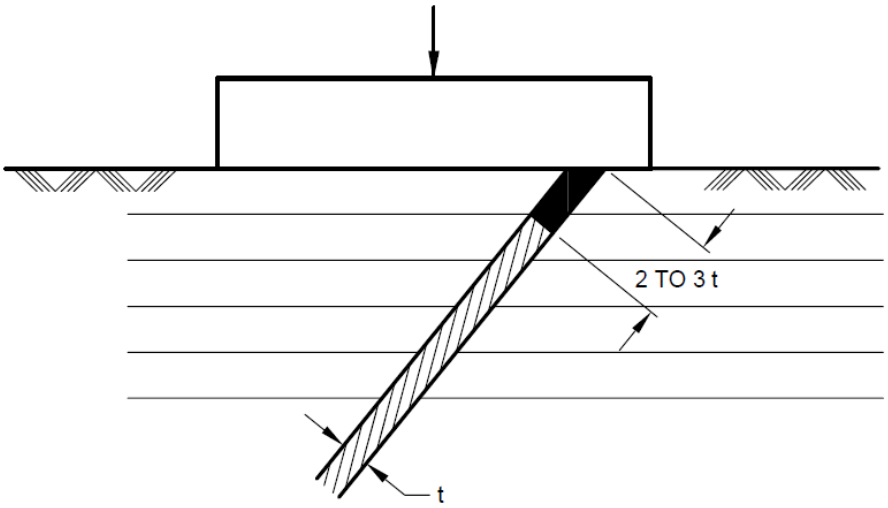

FIG. 6 WEAK SEAMS UNDER FOUNDATION LESS THAN 20 PERCENT OF AREA

8.1.2 If the area of weak seams under the foundation is more than 20 percent of the total base area, treatment as per **8.2** shall be done (*see* Fig. 7).

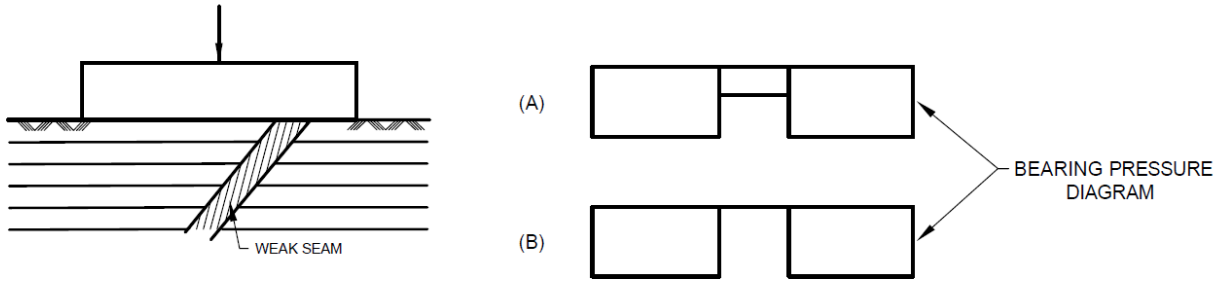

FIG. 7 WEAK SEAMS UNDER FOUNDATION MORE THAN 20 PERCENT OF BASE AREA

8.2 Foundation Rocks of Different Compressibility

When foundation spans rock material of different compressibility, the following conditions should be complied with.

8.2.1 The design of the foundation shall be carried out for bearing pressures inversely proportional to the compressibility of the strata. The foundation section shall be designed for one and half times the moments and shear forces so calculated. Alternatively, the design of foundation can be carried out considering no bearing on weaker strata.

8.2.2 The maximum bearing pressure under the foundation shall also not exceed the allowable bearing pressure for the weaker strata.

8.2.3 The minimum reinforcement spanning the weaker strata shall be not less than 0.5 percent of the cross section of foundation.

