GUIDELINES FOR

RECONSTRUCTION OF HOUSES AFFECTED BY TSUNAMI IN TAMIL NADU

PART I – GENERAL PROVISIONS

REVENUE ADMINISTRATION, DISASTER MANAGEMENT & MITIGATION DEPARTMENT

GOVERNMENT OF TAMIL NADU

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FOREWORD

The tsunami which struck the coast of Tamil Nadu due to a very severe earthquake measuring magnitude of M9.0 near northern Sumatra, Indonesia at 00:58:50 UTC on 26.12.2004 had a widespread impact on fishing villages and towns all along the coastline of Tamil Nadu. A calamity of this nature had never been known in this State as evidenced by the death toll of over 8000 human lives. Lakhs of people were rendered homeless. It totally damaged the entire coastal economy of Tamil Nadu.

In order to bring back the lives of the affected people to normalcy, Government of Tamil Nadu under the strong and dynamic leadership of the Hon'ble Chief Minister took a series of measures to restore their shelter and livelihoods. Relief operations were mounted on an unprecedented scale and all the resources at the disposal of the State were commandeered. Government of India lent considerable support through armed forces, para military personnel and relief and response packages of assistance. NGOs, Corporates and Civil Society representatives assisted the Governmental efforts admirably.

It was realized that most of the buildings which had collapsed / damaged due to tsunami were mainly due to poor construction practices without considering the hazard proneness of the area. In order to mitigate such risks in future, it is imperative that all the houses / infrastructure to be constructed in hazard prone areas should incorporate disaster resistant technologies stipulated in Bureau of Indian Standards Codes. The Revenue Administration, Disaster Management and Mitigation Department considered it appropriate to bring out detailed guidelines for construction of houses for the affected people at the relocated sites.

These guidelines deal with general provisions to be followed during construction of houses considering multi hazard perspective. A separate detailed technical guidelines is also being brought out.

I wish to place on record the efforts taken by the following experts ably coordinated by Thiru C.V. Sankar, Officer on Special Duty (Relief and Rehabilitation).

1) Dr. N. Lakshmanan, Director,
Structural Engineering Research Centre, Chennai

2) Dr. A. R. Santhakumar,
Advisor - Shelter Reconstruction and Rehabilitation
United Nations Team for Recovery Support in Tamil Nadu, Chennai

3) Thiru K.R. Thiagarajan, Chief Engineer,
Tamil Nadu Slum Clearance Board, Chennai

4) Dr. K.P. Jaya, Assistant Professor,
Structural Engineering Division, Anna University, Chennai

5) Thiru C.R. Suresh, Joint Chief Architect,
Public Works Department, Chennai

6) Thiru S. Nagarajan, Deputy Chief Engineer (Buildings),
Public Works Department, Chennai

7) Thiru S. Ponnivel, Superintending Engineer (i/c),
Tamil Nadu Housing Board, Chennai

8) Thiru Anindya Kumar Sarkar
Shelter Coordinator, UNDP - Orissa programmes

in bringing out the guidelines.

I am sure that the guidelines will be helpful in the planning and construction of houses and help in reducing the future risk.

R. Santhanam,
Special Commissioner and
Commissioner of Revenue Administration and
State Relief Commissioner, Chennai 600 005

While hazards are inevitable, each hazard need not convert into a disaster as what comes in between is the culture of safety and prevention.
(High Power Committee, Government of India - 2001)

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INTRODUCTION

A very severe earthquake measuring magnitude of 8.9 on Richter Scale struck northern Sumatra, Indonesia at 00:58:50 UTC or 06:28 AM IST. The earthquake driven tsunami was felt widely along the east coast of India. The calamity which struck the Tamil Nadu coast was unprecedented in its suddenness and ferocity. It was also widespread in scale affecting villages and towns all along the coastline. "A calamity of this nature has never been known".

