NEPAL NATIONAL BUILDING CODE

NBC 108 : 1994

SITE CONSIDERATION FOR SEISMIC HAZARDS

His Majesty's Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
2060

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This publication represents a standard of good practice and therefore takes the form of recommendations. Compliance with it does not confer immunity from relevant legal requirements, including bylaws

श्री ५ को सरकार (मन्त्रिपरिषद्) को मिति २०६०।४।१२ को निर्णयानुसार स्वीकृत

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Preface

This Nepal Standard was prepared during 1993 as part of a project to prepare a draft National Building Code for Nepal.

In 1988 the Ministry of Housing and Physical Planning (MHPP), conscious of the growing needs of Nepal's urban and shelter sectors, requested technical assistance from the United Nations Development Programme and their executing agency, United Nations Centre for Human Settlements (UNCHS).

A programme of Policy and Technical Support was set up within the Ministry (UNDP Project NEP/88/054) and a number of activities have been undertaken within this framework.

The 1988 earthquake in Nepal, and the resulting deaths and damage to both housing and schools, again drew attention to the need for changes and improvement in current building construction and design methods.

Until now, Nepal has not had any regulations or documents of its own setting out either requirements or good practice for achieving satisfactory strength in buildings.

In late 1991 the MHPP and UNCHS requested proposals for the development of such regulations and documents from international organisations in response to terms of reference prepared by a panel of experts.

This document has been prepared by the subcontractor's team working within the Department of Building, the team including members of the Department and the MHPP. As part of the proposed management and implementation strategy, it has been prepared so as to conform with the general presentation requirements of the Nepal Bureau of Standards and Metrology.

The subproject has been undertaken under the aegis of an Advisory Panel to the MHPP.

The Advisory Panel consisted of :

Mr. UB Malla, Joint Secretary, MHPP	**Chairman**
Director General, Department of Building (Mr. LR Upadhyay)	**Member**
Mr. AR Pant, Under Secretary, MHPP	**Member**
Director General, Department of Mines & Geology (Mr. PL Shrestha)	**Member**
Director General, Nepal Bureau of Standards & Metrology (Mr. PB Manandhar)	**Member**
Dean, Institute of Engineering, Tribhuvan University (Dr. SB Mathe)	**Member**
Project Chief, Earthquake Areas Rehabilitation & Reconstruction Project	**Member**
President, Nepal Engineers Association	**Member**
Law Officer, MHPP (Mr. RB Dange)	**Member**
Representative, Society of Consulting Architectural & Engineering Firms (SCAEF)	**Member**

Representative, Society of Nepalese Architects (SONA) **Member**
Deputy Director General, Department of Building,
(Mr. JP Pradhan) **Member-Secretary**

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0 Foreword

This document sets out some of the factors to be considered during site selection for buildings in order to minimise the risks to the buildings from both primary and secondary seismic hazards.

It also outlines the fundamental requirements for site investigation for the foundation design of buildings.

The degree to which each factor should be considered will depend on the importance and size of the building under consideration. The document is particularly applicable for State of Art Design and Engineered buildings.

1 Scope

This standard covers the principles of site selection and site investigation for buildings in both the mountainous and Terai regions of Nepal.

Conceptual and detailed aspects of the selection and design of building and foundation types are not dealt with by this Standard, although recommended references are given for good practice in these matters.

1.1 Applicability

In general, the provisions of this standard should be applied to all buildings to be constructed in Nepal.

The site considerations detailed out in this Standard shall be mandatory for all important buildings in Nepal.

The State of Art Design and engineered buildings of all categories should carry an appropriate level of site investigation and formal reporting at the beginning of the design process and it shall be incorportated in the permit application documents.

Subject to the mandatory rules-of-thumb and/or advisory guidelines the designer should considered it as an indication of good practice and apply same as appropriate.

2 Interpretation

2.1 General

2.1.1 In this standard the word "shall" indicates a requirement that is to be adopted in order to comply with the standard, while the word "should" indicates recommended practice.

