NEPAL NATIONAL BUILDING CODE

NBC 000 : 1994

REQUIREMENTS FOR STATE-OF-THE ART DESIGN
AN INTRODUCTION

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
Reprinted : 2064

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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

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

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Preface

This Nepal National Building Code was prepared during 1993 as part of a bigger project to mitigate the effect of earthquakes on the building of 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

The Subcontractor was BECA WORLEY INTERNATIONAL CONSULTANTS LTD. of New Zealand in conjunction with subconsultants who included :

Golder Associates Ltd., Canada
SILT Consultants P. Ltd., Nepal
TAEC Consult (P.) Ltd., Nepal
Urban Regional Research, USA

A number of individual subconsultants and HMGN counterparts also provided input to the draft Standards and other documents making up this Code. A particularly important contribution was made by Dr.AS Arya, Professor Emeritus, University of Roorkee, India.

Revisions and Updated to this code came from:

Mr. Purna P.Kadariya, DG, DUDBC
Mr. Kishore Thapa, DDG, DUDBC
Mr. Mani Ratna Tuladhar, Sr. Div. Engineer, DUDBC
Mr. Jyoti Prasad Pradhan, Ex. DG, DOB
Mr. Bhubaneswor Lal Shrestha, Ex. DDG, DOB
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0. Foreword

This National Building Code is the first such document prepared in Nepal and it is intended that its implementation be enforced through the Parliamentary Bill Act and concerned, local authority by-laws.

Most countries which have successfully implemented building controls have only achieved it over a very long period which is normally measured in decades.

The technical documents making up building regulations are normally the subject of a continual process of revision, correction and expansion as per requirements.

There is a strong movement towards uniform standards and many countries have adopted those of the International Standards Organisation in some areas. Where it has been considered appropriate, the adoption of certain Indian Standards, with or without some modification has been made in this document.

The degree to which national building codes and standards are enforced by law varies from country to country. In some countries, the national building code is taken by the law courts as a measure of good practice. India is one of the countries adopting such a system.

This first Nepal National Building Code has been produced by a team of Nepalese and international consulting engineers and architects and is based on the given term of reference.

It deals primarily with matters relating to the strength of buildings. However there are some chapters on site considerations and safety during construction and fire hazards.

Each section of this Code has been drawn up as a draft Standard for possible adoption by the Nepal Bureau of Standards and Metrology. It has been proposed that the future revision and re-issue of these sections be undertaken by the specialist committees brought together on a regular basis by the Bureau. This system which has been adopted in Nepal for a number of years, ensures that all special, general and public interest groups can give their full input to this important regulatory process.

As of recent years, most of the uncontrolled building processes are rapidly producing structures of unacceptable standard and prone to the risk of damage and collapse under earthquake. The designs and personnel involved in the construction industry, industry, therefore, should adopt this code sincerely so as to achieve a meaningful improvement in that standard of building construction in Nepal.

1 Scope

1.1 General

This National Building Code provides both regulations and guidelines for the construction of buildings in all areas of Nepal.

This first version deals primarily with matters of strength. It is intended that, in time, revised versions of the National Building Code will be developed that will also address the wider issues of planning, plumbing, electrical wiring, etc. In the meantime, the designer should observe such by-laws covering these matters as have already been put in place by local authorities. Furthermore, designers should use their professional judgement in recommending to their clients the adoption of appropriate design standards used in similar countries to Nepal when there is yet no Nepalese Standard for these disciplines.

The lack of an appropriate Nepal Standard should not be an excuse for poor design.

The four different levels of sophistication of design and construction that are being addressed in this National Building Code are :

- International state-of-art
- Professionally engineered structures
- Buildings of restricted size designed to simple rules-of-thumb
- Remote rural buildings where control is impractical.

The first part of the Code describes how a potential designer should determine which of the above levels should apply to the structure under consideration.

As the component Standards making up this Code may be revised from time to time and the revisions adopted as part of the Code, the designer should check that the latest version of the Code is being used.

Each of the four levels are introduced below.

1.1.1 International State-of-the-Art (Part I)

Because the major thrust of the Code is aimed at the typical and most common buildings currently being erected in Nepal, it deliberately does not suggest as being practical for everyday consideration the sophisticated design philosophies and analytical techniques that are appearing in the codes of more wealthy countries.

However, it is important that both Nepalese engineers and international consultants who can produce such designs in a routine fashion and can ensure that their designs can be built to the corresponding standards should not be prevented from doing so. Moreover, these structures should be seen to be meeting the Nepalese requirements with respect to minimum design loads and configuration. There is then no reason for any designer to ignore the Nepal regulations in their entirety.

This part therefore describes some of the philosophy behind the selection of loads (in particular, the earthquake ones) and therefore allows the sophisticated designer and/or international designer to build up a design philosophy consistent with, and encompassing, the basic requirements. The onus shall be on the designer to prove to the permit-issuing authority that the Nepal Code requirements have been met and/or exceeded.

It is important to note that the Nepal National Building Code's requirements for seismic resistant are, in many cases, more onerous than those commonly practiced in other countries of the region.

1.1.2 Professionally Engineered Structures (part II)

This contains the standard code requirements that all professionally qualified engineers will recognize and must meet as a minimum when designing structures in Nepal. It covers all usual structures such as hospitals, meeting halls, factories, warehouses, multi-story buildings and residential buildings.

Materials, analysis and design, construction safety and site considerations are all covered.

1.1.3 Mandatory Rules-of-Thumb (Part III)

This part recognises that it is not practical in Nepal at present to insist that all small buildings be designed for strength by a professional adviser. Therefore, for classes of buildings not exceeding certain simple criteria as to height, number of stories and floor area, mandatory rules-of-thumb are provided. The explanatory documents are such that an experienced overseer will be able to understand them and present sufficient details at the time of permit application to prove to a skilled appraiser at the Local Authority that the requirements have been met.

The requirements are in terms of limits on spans and heights, minimum reinforcing and member sizes, positioning of earthquake-resisting elements and other such rules.

1.1.4 Guidelines for Remote Rural Buildings (Part IV)

These guidelines address about a dozen typical building styles that have been condensed from an inventory of approximately fifty-five surveyed intensively during 1993. In the form of diagrams and descriptions aimed at the technical advisers to owner/builders in villages, these guidelines emphasized those changes that should be made to current practices to improve the seismic resistance of these building which are not subject to modern quantitative analysis and rational design consideration. These structures are normally of earthen construction (unfired masonry, mud mortar, rubble, dry stone, wattle and daub, etc).

Whereas these recommendations are described as guidelines, it is intended that it will be mandatory for such structures built in areas controlled by a building permit-issuing local authority to comply with them.

In addition, all such structures erected by departments and agencies of Government of Nepal, regardless of their location in Nepal, should incorporate the recommendations of this section.

HOW TO USE THIS NATIONAL BUILDING CODE

The fundamental documents of this Code are those of Part II- Professionally Engineered Structures. In principle, all structures should be designed to meet the applicable provisions appearing there.

Structures of certain common modern building types which do not exceed prescribed height and plinth area limits will be deemed to have met the part II strength provisions if they have been detailed to the appropriate rules of thumb described in part III of this code.

Structures built of traditional local materials should not exceed three storeys in height. It is preferable that all such structures incorporate strength features, described in the guidelines forming Part IV of this Code. Structures of this type to be built in certain areas of Nepal where local authorities have building permit systems in place will be required to incorporate such details. All such structures funded by Government of Nepal and its agencies, departments and corporations shall incorporate these features, whether or not there is such a local authority requirement.

The strength design of any structure, whether or not it conforms to the limits, areas and building types of the structures permissible under Part III and IV of this Code, will be acceptable if it meets the requirements of Part II- Professionally Engineered Structures of this Code.

Each application for permission to construct a structure designed to international standards or Codes of Practice shall provide detailed proof that the requirements of Part I and II have been met or exceeded both qualitatively and quantitatively.

Figure 1 describes the process that should be followed by a building designer in determining which requirements should be met for a particular structure.

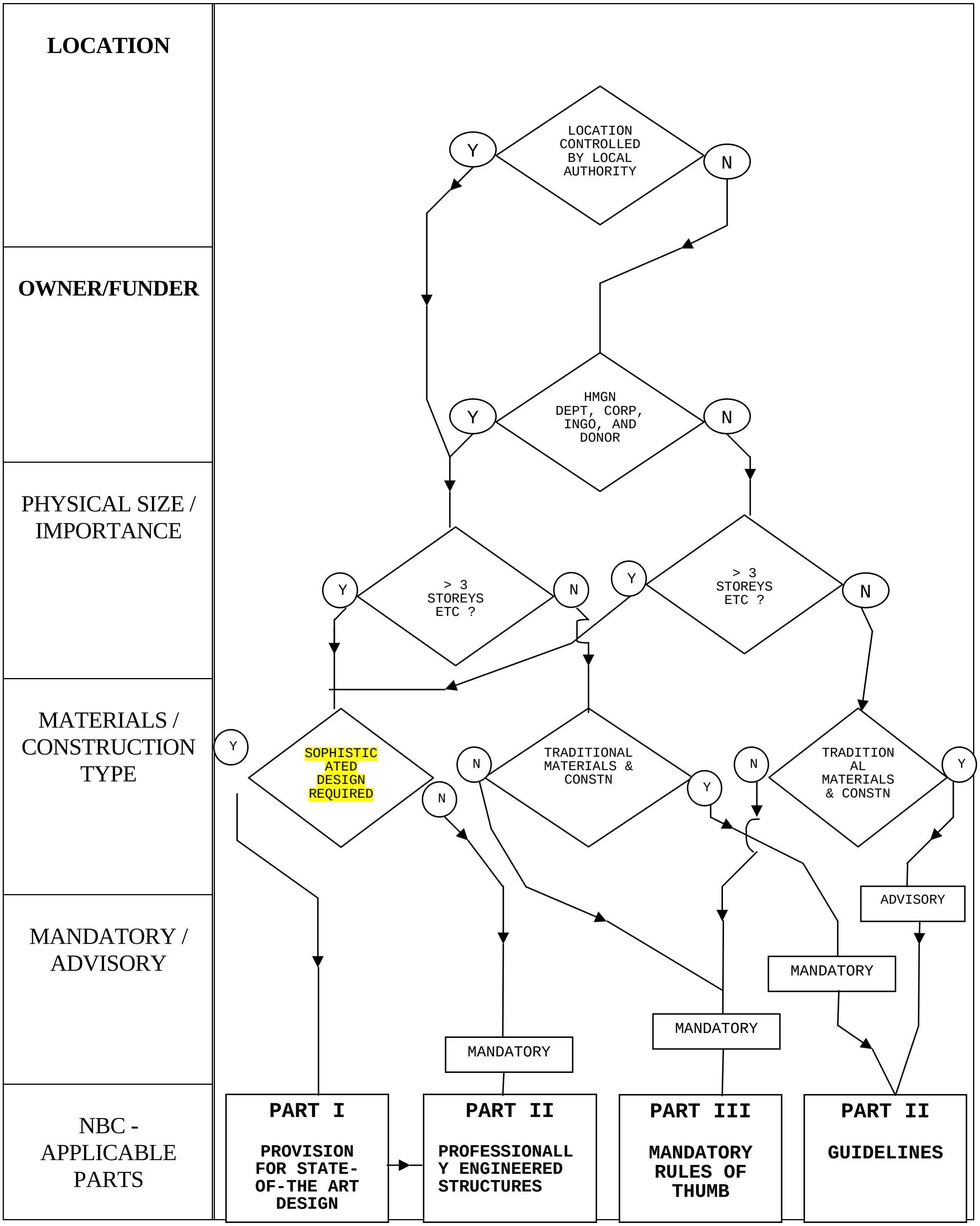

Figure 1: Flow Chart Showing Minimum Design Requirements

PART 1 REQUIREMENTS FOR STATE-OF-THE-ART DESIGN

1.1 Introduction

This Part addresses the considerations that should be taken into account by designers who wish to design structures for Nepal by alternative methods to those described in Part II of this Code. The onus is on the designer using alternative methods to demonstrate that the finished structure will meet or exceed, both qualitatively and quantitatively, the requirements of Part II.

The strength provisions of this National Building Code are controlled overall by the aim of increasing the safety of structures in Nepal under earthquake shaking.

The achievement of an acceptable level of safety requires the adoption of sound structural concepts and the realisation of these concepts through appropriate detailed design and the use of materials and construction practices meeting the assumptions used during design.

The designers of structures for Nepal should make sure that they are familiar with the quality of materials and construction practices that will be available to them.

The following sections describe the background to the design practices adopted in part II of this National Building Code.

1.2 Seismic Design

Nepal is a highly seismic country, lying as it does at the interface between two of the world's major tectonic plates. All parts of Nepal are at risk from the effects of severe ground shaking and there have been many reminders of this within living memory. Kathmandu experienced catastrophic damage in 1934 and approximately 60000 mainly residential buildings were severely damaged or collapsed in an earthquake in the East of Nepal in 1988.

The seismic risk in Nepal is greater than in the majority of neighbouring India and Tibet.

A state-of-the-art seismic hazard analysis was undertaken during 1992 and 1993. All available geological evidence, instrumentally-recorded seismic city and historical writings were considered in the formation of the forward-looking model which covered Nepal and extended into neighbouring countries. This model and the resultant risk analysis are comprehensively described in a report prepared as subcomponent I of the UNDP/UNCHS (Habitat)/HMGN subproject NEP/88/054/21.03. Some indicative secondary hazard (landslides and liquefaction) maps for Nepal, and in more details for the Kathmandu Valley, are also described.

Seismic zoning for Nepal was prepared as a result of the risk analysis and is incorporated in the proposed draft standard for Seismic Design of Buildings in Nepal (NBC105). This is one of the documents for professionally engineered design in Part II of this Code.

The return period for the onset of damage for a typical building of ordinary importance has been chosen as 50 years. The return period for the strength of buildings has been chosen as 300 years.

The basic philosophy adopted for seismic design is to :………..

The level of earthquake load for design is calculated from consideration of seismic zone, location, structural type, natural period and foundation soil conditions. Structures with less inherent ductility incur higher design loads.

Unusual structures, water retention structures, bridges and earthworks are not specifically covered by this Code. For these, special studies should be undertaken based on the principles embodied in the relevant sections of the Nepal National Building Code.

1.3 Other Loads

Occupancy and other environmental (wind and snow) loads have been addressed by proposed draft Nepalese Standards which adopt the corresponding Indian Standards, with adjustments for the particular Nepalese topology where appropriate. The loading described in these Nepalese Standards shall be used for all engineered structures in Nepal except for when more reliable and comprehensive data is available for the specific site.

The draft Nepalese Standard for Wind Load (NBC 104) Provides references to what recorded wind data is available for Nepal.

Information on maximum and minimum temperatures in Nepal are to be found in the proposed draft Nepalese Standard for Steel Design (NBC 111) which modifies the Indian Standard IS 800:1984.

1.4 Materials

The principal construction materials addressed so far by the Nepal National Building Code are Reinforced Concrete, Steel and Reinforced Masonry. The philosophies addressed by the Standards or Codes of practice for each are outlined below.

1.4.1 Reinforced Concrete

A modified version of the Indian Standard 1S 456:1978 has been adopted. This provides design rules in accordance with the principles of Limit State Design.

No specific calculations are required to justify the ductility level chosen within the Nepal Seismic Design Standard (NBC 105). Instead, detailing in accordance with the requirements of IS 4326 (Code of Practice for Earthquake Resistant Design and Construction of Buildings is required. These provisions will introduce general ductility into the reinforced concrete members of a frame, but will not necessarily lead to the predictable hierarchy of failure that would be achievable under the much more onerous capacity design approach.

For any other standard to be acceptable for the design of a professionally engineered structure in Nepal, it must be shown to be at least as good as that described above.

1.4.2 Steel

A working stress method of design is prescribed by reference to a slightly modified version of the Indian Standard 1S 800:1984.

1.4.3 Masonry

The use of burnt-brick-in-cement-mortar masonry as a structural element in a highly seismic country like Nepal is not preferred and alternative materials should be chosen wherever possible.

However, it is inevitable that such masonry structures of limited size should be able to be built in Nepal. A draft code of practice (NBC 109: *Unreinforced Masonry*) has been developed specially for Nepal conditions. This sets out detailing rules whereby the inclusion of non-calculated reinforcing steel both within the brickwork and in reinforced concrete bands and lintels will improve the seismic resistance of such structures. It must be accepted, however, that the seismic performance of a structure so detailed may be less satisfactory than that of a comparable structure in reinforced concrete or structural steel designed in accordance with the Nepal Standards for those materials.

On the other hand, the use of suitably reinforced and grouted hollow concrete block masonry is to be encouraged in Nepal. While no specific document has yet been incorporated in this Code for the rational design of such structural elements, there are a number of international documents, which could be used to determine typical strengths of this type of construction.

Ungrounded concrete masonry in cement mortar should be considered in the same manner as burnt-brick masonry.

PART II PROFESSIONALLY ENGINEERED STRUCTURES

II.1 Introduction

This part describes the minimum standard, which shall be met by all structures, which are required to be designed strength-wise by rational scientific methods.

Stand-alone documents in the form of proposed draft Nepalese Standards address each of the aspects so far developed for Nepal.

The documents covering Site Considerations (NBC 108) and Fire Safety (NBC 107) are largely couched in advisory terms at this stage of their development.

A document on Construction Safety (NBC 114) has been included. Many of the recommendations of this document are also advisory.

Certain types of structure conforming to specific limits of area, height and configuration may be instead detailed to the Mandatory Rules-of-Thumb described in part III of this National Building Code.

Structures to be built with traditional materials and by traditional methods are usually very difficult, or impractical, to design rationally because of the variability of materials and construction methods. Guidelines addressing the important strength features to be included in such structures are presented in part IV of this Code.

The following aspects have been covered by the documents making up this Part:

Site Consideration (NBC 108)

Materials

- **Materials Specification**
- **Unit Weight of Materials**

Load Derivation

- **Occupancy Load**
- **Wind Load**
- **Earthquake Loads and Design**
- **Snow Load**

Design Requirements

- **Masonry: Unreinforced**
- **Plain and Reinforced Concrete**

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MATERIALS SPECIFICATIONS

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SILT Consultants P. Ltd., Nepal
TAEC Consult (P.) Ltd., Nepal
Urban Regional Research, USA

Principal inputs to this standard came from :

Mr. YK Parajuli, TAEC
Mr. D Bhattarai, Assoc. Prof. of Construction Management, IoE.
Mr. AM Tuladhar, DoB, HMGN
Mr. JK Bothara, TAEC
Dr. RD Sharpe, BECA (Team Leader)

Revisions and Updated to this code came from:

Mr. Purna P.Kadariya, DG, DUDBC
Mr. Kishore Thapa, DDG, DUDBC
Mr. Mani Ratna Tuladhar, Sr. Div. Engineer, DUDBC
Mr. Jyoti Prasad Pradhan, Ex. DG, DOB
Mr. Bhubaneswor Lal Shrestha, Ex. DDG, DOB
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Mr. Manohar Lal Rajbhandhari, Sr. Structural Engineer, MR Associates
Mr. Amrit Man Tuladhar, Civil Engineer, DUDBC

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0. Foreword

This Standard deals with the requisite quality and effectiveness of construction materials used mainly in the building construction. It also deals with the storage of materials where storage has relevance to strength.

0.1 Since the quality requirements and test methods used to determine the quality are enumerated in the relevant materials standards, this standards provide a list of Nepal Standards (NS) for key materials used in the building construction. A list of related Indian Standards (IS) has been included for those materials for which Nepal Standards (NS) do not exist as yet. When NS or IS prepare Standards for other materials having a bearing on the strength characteristics of the buildings, or revised version of the existing Standard, these shall be deemed to be the requirement of this Standard. If it exists, the requirements of NS will govern and be mandatory unless the designer has based his design on a standard other than NS. The use of appropriate, adopted or new materials is encouraged, provided these materials have been proven to meet their intended purposes.

1 Scope

The minimum requirements of building materials for buildings complying with the National Building Code are set forth in this part of Standard. Criteria for accepting the use of appropriate and adopted new materials are also outlined.

2 Interpretation

2.1 General

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.

Commentary clauses are prefaced by the letter C and the number of the appropriate clause subject to comment.

3 Materials

The use of materials confirming to NS or IS or any other approved standards agency shall deem to have satisfied the requirements of this Standard. A list of such Nepal Standards and Indian Standards appear in section 9 below.

4 Appropriate, Adopted or New Materials

Any appropriate, adopted or new materials that are not covered by the provision of this Standard may also be used in buildings requiring National Building code compliance, provided that these materials are equivalent, or better in quality, strength, effectiveness, fire resistance, durability, safety, maintenance and compatibility. Prior to the use of such materials, it shall be the responsibility of the building owner, or the authorised representative of the building owner, to obtain proof of equivalency.

5 Recycled / Used Materials

If recycled / used materials meet the requirements of the Standard, they may also be used.

6 Storage of the Materials

All building materials shall be stored in such a manner that no deterioration or loss or impairment of their structural and other inherent properties takes place.

7 Transportation of Materials

All building materials shall be transported so as not to impair their inherent properties.

8 Methods of Test

The testing of materials necessary to fulfill the requirements of this Standard shall be carried out in accordance with the procedures laid down by NS. Where a NS procedure is not available, the testing shall conform to the procedures stipulated by IS or any other authority of similar stature. The test are to be carried out by appropriately-competent persons in a suitable laboratory. The list of Nepal Standards and Indian Standards for materials, which appear in the following section, also stipulate the procedures for testing.

9 List of Standards

Table 9.1 lists those Standards which are mandatory as minimum requirements for buildings designed to comply with other Nepal Standards for Engineered design.

The latest version of a Standard shall be used.

Table 9.1 : LIST OF RELATED MATERIALS STANDARDS

INDIAN STANDARDS	NEPAL STANDARDS
A. GENERAL	
IS : 1911-1967 Schedule of unit weights of buildings materials (first revision)	NBC 102-94 : Unit weight of Materials
B. CEMENT AND CONCRETE	
1. Aggregates	
IS : 383-1970 : Specification for coarse and fine aggregates from natural sources for concrete (second revision) Specification for standard sand for testing of cement	
IS:2386 Methods of test for aggregates for concrete:	
IS: 2386 (Part I) - 1963, Part I: Particle size and shape.	
IS: 2386 (Part II) - 1963, Part II: Estimation of deleterious materials and organic impurities.	
IS: 2386 (Part III) - 1963, Part III : Specific gravity, density, voids, absorption and bulking.	
IS: 2386 (Part IV) - 1963, Part IV : Mechanical properties.	
IS: 2386 (Part V) - 1963, Part V: Soundness.	
IS: 2386 (Part VI) - 1963, Part VI : Measuring mortar making properties of fine aggregate.	

INDIAN STANDARDS	NEPAL STANDARDS
IS: 2386 (Part VII) - 1963, Part VII: Alkali aggregate reactivity. **IS:** 2386 (Part VIII) - 1963, Part VIII: Petrographic examination. **IS:** 2430 - 1969: Methods of sampling of aggregates for concrete. **IS:** 9103-1979 : Specification for admixtures for concrete. **IS:** 9142-1979 : Specification for artificial light weight aggregates for concrete masonry units.	
2. Cement **IS :** 269-1976 : Specification for ordinary and low heat Portland cement. **IS :** 2645-1975 : Specification for integral cement waterproofing compounds (First revision). **IS :** 8042-1978 : Specification for white Portland cement (first revision). **IS :** 8042-1978 : Specification for high strength ordinary Portland cement.	NS 49/2041 : Ordinary Portland Cement
3. MORTAR **IS :** 2250-1980 Code of practice for preparation and use of masonry mortar (first revision) Cement and concrete sampling and methods of test. **IS :** 516-1959 : Methods of test for strength of concrete.	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 1199-1959 Methods of sampling and analysis of concrete. **IS :** 2770 (Part I) -1967 : Methods of testing bond in reinforced concrete. **Part I :** Pullout test. **IS :** 3085-1965 : Methods of test for permeability of cement mortar and concrete. **IS :** 5816-1970 : Methods of test for splitting tensile strength of concrete cylinders. **IS :** 6925-1973 : Methods of test for determination of water soluble chlorides in concrete admixtures. **IS :** 8142-1976 : Methods of test for determining setting times of concrete by penetration resistance.	
4. Precast concrete products	
IS : 2185 Specification for concrete masonry units : **IS :** 2185 (Part I) -1979 Part I : Hollow and solid concrete blocks (Second revision). **IS :** 2185 (Part II) -1983, Part II : Hollow and solid lightweight concrete blocks. **IS :** 2185 (Part III) -1984, Part III : Autoclaved cellular (aerated) concrete blocks (Under print). **IS :** 5751-1984: Specification for precast concrete coping blocks (First revision) (under print).	**NS 119/2042 Hollow Cement Block**

INDIAN STANDARDS	NEPAL STANDARDS
IS : 5758-1984: Specification for precast concrete kerbs (First revision) (under print). **IS :** 5820-1970: Specification for precast concrete cable covers. **IS :** 6523-1983: Specification for precast reinforced concrete door and window frames (First revision). **IS :** 9872-1981: Specification for precast concrete septic tanks. **IS :** 9893-1981: Specification for precast concrete blocks for lintels and sills. **C. ASBESTOS CEMENT PRODUCTS** **IS:** 459-1970: Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets (second revision). **IS :** 1626: Specification for asbestos cement building pipes and pipe fittings, gutters and gutter fittings and roofing fittings: **IS :** 1626 (Part I) -1980, Part I: Pipes and pipe fittings (first revision). **IS :** 1626 (Part I) -1980, Part I: Pipes and pipe fittings (first revision). **IS :** 1626 (Part II) -1980, Part II: Gutters and gutter fittings (first revision). **IS :** 1626 (Part III) -1981, Part III: Roofing accessories (first revision).	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 2096-1966 : Specification for asbestos cement flat sheets. **IS** : 2098-1964 : Specification for asbestos cement building boards. **IS** : 5913-1970 : Methods of test for asbestos cement products. **IS** : 6908-1975 : Specification for asbestos cement pipes and fittings for sewerage and drainage. **IS** :7639-1975 : Method of sampling asbestos cement products. **IS** :9627-1980 : Specification for asbestos cement pressure pipes (light duty).	
D. CONCRETE PIPES	
IS : 458-1971 : Specification for concrete pipes (with and without reinforcement) (second revision).	NS 080/2042 :Hume Pipe
IS : 1916-1963 : Specification for steel cylinder reinforced concrete pipes. **IS** : 3597-1966 : Methods of test for concrete pipes. **IS** : 4350-1967 : Specification for concrete porous pipes for under drainage. **IS**: 7319-1974: Specification for perforated concrete pipes. **IS** : 7322-1974 : Specification for specials for steel cylinder reinforced concrete pipes.	