Cyclones:

Tamil Nadu being located in a highly vulnerable part of Peninsular India - the Deccan Plateau and flanked by the Bay of Bengal and the Arabian Sea, is frequently subjected to overwhelming devastation by natural calamities due to cyclonic storms and flooding in its coastal districts. Records of the past occurrences of cyclonic storms highlight the alarming fact that severe cyclonic storms are more frequent in the Bay of Bengal than in the Arabian Sea and records indicate that from the beginning of this century about 400 cyclonic storms formed in the Bay of Bengal as compared to just 80 in the Arabian Sea. Almost every year on an average, one severe cyclone in the pre-monsoon period and one or two in the post-monsoon period are expected during the Northeast monsoon period in the Bay of Bengal. The area normally affected by cyclones is the entire first line coastal taluks right from Chennai district to Ramanathapuram district. Tamil Nadu is one of the most vulnerable States in the country affected by cyclones.

As per the Wind & Cyclone zoning map as given in IS 875(Part-3) - 1987, brought out by BMTPC, Vulnerability Atlas of India, there are six basic wind speeds considered for zoning, i.e. 55, 50, 47, 44, 39 and 33 m/sec. These peak wind speeds represent the peak gust velocity averaged over a short duration of 3 sec., at a height of 10 m above the ground level in an open terrain with a return period of 50 years. From wind damage point of view, these are categorized as follows:

55 m/sec	Very high damage risk zone – A
50 m/sec	Very high damage risk zone – B
47 m/sec	High damage risk zone
44 m/sec	Moderate damage risk zone – A
39 m/sec	Moderate damage risk zone – B
33 m/sec	Low damage risk zone

The wind speed zoning map of Tamil Nadu as per the Vulnerability Atlas of India is shown in Fig.1. Tamil Nadu falls in three categories of the wind zones

50 m/sec	Very high damage risk zone – B
47 m/sec	High damage risk zone
44 m/sec	Moderate damage risk zone – A

Importance factor to be considered for the following types of buildings is:

Special Buildings including Societal buildings, Schools, Hospitals	- 1.3
Industrial structures	- 1.1
Normal buildings	- 1.0

Earthquakes:

Though not as seismically active as States in the northern and western parts of the country, small to moderate earthquakes have occurred in the state of Tamil Nadu. Earthquakes in the state of Tamil Nadu are mid-plate in nature and the frequency of earthquakes is low i.e. the gap between moderate sized events is fairly long. Tremors have been felt in almost every corner of the state, mostly from distant earthquakes in adjoining States or from the Indian Ocean. Historically however, most earthquakes have originated in western and northeastern regions. Seismic activity in the recent past has occurred in clusters along the borders with Andhra Pradesh, Karnataka and Kerala.

Several faults have been identified in this region out of which many show evidence of movement during the Holocene period. The east-west trending Cauvery Fault, Tirukkovilur - Pondicherry Fault and Vaigai River Fault and the north-south trending Comorin-Point Calimere Fault and Rajapatnam-Devipatnam Fault are some of them and run close to major urban centres like Coimbatore, Madurai, Nagapattinam, Thanjavur and Pondicherry.

Latest Seismic zoning map of Bureau of Indian Standards classifies Tamil Nadu into two categories - Zone II and Zone III which are under low risk and Moderate risk respectively (Fig.2.).

Summary:

These guidelines have been specifically framed for the reconstruction of houses considering multi hazard perspective, for the communities which have been affected by the tsunami of 26th December 2004 in coastal districts of Tamil Nadu. These guidelines will also be helpful for the construction of houses in other districts apart from the coastal districts, which are prone to cyclones and earthquakes.

For high-rise residential buildings or for buildings having spans larger than 3m, the structural design should be made by a qualified structural engineer incorporating the provisions of the codes referred in this document. Such analysis and design should be proof checked and cleared by specialized agencies such as Structural Engineering Research Center (SERC), CSIR campus, Taramani, Chennai and IIT (Madras) or Structural Engineering Division, Anna University.

Public buildings such as schools, hospitals etc. should be suitably planned and designed. For such buildings, analysis and design can be carried out through the specialized agencies mentioned above.