2.1.2 Words implying the singular only also include the plural unless this is inconsistent with the context.

2.2 Terminology

In this standard, unless inconsistent with the context, the following definitions shall apply :
BEARING PRESSURE, SAFE means the intensity of the loading that the soil will carry without undergoing settlement more than permissible for the structure.

CLAY means a type of soil with more than 50 % of the constituent particles smaller than 2 µm. It is plastic within a moderate range of water content.

CLAY, FIRM means a clay which at its natural water content can be moulded by substantial pressure with the fingers and can be excavated with a spade.

CLAY, SOFT means a clay which at its natural water content can be easily moulded with the fingers and can be readily excavated.

CLAY, STIFF means a clay which at its natural water content can not be moulded by substantial pressure with the fingers and requires a pick for its removal from the parent body.

ENGINEERED BUILDING means any building designed in accordance with the engineered structures provisions of the Nepal National Building Code.

FOUNDATION means that part of the structure which is in direct contact with the soil and transmits load to it.

FOUNDATION SOIL means the soil at the sub-surface which is in direct contact with the foundation and bears the load due to the structure.

FROST ACTION means the weathering process caused by repeated cycles of freezing and thawing.

GRAVEL means a cohesionless soil with more than 50 % of the constituent particles having size greater than 4.75 mm and less than 80 mm.

HAZARD means the probability of occurrence of a destructing phenomena.

IMPORTANT BUILDINGS are those which :

- contain critical facilities which are essential before and immediately after a disaster (eg, hospitals, fire and police stations, communication centres etc),
- by their very purpose have to house many persons at a time (eg, cinema halls, schools, convention centres, etc),
- have national and international importance (eg, historical palaces, monuments, etc),
- are to be used for storage of toxic or explosive materials.

LANDSLIDE means the downward and outward movement of slope-forming materials.

LIQUEFACTION means the phenomenon exhibiited when relatively loose, saturated sandy soils lose a large proportion of their strength under seismic shaking.

ORDINARY BUILDING is one which is not an important building (eg, a residential, general commercial or ordinary office building, etc)

ROCK MASS means those naturally occurring mineral aggregates in-situ with all their planes of discontinuities.

ROCK MATERIAL means a piece of rock detached from the rock mass and bounded by natural planes of discontinuities or induced fractures.

SAND means a cohesionless soil with more than 50 % of its constituent particles having a size greater than 75 µm and less than 4.75 mm.

SAND, COARSE means a cohesionless soil with 50 % or more of its constituent particles having a size greater than 2 mm and less than 4.75 mm.

SAND, FINE means a cohesionless soil with 50 % or more of its constituent particles having a size greater than 75 µm and less than 0.425 mm.

SAND, MEDIUM means a cohesionless soil with 50% or more of its constituent particles having a size greater than 0.425 mm and less than 2.0 mm.

SILT means a fine-grained soil with 50 % or more of its constituent particles having a size greater than 0.2 µm and less than 75 µm.

SOIL means a mineral aggregate or product of rock weathering lying at the place of formation or deposited after being transported by different natural means of transportation.

SOIL, COARSE GRAINED means a soil with more than 50 % of its materials grains larger than 0.75 µm.

SOIL, FINE GRAINED means a soil with more than 50 % of its material grains smaller than 0.75 µm.

TERAI means the predominant alluvial plain to the south of the Siwalik range. This is one of the five physiographic divisions of Nepal.

WATER TABLE means the locus of points in soil water at which the pressure is equal to atmospheric pressure.

WEATHERING means the group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

3 Site Considerations

3.1 Consideration of Potential Fault Rupture Hazard

A surface fault rupture occurs when an earthquake fault breaks the earth's surface and it may result in several centimetres to several metres of differential ground displacement. This instantaneous ground displacement may occur along an approximately linear path that may extend for several tens of kilometres. If the fault traverses houses, buildings or infrastructures and lifelines, it may damage or destroy the facilities.