INDIAN STANDARDS	NEPAL STANDARDS
E. BUILDING LIMES	
IS : 712-1973 : Specification for building limes (second revision).	NS 002/2036 Lime for construction
IS : 1624-1974 : Method of field testing of building lime (first revision).	
IS :3068-1975 : Specification for broken brick (burnt-clay) coarse aggregates for use in lime concrete (first revision):	
IS :6932 (Part I)-1973 Part I Determination of insoluble residue, loss on ignition, insoluble matter, silicon dioxide, ferric and aluminum oxide, calcium oxide and magnesium oxide.	
IS : 6932 (Part II)-1973 Part II Determination of carbon dioxide content.	
IS : 6932 (Part III)-1973 Part III Determination of residue on slaking of quicklime.	
IS : 6932 (Part IV)-1973 Part IV Determination of fineness of hydrated lime.	
IS : 6932 (Part V)-1973 Part V Determination of unhydrated oxide	
IS : 6932 (Part VI)-1973 Part VI Determination of volume yield of quicklime	
IS : 6932 (Part VII)-1973 Part VII Determination of compressive and transverse strength	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 6932 (Part VIII)-1973 Part VIII Determination of workability.	
IS : 6932 (Part IX)-1973 Part IX Determination of soundness.	NS 184/2045 Methods of sampling for Dolomite, Magnesite, and allied minerals
IS : 6932 (Part X)-1973 Part X Determination of popping and putting of hydrated lime.	
IS : 6932 (Part XI)-1983 Method of test for building limes : Part XI Determination of setting time of hydrated lime Stones	
F. NATURAL BUILDING STONES	
IS : 1121 Method of test for determination of strength properties of natural building stones:	
IS : 1121 (Part I)-1974 Part I Compressive strength (first revision)	
IS :1121 (Part II)-1974 Part II Transverse strength (first revision) .	
IS :1121 (Part III)-1974 Part III Tensile strength (first revision)	
IS :1122 (Part IV)-1974 Part IV Shear strength (first revision)	
IS :1122-1974 Methods for determination of true specific gravity of natural building stones (first revision)	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 1123-1975 Method of identification of natural building stones (first revision) **IS**:1125-1974 Method of test for determination of weathering of natural building stones (first revision) **IS**.1126-1974 Method of test determination of durability of natural building stones (first revision) **IS**:1127-1970 Recommendations for dimensions and workmanship for natural building stones for masonry work (first revision) **IS** : 1128-1974 Specification for limestone (slab and tiles) (first revision) **IS** : 1130-1969 Specification for marble (blocks, slabs & tiles) **IS.**1706-1972 Method of determination of resistance to wear by abrasion of natural building stones (first revision) **IS** : 3316-1974 Specification for laterite stone block for masonry (first revision) **IS** : 3620-1979 Specification for sand stone (slabs and tiles) (first revision) **IS**: 4121-1967 Method of test for determination of water transmission rate by capillary action through natural building stones. **IS**: 4348-1973 Methods of test for determination of permeability of natural	

INDIAN STANDARDS	NEPAL STANDARDS
building stones (first revision)	
IS:5218-1969 Method of test for toughness of natural building stones	
IS: 5640-1970 Method of test for determining the aggregates impact value of soft coarse aggregates.	
IS : 6250-1981 Specification for roofing slate tiles (first revision).	
IS : 7779 Schedule for properties and availability of stones for construction purposes:	
G. CLAY PRODUCTS FOR BUILDING	
1. Bricks	
IS : 1077-1976 Specification for common burnt clay building bricks (third revision):	**NS 1/2035 Brick**
IS :3495 (Part I)-1976 Part I Determination of compressive strength (second revision)	
IS :3495 (Part II)-1976 Part II Determination of water absorption (second revision)	
IS :3495 (Part III)-1976 Part III Determination of efflorescence (second revision)	
IS :3495 (Part IV)-1976 Part IV Determination of warpage (second revision)	
IS : 5454-1978 Methods for sampling of clay building bricks (first revision)	
IS : 5779-1970 Specification for burnt clay soling bricks.	

INDIAN STANDARDS	NEPAL STANDARDS
IS: 6165-1971 Dimensions for special shapes of clay bricks.	
2. Tiles	
IS: 654-1972 Specification for clay roofing tiles, Mangalore pattern (second revision)	**NS 047/2041 Mosaic tiles**
IS: 1464-1973 Specification for clay ridge and ceiling tiles (first revision)	**NS 0776/2041 Flooring tiles**
IS : 1478-1969 Specification for clay flooring tiles (first revision)	
IS: 2690 Specification for burnt clay flat terracing tiles:	
IS: 8920-1978 Methods for sampling of burnt clay tiles	
H. TIMBER TESTING	
IS: 4907-1968 Method of testing timber connectors .	
IS: 8242-1976 Methods of test for split bamboos.	
IS: 8292-1976 Methods for evaluation of working qualities of timber under different operations.	
I. FLOOR COVERINGS AND OTHER FINISHES	
IS: 777-1970 Specification for glazed earthenware tiles (first revision)	
IS: 1237-1980 Specification for cement concrete flooring tiles (first revision)	
IS : 1542-1977 Specification for sand for plaster (first revision).	

INDIAN STANDARDS	NEPAL STANDARDS
IS :2333-1981 Specification for plaster of Paris (first revision)	
IS : 3461-1980 Specification for PVC asbestos floor tiles (first revision)	
IS : 3462-1979 Specification for flexible PVC flooring (first revision)	
J. WATER PROOFING AND DAMP-PROOFING MATERIALS	
IS .1322-1982 Specification for bitumen felts for waterproofing and damp proofing (third revision)	
IS: 1580-1969 Specification for bituminous compound for waterproofing and caulking purposes (first revision)	
IS .3037-1965 Specification for bitumen mastic for use in waterproofing of roofs.	
IS :3384-1965 Specification for bitumen primer for use in waterproofing and damp-proofing.	
IS :5871-1970 Specification for bitumen mastic for tacking and damp- proofing	
K. WOOD PRODUCTS	
1. Plywood	**NS 38/2040 Plywood**
IS :303-1975 Specification for plywood for general purposes (second revision)	**NS 114/2042 Test methods of Plywood.**
IS : 1328-1982 Specification for veneered decorative plywood (second	

INDIAN STANDARDS	NEPAL STANDARDS
revision) **IS** : 4990-1981 Specification for plywood for concrete shuttering work (first revision) **IS** : 5509-1980 Specification for fire retardant plywood (first revision) **2. Particle boards and fibre boards** **IS:** 1658-1977 Specification for fibre hardboards (second revision) **IS** : 1659-1979 Specification for block boards (second revision) **IS**: 2380 (Parts I to XXI)-1977 Methods of test for wood particle boards and boards from other lignocellulosic materials (first revision) **3. Doors and windows** **IS** : 1003 Specification for timber panelled and glazed shutters: **IS** :1003 (Part I)-1977 Part I Door shutters (second revision) **IS** : 1826-1961 Specification for Venetian blinds for windows **IS** : 2191 Specification for wooden flush door shutters (cellular and hollow core type): **IS** : 2191 (Part I)-1983 Part I Plywood face panels (fourth revision) **IS** :2191 (Part II)-1983 Part II Particle board face panels and hardboard face panels (third revision) **IS** : 2202 Specification for wooden flush	

INDIAN STANDARDS	NEPAL STANDARDS
doors shutters (solid core type): **IS** : 2202 (Part I)-1983 Part I Plywood face panels (fourth revision) **IS** : 2202 (Part II)-1983 Part II Particle board face panels and hardboard face panels (third revision) **IS** : 4020-1967 Methods of tests for wooden flush doors: Type tests . **IS** : 4121-1983 Specification for timber door, window and ventilator frames (second revision) **IS** : 4962-1968 Specification for wooden side sliding doors. **IS** : 6198-1983 Specification for legged, braced and battened timber door shutters (1st rev.) **L. METAL DOOR AND WINDOW FRAMES, AND SHUTTERS** **IS** : 1038-1983 Specification for steel doors, windows and ventilators (third revision) **IS** : 1361-1978 Specification for steel windows for industrial buildings (first revision) **IS** : 1948-1961 Specification for aluminum doors, windows and ventilators **IS** : 1949-1961 Specification for aluminum windows for industrial buildings. **IS** . 4351-1976 Specification for steel door frames (first revision)	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 6248-1979 Specification for metal rolling shutters and rolling grills (first revision)	
IS : 7452-1982 Specification for hot rolled steel sections for doors, windows and ventilators (first revision)	
IS : 10451-1983 Specification for steel sliding shutters (top hung type)	
IS : 10521-1983 Specification for collapsible gates	
M. CONCRETE REINFORCEMENT	
IS :432 Specification for mild steel and medium tensile steel bards and hard drawn steel wire for concrete reinforcement:	
IS :432 (Part I)-1982 Part I Mild steel and medium tensile steel bards (third revision)	**NS 84/2042 Mild Steel Rod**
IS :432 (Part II)-1982 Part II Hard drawn steel wire (third revision)	
IS :1139-1966 Specification for hot rolled mild steel, medium tensile steel and high yield strength steel deformed bards for concrete reinforcement (revised)	
IS :1566-1982 Specification for hard drawn steel wire fabric for concrete reinforcement (second revision)	
IS : 1785 Specification for plain hard drawn steel wire for prestressed concrete:	

INDIAN STANDARDS	NEPAL STANDARDS
IS :1785 (Part I)-1983 Part I Cold drawn stress-relieved wire (second revision) **IS** : 1785 (Part II)-1983 Part II As drawn wire (first revision)	
IS :1786-1979 Specification for cold worked steel high strength deformed bars for concrete reinforcement (second revision)	**NS 191/2046 Deformed steel bar and wire for concrete reinforcement**
IS : 2090-1983 Specification for high tensile steel bars used in prestressed concrete (first revision) **IS** : 6003-1983 Specification for indented wire for prestressed concrete (first revision) **IS** : 6006-1983 Specification for uncoated stress-relieved strand for prestressed concrete (first revision)	
N. STRUCTURAL STEEL	
IS : 226-1975 Specification for structural steel (standard quality) (fifth revision) **IS** : 961-1975 Specification for structural steel (high tensile) (second revision) **IS** :1977-1975 Specification for structural steel (ordinary quality) (second revision) **IS** : 2062-1984 Specification for weldable structural steel (third revision) (under print) **IS** :2830-1975 Specification for carbon steel billets, blooms and slabs for re-rolling into structural steel (standard	

INDIAN STANDARDS	NEPAL STANDARDS
quality) (first revision)	
IS :2831-1975 Specification for carbon steel billets, blooms and slabs for re-rolling into structural steel (ordinary quality) (second revision)	
IS : 8500-1977 Specification for weldable structural steel (medium and high strength qualities)	
0. BARS, RODS, WIRE AND WIRE RODS	
IS : 280-1978 Specification for general engineering purposes (third revision)	
IS : 1148-1982 Specification for hot rolled steel rivet bars (up to 40 mm diameter) for structural purposes (third revision)	
IS : 1149-1982 Specification for high tensile steel rivet bars for structural purposes (third revision)	
IS : 2591-1982 Dimensions for hot rolled bars for threaded components (second revision)	
IS :7887-1975 Specification for mild steel wire rods for general engineering purposes	
P. PLATES	
IS .3502-1979 Specification for steel chequered plates	
Q. TUBES AND TUBULARS	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 1161-1979 Specification for steel tubes for structural purposes (third revision) **IS** :1239 Specification for mild steel tubes, tubulars and other wrought steel fittings: **IS** :1239 (Part I)-1979 Part I Mild steel tubes (fourth revision) **IS** :1239 (Part II)-1982 Part II Mild steel tubulars and other wrought steel pipe fittings (third revision) **IS** : 4270-1983 Specification for steel tubes used for water wells (first revision) **IS** :4516-1968 Specification for elliptical mild steel tubes. **IS** :4923-1968 Specification for hollow mild steel sections for structural use **IS** : 733-1983 Specification for wrought aluminum and aluminum alloys, bars, rods and sections for general engineering purposes (third revision) **IS** : 737-1974 Specification for wrought aluminum and aluminum alloys, sheet and strip (for general engineering purposes) (second revision) **IS** : 738-1977 Specification for wrought aluminum and aluminum alloy drawn tube for general engineering purposes (second revision) **IS** : 1254-1975 Specification for corrugated aluminum sheet (second	

INDIAN STANDARDS	NEPAL STANDARDS
revision)	
IS :1285-1975 Specification for wrought aluminum and aluminum alloys, extruded round tube and hollow sections (for general engineering purposes) (second revision)	
IS : 7094-1973 Specification for aluminum alloys welded tubes for general engineering purposes	
R. WELDING ELECTRODES AND WIRES	
IS : 814 Specification for covered electrodes for are welding of structural steels:	
IS :814 (Part I)-1974 Part I for welding products other than sheets (fourth revision)	
IS :814 (Part II)-1974 Part II for welding sheets (fourth revision)	
IS : 815-1974 Classification and coding of covered electrodes for metal are welding of structural steels (2nd Rev.)	
IS : 1278-1972 Specification for filler rods and wires for gas welding (second revision)	
IS : 1395-1982 Specification for low and medium alloy steel covered electrodes for manual metal are welding (third revision)	
IS :3613-1974 Acceptance tests for wire-flux combinations for submerged-arc welding of structural steel (first revision)	

INDIAN STANDARDS		NEPAL STANDARDS
	IS : 4972-1968 Specification for resistance spot-welding electrodes	
	IS :6419-1971 Specification for welding rods and base electrodes for gas shielded are welding of structural steel	
	IS : 6560-1972 Specification for molybdenum and chromium-molybdenum low alloy steel welding rods and base electrodes for gas shielded dare welding.	
	IS :7280-1974 Specification for base wire electrodes for submerged-are welding of structural steels	
	IS :.8363-1976 Specification for bare wire electrodes for electroslag welding of steels.	
S.	**BOLTS, NUTS AND FASTENERS ACCESSORIES**	
	IS :207-1964 Specification for gate and shutter hooks and eyes (revised)	**NS 167 : Part 3/2045 wood screw part 3-slotted counter sunk screw.**
	IS : 451-1972 Specification for steel countersunk head wire nails (second revision)	
	IS :724-1964 Specification for mild steel and brass cup, ruler and square hooks and screw eyes (revised)	
	IS : 730-1978 Specification for hook bolts for corrugated sheet roofing (second revision)	
	IS .1120-1975 Specification for coach screws (first revision)	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 1363-1967 Specification for black hexagonal bolts, nuts and lock nuts (dia. 6 to 39 mm) and black hexagonal screws (dia. 6 to 24 mm) (first revision) **IS** : 1365-1978 Specification for slotted countersunk head screws (third revision) **IS** : 1366-1982 Specification for slotted cheese head screws (dia. range 1.6 to 20 mm) (second revision) **IS :** 2016-1967 Specification for plain washers (second revision) **IS :** 2389-1968 Specification for precision hexagon bolts, screws, nuts and lock nuts (dia. range 1.6 to 5 mm) (first revision) **IS** :2585-1968 Specification for black square bolts and nuts (dia. range 6 to 39 mm) and black square screws (dia. range 6 to 24 mm) (first revision) **IS** :2687-1975 Specification for cap nuts (first revision) **IS**:3063-1972 Specification for single coil rectangular section spring washers for bolts, nuts and screws (first revision) **IS** : 3468-1975 Specification for pipe nuts (first revision) **IS** :3753-1972 Specification for high tensile friction grip bolts (first revision)	

INDIAN STANDARDS	NEPAL STANDARDS
IS:4206-1967 Dimensions for nominal lengths, and thread lengths for bolts, screws and studs	
IS : 4762-1968 Specification for worm drive hose clips for general purposes	
IS : 5369-1975 General requirements for plain washers and lock washers (first revision)	
IS:.5372-1975 Specification for taper washer for channels (ISMC) (first revision)	
IS :5373-1969 Specification for square washers for wood fastenings	
IS :5624-1970 Specification for foundation bolts	
IS :6113-1970 Specification for aluminum fasteners for building purposes	
IS :6610-1972 Specification for heavy washers for steel structures	
IS : 6623-1972 Specification for heavy washers for steel structures	
IS : 6639-1972 Specification for hexagon bolts for steel structures	
IS : 6649-1972 Specification for high tensile friction grip washers	
IS : 6733-1972 Specification for wall and roofing nails **IS** : 6736-1972 Specification for slotted raised countersunk head wood screws.	
IS : 6739-1972 Specification for slotted round head wood screws	

INDIAN STANDARDS	NEPAL STANDARDS
IS: 6760-1972 Specification for slotted countersunk head wood screws.	
IS: 8033-1976 Specification for round washers with square hole for wood fastenings	
IS :8412-1977 Specification for slotted countersunk head bolts for steel structures	
IS:8822-1978 Specification for slotted mushroom head roofing bolts	
IS :8869-1978 Specification for washers for corrugated sheet roofing	
IS :8911-1978 Specification for slotted raised countersunk head screws	
IS :10238-1982 Specification for step bolts for steel structures	
T. SCREW THREADS AND RIVETS	
IS :554-1975 Dimensions for pipe threads where pressure tight joints are required on the threads (second revision)	
IS :1929-1982 Specification for hot forged steel rivets for hot closing (12 to 36 mm diameter) (first revision)	
IS:.2155-1982 Specification for cold forged solid steel rivets for hot closing (6 to 16 mm diameter) (first revision)	
IS :2643 Dimensions for pipe threads for fastening purposes:	
IS :2643 (Part I)-1975 Part I Basic profile and dimensions (first revision)	
IS :2643 (Part II)-1975 Part II Tolerances (first revision)	

INDIAN STANDARDS		NEPAL STANDARDS
	IS:2643 (Part III)-1975 Part III Limits of sizes (first revision) **IS** : 10102-1982 Technical supply conditions for rivets	
	IS :2907-1964 Specification for cold forged steel rivets for cold closing (1 to 16 mm diameter (first revision)	
U.	**WIRE ROPES AND WIRE PRODUCTS**	
	IS :278-1978 Specification for galvanized steel barbed wire for fencing (third revision)	
	IS : 1835-1976 Specification for steel wire for ropes (third revision)	
	IS :2140-1978 Specification for stranded galvanized steel wire for fencing (first revision)	
	IS :2266-1977 Specification for steel wire suspension ropes for general engineering purposes (second revision)	
	IS : 2365-1977 Specification for steel wire suspension ropes for lifts, elevators and hoists (first revision)	
	IS :2721-1979 Specification for galvanized steel wire chain link fences (first revision)	
	IS :3121-1981 Specification for rigging screws and stretching screws (first revision)	
	IS : 6594-I977 Technical supply	

INDIAN STANDARDS	NEPAL STANDARDS
conditions for wire ropes and strands (first revision)	
V. GLASS	
IS : 2553-1971 Specification for safety glass (second revision)	
IS : 2835-1977 Specification for flat transparent sheet glass (second revision)	
IS :5437-1969 Specification for wired and figured glass.	
W. FILLERS, STOPPERS AND PUTTIES	
IS : 110-1968 Specification for ready mixed paint, brushing, grey filler, for enamels, for use over primers (1st rev.)	
IS :345-1952 Specification for wood filler, transparent, liquid	
IS :419-1967 Specification for putty for use on window frames (first revision)	
IS : 3709-1966 Specification for mastic cement for bedding of metal windows	
IS :7164-1973 Specification for stopper	
X. WATER BASED PAINTS	
IS: 427-1965 Specification for distemper, dry, colour as required (revised)	
IS : 428-1969 Specification for distemper, oil emulsion, colour as required (first revision)	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 5410-1969 Specification for cement paint, colour as required	
IS : 5411 Specification for plastic emulsion paint:	
IS : 5411 (Part I)-1974 Part I For interior use.	
IS : 5411 (Part II)-1972 Part II For exterior use.	
Y. READY MIXED PAINTS AND ENAMELS	
IS :101-1964 Methods of test for ready mixed paints and enamels (second revision)	
IS :102-1962 Specification for ready mixed paint, brushing, red lead, non-setting, priming (revised)	
IS :104-1979 Specification for ready mixed paint, brushing, zinc chrome, priming (second revision)	
IS : 109-1968 Specification for ready mixed paint, brushing, priming, plaster, to Indian Standard colours No. 361 and 631 (first revision)	
IS : 111-1950 Specification for ready mixed paint, brushing, undercoating, exterior, to Indian Standard colours No. 101,216,352,358,443 and 632	
IS :112-1950 Specification for ready mixed paint, spraying, undercoating, exterior, to Indian Standard colours No. 101,216,352,358,443 and 632	

INDIAN STANDARDS	NEPAL STANDARDS
IS : 113-1950 Specification for ready mixed paint, brushing, undercoating, interior, to Indian Standard colours No. 101,216,352,358,443 and 632	
IS :114-1950 Specification for ready mixed paint, spraying, undercoating, interior, to Indian Standard colours No. 101,216,352,358,443 and 632	
IS :115-1950 Specification for ready mixed paint, brushing, undercoating, exterior, matt finish to Indian Standard colours No. 352 and 632	
IS:116-1950 Specification for ready mixed paint, spraying, undercoating, exterior, matt finish, to Indian Standard colours No. 352 and 632	
IS : 117-1964 Specification for ready mixed paint, brushing, finishing exterior, semi-gloss, for general purposes, to Indian Standard colours Light Colours No. 101, 102, 174, 216, 217, 275, 281. 352, 353, 354, 358, 361, 364, 365, 384, 385, 386, 387, 388, 397, 442. 443, 628, 629, 630, 631, 693, 694 and 697; Dark Colours No. 103, 104, 169, 219, 278, 280, 283, 359, 360, 362, 363, 410, 444, 632, 635 and 692 (revised)	
IS :120-1962 Specification for ready mixed paint, brushing, finishing, semi-gloss, for general purposes, to Indian Standard colours No.537,538, 540, 541, 570 and 574 (revised)	
IS :121-1962 Specification for ready mixed paint, brushing, finishing, semi-gloss, for general purposes, to Indian Standard colour No.414 (revised)	
IS :122-1962 Specification for ready mixed paint, brushing, finishing, semi-gloss, for general purposes, to Indian	

INDIAN STANDARDS	NEPAL STANDARDS
Standard colours No.411,412 and 413 (revised)	
IS : 123-1962 Specification for ready mixed paint, brushing, finishing, semi-gloss, for general purposes, to Indian Standard colours No.445,446, 448,449, 451 and 473; and red oxide (colour unspecified) (revised)	
IS :124 Specification for ready mixed paint, brushing, finishing, semi-gloss, for general purposes:	
IS :124 (Part I)-1976 Part I (second revision)	
IS :124 (Part II)-1979 Part II (second revision)	
IS :124 (Part III)-1979 Part III	
IS :126-1962 Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes, to Indian Standard colour No. 671 (revised)	
IS :127-1962 Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes, while (revised)	
IS : 128-1962 Specification for ready mixed paint, brushing, finishing, semi-gloss for general purposes, black (revised)	
IS : 129-1950 Specification for ready mixed paint, brushing, finishing interior, oil gloss, for general purposes, to Indian Standard colours No. 101, 102, 103, 104, 169, 216, 217, 219, 352, 353, 354, 358,	

INDIAN STANDARDS	NEPAL STANDARDS
359, 360, 361, 362, 363, 364, 410, 443, 444, 628, 629, 630, 631, 632, 633, 634 and 635	
IS :133-1975 Specification for enamel, interior (a) undercoating, (b) finishing (second revision)	
IS :137-1965 Specification for ready mixed paint, brushing, matt or egg- shell flat, finishing, interior, to Indian Standard colour, as required (revised)	
IS :155-1950 Specification for ready mixed paint, brushing, matt, black for use on wood	
IS :156-1950 Specification for ready mixed paint, brushing, for use on floors, colour as required	
IS : 158-1981 Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, and heat resisting (third revision)	
IS :1 62-1950 Specification for ready mixed paint, brushing, fire resisting silicate type, for use on wood, colour as required	
IS : 168-1973 Specification for ready mixed paint, air-drying semi-glossy/matt, for general purposes (second revision).	
IS :290-1961 Specification for coal tar black paint (revised)	
IS :341-1973 Specification for black Japan, Types A, B and C (first revision)	
IS : 641-1964 Specification for ready mixed paint, brushing, finishing, interior,	