8.3 Foundation on Steeply Dipping Rock Surface

Normally the foundations on steeply sloping (more than 15° with horizontal) rock surface is avoided. If it is necessary to do so, the following safety measures shall be adopted in their design:

a) The foundation shall be embedded to a certain depth (d) inside the rock such that the prescribed factor of safety in sliding along the foundation plane are obtained. In these calculation, the support provided by the rock on down slope face of footing is accounted for (*see* Fig. 8). Shear strength of rock/cable anchors, even if provided, is not considered in these calculations;
b) The stability of foundation without bearing resistance on the down slope face shall also be checked. To ensure the desired factor of safety against sliding, rock/cable anchors may be provided. The size and number and depth of the anchors shall be worked out considering the required shearing strength of anchors, foundation size and the foundation rock;
c) Depth (d) shall not be less than 60 cm in any case;
d) Foundation level benches may be provided if possible at site. In such cases also the sliding stability shall be checked as if no benching was there; and
e) Wherever provisions of anchors are necessitated for increasing the stability of the structure, caution may be exercised to ensure that the sufficient length of anchors are embedded in the massive and fresh rock to mobilise rock action, and anchors shall extend well beyond slump mass and computations for the mass of slump mass be also taken into consideration.

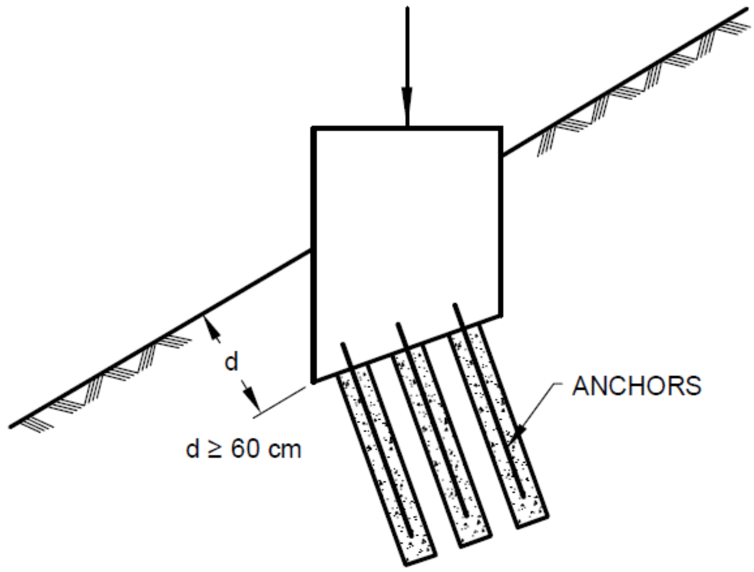

FIG. 8 FOUNDATION ON STEEPLY DIPPING SLOPES

8.4 Foundation on Moderate Slopes

At locations, where the rock surface is gently dipping (less than 15° with horizontal), the rock footing shall be taken deep enough (not less than 30 cm) inside the rock such that desired factor of safety in sliding along the rock surface is achieved having considered the bearing resistance on down slope face. It should also be checked that even without the bearing support on down slope face of foundation, the factor of safety against sliding in worst loading condition is not less than 1.10 (*see* Fig. 9).