Figure 1

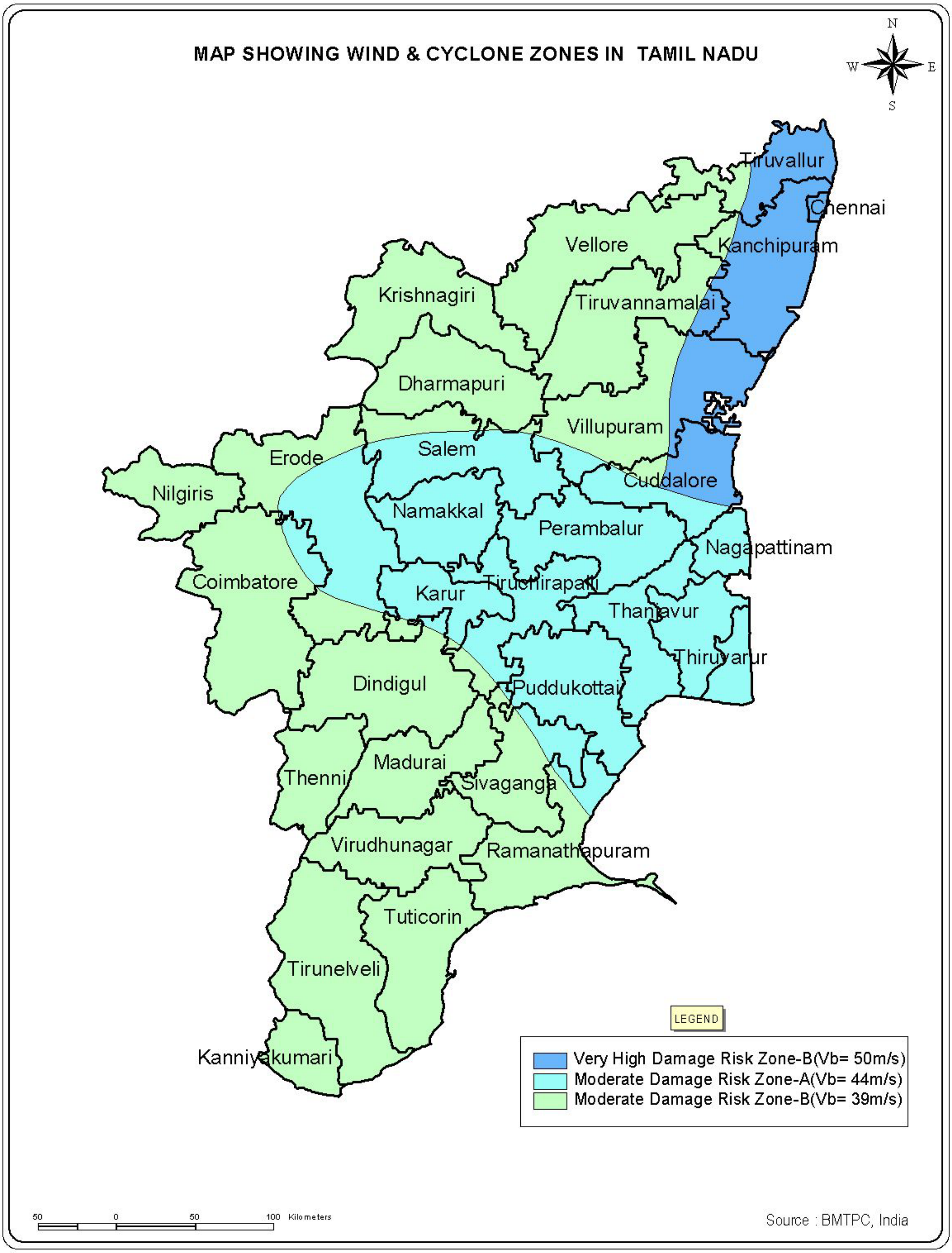