INDIAN STANDARDS	NEPAL STANDARDS
semi-gloss, for general purposes, white (revised)	
IS : 871-1956 Specification for ready mixed paint, brushing, finishing, egg shell gloss, for interior use, to Indian Standard colours-Class A No. 218 and Class B No.221	
IS : 872-1956 Specification for ready mixed paint, brushing, finishing, egg shell gloss, for interior use, to Indian Standard colours No. 412 and 413	
IS : 1188-1957 Specification for ready mixed paint, brushing, oil gloss, genuine zinc oxide, for general purposes	
IS : 1232-1964 Specification for ready mixed paint, brushing, yellow ochre, semi-gloss, for general purposes (revised)	
IS : 2074-1979 Specification for ready mixed paint, red oxide-zinc chrome, priming (first revision)	
IS : 2075-1979 Specification for ready mixed paint, shoving, red oxide-zinc chrome, priming (first revision)	
IS :2339-1963 Specification for aluminum paint for general purposes, in dual container	
IS : 2932-1974 Specification for enamel, synthetic, exterior, (a) undercoating, (b) finishing (first revision)	
IS : 2933-1975 Specification for enamel, exterior (a) undercoating, (b) finishing	

INDIAN STANDARDS	NEPAL STANDARDS
(first revision) **IS** : 3536-1966 Specification for ready mixed paint, brushing, wood primer, pink **IS** :3537-1966 Specification for ready mixed paint, finishing, interior for general purposes, to Indian Standard colours **IS** : 3539-1966 Specification for ready mixed paint, undercoating, for use under oil finishes, to Indian Standard colours, as required **IS** : 3585-1966 Specification for ready mixed paint, aluminum brushing, priming, water resistant, for wood work **IS** :3678-1966 Specification for ready mixed paint, thick white, for lettering **IS** :3678-1966 Specification for ready mixed paint, thick white, for lettering **IS** : 8662-1966 Specification for enamel, synthetic, exterior, (a) undercoating, (b) finishing, for railway coaches **IS** :9862-1981 Specification for ready mixed paint, brushing, bituminous black, lead free, acid, alkali, water and chlorine resisting **Z. THINNERS AND SOLVENTS** **IS** : 82-1973 Methods of sampling and test for thinners and solvents for paints (first revision) **IS** :324-1959 Specification for ordinary denatured spirit (revised) **IS** :533-1973 Specification for gum spirit	

INDIAN STANDARDS	NEPAL STANDARDS
of turpentine (oil of turpentine) (first revision)	
AA. VARNISHES AND LACQUERS	
IS :197-1969 Methods of sampling and test for varnishes and lacquers (first revision)	
IS : 337-1975 Specification for varnish, finishing, interior (first revision)	
IS : 340-1978 Specification for varnish, mixing (first revision)	
IS : 346-1952 Specification for varnish, spirit, clear, hard	
IS : 347-1975 Specification for varnish, shellac, for general purposes (first revision)	
IS : 348-1968 Specification for French polish (first revision)	
IS : 349-1955 Specification for lacquer, cellulose, nitrate, clear, finishing, glossy for metal (first revision)	
IS :524-1968 Specification for varnish, finishing, exterior, synthetic (first revision)	
IS : 525-1968 Specification for varnish, finishing, exterior and general purposes (first revision)	
IS : 642-1963 Specification for varnish medium for aluminum paint (revised)	

INDIAN STANDARDS	NEPAL STANDARDS
	NS 046/2041 Nails NS 061/2041 Inch screw thread NS 067/2041 Basic dimensions of metric screw thread
AB. OTHERS	NS 085/2042 Powder cement pain NS 112/2042 Enamel paint Part I For external use Part IJ For internal use NS 133/2043 Linseed oil (not edible) NS 141/2043 Galvanized corrugated sheet NS 143/2043 Wood adhesive based on polyvinyl acetate dispersion NS 157/2044 Hexagonal nuts and bolts Part I Basic dimensions Part II Screw threads NS 161/2044 Plastic emulsion paint Part I For internal use Part II for external use NS 163/2045 Galvanized coating on wire NS 167/2045 **Wood** screw **Part I** General requirements **Part II** Slotted rounded counter sunk head **Part III** Slotted counter

INDIAN STANDARDS	NEPAL STANDARDS
	sunk head Part IV Slotted round head NS 168/2045 Galvanized steel barbed wire NS 169/2045 Mild steel wire metal NS 172/2045 Hinges NS 177/2045 Methods of tests for ready mixed paints and enamels NS 180/2045 Dimensions for hot rolled steel channel sections NS 181/2045 Hardness conversion tables for NS 189/2046 Ready mixed paint, aluminum, wood primer NS 190/2046 Ready mixed paint cement primer NS 192/2046 Methods for Brinell hardness tests for steel NS 193/2046 Methods for Vickers hardness tests for steel NS 194/2046 Methods for Rockwell hardness tests for steel NS 199/2046 Galvanized steel pipes for water supply NS 202/2046 Bolts, screws studs-nominal length and thread length for general purpose bolts NS 203/2046 Tensile testing of metals NS 205/2046 Ready mixed wood

INDIAN STANDARDS	NEPAL STANDARDS
	primer, pink, brushing NS 206/2046 PVC pipe for drinking water supply NS 234/2047 Cold rolled light structural steel NS 246/2048 Vertically cast-cast iron pipes NS 254/2048 Cast iron pipes centrifugally cast

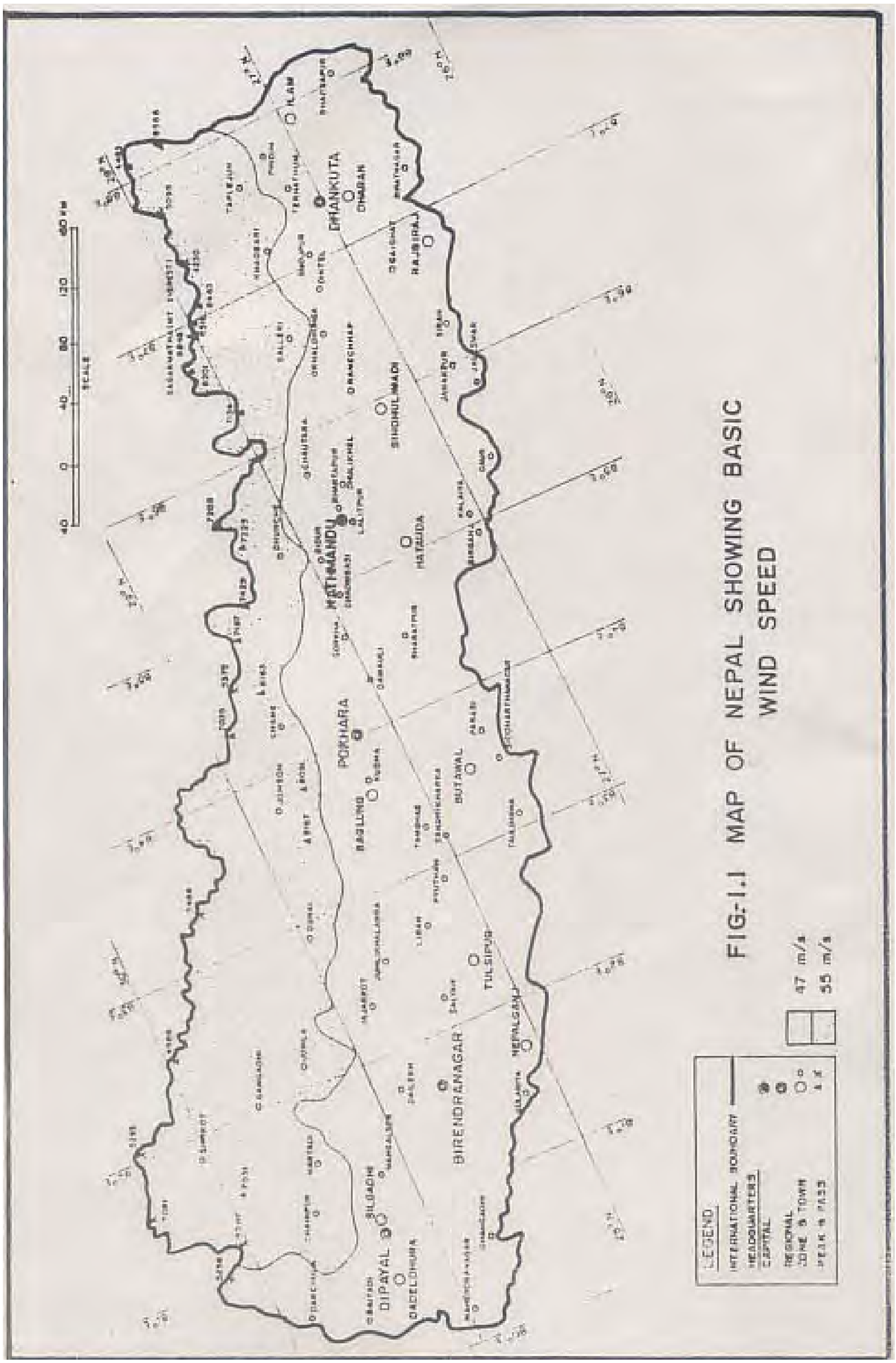

FIG-1.1 MAP OF NEPAL SHOWING BASIC WIND SPEED

NEPAL NATIONAL BUILDING CODE

NBC 102 : 1994

UNIT WEIGHT OF MATERIALS

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
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N E P A L   N A T I O N A L   B U I L D I N G   C O D E

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UNIT WEIGHT OF MATERIALS

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

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0 Foreword

This Nepal Standard for Unit Weight of Materials adopts the Indian Code IS:875 (Part 1) - 1987 Code fo Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 1, Dead Loads-Unit Weights of Building Materials and Stored Materials, (Second Revision).

1. SCOPE

JUSTIFICATION FOR ADOPTING IS:875 (PART I)

During the desk study of codes from various countries (Uniform Building Code, Indonesian Earthquake Code, National Building Code of Indian and Yugoslavian Code, New Zealand Code) it was found that unit weight of very common types of materials were maintained the same in each country. For country-specific materials, their variation in unit-weight with respect to those of similar materials in other countries was also found to be minimal. Because of the unavailability of specific unit weights of Nepalese materials for various uses, and because of the similarity of materials and their uses in Nepal and India, Indian Standard IS: 875 (Part I) -1987 has been recommended for adoption in Nepal.

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OCCUPANCY LOAD
(IMPOSED LOAD)

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
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N E P A L   N A T I O N A L   B U I L D I N G   C O D E

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0 Foreword

This Nepal Standard for Occupancy Load adopts the Indian Code IS:875 (Part 2) - 1987 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 2 Imposed Load, (Second Revision).

1. SCOPE

JUSTIFICATION FOR ADOPTING IS:875 (PART I)

During the desk study of codes from various countries (Uniform Building Code, Indonesian Earthquake Code, The National Building Code of Indian, the Yugoslavian Code and the New Zealand Code) it was found that recommended occupancy loads were more or less similar. In the absence of any specific information indicating that typical Nepalese occupancy loads are unusually different, the Indian Standard IS: 875 (Part 2) -1987 has been recommended for adoption in Nepal because of the similarity of the situations in Nepal and India..

NEPAL NATIONAL BUILDING CODE

NBC 104 : 1994

WIND LOAD

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
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NEPAL NATIONAL BUILDING CODE

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WIND LOAD

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TAEC Consult (P.) Ltd., Nepal
Urban Regional Research, USA

Principal inputs to this standard came from:

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Mr. AS Arya, University of Roorkee, Roorkee, India
The Deputy Director- General, Metrological Department (IMD), India
Mr. S. Shrestha, TAEC
Mr. JK Bothara, TAEC
Dr. RD Sharpe, BECA (Team Leader)

Revisions and Updated to this code came from:

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0 Foreword

This Nepal Standard on **"Wind Load"** comprises the India Standard IS:875 (Part 3) 1987: **CODE OF PRACTICE FOR DESIGN LOADS (OTHER THAN EARTHQUAKE) FOR BUILDINGS AND STRUCTURES** (Second Revision) with amendments as set out herein.

These amendments have been necessary to ensure the requirements of Nepalese context. Particularly the wind zoning map of Nepal.

1. SCOPE

NEPAL AMENDMENTS TO BE: 875 (Part 3)-1987

0 Foreword Delete 0.1 to 0.3 and replace with:

Wind speed is monitored at only a few stations in Nepal. The average monthly wind speed data recorded at a particular time of the day is available from 40 stations distributed in various parts of the country. Of these, the station at Tribhuvan International Airport 1030) records the average daily wind speed, maximum hourly gust and maximum gust. The data from this station, however, is not continuous and this information is available only for the period 1971 to 1975 and 1985 to 1986. For the 1985-1986 periods, only the average monthly wind speed is available. This is published in book-form. The general data is available in a booklet published by the Department of Hydrology and Meteorology.

The Snow and Glacier Hydrology Project and the Kagbeni Wind Power Project are two projects which, at present, are measuring wind speed in some parts of the country. The former has established three anemometer stations in Upper Langtang Valley, Khumbu (Everest region) and Modi Khola Valley (Annapurna region) where the hourly wind speed and direction have been measured since 1987. The project has further plans to establish more stations in higher regions in the future. The latter was Nepal's first wind power generation project. Maximum, minimum and average daily wind records since 1989 for Kagbeni in Mustang district of West Nepal are available. It is proposed to establish eight more stations in various parts of the country.

The available data base is inadequate both in terms of spatial distribution and duration. Modern wind design codes are based on the peak gust velocity averaged over a short interval of about 3 seconds that has a 50 year return period. The available Nepalese wind data base is insufficient and irrelevant to prepare wind zone map.

The Indian Standard IS : 875 (part 3) –1987 Code of practice for Design Wind Load has presented a wind zoning of India based on an average peak gust velocity of 3 seconds with a 50 year return period. According to this map, the plains have a basic wind velocity of 47 meters per second and the hilly northern areas in Uttar Pradesh and Himanchal pradesh have a basic wind velocity of 39 meters per second-with a marginal adjustment for Dehra Dun for which the basic wind velocity is 47 meters per second. The basic wind speed for the Laddakh region, which has high hills and valleys all through it, is 55 meters per second.

In Nepal, the wind velocities in the lower valleys are smaller in magnitude than those in the higher valleys and mountain ranges. This is evident from the speeds observed in Kathmandu Valley and in Kali Gandaki Valley. It appears reasonable to classify broadly the country into different wind zones for the purpose of setting the basic wind speeds. For this purpose, the Indian map has been used as a guide.

The country has been divided into two regions : a) the lower plains and hills and, b) the mountains. The first zone generally includes the southern plains of the Terai, the Kathmandu Valley and those regions of the country generally below an elevation of 3000 meters. The second zone covers all sreas above 3000 meters. For the Nepalese plains continuous with the Indian plans, a basic velocity of 47 m/s has been adopted. In the higher hills, a basic wind velocity of 55 meters per second has been selected. The wind zoning map of Nepal prepared on this basis is presented in Figure 1.1. While preparing the map, the physical boundaries of the Districts have also been kept in mind.

Available wind data collected during the preparation of this standard is presented separately in Appendices **NBC 104: 1 to 5.**

Note:

A. ***Discussions with the Deputy Director General of India's metrological Department (IMD) by Dr AS Arya on the use of the available wind data for Nepal concluded that the various parameters which control the peak gust velocities are extremely variable in the hilly/mountainous regions of the Himalayas. In addition, any extrapolation from average daily wind velocities and hourly mean velocities to peak gust velocities will be meaningless and, therefore, should not be attempted.***

B. ***The design wind velocity for a structure depends on the following main parameters:***

- ***Probability factor,***
- ***Terrain, height and structure size factor, and***
- ***Topography factor***

These factors are fully described in IS:875 (Part 3)- 1987 and are easily discernable for areas in Nepal. Therefore, it will be reasonable to use the Indian Standard for the computation of wind forces on structures in Nepal, taking the wind velocities as suggested here above.

C. ***All organizations planning to build important light roof type structures or tall structures are advised to collect data on wind direction and speed with the help of appropriate instruments.***

D. ***Data and information collected during the course of preparing this Standard appear in a separate Appendix, NBC: 104-2250***

1.1.3 4th line, add "Indian" before codes.
5th line, replace "code" with "Standard"

4

4.2. **Delete** this clause inclusively.

4.8 **Add** new clause:

4.8.1 In this Standard the word " shall" indicates a requirement that must be adopted in order to comply with the Standard, while the word "Should" indicates recommended practice.

5.

5.2. 2nd line, replace " India" with " Nepal".
Delete the last sentence.

5.3. Last sentence on note, replace " speed" with " speed".

5.3.1. Delete the first sentence and substitute with:

Figure 1 gives the approximate basis wind speed for Nepalese topography based on the Indian territory. It is believed to be applicable for Category 2 at 10 m above the ground level, based on a 50 years mean return period.

5.3.2.1 (a) Delete the portion of note " Open sea coast land"

5.3.2.1 (b) Delete the last sentence of note.

Figure 1 Replace " the Map of India" with " the Map of Nepal".

Table 1 Delete k_1 factor, and A and B coefficients for basic wind speeds of 33, 39, 44 and 50 m/s.

5.3.2.1 (c) Note- 3, delete the sentences.

5.3.3. Delete the first two sentences and replace with:

The basic wind speed given in Figure 1 is generally estimated from the height of the places above the mean sea level. Special attention has been given to the Kali Gandaki River valley where the average wind velocity is extremely high. The boundaries of Districts have also been taken into consideration when demarcating the wind zones.

5.5. Delete this clause inclusively.

6

6.2.2.9. Last sentences, replace " windword" with "windward".

8.

8.2. 5th line, insert "factor" before "at".

Note- 3rd line, replace "India" with "Nepal" and

Note- 4th line, delete, "cyclone and".

APPENDIX D

4th paragraph, delete "likely to be found in India"

NEPAL NATIONAL BUILDING CODE

NBC 105 : 1994

SEISMIC DESIGN OF BUILDINGS IN NEPAL

Government of Nepal
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0. Foreword

1. Design Procedure

This Standard provides minimum requirements for the seismic design of structures which are within the scope of this Standard as defined in **1**.

2. Related Codes

The requirements of this section of the Nepal Building Code shall be applied in conjunction with, IS 4326 - 1976 Code of Practice for Earthquake Resistant Design and Construction of Buildings.

Where conflict exists between any requirements of this Standard and IS 4326, the requirements of this Standard shall be taken.

3. Commentary

A commentary, which explains the reasons for many of the clauses in this Standard, forms an accompanying volume to this document. This Standard should always be read in association with the Commentary.

1 Scope

This standard sets down requirements for the general structural design and seismic design loadings for structures within any of the following categories :

(a) All buildings having a floor area greater than 20 square metres.

(b) Any building with a height greater than five metres.

(c) All masonry or concrete walls greater than 1.5 metres in height.

(d) Elevated tanks of up to 200 cubic metres capacity. Larger tanks than this should be the subject of a special study.

(e) All buildings to which the general public have access.

The requirements are not intended to apply to :

(a) Unusual buildings or structures (eg, those with unusual configurations or risk - such as nuclear power stations, etc).

(b) Civil engineering works (eg, bridges, dams, earth structures, etc).

(c) Buildings or structures greater than 90 m in height.

2 Interpretation

2.1 General

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

2.1.2 Commentary clauses (in Part 2) are prefaced by the letter C and the number of the appropriate clause subject to comment.

2.2 Terminology

In this standard, unless inconsistent with the context :

ANALYSIS METHODS :

SEISMIC COEFFICIENT METHOD means a method of analysis using static loads to simulate the effects of earthquake ground motion.

MODAL RESPONSE SPECTRUM METHOD means a method of dynamic analysis in which a given earthquake design spectrum is applied to a mathematical model of the structure and the response of several modes are determined, and combined.

DEAD LOAD means the weight of all permanent components of a building including walls, partitions, columns, floors, roofs, finishes and fixed plant and fittings that are an integral part of the structure.

DESIGN means the use of rational computational or experimental methods in accordance with the established principles of structural mechanics.

DIAPHRAGM means a member composed of a web (such as a floor or roof slab), or a truss which distributes forces to the horizontal load resisting system.

DUCTILITY means the ability of the building or member to undergo repeated and reversing inelastic deflection beyond the point of first yield while maintaining a substantial proportion of its initial maximum load carrying capacity.

ELEMENTS includes primary and secondary elements :

PRIMARY ELEMENTS means elements forming part of the basic load resisting structure, such as beams, columns, diaphragms, or shear walls necessary for the building's survival when subjected to the specified loadings.

SECONDARY ELEMENTS means elements such as intermediate or secondary beams, partition walls, panels, or veneers not necessary for the survival of the building as a whole but which may be subject to stresses due to load applied directly to them or to stresses induced by the deformations of the primary elements.

FRAME means a system composed of interconnected members functioning as a complete self-contained unit with or without the aid of horizontal diaphragms or floor bracing systems.

MOMENT RESISTING FRAME means a load carrying frame in which the members and joints are capable of resisting horizontal loads through bending moments.

HORIZONTAL LOAD RESISTING SYSTEM means that part of the structural system to which the horizontal loads prescribed by this Standard are assigned.

LEVEL OF LATERAL RESTRAINT is the level at which the ground motion of the earthquake is transmitted to the structure by interaction between the foundation materials and the foundation elements by friction and bearing.

LIVE LOAD means the load assumed or known to result from the occupancy or use of a building and includes the loads on floors, loads on roofs other than wind, loads on balustrades and loads from movable goods, machinery, and plant that are not an integral part of the building.

SET BACK means any offset horizontally in from the plane of an exterior wall of a structure.

SHEAR WALL means a wall of any material required to resist horizontal loads through the transfer of shear forces.

STOREY means the space between two adjacent floors or platform levels.

2.3 Symbols

Symbols used in the Standard shall have the following meanings :

b	maximum horizontal dimension of the building at the particular level measured perpendicular to the direction of loading
C	*basic seismic coefficient for the seismic coefficient method*
$C(Ti)$	*ordinate of the basic response spectrum for translational period* T_i
C_d	*design horizontal seismic force coefficient*
$C_d(T_i)$	*ordinate of the design spectrum for translational period* T_i
DL	*design dead load*
D'	*overall length of the building at the base in the direction under consideration (m)*
d_i	*horizontal displacement of the centre of mass at level i under the horizontal seismic loading specified by this Standard (ie Fi)*
E	*design earthquake load*
e_d	*design eccentricity of the seismic load at a particular level*
e_c	*computed eccentricity of the centre of mass from the centre of rigidity*
F_i	*horizontal seismic force applied at a level designated as i*
F_p	*design seismic force for elements and components designed in accordance with 8*
g	*acceleration due to gravity. To be taken as* $9.81\ m/s^2$
H	*height to the top of the main portion of the building or the eaves of the building (m)*
h_i	*height to the level designated as i from the level of lateral restraint*
I	*importance factor for the building*

K	*structural performance factor appropriate for the particular structural type*
K_p	*component seismic performance coefficient*
LL	*design live load*
P	*structural response factor*
S	*modal combination factor*
SL	*design snow, or ice load*
T_1	*natural period of vibration of the first mode of the structure*
Ti	*translational period of vibration for mode i*
V	*total horizontal seismic base shear*
W_i	*proportion of* W_t *contributed by level i*
W_p	*weight of the element, component or item of equipment*
W_t	*total of the gravity loads* W_i *above the level of lateral restraint*
Z	*seismic zoning factor*

3 General Principles of Ductile Seismic Design and Detailing

3.1 Structural System

Buildings shall be designed with a clearly defined (identifiable) load path, or paths, to transfer the inertial forces generated in an earthquake to the supporting soils.

3.2 Ductility

Buildings and all their seismic load resisting elements should be designed and detailed to perform in a ductile manner.

Satisfactory ductility can be assumed if the structure will withstand, without significant loss of vertical and/or lateral load carrying capacity, the lateral deflections specified in **9.1** applied through several reversals (cycles).

For the purposes of this Standard the above general requirement may be assumed to be adequately met if the specific requirements of Table **8.2** are complied with.

3.3 Energy Dissipation

In addition to the provision of adequate ductility, structures should also be designed to prevent the concentration of the demand for ductility in a few members, except where special provisions are made to increase the ductility available in those members.

The demand for ductility should be spread throughout the structure so that the earthquake induced energy is dissipated uniformly.

For the purpose of this Standard the above general requirements may be assumed to be adequately met if the specific requirements of Table **8.2** are complied with.

3.4 Symmetry

The seismic load resisting elements of a structure should be located, as nearly as practicable, symmetrically about the centre of mass of the structure.
Re-entrant angles in the plan shape of a structure should be avoided.

3.5 Uniformity of Storey Stiffness

Significant changes in the stiffness over the height of the building should be avoided.

3.6 Floor Diaphragms and Bracing

The horizontal bracing system or diaphragm at each floor shall be designed to distribute forces to the individual elements of the horizontal load resisting system in proportion to their rigidities.