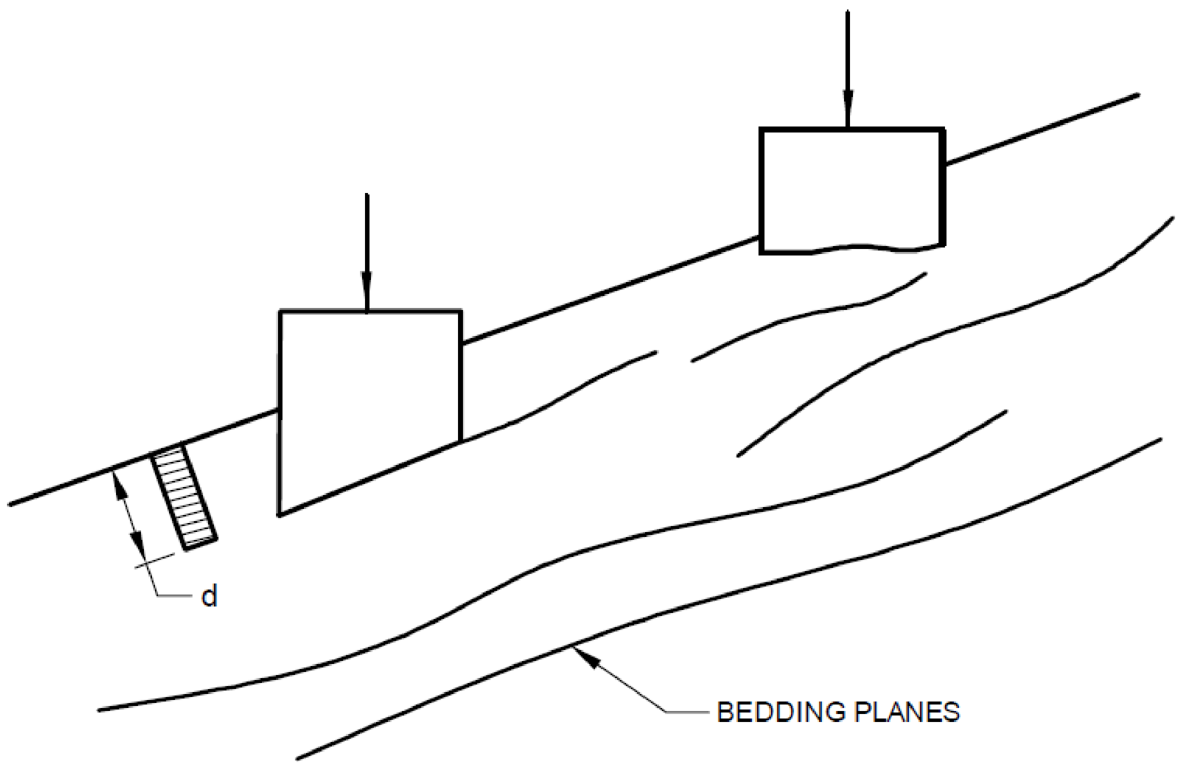

FIG. 9 FOUNDATIONS ON MODERATE SLOPES

8.5 Foundation on a Bench

If a foundation is provided over a bench whose bedding planes, or weaker planes are steeply dipping and getting exposed on the slope face, the stability of the rock mass along with the superimposed loads by the foundation, shall be checked along the deepest exposed weak plane and it shall be ensured that:

a) Desired factor of safeties are achieved. If not, rock anchors may be provided to achieve it (*see* Fig. 10); and
b) If rock anchors are required to make the wedge stable, factor of safety against sliding shall also be checked ignoring the shearing strength of rock anchors and it shall be not less than 1.10 in worst probable condition.

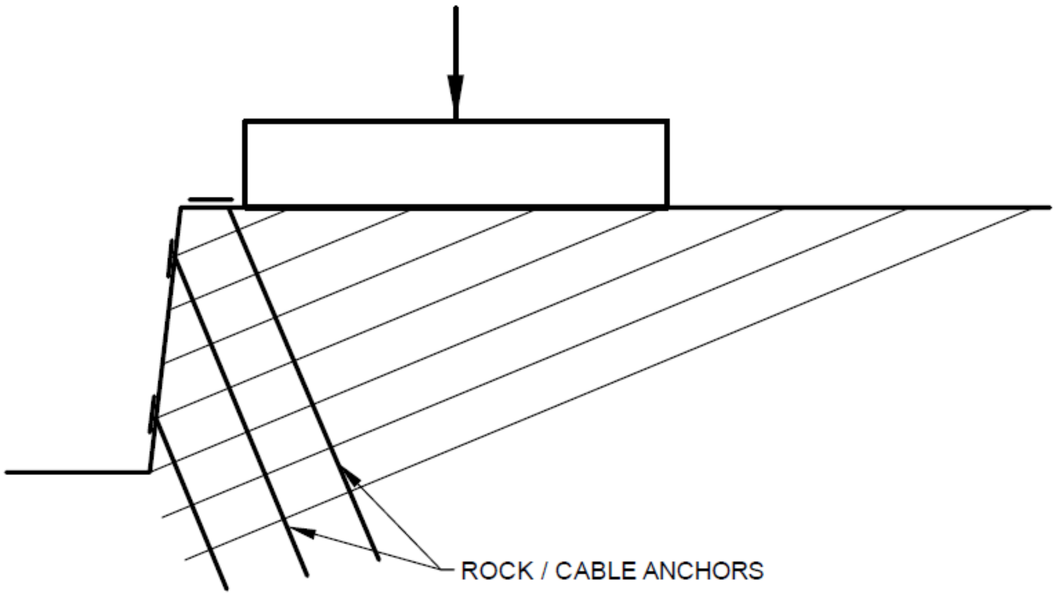

FIG. 10 FOUNDATION OF STEEPLY DIPPING STRATA ON A BENCH

8.6 Foundation on Rock Shelf

8.6.1 If a foundation is so located that the bearing strata is underlain by soft material and the minimum depth of the hard rock under the base of footing is more than the thickness of footing [*see* Fig. 11(A)]. In such cases, the soft material shall be removed up to a distance and filled up with concrete so that the soft material is not encountered up to the thickness equal to half the width or twice the thickness of the footing whichever is larger.