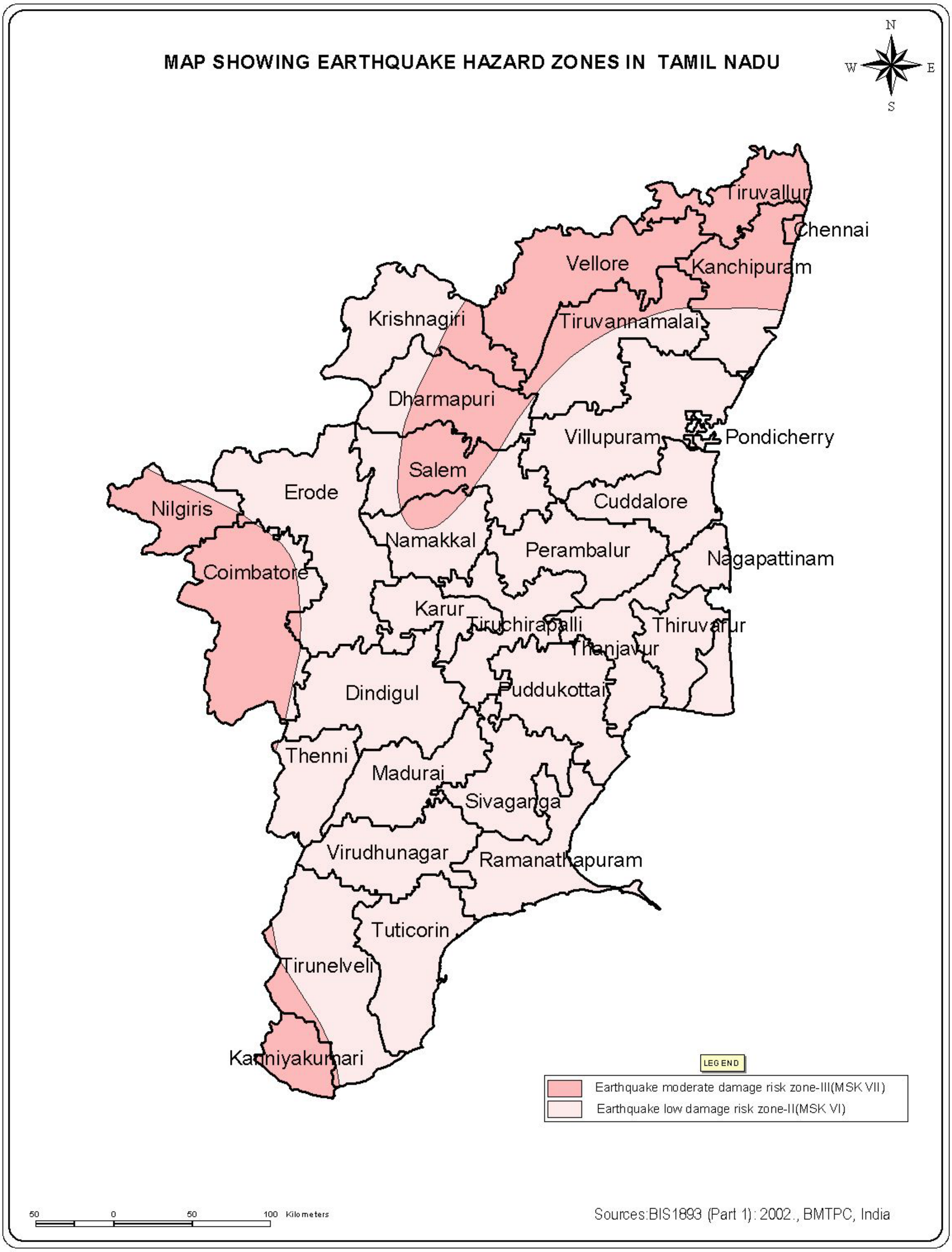