3.7 Interconnection of Floors and Roof

Concrete and masonry walls shall be anchored to all floors or roofs that are required to provide them with horizontal support or stability. Such anchorage shall be designed for the loads determined from **12**, or a minimum load of 3 kN per metre of wall, whichever is greater. Spacing of such anchors shall not exceed one metre unless the wall is designed to span between them.

Such connections to walls shall also comply with the requirements of **12.2**.

3.8 Interconnection of Foundations

Individual foundations of a building shall be interconnected in two directions, generally at right angles, by members designed for an axial tension and compression equal to 10 % of the maximum vertical load on either foundation under seismic conditions.

If the axial load on one of the interconnected foundations is less than 20 % of that on the other, the design axial load in the interconnecting elements shall be taken as 10 % of the average vertical load on the two foundations under seismic conditions.

4 Design Methods & Load Combinations

4.1 General

Design for earthquake actions shall be in accordance with either :

(a) The Working Stress Method (elastic method), or

(b) The Limit State Method

provided that reinforced concrete design shall be in accordance with the Limit State Method unless specifically noted otherwise.

4.2 Increase in Allowable Material Stresses for the Working Stress Method

Whenever earthquake forces are considered along with other design forces, the allowable material stresses may be increased by one third but shall not exceed the following limits :

(a) Steels with a definite yield stress; the yield stress

(b) Steels without a definite yield stress; 80 percent of the ultimate strength or the 0.2 percent proof stress whichever is smaller.

4.3 Increase in Allowable Soil Bearing Pressure

Whenever earthquake forces are considered along with other design forces, the allowable soil bearing pressures may be increased by up to 50 percent.

4.4 Design Load Combinations for the Working Stress Method

The design loads including earthquake for the Working Stress Method shall be not less than whichever of the following load combinations gives the greatest effect :

$$DL + LL + E$$

$$0.7\,DL + E$$

$$DL + SL + E$$

4.5 Design Load Combinations for the Limit State Method

The design loads including earthquake for the Limit State Method shall be not less than whichever of the following load combination gives the greatest effect :

$$DL + 1.3\,LL + 1.25\,E$$

$$0.9\,DL + 1.25\,E$$

$$DL + 1.3\,SL + 1.25\,E$$

5 Methods of Analysis

5.1 General

Analysis for the design earthquake actions shall be in accordance with one of the following methods :

(a) The Seismic Coefficient Method as outlined in **10**, or,

(b) The Modal Response Spectrum method as outlined in **11**.

Note : Analysis using numerical integration time history procedures is not covered by this Standard.

5.2 Selection of Method of Analysis

For structures of up to 40 m in height the Seismic Coefficient Method may be used. For all other structures the Modal Response Spectrum Method shall be used.

The Modal Spectrum Method should be used for :

a) Buildings with irregular configurations

(b) Buildings with abrupt changes in lateral resistance

(c) Buildings with abrupt changes in lateral stiffness with height

(d) Buildings with unusual shape, size or importance.

6 Seismic Weight

The seismic weight at each level, W_i, shall be taken as the sum of the dead loads and the seismic live loads between the mid-heights of adjacent storeys.

The seismic live load shall be taken as a percentage of the design live load as given in Table 6.1.

Design Live Load	Percentage of Design Live Load
Up to 3 kPa	25
Above 3 kPa and for vehicle garages	50
For Roofs	NIL

Table 6.1

The seismic weight for roofs shall include allowance for ice if appropriate.

7 Periods of Vibration

7.1 The periods of vibration, T_i, shall be established from properly substantiated data, or computation, or both.

7.2 Where the Seismic Coefficient Method is used, the fundamental translation period in the direction under consideration, T_i, shall be determined from :

$$T_i = 2\pi \sqrt{\Sigma W_i d_i^2 / g \Sigma F_i d_i} \qquad 7.1$$

where d_i may be calculated ignoring the effects of torsion.

7.3 For the purposes of initial member sizing, the following approximate formulae for T_i may be used :

(a) For framed structures with no rigid elements limiting the deflection :

$$T_1 = 0.085\, H^{3/4} \text{ for steel frames} \qquad 7.2$$

$$T_1 = 0.06\, H^{3/4} \text{ for concrete frames} \qquad 7.3$$

(b) For other structures :

$$T_1 = \frac{0.09\, H}{\sqrt{D'}} \qquad 7.4$$

If T_1 calculated using these equations is greater than 120 percent of that finally calculated using Equation 7.1, the seismic forces shall be re-assessed.

8 Seismic Design Actions

8.1 Design Spectra and Lateral Force Coefficients

8.1.1 Design Horizontal Seismic Coefficient for the Seismic Coefficient Method

The design horizontal seismic force coefficient, C_d shall be taken as :

$$C_d = CZIK \qquad 8.1$$

Where C is the basic seismic coefficient for the fundamental translational period in the direction under consideration.

8.1.2 Design Spectrum for the Modal Response Spectrum Method

The design spectrum, $C_d\,(T_i)$, shall be taken as :

$$C_d\,(T_i) = C\,(T_i)\,ZIK \qquad 8.2$$

Where $C\,(T_i)$ is the ordinate of the basic response spectrum for translational period, T_i.

8.1.3 Basic Seismic Coefficient

The basic seismic coefficient, C, shall be determined from Figure 8.1 for the appropriate site subsoil category using the fundamental structural period determined in accordance with **7.2** for the direction under consideration.

8.1.4 Basic Response Spectrum

The basic spectrum, $C(T_i)$, shall be determined from Figure 8.1 for the appropriate site subsoil category, and period, T_i.

8.1.5 Site Subsoil Category

The site shall be classified into one of the following site subsoil categories :

Type I Rock or Stiff Soil Sites.

Sites with bedrock, including weathered rock with an unconfined compression strength greater than 500 kPa, overlain by less than 20 m of :

(a) very stiff cohesive material with an unconfined compression strength greater than 100 kPa, or

(b) very dense cohesionless material with $N > 30$, where N is the standard penetration (SPT) value.

Such sites will typically have a low amplitude natural period of less than 0.2 s.

Type II Medium Soil Sites

Sites not described as either Type I or Type III

Type III Soft Soil Sites

Sites where the depth of soil of a particular type exceeds the following values :

a) Cohesive Soils

Cohesive Soil Classification	Representative undrained shear strength (kPa)	Minimum Depth of Soil (m)
Soft	12.5 - 25	20
Firm	25 - 50	25
Stiff	50 - 100	40
Very Stiff	100 - 200	60

contd.../

b) Cohesionless Soils

Cohesionless Soils Classification	Representative SPT values (N)	Minimum Depth of Soil (m)
Loose	4 - 10	40
Medium Dense	10 - 30	45
Dense	30 - 50	55
Very Dense	> 50	60
Gravels	> 30	100

Such sites will typically have a low amplitude natural period greater than 0.6 s.

8.1.6 Seismic Zoning Factor

The seismic zoning factor, Z, shall be obtained from Figure 8.2 for the appropriate location.

8.1.7 Importance Factor

The importance factor, I, for the structure shall be obtained from Table 8.1.

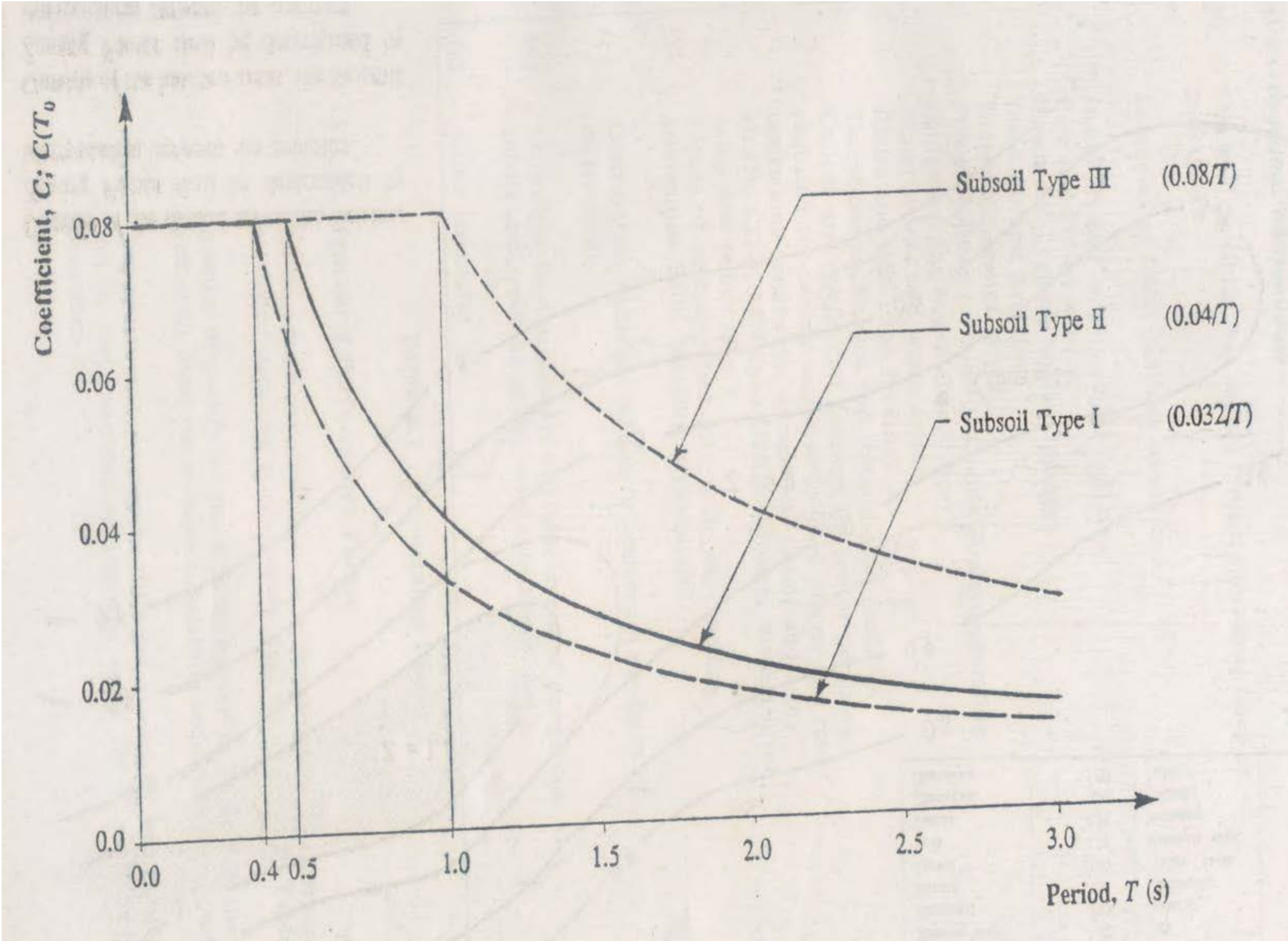
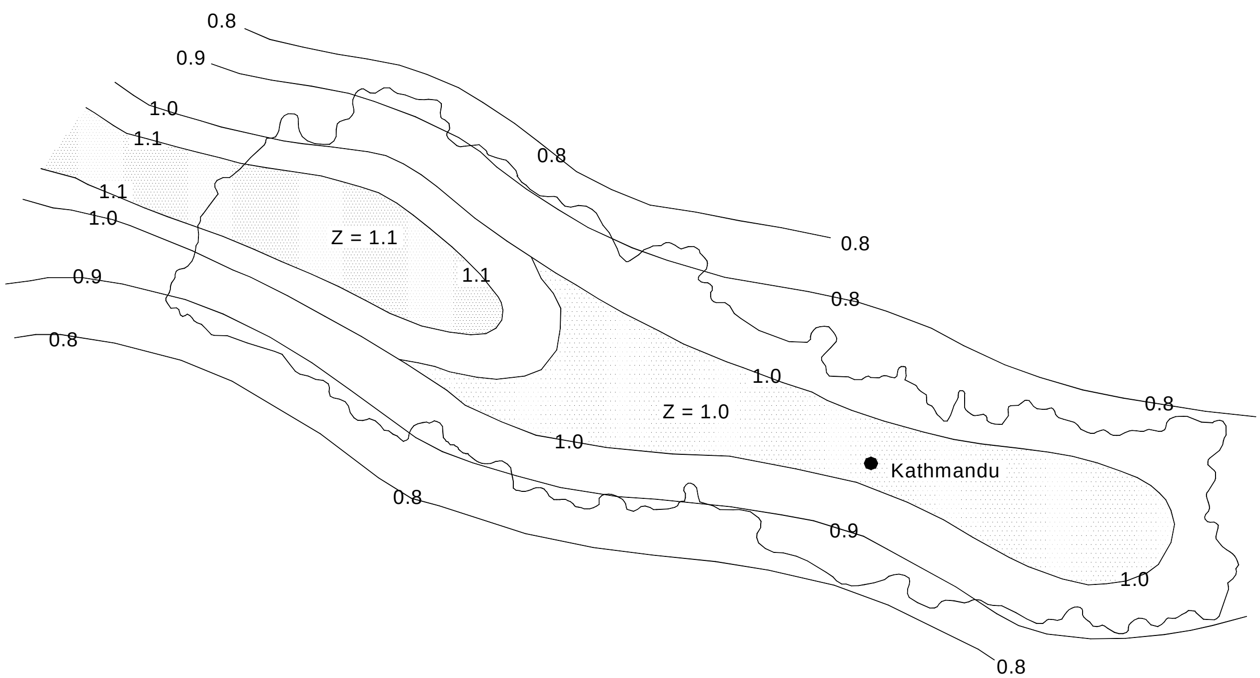


Figure 8.1 : BASIC SEISMIC COEFFICIENT, C
BASIC RESPONSE SPECTRUM, $C(T_I)$

ZONE FACTORS FOR SELECTED MUNICIPALITIES			
MANICIPALITY	FACTOR.Z	MUNICIPALITY	FACTCR.Z
Shadrapur	0.93	Dharan	1.00
Bharatpur	0.99	Dipayal	1.10
Bidur	1.00	Gaur	0.82
Birendra Nagar	1.02	Ilam	0.97
Biratnagar	0.93	Janakpur	0.89
Birganj	0.85	Kathmandu	
Butwal	0.90	Valley Towns	1.00
Byas	1.00	Mahendra Nagar	0.91
Damak	0.96	Nepalganj	0.91
Dhanagadi	0.90	Pokhara	1.00
Dhanakuta	1.00	Tulsipur	1.00



Outside of the shaded areas. the Seismic Zoning Factor shall be determined by interpolation between the contours.

Outside of the hatched areas, the Seismic Zoning Factor shall be determined by interpolation between the contours.

Figure 8.2 : SEISMIC ZONING FACTOR, *Z*

	Type of Building	Importance Factor *I*
(a)	Monumental Buildings	1.5
(b)	Essential facilities that should remain functional after an earthquake Examples of these facilities would be : Hospitals and other medical facilities Fire and Police stations Emergency vehicle shelters/garages Food storage structures Emergency relief stores Power stations (including standby power-generating equipment for essential facilities) Water works and water towers Radio and television facilities Telephone exchanges and transmission facilities Offices and residential quarters for senior personnel required for central and district-level rescue and relief operations (ministers, secretaries, police and army chiefs; CDO, LDO and DDC chairmen, district-level army and police chiefs Places of assembly (schools, colleges, cinemas, convention halls, temples, dharmsalas).	1.5
(c)	Distribution facilities for gas or petroleum products in urban areas.	2.0
(d)	Structures for the support or containment of dangerous substances (such as acids, toxic substances, etc.).	2.0
(e)	Other structures	1.0

Table 0.1 : Importance Factor *I*

8.1.8 Structural Performance Factor

The minimum permissible value of the structural performance factor, *K*, and associated detailing requirements shall be as given in Table 8.2.

In order to qualify for the *K* factors given in Table 8.2, the chosen structural type shall meet the minimum detailing requirements shown.

The structural type may be different in each of two directions in a building and in that case the appropriate value for *K* shall be selected for each direction.

When more than one structural type is used in the structure, for the direction under consideration, the structural performance factor for the element providing the majority of the seismic load resistance shall be applied provided that the elements of the other structural types have the ability to accept the resulting deformations.

Item	Structural Type	Minimum Detailing Requirements	Structural Performance Factor *K*
1.(a)	Ductile moment-resisting frame	Must comply with the detailing for ductility requirements.	1.0
(b)	Frame as in 1(a) with reinforced concrete shear walls	For frames : as for 1(a). Reinforced concrete shear walls must comply with appropriate[3] detailing for ductility requirements.	1.0[1]
2.(a)	Frame as in 1(a) with either steel bracing members detailed for ductility or reinforced concrete infill panels	For frames : as for 1(a). Steel bracing members must comply with the detailing for ductility requirements NBC 111-94. Reinforced concrete infill panels must comply with the detailing requirements of NBC 109-94.	1.5[1,2]
(b)	Frame as in 1(a) with masonry infills	Must comply with the detailing for ductility requirements.	2.0[1,2]
3.	Diagonally-braced steel frame with ductile bracing acting in tension only	Must comply with the detailing for ductility requirements of Nepal Steel Construction Standard	2.0
4.	Cable-stayed chimneys	Appropriate materials Standard	3.0
5.	Structures of minimal ductility including reinforced concrete frames not covered by 1 or 2 above, and masonry bearing wall structures.	Appropriate materials Standard	4.0

cont..../

Table 0.2 :
Structural Performance Factor *K* and other Design Requirements for Horizontal Load-Resisting Systems of Buildings and other Structures

Table 8.2 continued

NOTES :

1. *These factors shall apply only if the steel bracing members, the shear walls and/or the infill panels are taken into consideration in both the stiffness and lateral strength calculations.*

2. *These factors shall apply only if the frame acting alone is capable of resisting at least 25 percent of the design seismic forces.*

8.2 Direction of Forces and Design Eccentricity

8.2.1 Direction of Forces

For structures with seismic resisting systems located along two perpendicular directions, the specified forces may be assumed to act separately along each of these two horizontal directions. For other buildings, different directions of application of the specified forces shall be considered so as to produce the most unfavourable effect in any structural element.

8.2.2 Design Eccentricity

The design eccentricity, e_d , shall be determined as follows :

(a) If e_c is less than 0.1 b and the building is 4 storeys or less in height :

e_d may be taken as equal to 0

(b) If e_c is less than 0.3 b and **8.2.2(a)** does not apply;

$$e_d = e_c + 0.1\,b \quad \text{or} \quad e_d = e_c - 0.1\,b \qquad 8.3$$

whichever is the most severe for the element under consideration.

(c) If e_c is greater than 0.3 b, the structure should be analyzed using a three-dimensional modal response spectrum analysis with the mass at each level displaced by ± 0.1 b, whichever is the most severe for the element under consideration.

8.3 Vertical Seismic Forces

The effect of the vertical components of seismic motion need not be considered in design of a structure except as specified in **12**. Where consideration of vertical seismic forces is required, the design vertical seismic coefficient shall be taken as one half of the horizontal seismic coefficient given in **8.1.1**.

9 Deformation Due to Earthquake Forces

9.1 Derivation of Design Lateral Deformations

The design lateral deformations shall be taken as the deformations resulting from the application of the forces or design spectrum as specified in **10** or **11** respectively, multiplied by the factor $5/K$.

9.2 Building Separations

9.2.1 To Boundaries

Above ground level, each building of greater than three storeys shall have a separation from the boundary, except adjacent to a designed street or public way, of not less than the design lateral deflection determined in accordance with **9.1** or 0.002 h_i or 25 mm which ever is the greater.

9.2.2 Within Site

Parts of buildings or buildings on the same site which are not designed to act as an integral unit shall be separated from each other by a distance of not less than the sum of the design lateral deflections determined in accordance with **9.1** or 0.004 h_i or 50 mm which ever is the greater.

9.2.3 Separation Space Width

Separation spaces shall be detailed and constructed to remain clear of debris and other obstructions. The width of such spaces shall allow for all constructional tolerances.

9.3 Inter-Storey Deflections

The ratio of the inter-storey deflection to the corresponding storey height shall not exceed 0.010 nor shall the inter-storey deflection exceed 60 mm (refer also to **12.6.2**).

10 Seismic Coefficient Method

10.1 Horizontal Seismic Base Shear

10.1.1 The horizontal seismic shear force acting at the base of the structure, in the direction being considered, shall be :

$$V = C_d\, W_t \qquad 10.1$$

where C_d is as defined in **8.1.1**.

10.2 Horizontal Seismic Forces

10.2.1 The horizontal seismic force at each level i shall be taken as :

$$F_i = V\, W_i\, h_i \,/\, \Sigma\, W_i\, h_i \qquad 10.2$$

Provided that :

(a) Where the height to width ratio of the horizontal load resisting system is equal to or greater than 3, then 0.1 V shall be considered as concentrated at the top storey and the remaining 0.9 V shall be distributed in accordance with the equation above.

(b) For chimneys and smoke-stacks resting on the ground, 0.2 V shall be considered as concentrated at the top and the remaining 0.8 V shall be distributed in accordance with the equation above.

(c) For elevated tanks, the force F_i is equal to V and acts through the centre of gravity of the total weight of the structure and contents.

10.2.2 The set of equivalent static forces specified in this clause shall be assumed to act simultaneously at each level in the direction being considered and shall be applied through points eccentric to the centre of rigidity as specified in **8.2.2**.

11 Modal Response Spectrum Method

11.1 Design Spectrum

The design spectrum used for the Modal Response Spectrum Method shall as given in **8.1.2**.

The relative response of each contributing mode i shall be determined by multiplying the mode response by the value of $C(T_i)$ from **8.1.2**.

11.2 Number of Modes to be Considered

A sufficient number of modes shall be considered to ensure that at least 90 % of the mass is participating in the direction under consideration.

11.3 Combination of Modal Effects

11.3.1 An established method shall be used for the combination of modal effects.

11.3.2 The combination method shall take into account the effect of closely spaced modes. Modes shall be considered to be closely spaced if their frequencies are within 15 %.

11.3.3 The combined modal effects shall be scaled by the modal combination factor, *S*, where :

$$S = \frac{0.9\, C_d\, W_t}{\Sigma \text{ combined modal base shears in the direction under consideration}} \qquad 11.1$$

provided that *S* shall not be taken as less than 1.0.

11.4 Torsion

11.4.1 General

An analysis for torsional effects may be conducted by the static method in **11.4.2**.

For structures where e_c is greater than 0.3 *b*, torsional effects should evaluated using three-dimensional analysis and the provisions of **11.4.3.**

11.4.2 Static Analysis for Torsional Effects

For a static analysis for torsional effects, the applied torsion at each level shall use either the forces calculated by the Seismic Coefficient Method or the combined storey inertial forces found in a translational two-dimensional modal response spectrum analysis, and a design eccentricity, e_d calculated in accordance with **8.2.2**.

Torsional effects shall be combined with the translational effects by direct summation, with signs chosen to produce the most adverse combined effects in the element under consideration.

11.4.3 Three-Dimensional Analysis

For each direction of loading the position and distribution of the mass at each level shall be adjusted to account for an eccentricity about the centre of mass of $\pm$ 0.1 *b*. The sign of the eccentricity shall be that producing the largest design actions in the element under consideration.

12 Seismic Design Requirements for Secondary Structural Elements, Architectural Finishes and Mechanical and Electrical Equipment

12.1 General

All architectural elements and mechanical and electrical systems shall meet the requirements of **12** as these may be a safety hazard in the event of an earthquake or may be required to be functional immediately following such an event.

Contents of museums and similar items of historical or artistic value that are non-functional items should be restrained against seismic loads. Specialist advice should be obtained for detailing such restraints.

12.2 Connections

All elements, components or equipment shall be positively connected to the structure to resist the specified seismic loads. Friction due to gravity shall not be used to provide the required resistance to horizontal loads.

Connections to ornamentations, veneers, appendages and exterior panels including anchor bolts, shall be corrosion-resisting and ductile, with adequate anchorages. In the case of precast concrete panels, anchorages shall be attached to, or hooked around, panel reinforcing.

12.3 Separation from Structural System

Interaction with the structural system shall be avoided where specified in **12.6.1** by providing adequate separations as defined in **12.6.2**.

12.4 Services Cut-Offs

If continued operation of a facility during strong seismic motions presents an excessive risk, an automatic shut-off system, which will operate at a pre-determined ground acceleration, not exceeding 0.2 g, shall be provided. In such cases, all equipment required for safe shut-down shall be capable of resisting the shut-off level irrespective of other requirements of this Section.

12.5 Design Forces

All elements and components shall be designed for a seismic force F_p, in any direction given by :

$$F_p = C_p \, P \, K_p \, W_p \qquad 12.1$$

For elements supported by the structure, C_p is equal to C_d for the structure determined in accordance with **8.1.1** or **8.3** as appropriate.

For elements supported on the ground and independent of the structure, C_p is equal to C_d determined in accordance **8.1.1** using the element fundamental period.

12.5.1 Structure Response Factor

The structural response factor, P, reflects the distribution and amplification of the ground motion by the structure supporting the particular component and shall be taken as :

$$P = 1.0 + h_i \, / \, H \qquad 12.2$$

P shall be taken as 1.0 for structures supported directly on the ground.

The P factor for more important elements of the structure should be calculated from a more detailed analysis using the Modal Response Spectrum Method.