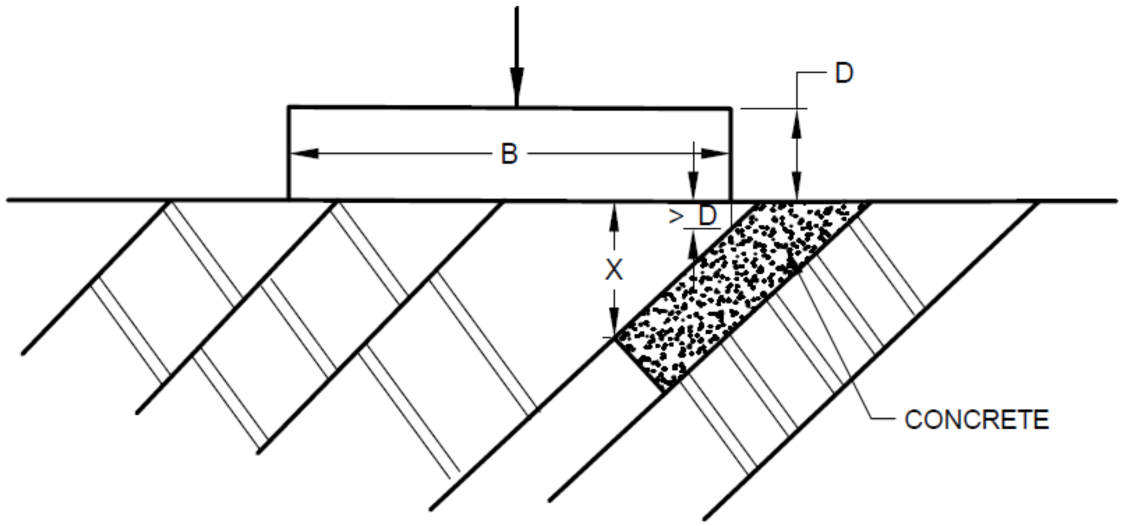

FIG. 11(A) FOUNDATION ON STEEPLY DIPPING CLAY SEAM

8.6.2 If removal of soft material, as required in **8.6.1**, loosen or dislocate the top rock mass or the thickness of top hard rock is less than the thickness of footing, the top rock shall be removed and the foundation shall be laid on the lower hard strata [*see* Fig. 11(B)]. In such case, the side support from top hard strata shall be ignored in calculations.