MAP SHOWING WIND & CYCLONE ZONES IN TAMIL NADU
N
W
E
S
Tiruvallur
Chennai
Kanchipuram
Vellore
Krishnagiri
Tiruvannamalai
Dharmapuri
Villupuram
Salem
Erode
Cuddalore
Nilgiris
Namakkal
Perambalur
Nagapattinam
Coimbatore
Karur
Tiruchirapalli
Thanjavur
Thiruvarur
Dindigul
Puddukottai
Madurai
Thenni
Sivaganga
Virudhunagar
Ramanathapuram
Tuticorin
Tirunelveli
Kanniyakumari
LEGEND
Very High Damage Risk Zone-B(Vb= 50m/s)
Moderate Damage Risk Zone-A(Vb= 44m/s)
Moderate Damage Risk Zone-B(Vb= 39m/s)
50 0 50 100 Kilometers
Source : BMTPC, India

Figure 2


MAP SHOWING EARTHQUAKE HAZARD ZONES IN TAMIL NADU
N
W
E
S
Tiruvallur
Chennai
Vellore
Kanchipuram
Krishnagiri
Tiruvannamalai
Dharmapuri
Villupuram
Pondicherry
Salem
Erode
Nilgiris
Cuddalore
Namakkal
Perambalur
Nagapattinam
Coimbatore
Karur
Tiruchirapalli
Thiruvarur
Thanjavur
Dindigul
Puddukottai
Thenni
Madurai
Sivaganga
Virudhunagar
Ramanathapuram
Tuticorin
Tirunelveli
Kanniyakumari
LEGEND
Earthquake moderate damage risk zone-III(MSK VII)
Earthquake low damage risk zone-II(MSK VI)
50 0 50 100 Kilometers
Sources:BIS1893 (Part 1): 2002., BMTPC, India

1.0 SITING OF BUILDING

A. Essential Requirements

1. During very high velocity winds, the coastal areas suffer due to storm surge where huge loss of property takes place. Site selection should avoid areas likely to be submerged. It is desirable to locate the site such that it is
    a. At least 500m from the shore and
    b. +5m above Mean Sea Level
2. The sites need to be close to the present settlement. It should preferably be within a distance of one km from the present settlement so as to facilitate the fishers to carry out their economic activities easily.
3. Building should be located on stable foundation on soil strata having no susceptibility for liquefaction.
4. Terrain category and topography of the site should be assessed and based on these correct orientations of the buildings should be finalized.

B. Desirable

1. The area behind a mound or a hillock (Fig.3) or behind casuarinas plantation should be preferred in order to provide natural shielding (Fig.4).