12.5.2 Component Seismic Performance Factor

The component seismic performance factor, K_p is an allowance for both the estimated performance of the element or component and the importance of its performance during and immediately following an earthquake. The value of K_p shall be obtained from Table **12.1**.

If the period of vibration of an element is close to that of the structure, considerable amplification may occur. If the ratio of the period of the structure to that of the element is between 0.6 and 1.4, the value of K_p shall be multiplied by 2 unless a special analysis is carried out.

ELEMENT OR COMPONENT	K_p
GROUP A	
Secondary Elements or Components :	
1. Walls and Partitions	
(a) Adjacent to an exit way, street or public place or required to have a fire resistance rating.	4
(b) Cantilevered walls and parapets.	4
(c) All walls not specified in 1(a), 1(b) or 2.	2.5
2. Stairs and their enclosing shaft walls, and shaft walls for lifts.	4
3. Veneers, exterior prefabricated panels and ornamental appendages, and their connections.	8
4. Ceilings with tiles exceeding 2 kg in weight (Refer Note 5). (a) In an exit way or a ceiling required to have a fire rating.	3
(b) Other ceilings not included in 4(a).	2
5. Furniture	
In an exit way or furniture that would pose a safety hazard when subject to earthquake loads.	2
6. Towers, chimneys or smoke stacks not exceeding 10 % of the mass of the building (Refer Note 3).	2.5
7. Penthouse or plant room structures on the top of a structure.	2.5
8. Horizontally cantilevered floors, beams, sunshades, etc. Note : The force acts vertically upward or downward.	5

(continued on next page)

Table 12.1 : Component Seismic Performance Coefficient

ELEMENT OR COMPONENT	K_p
GROUP B	
Mechanical and Electrical Components :	
9. Boilers, furnaces, incinerators, water heaters or other equipment using combustible or high temperature energy sources. Pressure vessels. (Refer Note 1).	6
10. Containers and their supporting structures for (Refer Note 1) :	
(a) Toxic liquids and gases, spirits, acids, alkalis, molten metals or ıch dangerous materials.	6
(b) Fire sprinkler systems including wet and dry risers	6
(c) Other	4
11. Switchgear, transformers, substations, electrical motor control devices.	6
12. Lighting fixtures :	
(a) Rigidly mounted	2.5
(b) Hanging or swinging type fixtures. (Refer Note 2)	3.5
13. Duct and piping distribution systems (Refer Note 1) :	
(a) Rigidly mounted - (i) for toxic or dangerous substances	6
(ii) other	3
(b) Flexible supports - (i) for toxic or dangerous substances	8
(ii) other	5
14. Shelving for batteries and dangerous goods (Refer Note 4).	4
15. Lift machinery, guides, etc.	3
16. Emergency standby equipment required to function immediately after an earthquake.	6

(continued on next page)

Table 12.1 continued

Table 12.1 continued

NOTES :

1. *The seismic weight of containers and the like shall include the weight of the contents.*

2. *Hanging or swinging lights shall have a safety cable attached to the structure and the fixture, capable of supporting a lateral load equal to four times the weight.*

3. *Where towers, chimneys or smoke stacks exceed 10 % of the weight of the structure, the structure shall be analyzed considering these elements.*

4. *Shelving in Item 14 shall provide positive restraint to horizontal movement of the contents.*

5. *Suspended Ceilings :*

   Suspended ceilings with tiles weighing more than 2 kg shall satisfy the following requirements :

   (a) The support systems for suspended ceilings shall be designed and constructed so as the avoid sudden or incremental failure or excessive deformations that would release ceiling components.

   (b) Ceiling elements and lighting fixtures or other heavy fittings built into the ceiling, shall be positively anchored to their supports against a net upward force equal to one-third their weight.

   (c) The ceiling shall be designed for the horizontal loads in Item 4 with the support members positively connected to each other and to the building or other horizontal restraint.

   Ceilings in important areas (such as hospital operating rooms) where loss of ceiling units cannot be tolerated, should be fixed rigidly and directly to the structure.

   Ceilings with tiles weighing less than 2 kg need not be designed to these requirements.

12.6 Separation of Elements

12.6.1 Applicable Elements

The requirements of **12.6.2** for the separation of elements shall apply to the following :

(a) Elements such as stairways, rigid partitions, and non-structural masonry walls of part or full height.

(b) Flexible partitions not capable of altering the intended structural behaviour but required to have a fire resistance rating, provided that this need not apply when it can be shown that the partition retains its fire resistance after being subjected to the specified deformation.

(c) Precast concrete cladding and other cladding of similar mass.

(d) Glass windows and other rigid, brittle, exterior cladding.

Elements which can accept inter-storey deflections of four times those calculated in accordance with **9** without being damaged and without affecting the structure need not comply with the separation requirements of **12.6.2**.

12.6.2 Separation Requirements

Requirements for the separation from the structure of elements listed in **12.6.2** shall be as follows :

(a) Ratio of inter-storey deflection to storey height not exceeding 0.0012 : No requirements for separation.

(b) Ratios of inter-storey deflection to storey height exceeding 0.0012 but not greater than 0.015 or 60 mm : Elements shall be positively separated from the structure so as to allow the structure to deform as calculated in accordance with **9** without the elements coming into contact with the structure or with adjacent elements. A minimum separation of 10 mm shall be maintained between the structure and the vertical surfaces of the element. Construction tolerances shall not reduce the required separations.

13 Structural Variations to be Approved by Designer

The structural designer shall make the builder or contractor aware of the dangers that can arise when structural elements or details are changed or varied without the specific approval of the structural engineer. Any variations approved by the designer shall comply with the requirements of this Standard.

N E P A L   N A T I O N A L   B U I L D I N G   C O D E

NBC 106 : 1994

SNOW LOAD

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
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SNOW LOAD

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

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

Government of Nepal
Ministry of Physical Planning and Works
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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.

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Mr. AS Arya, Professor Emeritus, University of Rookee

Revisions and Updated to this code came from :

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0 Foreword

This Nepal Standard on "Snow Load" comprises the Indian Standard IS: 875 (Part 4) 1987 : CODE OF PRACTICE FOR DESIGN LOADS (OTHER THAN EARTHQUAKE) FOR BUILDINGS AND STRUCTURES (Second Revision) with amendments as set out herein.

These amendments have been necessary to ensure the requirements of Nepalese context.

1. Scope

NEPAL AMENDMENTS TO IS: 874 (Part 4) –1987

0 Foreword

Delete **0.1** to **0.3.2** inclusively and replace with:

Most of the mountainous districts of Nepal experience snowfall two to three times a year. The districts that experience snowfall are Darchula, Bajhang, Humla, Mugu, Jumla, Dolpa, Rukum, Mustang, Manang, Gorkha, Rasuwa, Sindhupalchok, Dolakha, Solukhumbu, Sankhuwasabha and Taplejung. The depth of snow that occurs in these places is variable.

The country can broadly be divided into five categories based on the physiographic regions. Of these five physiographic regions, the Terai, the Siwaliks and the Middle Mountains do not experience snowfall. The region falling in the high mountains, however, gets snow during two or three months of a year. The High Himalayas always have snow cover throughout the year. Figure 1.1 shows the regions of the country and the likelihood that each will experience snow.

During a study to produce an inventory of current building practices (as part of the National Building Code Development Project), the teams gathered information pertaining to historic experiences of snowfall in the locality of surveyed buildings. Based on owner's responses, a ground snow load of about 1.2 m. was estimated for Jomsom. Jomsom is located at an elevation of about 2800 m. above mean sea level in the High Himalayas region.

At high altitudes and adjoining areas, flat roofs are built with mud placed over timber planks or split pieces of wood. A slope is not provided because the wind speed is high and the rainfall is sparse. According to the local people, on roofs with only a mild slope the mud even gets eroded by rainfall of only moderate intensity. Only a nominal slope that is just enough to drain the melted snow and rain water is provided. Snow accumulates on the roof and the narrow space between the adjacent buildings is also filled. Snow accumulated on the roof is removed manually.

Historical snow data in Nepal does not exist and is only recently being recorded. The Snow and Glacier Hydrology Project has started to collect data in the higher regions. Depth, density and water equivalent are monitored. Readings are becoming available from the Langtang and some other regions of the country with glaciers. Stations close to human settlements do not exist.

The project dispatches teams to the stations in February. The team spends one week collecting the identified parameters. Typical information obtained from the project is given in Table 1. The snow depth obtained from the project, however, is far less than that obtained from verbal inquiry. For this reason, the concerned personnel and the institutions are being requested to collect information from in-depth studies and inquiries of the knowledgeable people of the locality and to make this information available for snow load derivation.

In many parts of the snow-prone region, buildings using foreign materials (e.g., glass and cement pointing of the front walls) are being built. However, no roofs are constructed of corrugated iron sheet. Rice and wheat straw are not available and hence thatched roofs are totally absent. No other alternative materials for roofing can be obtained in these regions because the land in this area consists mainly of sand mounds where vegetation growth is virtually nil. Human settlement in these regions is concentrated mainly on the river banks which are shifting downwards because the stream bed consists of a sand bed which is sharply cut by the water currents.

0.4 1st line, *delete* "part" and *substitute* with "Code".

1. 1st line, *delete* "part 4".

4th line, *delete* "in part 2 Imposed load".

Note, *delete* inclusively.

3. Note, delete all except the last sentence.

4.

4.21 *Replace* $0^{o} < ß <= 30^{o}$ with $0^{o} < ß < 15^{o}$, and
Replace $0^{o} < ß <= 30^{o}$ with $15^{o} < ß < 30^{o}$

6. *Add* new clause :

6.1 Minimum Slope for Roof

6.1.1 For efficient removal of the snow, the minimum slope for a roof should be in the ratio of 2:1 (V: H). Higher sloped roofs become better for snow. However, the case is the reverse for wind. The most favorable slope for both wind and snow is therefore about 2:1.

6.1.2 It is ironic that the areas which experience snowfall have flat roofs and the other areas, which do not experience snow have sloped ones. The probable reasons for providing a flat roof are the unavailability of suitable indigenous materials for a sloped one and the possibility of the wind blowing away the roof. Imported corrugated iron sheet is possibly the only realistic alternative. However, the intensity of wind and the economy of construction should be though of before a change to sloped roofs is suggested for traditional buildings.

6.1.3 The snow and Glacial Hydrology Project dispatches teams to the stations each February.The team spends one week collecting the identified parameters. The information obtained from the project is given in Table 1.

TABLE 1 : SUMMARY OF SNOW DEPTH/DENSITY IN LANGTANG AREA

Date	Location	Elevation (m)	Slope	Mean Depth of Snow (cm)	StandardDeviation of Snow	Number of Observeations	Density (gm/cm3)	Water Equivalent (mm)	Remarks
24/25-II-91	Tsergoti to Yala Peak	5000 to 4920	Varies	33.0	46.2	145	0.320	107.0	Density quite variable
26-II-91	Kyanging base camp	3900	SW	16.6	1.3	14	0.069	11.5	Just able to snow fall
27-II-91	Plateau # 1 near gauging	3700	W	16.9	2.5	15	0.11	19.0	Just after snow fall
27-II-91	Plateau # 2 near gauging	3760	W	15.4	0.8	10	0.134	21.0	One hour after snow strong sunshine
27-II-91	Plateau # 3 near gauging	3820		15.7	1.5	10	0.126	20	Two hours after snow
27-II-91	Bottom of trail to Nayang Khola	3880	N	34.3	3.5	15	0.123	42	Forest area, rough, shape, old snow, depth hoar frost present
27-II-91	Kyanging base house	3900	SW	19.2	3.0	57	0.11	20	Estimated from plateau # 1 just after snow fall
27-II-91	Kyanging base house	3900	SW	16.7	3.3	12	0.11	18.5	Sub set of above snow depth

Source : Snow and Glacier Hydrology Project

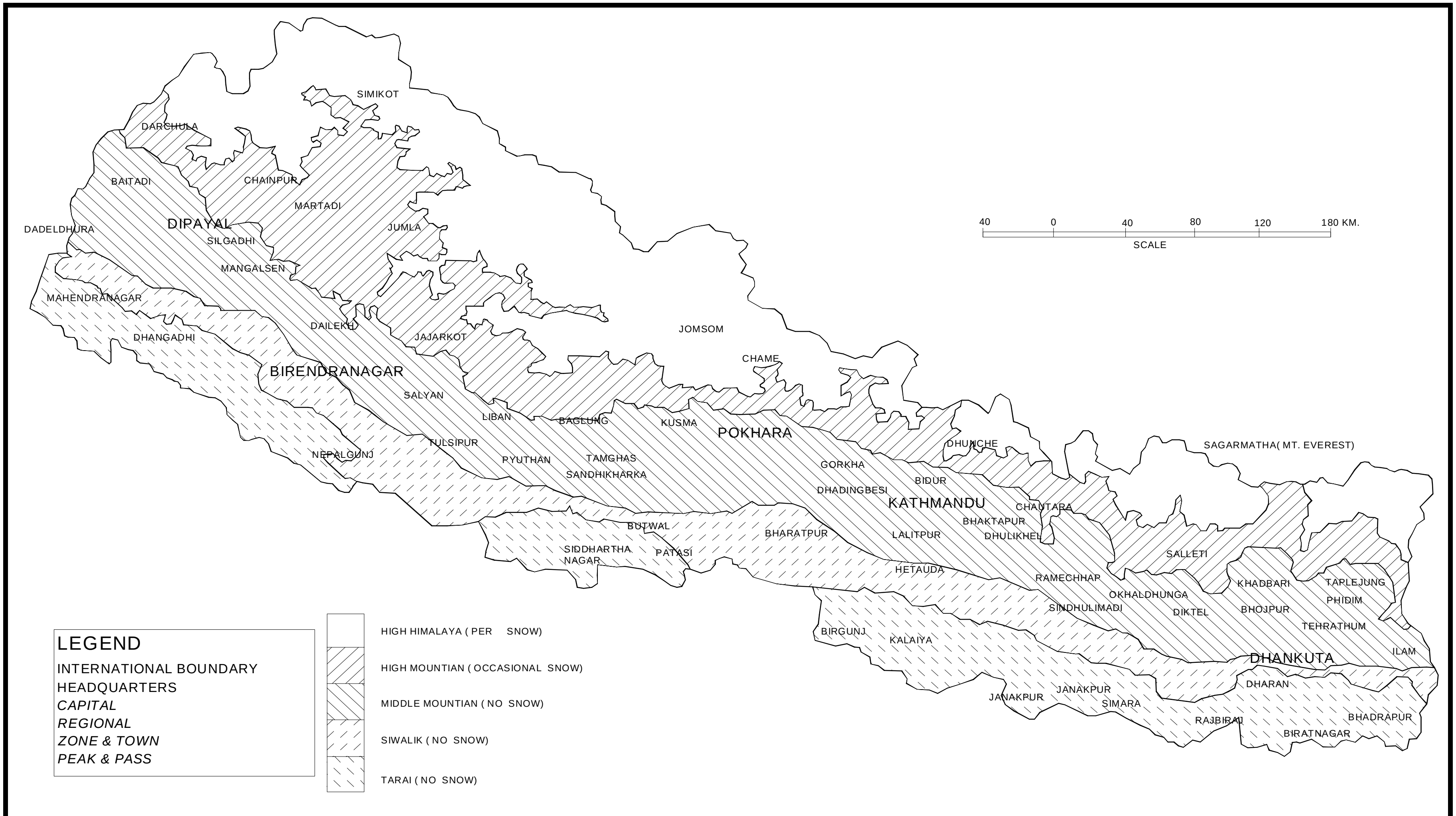

Figure 1.1 PHYSIOGRAPHIC REGION SHOWING SNOWFALL AREA

N E P A L   N A T I O N A L   B U I L D I N G   C O D E

NBC 107 : 1994

PROVISIONAL RECOMMENDATION ON FIRE SAFETY

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
Reprinted : 2064

NEPAL NATIONAL BUILDING CODE

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

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0. Foreword

0.1 This Standard covers the basic requirements for fire safety in the design of ordinary **buildings**.

0.2 This Standard, with due consideration to the severe limitations on the issue of fire protection in Nepali conditions, takes a modest approach. It deals only with the minimum requirements of exits from and access to ordinary residential buildings from the fire safety point of view. **Designers are encouraged, wherever possible, to incorporate higher levels of fire safety in their designs by following other relevant reference, Standards or Codes.**

1 Scope

1.1 This Standard provides fundamental requirements for fire safety in ordinary buildings. These requirements do not necessarily cover the fire safety provisions needed for other buildings. For the design of such other buildings, other relevant Codes and Standards which might be followed have been suggested.

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 Commentary clauses are prefaced by the letter C and the number of the appropriate clause subject to comment.

2.1.3 Words implying the singular also include the plural and vice-versa where the context requires it.

2.2 Terminology

For the purpose of this Standard, the following definitions shall apply, unless inconsistent with the context :

IMPORTANT BUILDINGS means those buildings which either house facilities essential before and after disaster (eg, hospitals, fire and police stations, communication centres, etc), or which by their very purpose have to house several persons at one time (eg, cinema halls, schools, convention centres, etc), or will have national and international importance (eg, palaces, etc), or which house hazardous facilities (eg, toxic or explosive facilities, etc).

ORDINARY BUILDINGS are the buildings, which do not come under the category of important buildings. They include commercial and office buildings.

3 Types of Construction and Appliances

3.1 Fire Places

All buildings having a kitchen should be provided **with a fireplace and a chimney** in order to reduce the possibilities of the occurrence of accidental fire. Open hearths should be discouraged and eliminated wherever possible. Timber construction should not be placed near the fire place, nor should it remain exposed in the vicinity of fire. Such surfaces should remain encased by plaster, whether of mud or other binders, suitable for the purpose.

3.2 Fire Extinguishers

Occupants are encouraged to install appropriate portable fire extinguishers in their building.

Where open hearth or kerosene stoves are used for cooking, sufficient water should be stored in containers for emergency use in case of fire.

4 Fire Zones

In urban areas, the demarcation of fire zones should be carried out in consultation with the relevant municipal authority as and when deemed necessary.

These shall conform to the requirements specified by the Department of Urban Development and Building Construction or any other agency responsible for developing and demarcating such fire zones.

5 General Requirements

All buildings shall be designed in such a way that they can contribute to the containment of a fire and thus reduce its spread to other buildings.

5.1 Provision of a Proper Access

Every building should have an access as defined by Architectural Design Requirements (NBC 206) and should be wide enouth to enable the fireman to easily approach to the building site.

5.2 Provision of Wide Doors

The entry door shall be as defined by Architectural Design Requirements (NBC 206) and should be sufficiently wide and tall so that easy access in available to the fire man.

5.3 Provision of Fire Escape Ways

All buildings should have sufficient ways as defined by Architectural Design Requirements (NBC 206) so as to allow the rapid evacuation of all occupants in the event of fire, if any. In addition to the main entrance, the side and/or rear entrance shall be incorporated in the design.

The set back and/ or open space shall conform to the planning and building by-laws adopted by the concerned and authorized territorial authority.

5.4 Provision of Open Space

The front entrance should have enough open space as defined by Architectural Design Requirements (NBC 206) so that a number of people can gather and contribute in extinguishing the fire, if any.

6 Exit Requirements

6.1 General Requirements

An exit normally shall consist of either a doorway, corridor or passageway to an internal staircase, to an external staircase, to a verandah leading to the street, to the roof of a building, or to the street. The exit may also lead to another building in the neighbourhood. The exit should :

a) be able to allow the evacuation of all the occupants in a relatively short time;

b) meet the minimum requirements as to size;

c) be free of any obstructions and shall not provide any resistance to movement;

d) be clearly visible, preferably with proper signs;

e) be continuous and shall not intrude into private space.

6.2 Number of Exits

6.2.1 Stairs

The number of stairs in any building, especially when it exceeds 500 square metres in plinth area, shall be a minimum of two, one internal and the other an external fire escape. Additional stairs shall be provided in proportion to any increase in the plinth area.

In the case of residential buildings, the minimum width of the stairs shall be 90 cm. For other buildings, the minimum width shall be 1.5 m. The distance from any point in a passageway to a staircase in a building shall not exceed 20 metres.

6.2.2 Fire Escapes

Every building more than five storeys high shall have a separate fire escape having a minimum width of 75 cm. The fire escape shall have a minimum tread width of 20 cm and each riser shall be not more than 19 cm high. The number of risers per flight shall not be more than 15. Such a fire escape shall carry users towards an open space.

6.2.3 Exit Doors

Exit doors shall open to a passageway or to a corridor.

They should open outwards, but without restricting the movement of people passing outside the door.

The maximum distance of such an exit doorway from any point in a passage shall be 20 m.
The exit doorway shall neither be smaller than 90 cm in width, nor 180 cm in height.

7 Access to a Building

It shall comply with all applicable zoning requirements and by-laws of the local planning and building authority.

The access leading to a building should preferably be by a road at least four metres wide, and no such road should lead to a dead end. The road should not have such sharp or restricted turns that the passage of a fire engine is made difficult in the event of fire.

8 Lightning Arresters/Conductors

There have been many incidents in Nepal when lightning strikes have resulted in fire in buildings and a consequential loss of life and property. The need to install lightning arresters/conductors is therefore important.

A lightning arrester shall be located in the highest part of every building and it shall be connected by a conductor to an earth rod buried in the earth. The lightning arrester shall be so located that as much as possible of the building lies inside the surface of an imaginary cone having a vertex angle of 45 degrees and its apex at the top of the arrester.

9 Referances

- National Building Code of India 1983, Part IV, Bureau of Indian Standards, New Delhi.
- United Building Code (UBC), Part VII, Chapters 33 & 37, USA.
- MV Lisitsyan and EC Pronin, "Architectural Design for Dwelling Houses", Moscow, 1990 (available in Russian and English).

NEPAL NATIONAL BUILDING CODE

NBC 108 : 1994

SITE CONSIDERATION FOR SEISMIC HAZARDS

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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.

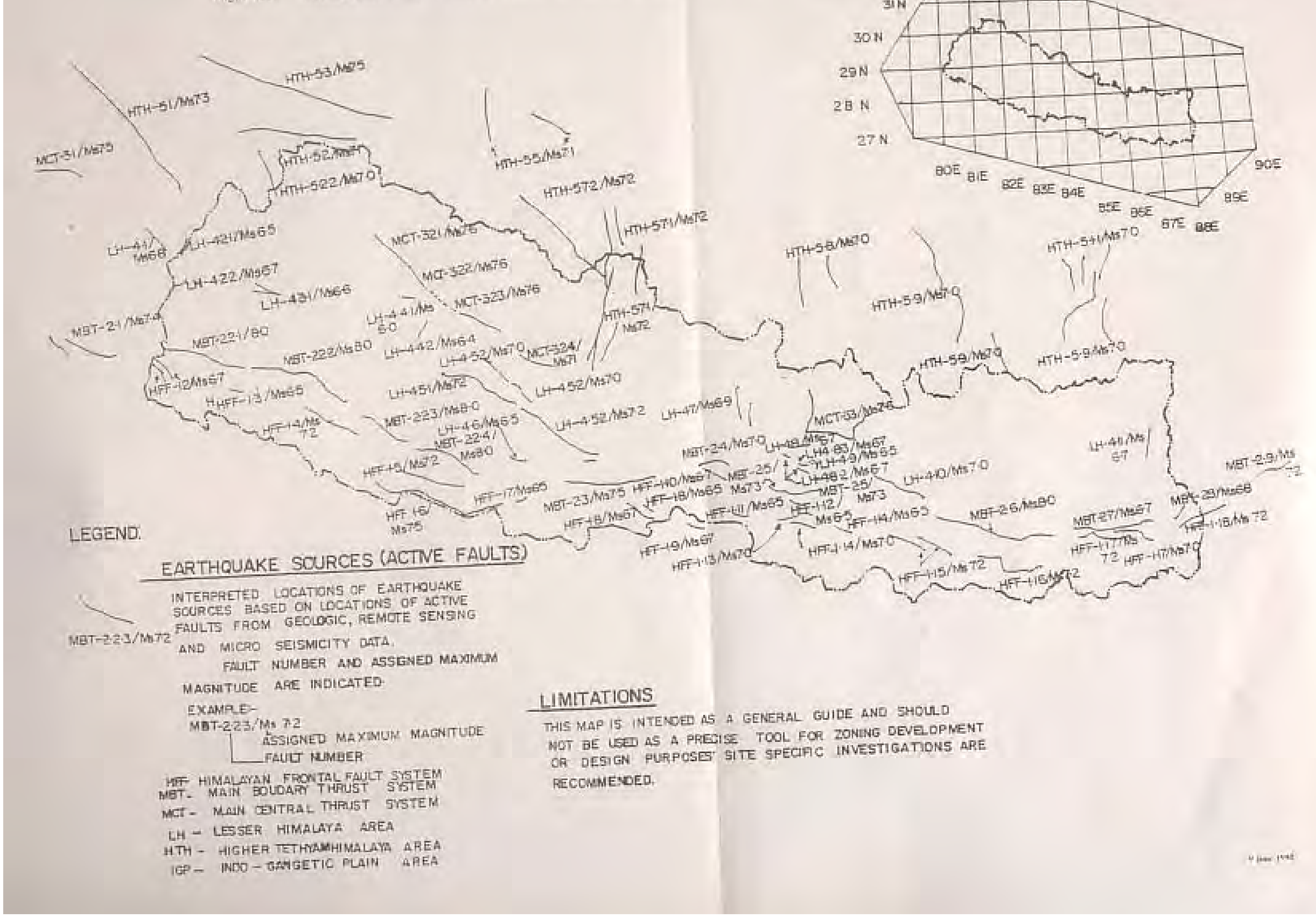


Figure 3.1 INTERPRETATED ACTIVE FAULTS OF NEPAL AND THE SURROUNDING REGION

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.