Therefore, while selecting the site for an important building or structure, it shall be ensured that the building is not located within a distance of 500 m from the surface trace of a known active fault.
Figure 3.1 depicts the principal active faults so far identified within Nepal and can be referenced for this purpose.

Areas closer than 500 m to the trace of an active fault should be used for activities unlikely to be severely affected by surface faulting. These include use as grassland, forest, gardens, parks, etc.

3.2 Consideration of Potential Liquefaction

Liquefaction of subsurface soil occurs when groundwater saturated, loose, granular soil is exposed to strong earthquake shaking for a relatively long duration. It commonly results in sand boils, fissuring of the ground, settlement of the ground surface and lateral spreading of the ground surface. These phenomena can cause different forms of damage to structures and properties lying across the soil failure areas.

The plains of the eastern Terai experienced wide-spread occurences of liquefaction during the Bihar-Nepal earthquake of 1934 and the Udaypur earthquake of 1988. Substantial damage resulted from this process. The most significant and spectacular of the phenomenon was the generation of numerous sand craters and upwelling of water in tube wells and dug wells.

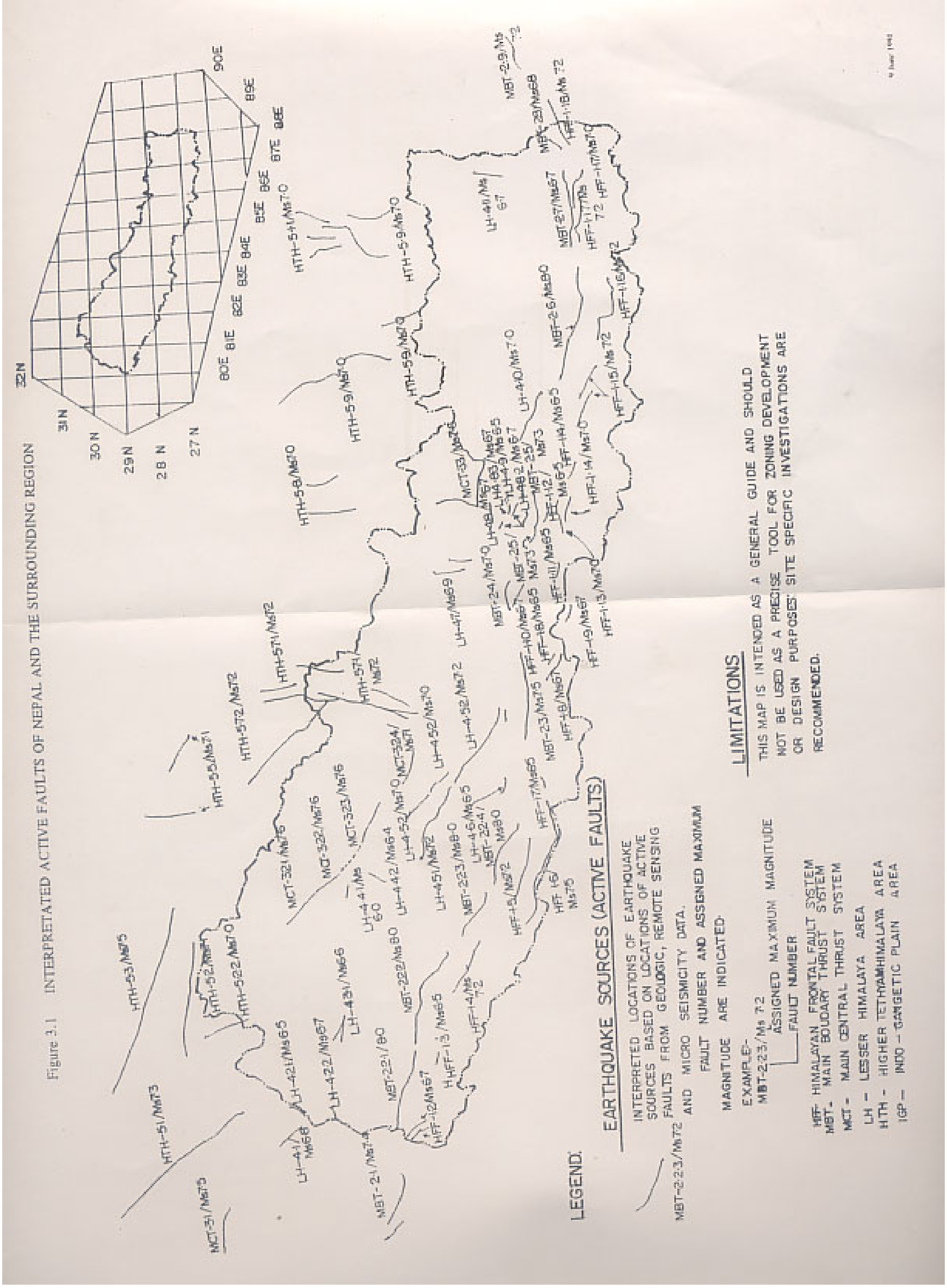


Figure 3.1 INTERPRETATED ACTIVE FAULTS OF NEPAL AND THE SURROUNDING REGION

The site selection for an important engineered building in the Terai and on alluvial river banks within the mountainous terrain shall be preceded by examination of the liquefaction susceptibility of the sub-surface ground. Necessary mitigation measures should be taken to minimise the potential risk. Sites located on ancient lake deposits (the Kathmandu Valley, for instance), shall be similarly investigated.

3.3 Consideration of Potential Landslides and Slope Instability

Earthquake-induced landslides can occur due to the strong ground shaking caused by an earthquake. All major earthquakes in mountainous terrain result in increased instances of landslides. The vast majority of these are rock falls, although more coherent landslides, such as debris slides and soil slumps, also take place.

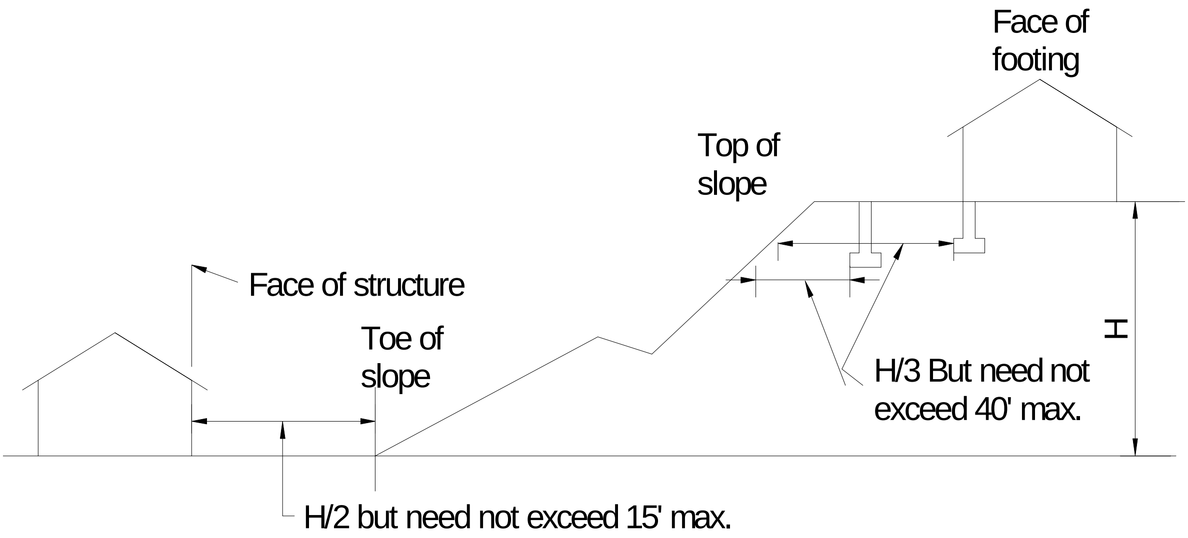
Clearly, areas that are susceptible to landslides from storm damage, river undercutting and quarrying are also susceptible to strong ground shaking from an earthquake.