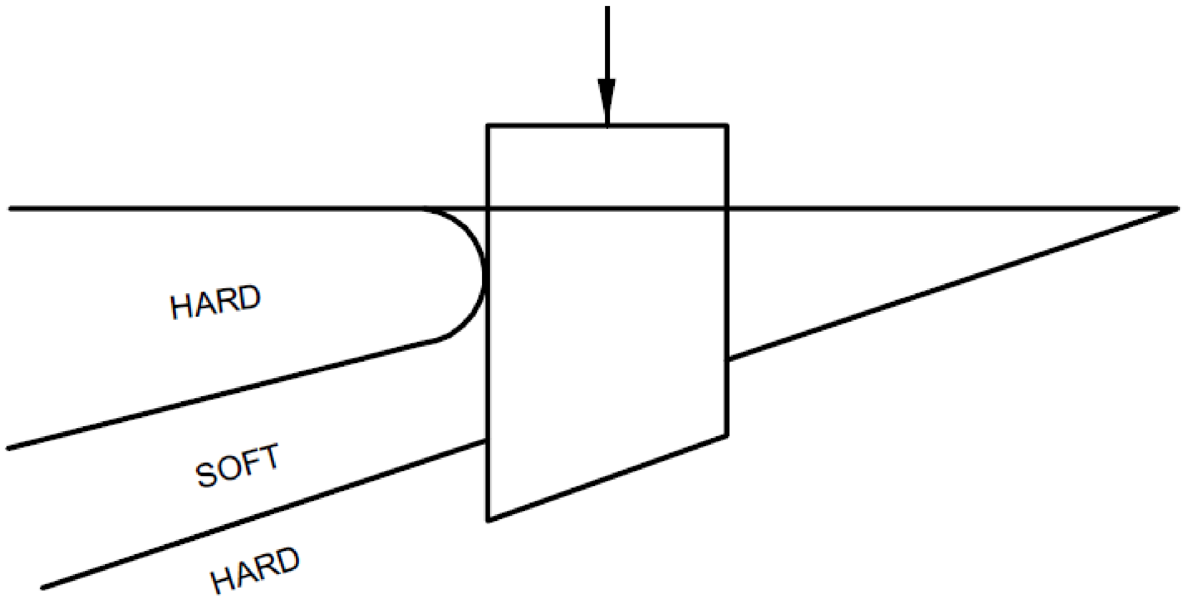

FIG. 11(B) FOUNDATION ON MODERATELY DIPPING CLEAR SEAM

FIG. 11 FOUNDATION ON ROCK SHELF

8.7 Undulating Rock Surface

If the rock surface profile is highly undulating due to solution cavities or any other reason (*see* Fig. 12) the loose material from the undulations shall be removed up to the depth that remaining surface area of loose material be not more than 20 percent of total area and shall be backfilled with lean concrete having allowable bearing stress more than maximum bearing pressure under the footing.

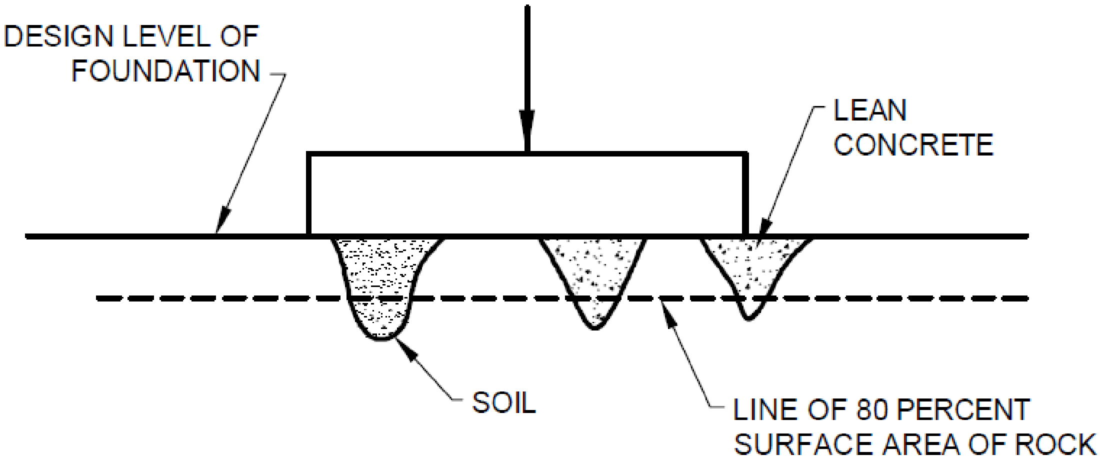

FIG. 12 FOUNDATION ON UNDULATING ROCK SURFACE

8.8 Foundation on Soft Rock Over Laid on Steeply Dipping Hard Rock

The footing shall be so located that the minimum thickness of bearing strata over the hard rock shall be more than one third of the base width of foundation and also more than 1 m (see Fig.13). Otherwise piles, bearing on hard strata, shall be provided.