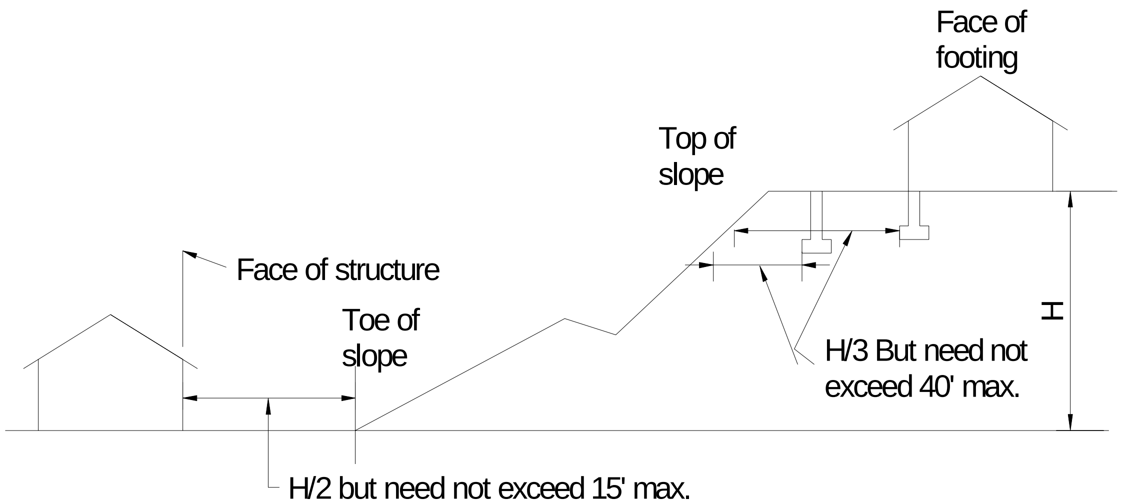
Clearly, areas that are susceptible to landslides from storm damage, river undercutting and quarrying are also susceptible to strong ground shaking from an earthquake.

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 eg 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

NEPAL NATIONAL BUILDING CODE

NBC 109 : 1994

MASONRY : UNREINFORCED

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
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Reprinted : 2064

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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

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

Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
Reprinted : 2064

Preface

This Nepal Standard was prepared during 1993 as part of a project to prepare a 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**

The Subcontractor was BECA WORLEY INTERNATIONAL CONSULTANTS LTD. of New Zealand in conjunction with subconsultants who included :

Golder Associates Ltd., Canada
SILT Consultants P. Ltd., Nepal
TAEC Consult (P.) Ltd., Nepal
Urban Regional Research, USA

Principal inputs to this standard came from :

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TABLE OF CONTENTS

0. Foreword

0.1 Design Aspect Covered

This Code of Practice covers the structural design aspect of unreinforced masonry elements in the buildings. It also deals with some aspect of earthquake-resistant design of buildings. References to seismic zoning, seismic coefficients, important factors, structural performance factors and performance coefficient are as per **NBC 105-94 Seismic Design of Buildings in Nepal**.

0.2 Related Codes

This Code should be read in conjunction with the Indian Standard **IS:1905-1987 Code of Practice for Structural Use of Unreinforced Masonry (Third Revision).**

1 Scope

1.1 Coverage

This is a Code of Practice for the Structural Design Aspects of Unreinforced Masonry Buildings in Nepal.

1.2 Limitation

The recommendations of this Code of Practice do not cover walls constructed in mud mortar and should not be used for such case.

1.3 Provisions for Historical Buildings

The provisions of this Code of Practice shall be construed as advisory when being applied to the repair, alternations or additions necessary for the conservation, preservation, restoration, rehabilitation, reconstruction or continued use of buildings of historical, architectural, cultural or archaeological significance.

2 Interpretation

2.1 General

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

2.2 Terminology

BEDDED AREA means the area of surface of a masonry unit which is in contact with mortar in the plane of joint.

CORBEL means one or more courses of brick projecting from a wall (such as a cornice), generally to form a support for wall plates, etc. A brick should not project more than one quarter of its length beyond the next lower course.

DEFINITIONS : The terminoloty given in Indian Standard **IS:1905-1987** in clauses 2.1 to 2.21.3 will apply, except as stated here below.

DIMENSION means the measured dimension of a designed item and, if used to describe masonry units, means the nominal dimension.

INFILL PANEL means a wall framed on four sides by columns and beams and contributing to shear resistance in the plane of the frame, but which is not designed to resist vertical loads other than its own weight.

LATERAL SUPPORT means a masonry structure support which enables a masonry element to resist lateral load and/or restrains the deflection of the masonry element at the point of support.

MASONRY means an arrangement of masonry units which may be brick, rectangularised stone, ashlar or cement blocks laid to a bond and joined together with mortar.

MASONRY UNIT means an individual unit which is bonded to similar units with the help of mortar to form a masonry element such as a wall, column, pier, buttress, etc., and conforming to the Nepal Standard **Brick Masonry NS: 1/2035**.

PANEL WALL means an exterior non load-bearing wall in framed construction wholly supported by beams and columns.

PARTITION WALL means an interior non load-bearing wall which is separated so as not to be part of the seismic resisting structure.

PARTY WALL means a wall built on land belonging to two adjoining owners, it being the joint property of both the owners.

SLENDERNESS RATIO means the ratio of effective height or effective length to the effective thickness which ever is less.

$$SR = \text{Slenderness Ratio}$$

$$= \frac{\text{Effective Height}}{\text{Effective Thickness}} \quad \text{or} \quad \frac{\text{Effective Length}}{\text{Effective Thickness}}$$

2.3 Symbols

The following letters, symbols and abbreviation are used for the purposes of this section and other symbols are specified at their respective places.

A Area of section

b Breadth of masonry unit or shorter dimension of a rectangular column

DL Dead load

E Modulus of elasticity

e Eccentricity

f_b Basic compressive stress

f_c Permissible compressive stress

f_d Compressive stress due to dead load

f_s	Permissible shear stress
K	Stiffness of member
k_a	Area factor
k_p	Shape modification factor
k_s	Stress reduction factor
LL	Live load
l	Axial load on a compression member
l_{ef}	Effective length or span
m	Modular ratio
W	Total load
WL	Wind load
w	Uniform distributed load
w_p	Breadth of crosswall, piers, or buttresses
Z	Modulus of section

3 Materials

3.1 Permissible Material

The materials used in masonry construction shall be in accordance with **NBC 101-94 Marerial Specifications** unless otherwise specified.

3.2 Masonry Unit

The specification and properties of the masonry shall conform to the Nepal Standard **Brick Masonry NS: 1/2035.** Its size is given below :

Dimensions of Nepal Standard Brick (mm)				
Length	Breadth	Height	Vertical Mortar Joint	Remark
240	115	57	10	For 10 mm mortar joint

Table 3.1 : Dimensions of a Nepal Standard Birck

Note : Length of Birck = 2 x Width of Birck + 1 Vertical Mortar Joint

3.3 Tolerances

Tolerance for First and Second Class bricks are as in given **Tables 3.2. and 3.3**

Individual Brick Size (Nominal Dimensions) (mm)				Length of 20 Bricks (mm)	
Class	Length	Breadth	Height	Minimum	Maximum
A	240	-	-	4700	4860
A	-	115	-	2240	2360
A	-	-	57	1170	1270

Table 3.2 : Individual Brick Size And Length of 20 Bricks (Class A)

Individual Brick Size (Nominal Dimensions) (mm)				Length of 20 Bricks (mm)	
Class	Length	Breadth	Height	Minimum	Maximum
B	240	-	-	4660	4880
B	-	115	-	2200	2360
B	-	-	57	1150	1270

Table 3.3 : Individual Brick Size and Length of 20 Bricks (Class B)

3.4 Classification of Bricks and Brickwork

3.4.1 First Class Brickwork

All the bricks used for masonry construction shall be thoroughly burnt, deep cherry red or copper in colour, regular in standard shape and size, free from cracks, emit a clear ringing sound on tapping with a steel trowel and have a crushing strength as per the Nepal Standard **Brick Masonry NS: 1/2035**. A brick shall not absorb more water than 15 % of its weight after 24 hours of soaking in water at normal temperatures. However, hand-made bricks with keys may have water absorption up to 25 % of their weight. For first class brickwork, the corresponding mortar types should be H1 and H2.

3.4.2 Limitation

Masonry units that have been previously used should not be re-used in brick work or brickwork construction unless they have been thoroughly cleaned and shown to conform to the Nepal Standard **Brick Masonry NS: 1/2035**.

3.5 Mortar

Mortar used in masonry construction shall, unless otherwise specified, conform to the specification listed in **NBC 101 – Material Specifications.**

Some of the commonly-used mortars in Nepal and their mix proportions, along with their strengths, are listed in **Table 3.4.**

Serial No.	Mix (by volume)			Minimum Compressive Strength at 28 days (N/mm^2)*	Mortar Type
	Cement	Lime	Sand		
1	1	0 to 0.25 C	3	10.0	H1
2(a)	1	0	4	7.5	H2
2(b)	1	0.5 C	4.5	6.0	H2
3(a)	1	0	5	5.0	M1
3(b)	1	1 C	6	3.0	M1
4(a)	1	0	6	3.0	M2
4(b)	1	2 C	9	2.0	M2
4(c)	0	1 A	2 to 3	2.0	M2
5(a)	1	0	8	0.7	L1
5(b)	1	3 C	12	0.7	L1
6	0	1 B or C	2 to 3	0.5	L2

* 1 N/mm^2 = 1 MPa = 10.2 kg/cm^2

Table 3.4 : Mix Proportions and Strength of Commonly- Used Mortars for Masonry

Notes :

i) *The strength of mortar may vary appreciably depending on the angularity, grading and fineness of the sand. The quantity of sand in the mix may, therefore, be decreased where found necessary to attain the desired strength.*

ii) *A, B and C denote eminently hydraulic lime, semi-hydraulic lime and fat lime respectively.*

iii) *When using plain cement sand mortars [S. No. 2(a), 3(a), 4(a), and 5(a)], it is desirable to include a plasticizer in the mix to improve workability.*

iv) *For mortar to S. No. 6, if lime C is used, part of the sand should be replaced by some pozzolanic materials (eg., burnt clay or fly ash), in order to obtain the required compressive stress.*

v) *In this table, the classification of mortars as* types *H1, H2, M1, M2, L1 or L2 has been given for convenience of reference in design calculations, the letter H standing for high strength, M for medium strength and L for low strength.*

vi) *For mortar types H2, M1, and M2, although the compressive strength of composite* *mortars (that is, cement and lime mortars) is somewhat less than that of cement mortars, the masonry strength may not be significantly affected.*

4 General Construction and Design Requirements

4.1 General

The porvisions in clause 4.1 to 4.7 of the Indian Standard **IS:1905-1987** shall be applicable for designing masonry structures. In addition, the following clauses will also be equally applicable :

4.2 Selection of Mortar

The requirements of a good mortar for masonry structure are workability, strength, water retentively and low drying shrinkage. Mortar strength in general should not be greater than that of the masonry unit. For commonly-used mortars conforming to **Table 3.4**, the optimum mortar mixes from a brick strength consideration are given in **Table 4.1**.

Masonry Unit Strength (N/mm^2)	Mortar Type
below 5	M2
5 to 14.9	M1
15 to 24.9	H2
25 or above	H1

Table 4.1 : Optimum Mortar Mixes For Maximum Masonry Strength with Masonry Units of Various Strengths

4.3 Thickness of Walls

a) The thickness of a load-bearing wall shall be sufficient at all points to ensure that stresses due to the worst condition of loading for which the wall is designed are within the safe limit. The thickness of non load-bearing walls shall be sufficient to meet considerations of stability and strength against lateral forces.

b) The thickness used for design calculation shall be the actual thickness of the masonry, not the nominal thickness. The actual thickness shall be computed as the sum of the average dimensions of the masonry units as specified in the Nepal Standard **Brick Masonry NS:1/2035**, together with the specified joint thickness. In masonry with raked joints, the thickness shall be reduced by the depth of raking. However, if joints are raked to provide a key for subsequent plastering and the mix of mortar for plastering is not weaker than the masonry mortar, raking may be ignored. Also, if the raking of joints is to be followed by flush-pointing using a mortar of the same or better strength, the raking may be ignored.

c) The thickness of a wall determined from strength considerations may not be always sufficient to satisfy requirements with regard to other properties of the wall such as resistance to fire, thermal insulation, sound insulation or resistance to rain penetration.

4.4 Stability Requirements

4.4.1 Lateral Support

Lateral support for a masonry element such as a wall or column is required:

a) to resist horizontal components of the forces so as to ensure stability of the structure against over-turning; and

b) to limit the slenderness of masonry elements in order to prevent failure by buckling.

4.4.2 Adequate Lateral Support

A wall or column may be considered to be provided with adequate lateral support if the construction providing the support is capable of resisting the greater of the following lateral forces :

a) The simple static reactions at the point of lateral support to the total applied horizontal forces ; or 2.5 percent of the total vertical load that the wall or column is designed to carry at the point of lateral support.

Lateral support may be provided in either the vertical or horizontal direction. Horizontal lateral support could consist of the floor/roof acting as a horizontal girder capable of transmitting without excessive stresses the horizontal forces to cross-walls acting as stiffening walls. Vertical support could consist of cross-walls/piers/buttresses capable of transmitting without excessive stresses the horizontal forces to the foundation.

4.5 Parapets and Compound Walls

4.5.1 General

Since, in the case of a free-standing wall such as a compound wall or parapet wall, there is no lateral support at its top and no cross-walls to brace the same, stability shall be achieved by designing the wall as a gravity structure such that the factor of safety against overturning is at least 1.5. As straight walls designed on this basis tend to be heavy, the stability of free-standing walls greater than 0.9 m in height should be achieved by staggering or by the provision of piers or buttresses. Even though a straight free-standing wall may be stable with the stipulated factor of safety (1.5), it will have some tension, because a condition of zero tension corresponds to a factor of safety of 3 against overturning. Mortar used in masonry of a straight, free-standing wall should not normally be weaker than type M1 indicated in **Table 4.1** unless walls are thick enough in relation to their height so as to be free from any tension.

4.5.2 Free-Standing Walls

A free-standing wall must be designed to be safe as a vertical cantilever. All partition walls inside a building must be held on their sides as well as at their tops.

4.5.3 Load Bearing Masonry Elements

In the case of an unreinforced load-bearing wall using ordinary Portland cement, the slenderness ratio shall not exceed 17.

4.5.4 Slenderness Ratio

The slenderness ratio for a load-bearing column shall not exceed 12.

4.5.5 Curtain Walls

Curtain walls shall be designed as panel walls to resist lateral forces caused by wind or earthquakes in addition to their own weight. The junction details at the lateral supports shall be such that any vertical deformations or rotations of the structural members providing the lateral support are not transferred to the curtain wall. Similarly, there shall be freedom for the curtain wall to have deformation in the vertical direction.

4.6 Structural Design

The specificaton laid down in clauses 5.1 to 5.5.5 of Indian Standard **IS:1905-1987** shall apply to the structural design of masonry. The additional clauses as given here under shall also apply.

4.7 Design Method

The structural design of non-reinforced masonry shall be as per the design procedures given below :

4.7.1 Design Procedures

The building as a whole shall be analysed by accepted principle of mechanics to ensure the safe and proper functioning in service of its component parts relative to the whole building. All component parts of the structure shall be capable of sustaining the most adverse combinations of loads to which the building may be reasonably expected to be subjected during or after erection.

4.7.2 Design Loads

Loads to be taken into consideration for designing masonry components of a structure are :

a) dead load of walls, column, floors and roofs;

b) live load on floors and roof;

c) wind load on walls and roof; and

d) seismic forces.

4.7.3 Design of Wall Footings

4.7.3.1 Depth of Footing

The net safe bearing capacity of the soil and the depth of foundation in the soil are best determined by modern soil investigation methods. In the absence of such an investigation report, a conservative minimum depth of footing may be determined using the following formula :

$$D = \frac{P}{W}\left(\frac{1 - Sin\lambda}{1 + Sin\lambda}\right)^2$$

where :

D = minimum depth of footing in metres.
P = net safe bearing capacity of soil (kPa).
W = unit weight of soil (kN/m^3).
λ = angle of repose of soil in degrees.

Note : The above formula is not valid if the soil condition is Soft or Weak as categorised in **Table 7.1**. In all cases, the footing should be founded below seasonal moisture variation and to consistent bearing

4.7.3.2 Width of Footing

The minimum width of the footing, B, shall be obtained by dividing the total load (including dead loads), live and wind load) by the allowable bearing capacity of the soil :

$$B = \frac{T}{P}$$

where :

B = width of footing in metres.
T = total load per metre.
P = safe bearing capacity.

Note : The above formula is not valid if the soil condition is Soft or Weak as categorised in **Table 7.1**.

4.7.4 Permissible Compressive Stresses

The permissible compressive stresses shall be in accordance with the Indian Standard **IS : 1905-1987** in which the design value of permissible compressive stress, f_c , depends on a combination of the following factors :

1) basic compressive stress based on type and strength of the masonry units and mix of mortar, f_b

2) factor for slenderness ratio and eccentricity of masonry elements, k_{se}

3) factor for shape and size of the masonry unit, k_p

4) factor for cross-sectional area of masonry, k_a and

5) factor for load type, k_l

so that :

$f_c = f_b \ k_{se} \, k_p \, k_a \, k_l$

The values of the basic compressive stresses and the various factors are given in **IS : 1905-1987,** clause 5 and its subclauses.

5 General Requirements

5.1 Deforming and Cracking

Special provisions shall be made to control or isolate thermal and other movements so that damage to the fabric of the building is avoided and its structural sufficiency is preserved. The design and installation of joints shall be done in accordance with accepted practice.

5.2 Cutting and Chasing

As far as possible, service (Electrical, Plumbing, etc.) should be planned with the help of vertical chases. Horizontal chases should be avoided.

For load-bearing walls, the depth of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry, respectively.

No chase shall be permitted in a half-brick load-bearing wall.

5.2.1 Stretches of Masonry

When narrow stretches of masonry (or short lengths of wall), such as between doors and windows, cannot be avoided, they should not be pierced with openings for soil pipes or waste pipes or timber joists, etc. Where there is a possibility of load concentration, such narrow lengths of walls shall be checked for stresses and high-strength bricks/mortar or concrete walls provided, if required.

5.2.2 Horizontal Chases

Horizontal chases, when unavoidable, shall be located in the upper or lower thirds of a storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chase shall exceed one metre in length.

5.2.3 Vertical Chases

Vertical chases shall not be closer than two metres in any stretch of a wall. These shall be kept away from the bearing of beams and lintels. If unavoidable, stresses in the affected area should be checked and kept within permissible limits.

5.2.4 Masonry Directly Above A Recess

Masonry directly above a recess, if wider than 30 cm (horizontal dimension), should be supported on lintel. Holes in masonry up to 30 cm width x 30 cm high may be provided without a lintel. In the case of circular holes in masonry, a lintel should be provided only if arch action can not be achieved.

5.3 Workmanship

The quality of workmanship has considerable effect on the strength of masonry and bad workmanship may reduce the strength of brick masonry to as low as half the intended strength. The basic compressive stress values for masonry given in **IS : 1905-1987, Table 8** are appropriate for commercially-obtainable standards of workmanship with a reasonable degree of supervision. If the work is going to be inadequately supervised, design strengths should be reduced to three-quarters of these values.

5.3.1 Bedding of Masonry Units

Masonry units shall be laid on a full bed of mortar with the frog, if any, upward and so that cross-joints and bed-joints are completely filled with mortar. Masonry units which are moved after their initial placement shall be re-laid in fresh mortar. Old or disturbed mortar shall be discarded.

5.3.2 Bond

The cross-joints in any course of one brick thick masonry walls shall be not less than one quarter of a masonry unit in horizontal measurement from the cross-joints in the course below. In masonry walls more than one brick in thickness, bonding through the thickness of the wall shall be provided by either header units or by other equivalent means.

6 Special Considerations for Earthquake Resistance

6.1 Siting

The site should be free from landslide and rock fall areas and liquefaction potential (loose, saturated sand up to about six metres depth below the ground surface). **See NBC 108-94 Site Considerations** for more details.

6.2 General Concepts

6.2.1 Categories of Buildings

For categorizing buildings for the purpose of achieving seismic resistance at economical cost, three parameters turn out to be significant :

a) Seismic Intensity Zoning where the building is located,

b) Important of the building and

c) Stiffness of the foundation soil.

A combination of these parameters will determine the extent of appropriate seismic strengthening of the building.

6.2.2 Seismic Zoning

The variation in seismic hazard with location in Nepal is defined for design purposes in Figure 8.2 of **NBC105-94 Seismic Design of Buildings in Nepal**. For the purpose of the design of unreinforced masonry, a simplified zonation based on this figure shall be used.

Three zones A, B and C are defined in **Table 6.1** and are shown in **Figure 6.1** below.

Zone	Zone Coefficient	Risk
A	$Z \geq 1.0$	Widespread Collapse and Heavy Damage
B	$0.8 \geq Z > 1.0$	Moderate Damage
C	$Z < 0.8$	Minor Damage

Table 6.1 : Seismic Zones for Unreinforced Masonry

6.2.3 Importance of Building

The importance of the building should be a factor in grading it for strengthening purposes. Importance depends upon its occupancy, use and need before and after a disaster as given in **Table 6.2**.

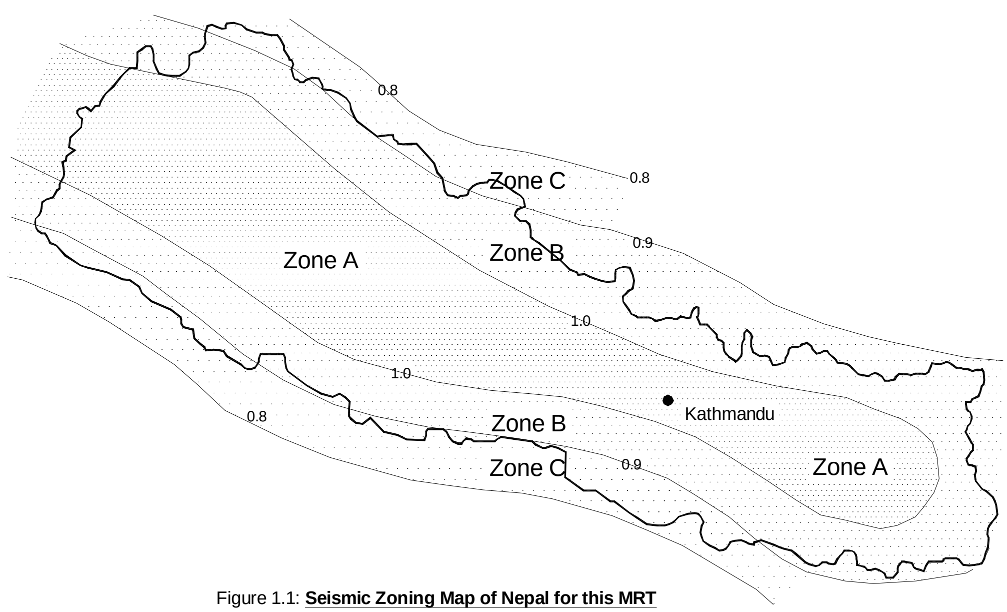


Figure 1.1: **Seismic Zoning Map of Nepal for this MRT**

Occupancy Category	Occupancy Type or Function of Structure
IMPORTANT CATEGORY	
1. Essential Facilities	Hospital and other medical facilities Fire and Police Station Tanks or other structures containing, housing or supporting water or other fire-suppression material or equipment required for the protection of essential or hazardous facilities. Emergency vehicle shelter and garage Structures and equipment in emergency-preparedness centres and relief stores. Power stations and standby power-generating equipment for essential facilities Structures and equipment in communication centres eg. radio, television facility, telephone exchange etc. Food storage structures Offices and quarters for personnel related to central and district level rescue and relief operations eg. ministers, secretaries, police and army chiefs, CDO, LDO, DDC chairman, district level army and police chiefs
2. Places of Assembly	Schools, colleges, hostels cinema hall, culture, covered hall convention halls, temples, dharmashalas
3. Monumental Buildings	Historic buildings, palaces
4. Distribution Facilities	Gas or petroleum products in urban areas
5. Hazardous Facilities	Structures housing, supporting or containing sufficient quantities of toxic or explosive substances to be dangerous to the safety of the general public if release
ORDINARY CATEGORY	
6. Ordinary Occupancy Structures	Any structure / building not described above eg residential, offices, etc.