Buildings may be destroyed by landslides because they are located on the body of the landslide body, or by the impact and covering of the building by debris derived from a landslide generated uphill from the site. The building and associated earthworks may also contribute to the instability of potential landslides.

Locating an important building on sloping ground in the mountainous terrain should be preceded by examination of the hill slope stability conditions and identification of necessary structures for counteracting the effects of the adverse conditions.

On a sloping ground, the location of all buildings should meet the requirements shown in Figure 3.2, unless special slope stability measures are taken.

Figure 3.2 LOCATION OF BUILDING IN SLPING TERRAIN



4 Site Investigation

4.1 General

All site investigations should address the following basic questions :

- Is there any danger of inherent natural susceptibility of the land to the process of sliding and erosion?
- Will the construction adversely affect the existing conditions and trigger landslide, erosion, land subsidence, pore pressure generation due to blockage of or otherwise the sub-surface flow of water; will the construction adversely affect the water table?
- What will be the extent of settlement of the building?
- Is the sub-surface capable of taking the load due to the proposed construction?
- Is there any other natural/geological process likely to threaten the integrity of the building? (eg, changes in a river course, flooding, failure of an irrigation canal ?)
- What are the possible engineering solutions for ensuring stability of the building foundation in view of the identified conditions?

Answers to some of these questions can be found by examining the existing local knowledge, records of any past exploration in the adjacent area and the behaviour of existing similar structures. If satisfactory answers to the questions can not be found, it will be necessary to undertake additional site investigation including subsurface exploration, in-situ and laboratory testing, geophysical surveys and testing, probing, etc.

4.2 Extent of Site Exploration

The extent of exploration will depend upon the geological and geomorphological nature of the terrain, and on the importance of the building and the scale of the project. Large-scale engineering geological mapping of the site and previous practices of construction in the adjacent area could form the basis for deciding the extent of exploration for an important building.

4.3 Depth of Exploration

The depth to be explored should be adopted based on the geological conditions at the site e.g the depth and type of subsurface soil, depth of weathering, the depth of ground water fluctuation, the depth of frost action, etc. Generally, the exploration should be carried out to the depths at which the induced stress due to the loads from the construction dissipates substantially and the strata can carry the load without undesirable settlement and with an acceptable factor of safety against failure. Past experience and performance of adjacent buildings could be of prime importance in deciding about the depth of exploration which shall not be less than one and a half times the estimated width or the lower dimension of the footing below the foundation level. In hilly areas, exploration up to the depth of sound bed rock will generally be sufficient.

For the analysis of liquefaction susceptibility, 20 m should suffice as the depth of exploration.

4.4 Allowable Bearing Pressure

The allowable bearing pressure should be calculated as per current good engineering practice.

5. Design of Foundations

The design of foundations shall be carried out in accordance with good engineering practice. Compliance with the following established codes/standards may be taken as the basis of good engineering practice :

The following Indian Standards :