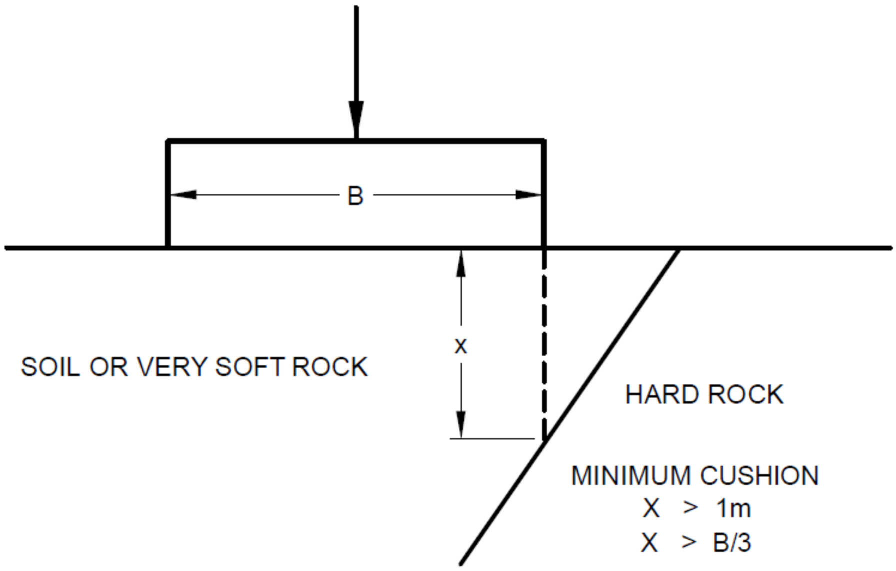

FIG. 13 STEEPLY DIPPING JOINT PLANE

8.9 Foundation on Different Rock Masses

If a building is so located that part of it rests on hard rock and remaining part on soft rock (*see* Fig. 14), then a settlement joint shall be provided in the foundation at such location that the minimum depth of soft rock under the base of one footing is not less than one third of the width of the footing and the other footing rest solely on the hard rock.

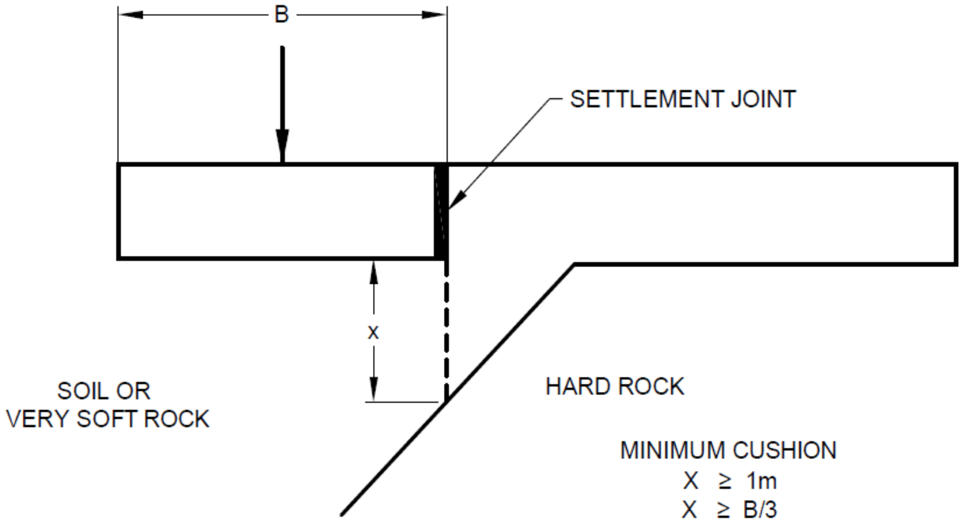

FIG. 14 FOUNDATION ON DIFFERENT ROCK MASSES

8.10 Stepped Foundation for Multistorey Frames

In case a multistorey building is to be constructed on hill slope (*see* Fig. 15) the following criteria shall be adopted:

a) The stability of the rock slopes along with the load on it due to the building shall be ensured;
b) The building frame shall be so planned that column points are located on inner side of the rock benches;
c) The columns shall be well anchored into the foundation rocks to provide complete fixity at base. The minimum depth of column foundation shall be at least 1 m below the excavated terrace level;
d) The beams shall be provided between the columns at plinth level as to increase the stiffness of the RCC frame of the building;
e) The frame may be anchored to rock mass with the help of horizontal anchors at each beam level, if required, to stabilize the terraces or the frame itself; and
f) The building frame shall be designed for the probable differential settlement due to non-uniformity of foundation rock. The common practice in such cases is to provide stiff column with slender beams so that the beam column joints behaves as hinge joints.