Table 6.2 : Occupancy Category

The buildings under the Important category have been subdivided into two groups from a constructions point of view. These are :

A. Buildings in accessible areas where modern materials such as cement and reinforcing bars can be easily transported

B. Buildings in remote inaccessible areas to where modern materials can not easily be transported.

7 Site Considerations

7.1 General

This section sets out some of the requirements to be considered during site selection for the construction of buildings in order to minimise the risks to buildings from both primary geological hazards and secondary seismic hazards such as fault rupture, landslide and liquefaction. Since this is the first such effort to introduce the importance of geotechnical conditions and the nature of foundation soil in the stability of Nepalese building, the requirements set out here have deliberately been kept low to encourage effective implementation.

7.2 General Considerations

As a good practice during the construction of a building, it is necessary to examine all existing local knowledge and the performance histories of existing building. The designer should thus be able to identify any dangers from an inherent natural susceptibility of the land to the processes of sliding, erosion, land subsidence and liquefaction during past earthquakes, or from any other natural/geological process likely to threaten the integrity of the building. The local practice of managing such hazards, if any, should be judged against the required level of acceptable risk.

7.3 Site Investigation Requirements

For load-bearing masonry buildings and reinforced concrete (RC) frame buildings with masonry infills, site exploration should be carried out by digging test pits, two as a minimum, and more if the subsurface soil conditions show a variation in soil types.

Generally the depth of exploration for the buildings should be a minimum of two metres. In hilly areas, exploration up to the depth of sound bed rock, if it lies shallower than two metres, should suffice.

No exploration shall be required if the site is located on rock or on fluvial terraces (Tar) with boulder beds.

The soils encountered in the test pits should be classified as per **Table 7.1**.

7.4 Allowable Bearing Pressure

The allowable bearing pressure could be calculated using the **Table 7.1**. in conjunction with the visual classification of the subsurface soil type.

Type of Soil/Rock	Foundation Classification	Presumed Safe Bearing Capacity (kN/m^2)
Rocks in different state of weathering; boulder beds; gravel; sandy gravel and sand-gravel mixtures; dense or loose coarse to medium sand; offering high resistance to penetration when excavated by tools; stiff to medium clay which is readily indented with a thumb nail.	Hard	≥ 200
Fine sand and silt (dry lumps easily pulverised by the finger); moist clay and sand-clay mixtures which can be indented with strong thumb pressure.	Medium	≥ 150 and < 200
Fine sand; loose and dry; soft clay indented with moderate thumb pressure.	Soft	≥ 100 and < 150
Very soft clay which can be penetrated several centimetres with the thumb; wet clays.	Weak	≥50

Table 7.1 : Classification of Foundaton Soil And Safe Bearing Capacity

Buildings can be constructed on hard, medium and soft soils but it will be dangerous to build them on weak soils. Hence, appropriate soil investigation should be carried out to establish the allowable bearing capacity and nature of soils. Weak soils must be avoided or compacted to improve them so that they qualify as at least Medium or Soft soils.

7.5 Combination of Parameters

For determining the categories of building for seismic strengthening purposes four categories (I to IV) are defined in **Table 7.2** in which category I will require maximum strengthening and category IV the least. The general planning and designing principles are, however, equally applicable to all categories.

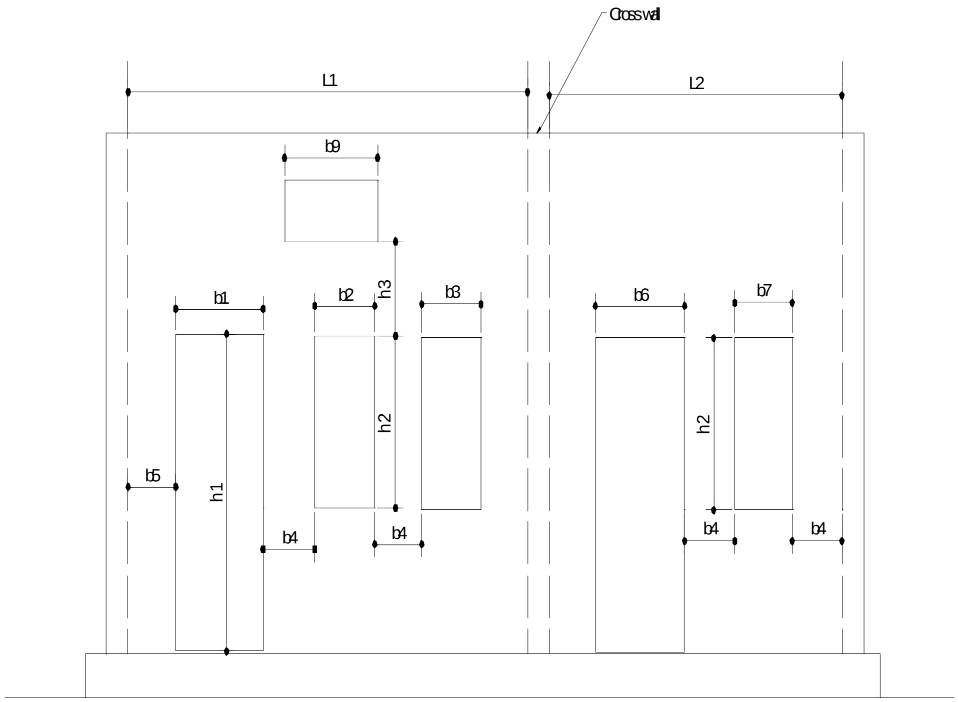
Category	Combination of Conditions for the Category
I	Important Building on Soft Soil in Zone A
II	Important Building on Firm Soil in Zone A Important Building on Soft Soil in Zone B Ordinary Building on Firm Soil in Zone A
III	Important Building on Firm Soil in Zone B Important Building on Soft Soil in Zone C Ordinary Building on Firm Soil in Zone A Ordinary Building on Soft Soil in Zone B
IV	Important Building on Firm Soil in Zone C Ordinary Building on Firm Soil in Zone B Ordinary Building on Firm Soil in Zone C Ordinary Building on Soft Soil in Zone C

Table 7.2 : Categories of Buildings for Strengthening Purposes

Notes :

i) *Seismic Zones A, B and C are as per Figure 6.1*

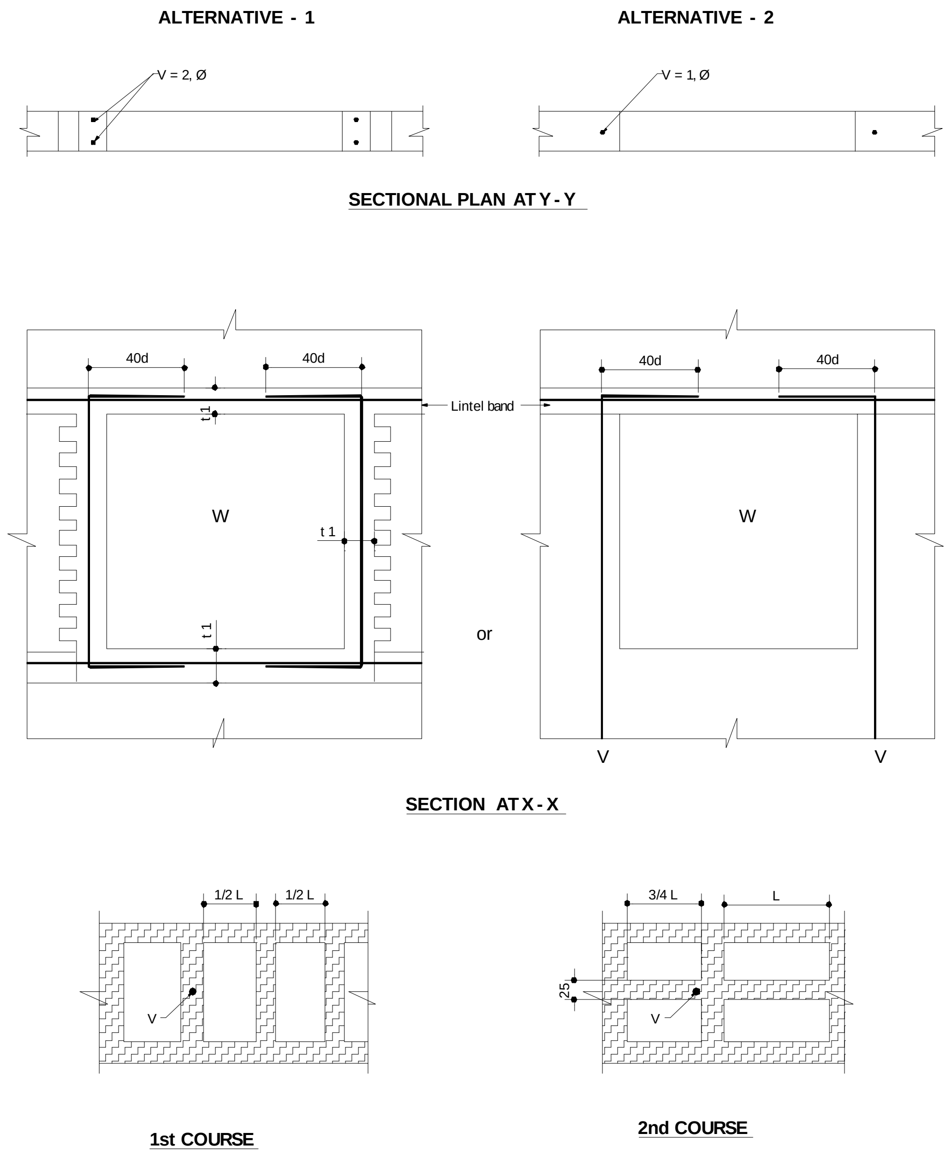
ii) *Weak soils liable to compaction and liquefaction under earthquake conditions are not covered here.*



Note:

i)	$b_1+b_2+b_3$	$<0.5\ L_1$ for one storey, $<0.42\ L_1$ for two-storeyed, $<0.33\ L_1$ for three-storeyed
ii)	b_6+b_7	$<0.5\ L_1$ for one storey, $<0.42\ L_1$ for two-storeyed, $<0.33\ L_1$ for three-storeyed
iii)	b_4	>0.5 h, but not less than 600 mm
iv)	b_5	>0.25 h, but not less than 600 mm
v)	b_3	> 600 mm and > 0.5 (bigger of b_2 and b_9)

Figure 7.1 : Recommendations Regarding Opeinings in Bearing Walls



∅ -- Diameter, W -- Window, V --- Vertical Reinforcing bar,

t -- Thickness of wall (minimu l brick length) ,

t1 -- Minimum thickness 75 mm., L -- Length of brick unit.

Figure 7.2 : Strengthening of Masonry Around Openings

8 Openings in Walls

a) Openings shall be located away from the inside corner by a clear distance equal to at least one-quarter of the height of openings, but not less than 600 mm.

b) The total length of openings shall not exceed 50 % of the length of the wall between consecutive cross-walls in single-storey construction, 42 % in two-storey construction and 33 % in three-storey buildings.

c) The horizontal distance (pier width) between two openings shall not be less than one-half of the height of the shorter opening **(Figure 7.1),** but not less than 600 mm.

d) The vertical distance from an opening to an opening directly above it shall not be less than 600 mm, nor less than one-half of the width of the smaller opening (**Figure 7.1**)

e) When openings do not comply with requirements (a) to (b), they should be boxed in reinforced jambs through the masonry (**Figure 7.2**)

f) Tops of openings in a storey should preferably be at the same level, so that a continuous band which includes the lintels throughout the building can be provided.

g) If a window or ventilator is to be projected out, the projection shall be in reinforced masonry or concrete and well-anchored.

h) If an opening is tall enough with respect to the full height of wall so as to divide effectively the wall into two portions, these portions shall be reinforced with at least 6 mm diameter horizontal bars at not more than 600 mm intervals on both the inner and outer faces. This steel at jambs and at corners or junctions of walls.

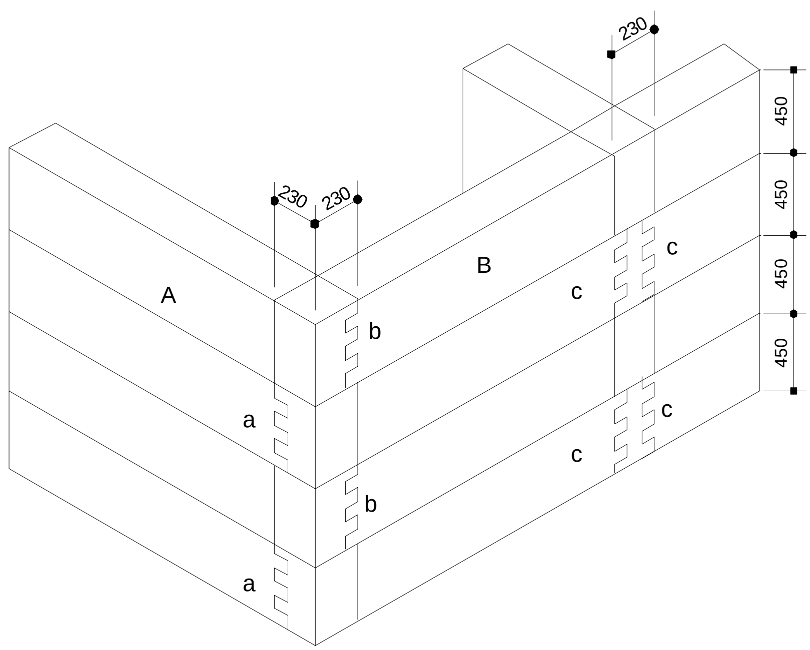
i) The use of arches to span over the openings is a source of weakness and shall be avoided unless steel ties are provided.

j) All the walls must be effectively tied together to avoid separation at vertical joints due to ground-shaking during an earthquake.

9 Masonry Bond

9.1 Vertical Joints between Perpendicular Walls

A sloped or stepped joint should be made in order to obtain full bond by making the corners first to a height of 600 mm and then building the wall in between them. Alternatively, a toothed joint should be made in each wall alternately in lifts of about 450 mm, as shown in **Figure 9.1.**



All dimensions are in mm.

a, b, c Toothed joint in walls A, B and C

(Alternating toothed joint in walls at corner and T-junctions)

Figure 9.1: **A Typical Detail of Jointing in Masonry**

10 Horizontal Reinforcement in Walls

Horizontal reinforcing of walls is required to give to them horizontal bending strength against plate-action for out-of-plane inertia loads, and for tying orthogonal walls together.

10.1 Horizontal Bands or Ring Beams

a) **Plinth Band**

A plinth band should be provided in all cases where the soil is soft or uneven in its properties.

b) **Lintel Band**

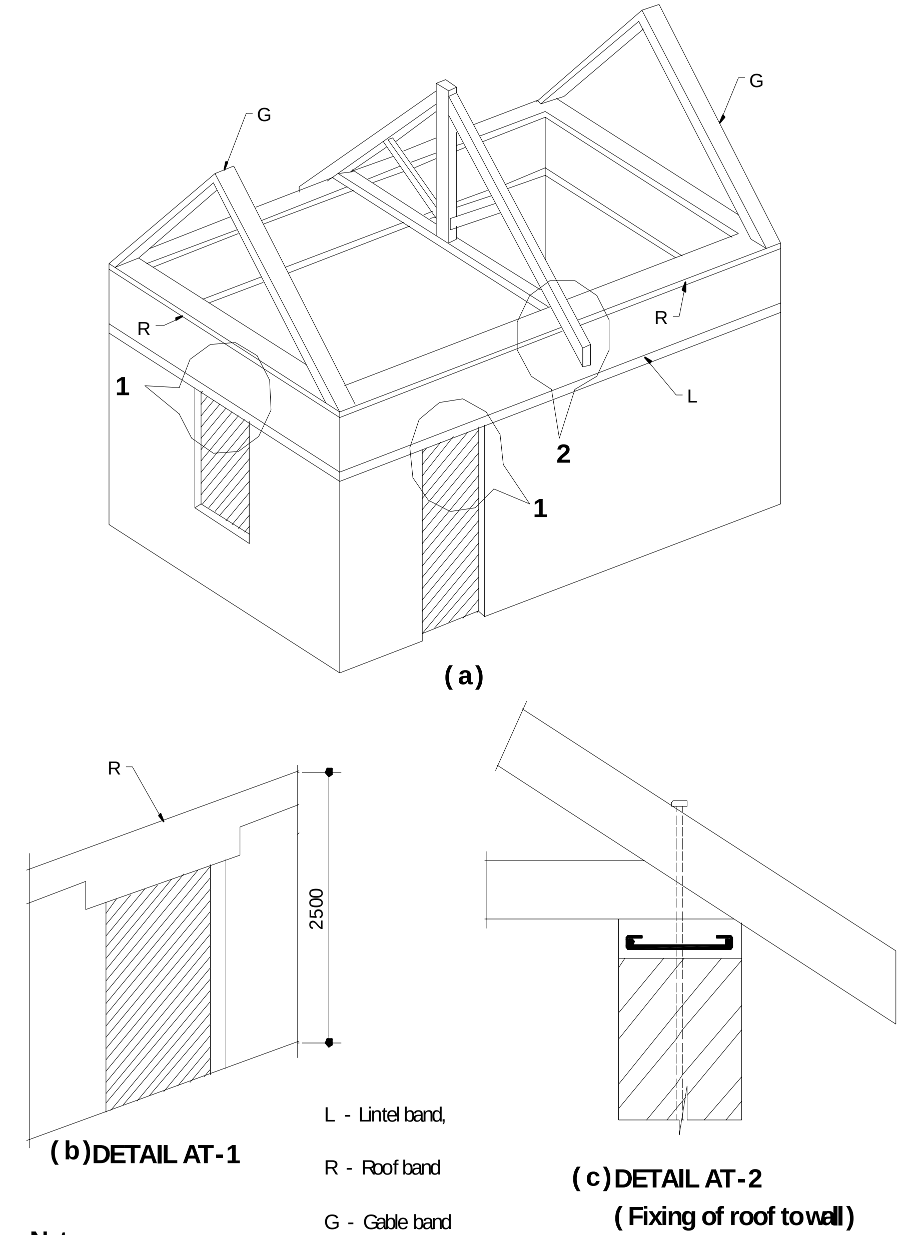
The lintel band shall incorporate all door and window lintels, the reinforcement of which should be extra to the lintel band steel. It must be provided in all storeys in all walls of the buildings as per **Table 11.1**.

c) **Roof Band**

A roof band shall be provided at the eave-level of trussed roofs (**Figure 4**), and also below or in the level of such floors that consist of joists and covering elements so as to properly integrate them at their ends and fix them into the walls.

d) **Gable Band**

Masonry gable-ends must have the triangular portion of masonry enclosed in a band, the horizontal part of which will be continuous with the eave-level band on longitudinal walls **(Figure 10.1)**.



Note:

i) As an alternative to the gable masonry, a truss or open gable may be used and the openings covered with a light material such as sheeting, matting etc.

ii) If the wall-height up to eave-level is less than or equal to 2.5 m , the lintel-level band may be ommitted and the lintel integrated with the eave-level band as shown in Detail 2.

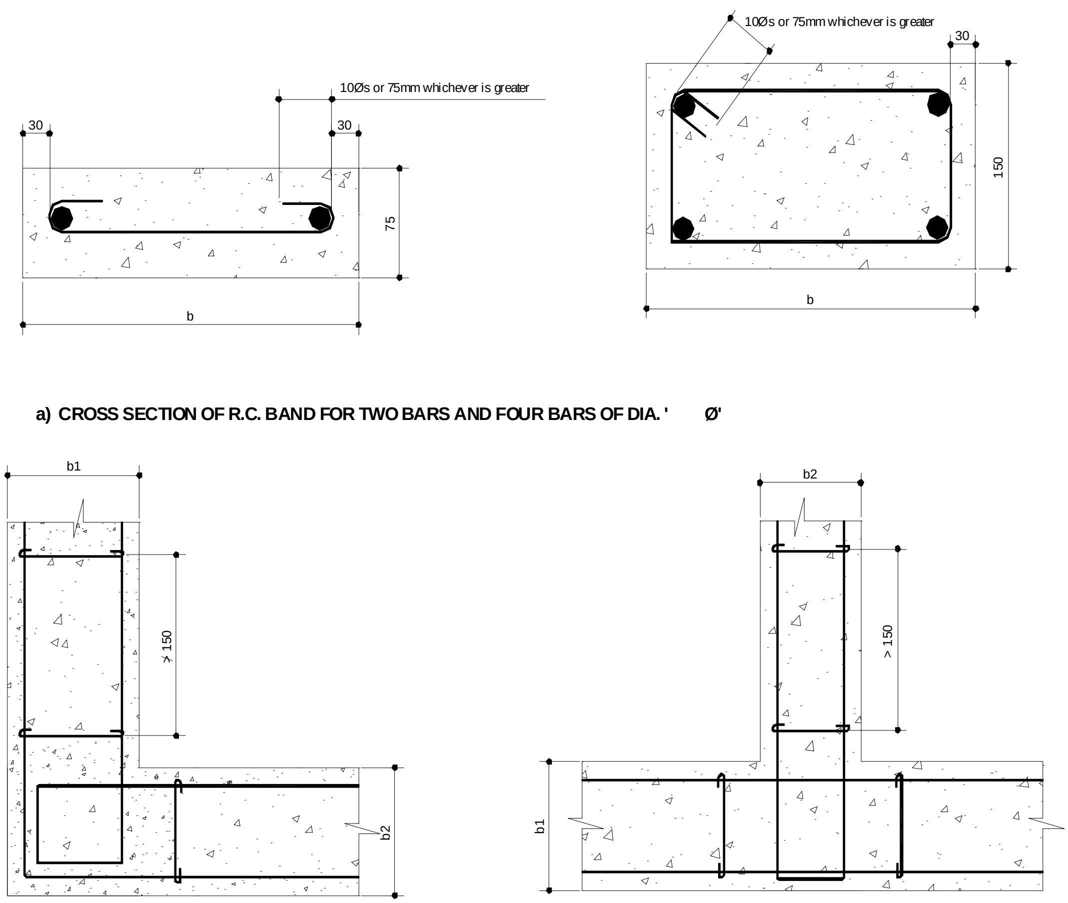
Figure 10.1 : **Gable Band and Roof Band in Barrack-Type Buildings**

11 Section of Bands or Ring Beams

A band consists of two (or four) longitudinal steel bars with stirrups embedded in 75 mm (or 150m mm) thick concrete **(Figure 11.1 and 11.2)**.

The thickness of the band may be made equal to, or a multiple of, a masonry unit, and its width shall equal the thickness of the wall.

The steel bars shall be located close to the wall faces with 25 mm cover, and full continuity shall be provided at corners and junctions.

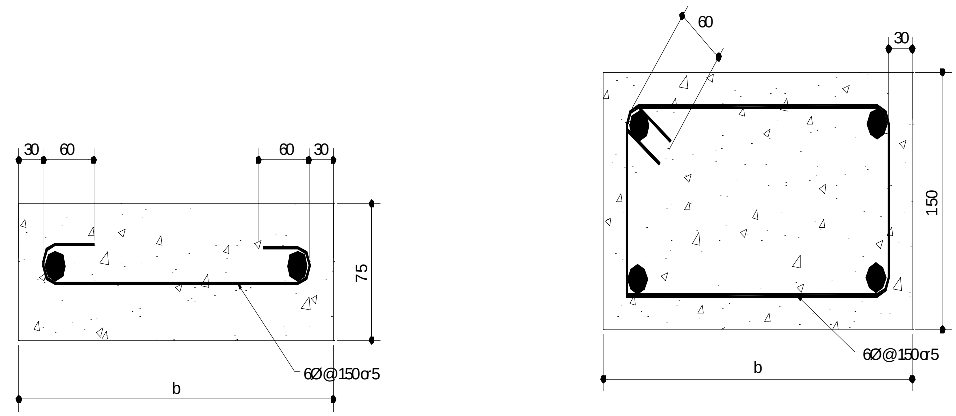


b) R. C. BAND REINFORCEMENT DETAILS AT CORNER AND T-JUCTION

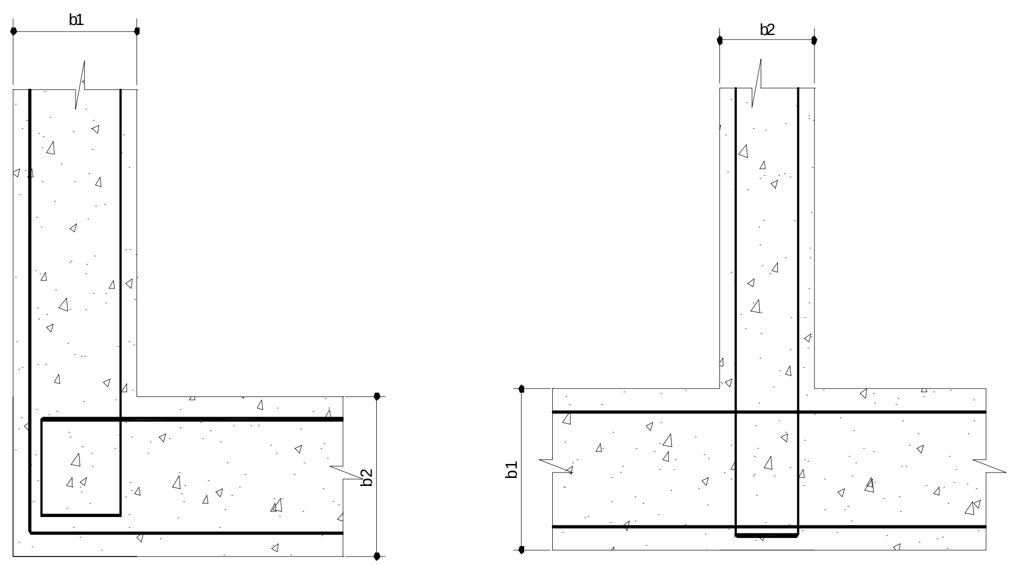
b, b1, b2 = Wall thickness
Concrete 1 : 2 : 4 or 15 N/ mm^2 cube strength.