INDIAN STANDARDS	INDIAN STANDARDS
(1) IS :1892-1979 Method of practice for sub-surface investigation for foundations (*first revision*) IS:2131-1981 Method for standard penetration test for soils (*first revision*) IS:2132-1972 Code of practice for thin walled tube sampling of soils (*first revision*) IS:4434-1978 Code of practice for *insitu* vane shear test for soils (*first revision*) IS:4968 Method for subsurface sounding for soils : IS:4968 (Part I)-1976 Part I Dynamic method using 50 mm cone without bentonite slurry (*first revision*) IS:4968 (Part II)-1976 Part II Dynamic method using cone and bentonite slurry (*first revision*) IS:4968 (Part III)-1976 Part III Static cone penetration test (*first revision*) IS:8763-1978 Code of practice for undisturbed sampling of sands IS:9214-1979 Method of determination of modules of subgrade reaction (*K*-value) of soils in field (2) IS:2720 Methods of tests for soils: IS:2720 (Part I)-1972 Part I Preparation of dry soil samples for various tests (*first revision*)	IS:2720 (Part II)-1973 Part II Determination of water content (*second revision*) IS:2720 (Part III)-1980 Part III Determination of specific gravity : Section 1 Fine grained soils (*first revision*) Section 2 Fine, medium and coarse grained soils (*first revision*) IS:2720 (Part IV)-1975 Part IV Grain size analysis (*first revision*) IS:2720 (Part V)-1970 Part V Determination of liquid and plastic limits (*first revision*) IS:2720 (Part X)-1973 Part X Determination of unconfined compressive strength (*first revision*) IS:2720 (Part XIII)-1972 Part XIII Direct shear test (*first revision*) IS:2720 (Part XV)-1965 Part XV Determination of consolidation properties IS:2720 (Part XXVIII)-1974 Part XXVIII Determination of dry density of soils in place by the sand replacement method (*first revision*) IS:2720 (Part XXIX)-1975 Part XXIX Determination of dry density of soils in place by the core cutter method (*first revision*)

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INDIAN STANDARDS	INDIAN STANDARDS
IS:2720 (Part XXXIII)-1975 Part XXXIII Determination of the density in-place by the ring and water replacement method IS:2720 (Part XXXIV)-1972 Part XXXIV Determination of density of soils in-place by rubber-balloon method IS :2720 (Part XXXIX/Sec1)-1977 Part XXXIX Direct shear test for soils containing gravel, Section 1 Laboratory test (3) IS:1498-1970 Classification and identification on soils for general engineering purposes (*first revision*) (4) IS:401-1982 Code of practice for preservation of timber (*third revision*) (5) IS:6403-1981 Code of practice for determination of allowable bearing pressure on shallow foundations (*first revision*) (6) IS:1888-1982 Method of load tests on soils (*second revision*) (7) IS:8009 (Part I)-1976 Code of practice for calculation of settlement of foundations: Part I Shallow foundations subjected to symmetrical static vertical loads (8) IS:1080-1980 Code of practice for design and construction of simple spread foundations (*first revision*) (9) IS:2911 (Part IV)-1979 Code of practice for design and construction of pile foundations : Part IV Load test on piles Section Bored cast in-situ piles (10) IS :2911 Code of practice for design and construction of pile foundations.	IS:2911 (Part 1/Sec 1)-1979 Concrete piles Section 1 Driven cast *in-situ* piles (*first revision*) IS:2911 (Part I/Sec 2)-1979 Concrete piles Section Bored cast *insitu* piles (*first revision*) (11) IS:2911 (Part 1/Sec 3)-1979 Code of practice for design and construction of pile foundations: Part I Concrete piles, Section 3 Driven precast piles (*first revision*) (12) IS:2911 (Part III)-1980 Code of practice for design and construction of pile foundations: Part III Under-reamed pile foundation (*first revision*) (13) IS :2911 (Part III)-1980 Code or practice for design and construction of pile foundations: Part II Timber piles (*first revision*) (14) IS:2974 Code of practice for design and construction of machine foundations IS:2974 (Part I)-1969 Part I Foundations for reciprocating type machine (*first revision*) IS:2974 (Part II)-1966 Part II Foundations for impact type foundations (drop and forge hammer foundations) IS:2974 (Part III)-1975 Part III Foundations for rotary type machines (medium and high frequency) (*first revision*) IS:2974 (Part IV)-1968 Part IV Foundations for rotary type machines of low frequency

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INDIAN STANDARDS	INDIAN STANDARDS
IS:2974 (Part V)-1970 Part V Foundations for impact type machines other than hammers (forging and stamping press: pig breaker, elevator and hoist tower) IS:3955-1967 Code of practice for design and construction of well foundations	IS:9556-1983 Code of practice for design and construction of diaphragm walls (15) IS:9214-1979 Method of determination of subgrade reaction (*K* value) of soils in the field