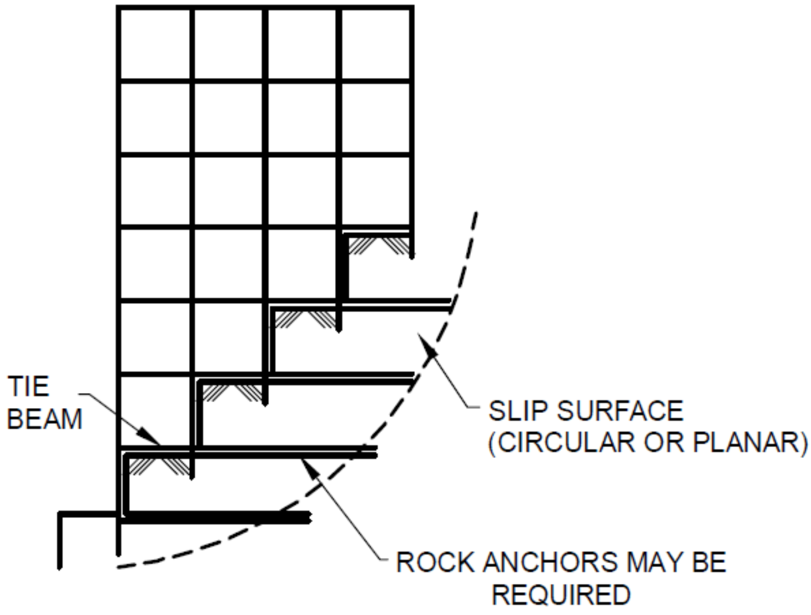

FIG. 15 MULTISTOREY BUILDING ON ROCK SLOPE HEAVY

8.11 Raft Foundations Adjacent to Hill Slope

If a raft foundation is to be constructed adjacent to hill slope, if possible, the building shall be so planned that heavier part of the building are located on the uphill side part of the raft to provide better stability (*see* Fig. 16).

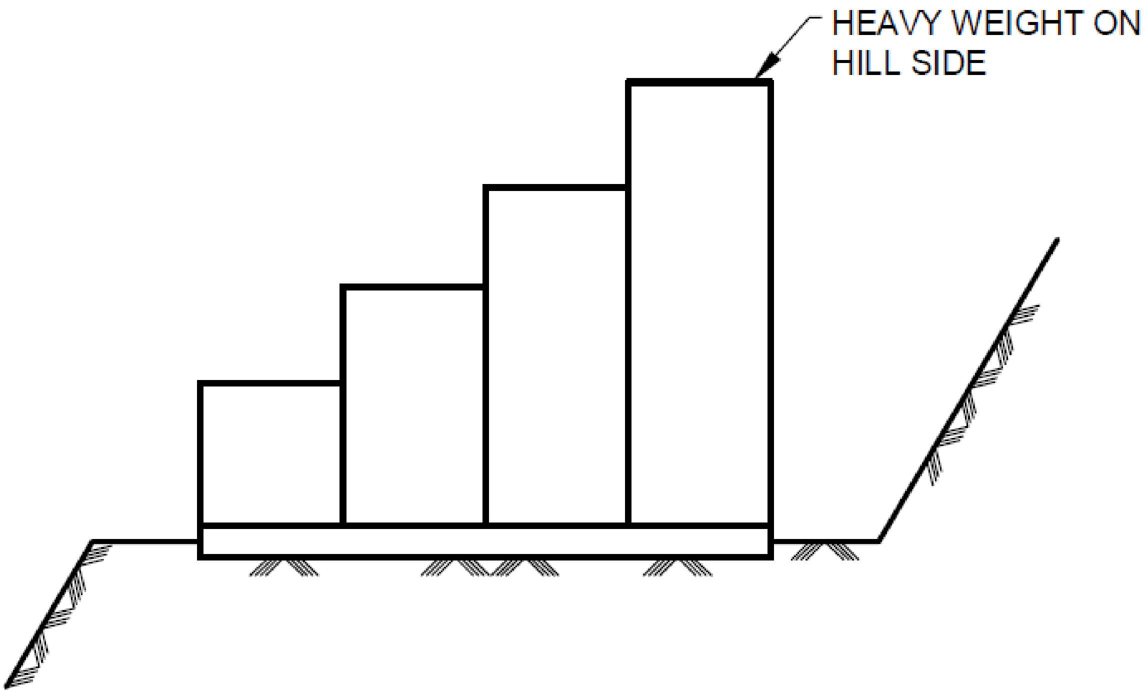

FIG. 16 RAFT FOUNDATION ADJACENT TO HILL SLOPES

8.12 Foundations on Slopes of Tallus Deposits

In case of buildings up to two storeys are required to be built on steep hill slopes dipping more than 15, wall and column construction will not be possible. At such sites, flexible structure which can withstand small ground movements is best suited. Still type foundation shown in Fig. 17 is one of that type. These consist of wooden or steel framed structures with fibre glass, aluminum or G.C. steel roofing and walls clad with PVC sheets. The roofs are constructed of wooden planks. The depth of foundation in loose tallus deposit shall be at least 2 m.