Note:
Provide overlaps for slicing bars outside the corner length of overlap to develop full band say 50 d.

Figure 11.1 : **Reinforced Concrete Band and Details**



a) CROSS SECTION OF R.C.C. BAND FOR TWO BARS AND FOUR BARS



b) R. C. BAND REINFORCEMENT DETAILS AT CORNER AND T-JUCTION

b, b1, b2 = Wall thickness

Concrete 1 : 2 : 4 or 15 N/mm^2 cube strength.

Note:

Provide overlaps for slicing bars outside the corner length of overlap to develop full band say 50 d.

Figure 11.2: **Reinforcement in Reinforced Concrete Band**

Longitudinal steel in Reinforced Concrete (RC) Bands												
Span of wall between cross wall (m)	Category I			Category II			Category III			Category IV		
	No. of Bars	Bar Dia. (mm)		No. of Bars	Bar Dia. (mm)		No. of Bars	Bar Dia. (mm)		No. of Bars	Bar Dia. (mm)	
		T*	K*		T	K		T	K		T	K
5 or Less	2	10	9	2	10	9	2	10	9	2	10	9
6	2	12	-	2	10	9	2	10	9	2	10	9
7	2	12	-	2	12	-	2	10	9	2	10	9

* T = High strength bar having an f_y of 415 N/mm² (Fe 415 Grade)
K = High strength bar having an f_y of 550 N/mm² (Fe 550 Grade)

Table 11.1 : Recommendation for Steel in RC Bands

Notes :

i) *Width of the RC band is assumed to be the same as the thickness of wall. Wall thickness shall be 230 mm minimum. A cover of 25 mm from face of wall shall be maintained.*

ii) *The vertical thickness of a RC band may be kept to a minimum of 75 mm where two longitudinal bars are specified and 150 mm where four longitudinal bars are specified.*

iii) *Concrete mix to be 1:2:4 by volume or to have an M15 Grade cube crushing strength at 28 days.*

iv) *The longitudinal bars shall be held in position by steel stirrups 6 mm in diameter spaced no more than 150 mm apart.*

12 Dowels at Corners and Junctions

Steel dowel bars shall be used at corners and T-junctions to integrate the box action of walls. Dowels (**Figures 12.1, 12.2, 12.3 and 12.4**) are to be taken into the walls to a sufficient length so as to provide their full bond strength.

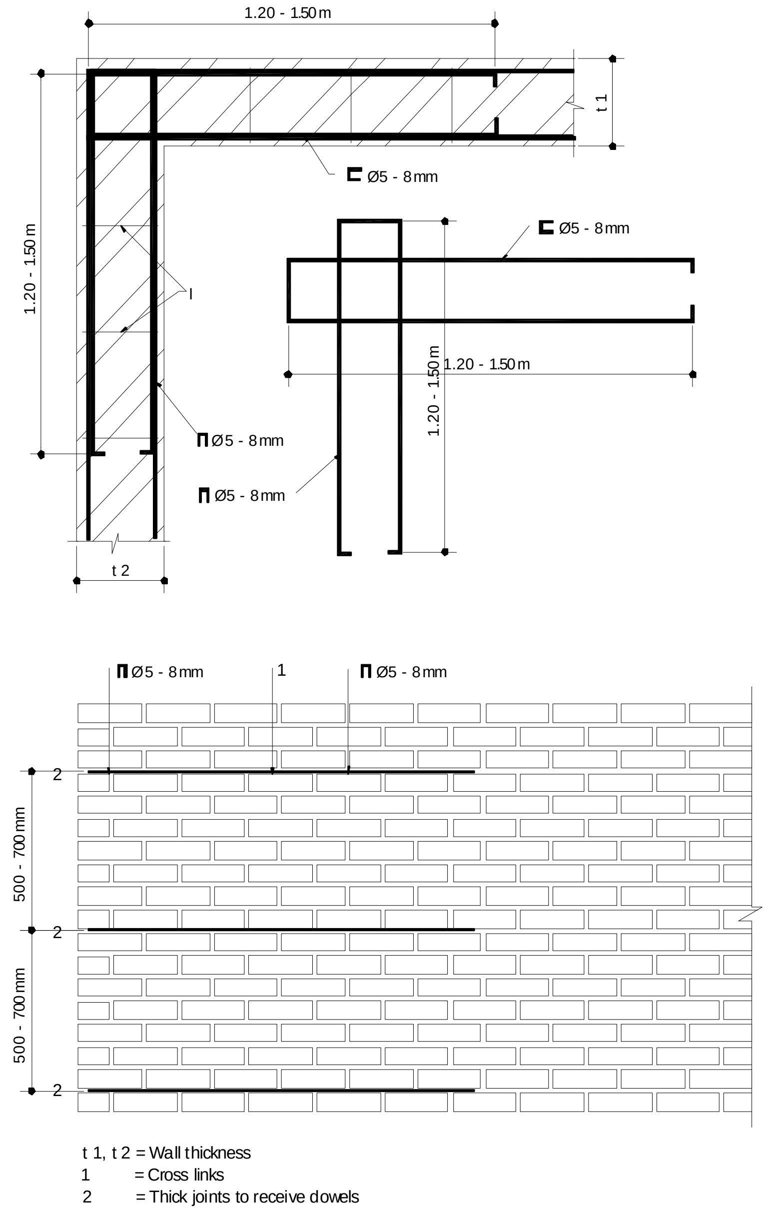
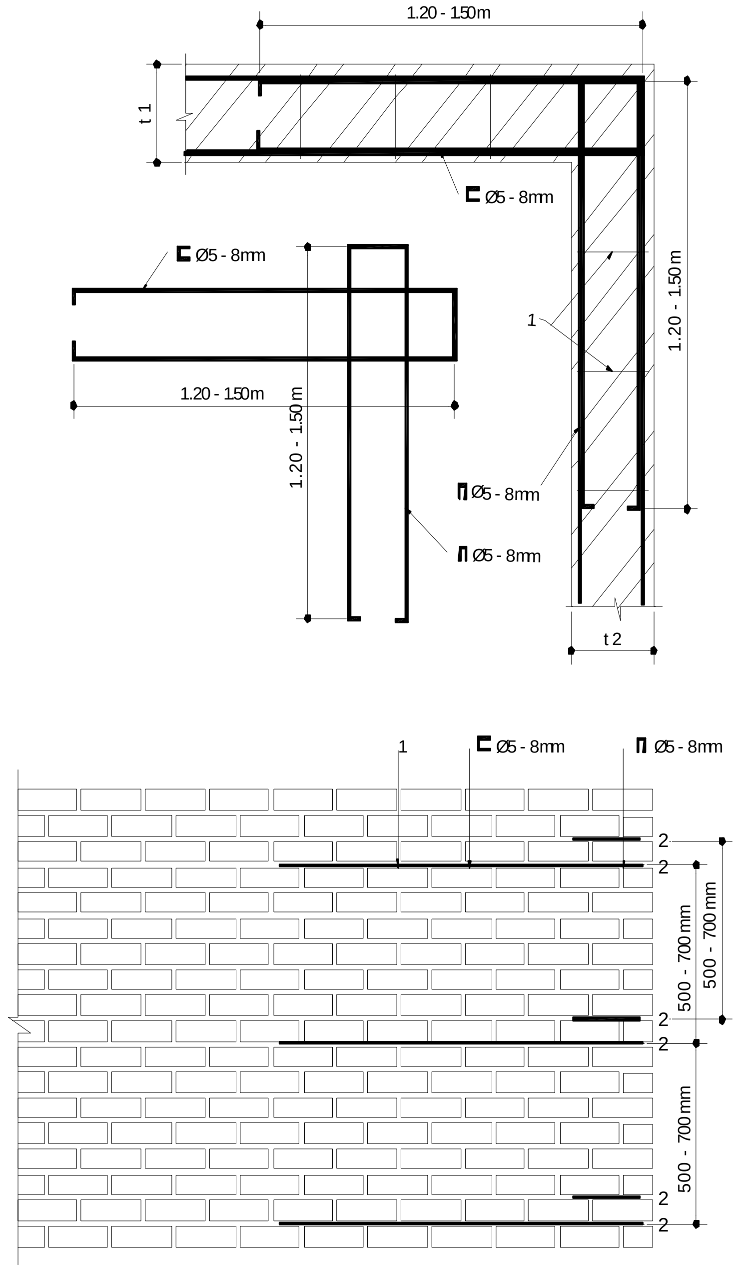


Figure 12.1 : **Corner-Strengthening by Dowel Reinforcement Placed in One Joint**



t 1, t 2 = Wall thickness
1 = Cross links
2 = Thick joints to receive dowels

Figure 12.1 : **Corner-Strengthening by Dowel Reinforcement Placed in Two Consecutive Joint**

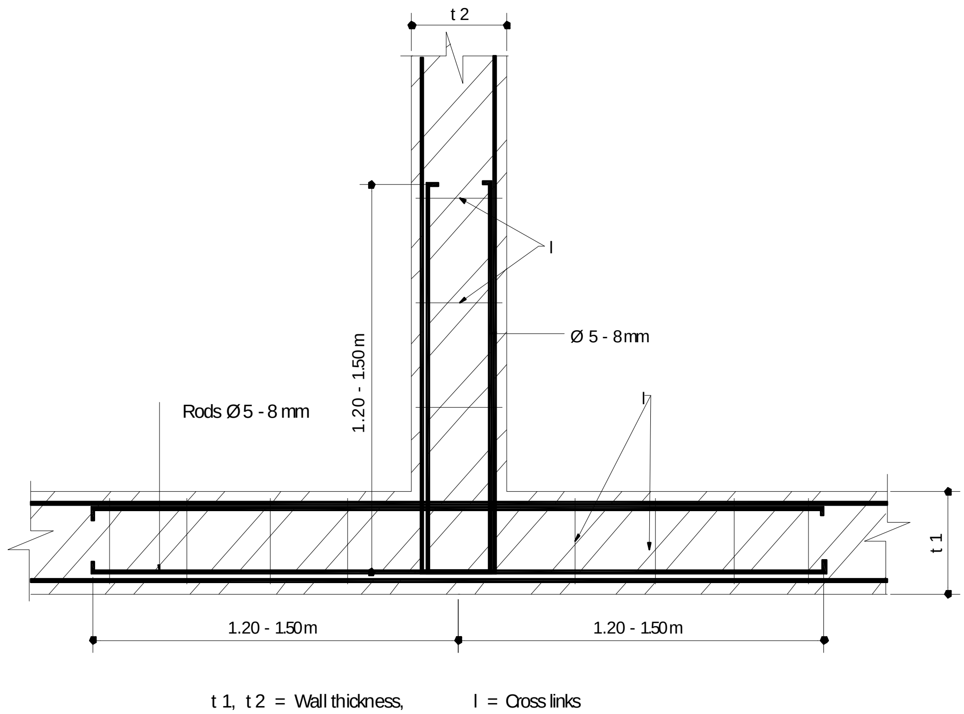


Figure 12.3 : **T-Junction Strengthening by Dowel Reinforcement**

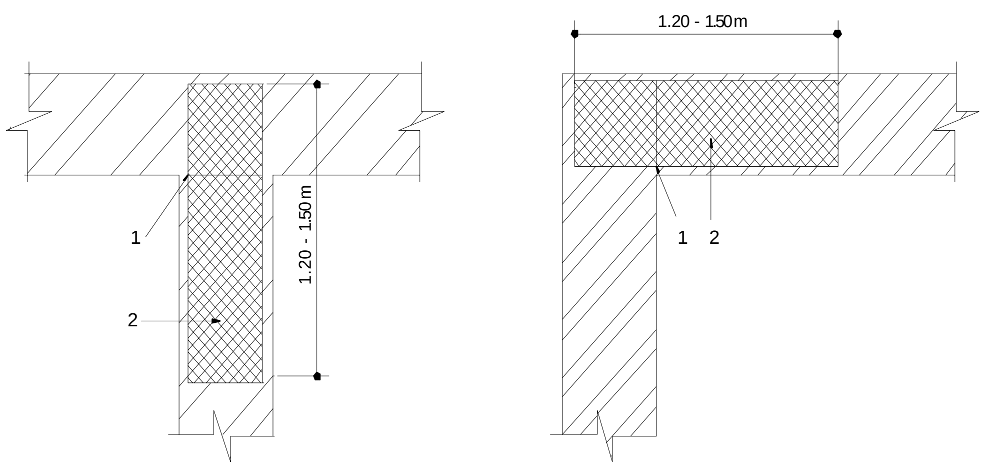


Figure 12.4 : **Strengthening by Wire Fabric at Junctions and Corners**

13 Vertical Reinforcement in Walls

Steel bars shall be installed at the critical sections (i.e. the corners of walls and jambs of doors right from the foundation concrete) and covered with cement concrete in cavities made around them during masonry construction (**Figure 13.1**). This concrete mix should be 1:2:4 by volume or stronger.

The vertical steel at an opening may be stopped by bending it into the lintel band but the vertical steel at corners and junctions of walls must be taken into the floor slab, roof slab, or roof band.

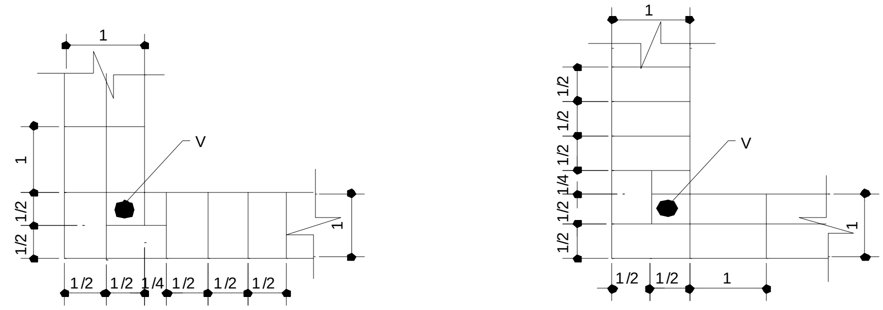
Number of Storeys	Storey	Diameter of mild steel single bar in mm at each critical section by Category		
		Category I	Category II	Category III
One		12	10	10
Two	Top Bottom	12 16	10 12	10 12
Three	Top Middle Bottom	12 16 16	10 12 12	10 10 12

Table 13.1 : Recommendation for Vertical Steel at Critical Sections

Notes :

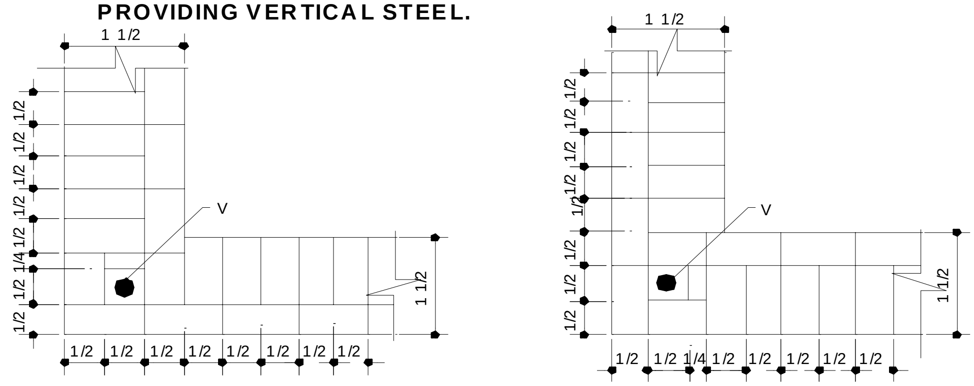
i) *The above vertical reinforcement in walls is valid for up to three-storeyed buildings*

ii) *Four-storeyed and above load-bearing wall construction may not be used for categories I and II buildings.*



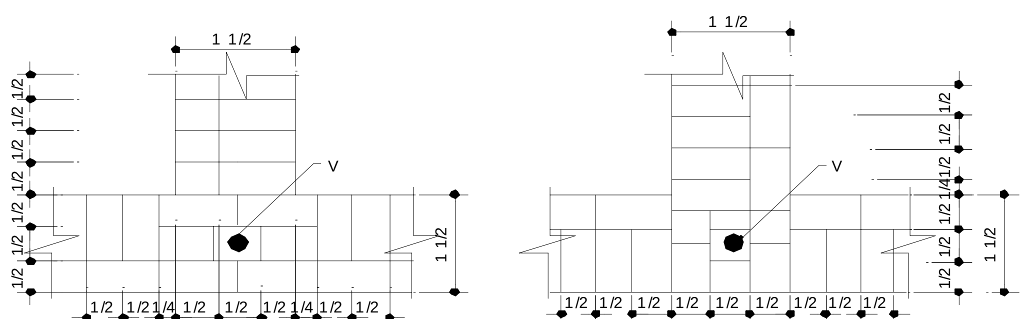
FIRST LAYER SECOND LAYER

CORNER JUNCTION DETAILS FOR ONE BRICK WALL FOR PROVIDING VERTICAL STEEL.



FIRST LAYER SECOND LAYER

CORNER JUNCTION DETAILS FOR ONE AND HALF BRICK WALL FOR PROVIDING VERTICAL STEEL.



FIRST LAYER SECOND LAYER

T- JUNCTION DETAILS FOR ONE AND HALF BRICK WALL FOR PROVIDING VERTICAL STEEL.

$\frac{1}{4}$, $\frac{1}{2}$, and 1 indicates: $\frac{1}{4}$ Brick wide, $\frac{1}{2}$ Brick wide, 1 Brick long etc.,
V - Vertical Bar

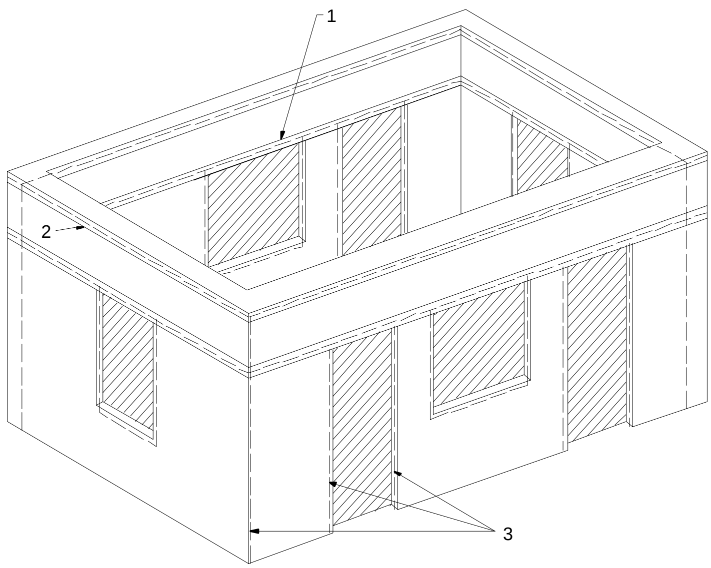
Figure 13.1 : **Vertical Reinforcement in Walls**

14 Reinforcement Details for Hollow Block Masonry

14.1 Horizontal Band

U-shaped blocks should be used for the construction of horizontal bands at various levels of the storey as per seismic requirements as shown in **Figure 4.1.**

The amount of horizontal reinforcement shall be taken as 25 % more than that given in **Table 11.1** and provided by using four bars and 6 mm diameter stirrups.



1 - Lintel Band
2 - Roof Band (only for pitched roofs and under roofs and floor)
3 - Vertical steel.

Figure 14.1 : **Overall Arrangement of Reinforcing Masonry Buildings**

15 Vertical Reinforcement

The vertical bars specified in **Table 13.1** can be conveniently located inside the cavities of the hollow blocks - one bar in one cavity. Where more than one bar is planned, these can be located in two or three consecutive cavities as shown in **Figures 15.1 and 15.2.**

15.1 Infill Panels and Non-Structural Walls

a) In-fill panel walls in a building shall be designed to ensure that they act together with the frame in full composite action.

b) The seismic load at each level shall be distributed to the individual wall in proportion to the product of each wall's thickness and length. This product is representative of the diagonal strut area and thus of the wall's shear stiffness.

c) Any frame is to be designed to resist all the gravity loads without any assistance from the infill walls as these walls may either fail or be very severely damaged in a large earthquake.

d) The centre of rigidity of the infill walls (except face wall) shall be as near as possible to the centre of rigidity of the complete system of walls.

e) An infill wall shall be so designed that it sustains minimum damage during any deflection of the supporting structure during an earthquake and shall be designed to resist all action resulting from in-plane and face loads.

f) The minimum thickness of an infilled wall shall be the same as that of partition walls, and its openings should be as small as possible and cover not more than 10 % of the panel area. The preferable location of an opening in a wall is outside the central two-thirds of the sides and away from the corners. If the opening must be near the centre of the wall, it shall be bounded by a reinforced concrete beam 75 mm thick, the other dimension to be equal to thickness of wall and reinforced with two 10 mm diameter Fe 415 grade bars longitudinally and 5 mm diameter Fe 550 grade bar link ties .

g) Partition walls shall have a minimum thickness shall have horizontal reinforcement (one 6 mm diameter bar in each face) in every sixth course of blockwork.

h) If the infill wall is constructed in a Category I or II building, the thickness of infill wall shall not be less than 230 mm.

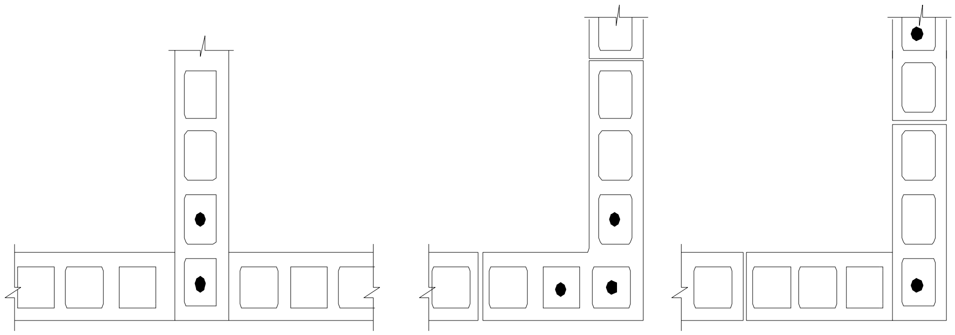
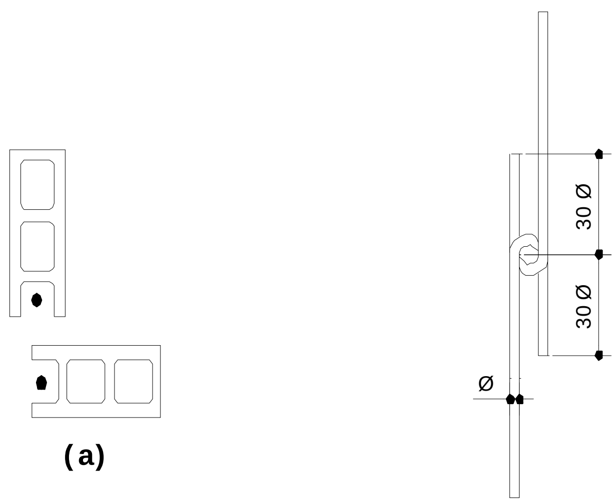


Figure 15.1 : **Vertical Reinforcement in Blockwork Cavities**



(a)

(b)

Figure 15.2 : **Vertical Reinforcement in Cavities**

16 Wall Thickness and Spacing

The minimun thicknesses and maximum spacings of masonry walls shall be as dexcribed in **Tables 16.1 and 16.2.**

	Height of Wall (m)	Length of Wall (m)	Thickness of Wall at Base (Bricks)
1.	Up to 4.5	Any*	1.5
2.	4.5 to 7.5	Any*	1.5
3.	7.5 to 9	Up to 14 Above 14	1.5 2
4.	9 to 12	Up to 9 9 to 14 14 to 18	1.5 2 2.5
5.	12 to 15	Up to 9 9 to 18	2 2.5
6.	15 to 18	Up to 9 9 to 14	2.5 3

* *Provision should be made for expansion/contraction joints.*

Table 16.1 : Thickness of Walls for Public Buildings, Warehouse and Incustrial Buildings

Notes :

(i) *An additional thickness of one-half a brick at the base will usually be sufficient where vibrating machinery is used.*

(ii) *The base thickness is reduced towards the top; for 5 m from the top of wall, the thickness should be 1.5 bricks, but where the wall does not exceed 9 m in height, the wall for 3.5 m from the top may be one brick thick if the wall is in a cement mortar.*

	Thickness of Load-Bearing Wall to be Stiffened (mm)	Height* of Storey not to exceed (m)	Stiffening Wall*		
			Thickness not less than (mm)		Max. Spacing (m)
			1 to 3 storeys	4 to 6 storeys	
1.	100	3.2	240	-	4.5
2.	240	3.2	360	480	6.0

* *Storey height and maximum spacing are given as centre-to-centre dimensions.*

Table 16.2 : Thickness and Spacing of Stiffening Walls