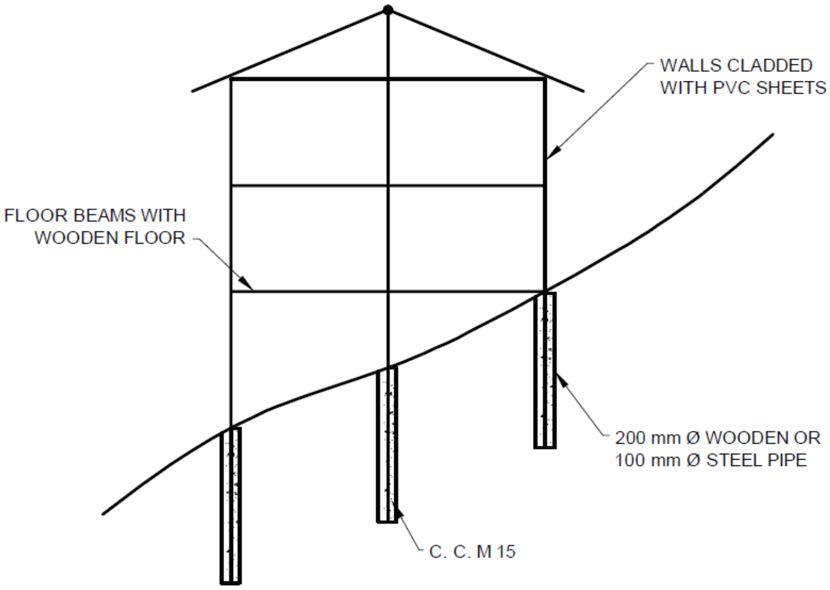

FIG. 17 STILL FOUNDATION

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 456 : 2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
IS 875 (Pat 2) : 1987	Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 imposed loads (Second Revision) (*second revision*)
IS 1888 : 1982	Method of load test on soils (*second revision*)
IS 1892 : 2021	Subsurface investigation for foundations — Code of practice (*second revision*)
IS 1904 : 2021	General requirements for design and construction of foundations in soils — Code of practice (*fourth revision*)
IS 2809 : 1972	Glossary of terms and symbols relating to soil engineering (*first revision*)
IS 6066 : 1994	Pressure grouting of rock foundations in river valley projects — Recommendations (*second revision*)
IS 7317 : 2020	Uniaxial jacking test for deformation modulus of rock mass — Code of practice (*second revision*)
IS 7746 : 2022	In-situ shear test on rock mass — Code of practice (*second revision*)
IS 8764 : 1998	Method for determination of point load strength index of rocks (*first revision*)
IS 9143 : 1979	Method for the determination of unconfined compressive strength of rock materials
IS 9179 : 1979	Method for preparation of rock specimen for laboratory testing
IS 10082 : 1981	Method of test for determination of tensile strength by indirect tests on rock specimens
IS 11315	Methods for quantitative description of discontinuities in rock masses:
(Part 1 to 1) : 2023	Orientation (*first revision*)
(Part 1 to 2) : 2023	Spacing (*first revision*)
(Part 1 to 3) : 2023	Persistence (*first revision*)
(Part 1 to 4) : 2023	Roughness (*first revision*)
(Part 1 to 5) : 2023	Wall strength (*first revision*)
(Part 1 to 6) : 2023	Aperture (*first revision*)
(Part 1 to 7) : 2023	Filling (*first revision*)
(Part 1 to 8) : 2023	Seepage (*first revision*)
(Part 1 to 9) : 2023	Number of sets (*first revision*)
(Part 1 to 10) : 2023	Block size (*first revision*)
(Part 1 to 11) : 2023	Core recovery and rock quality designation (*first revision*)
IS 12070 : 1987	Code of practice for design and construction of shallow foundations on rocks
IS 15681 : 2006	Geological exploration by geophysical method (Seismic refraction) — Code of practice
IS 15736 : 2007	Geological exploration by geophysical method (Electrical resistivity) — Code of practice