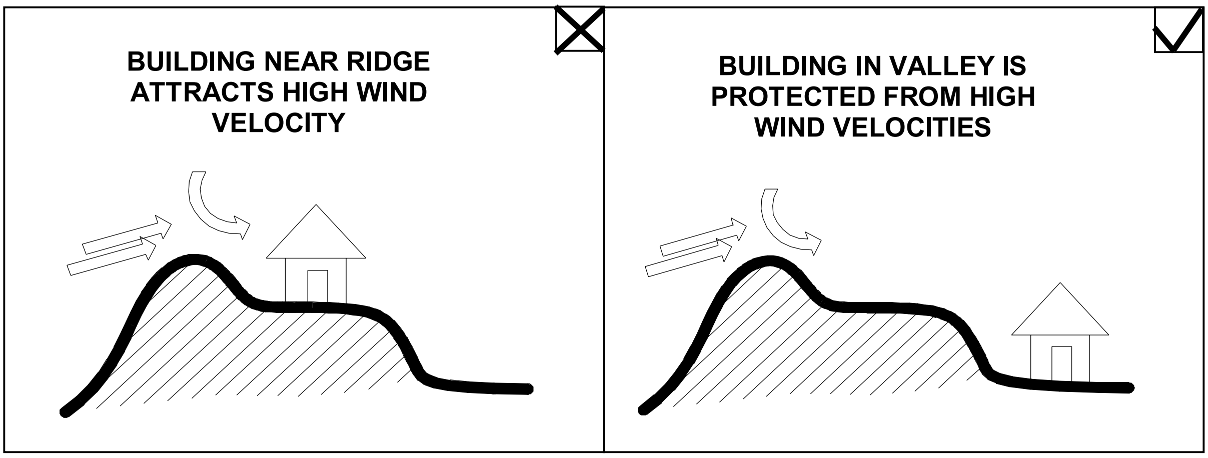


Fig.3

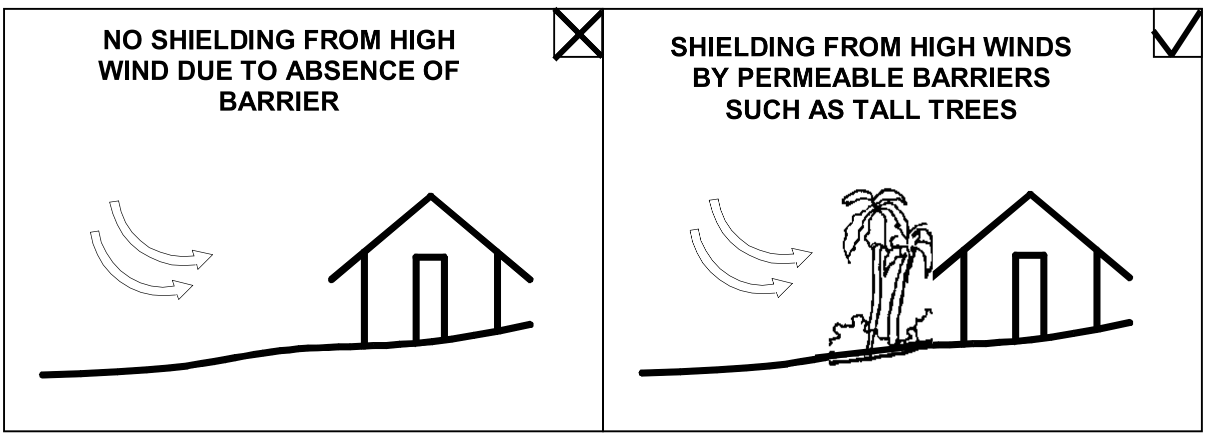


Fig.4

2. In case of non-availability of high-level natural ground, construction can be done either on raised earthen mounds or on stilts with no masonry or cross- bracing up to maximum tide level. In such cases the stilts should be strengthened by proper Knee bracings (Fig.5).

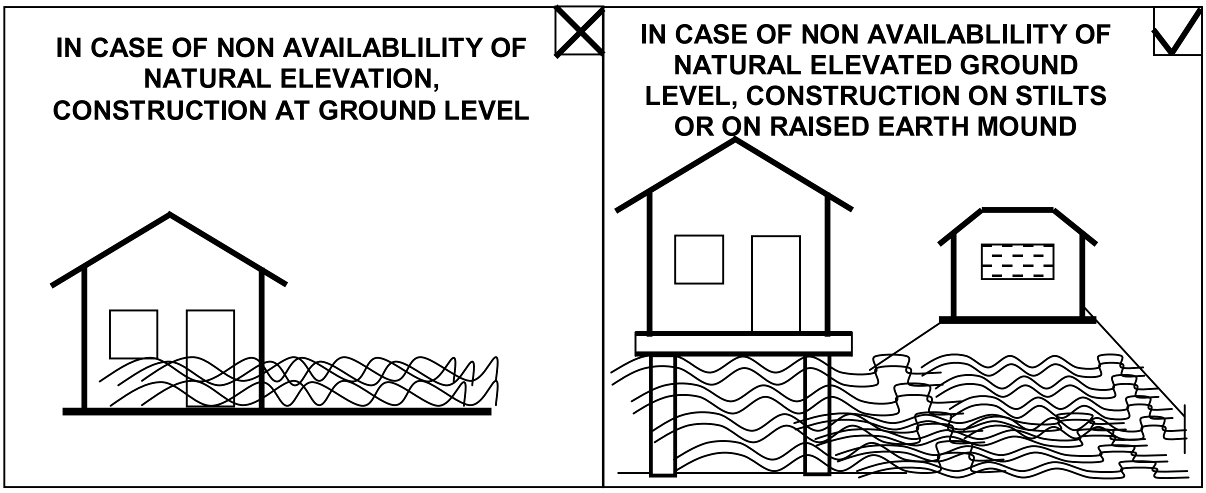


Fig.5

2.0 PLANNING ASPECTS

A. Essential Requirements

1. For individual buildings, a circular or polygonal plan shape is preferred over rectangle or square plans, but from the viewpoint of functional efficiency square plan form is desirable (Fig.6).

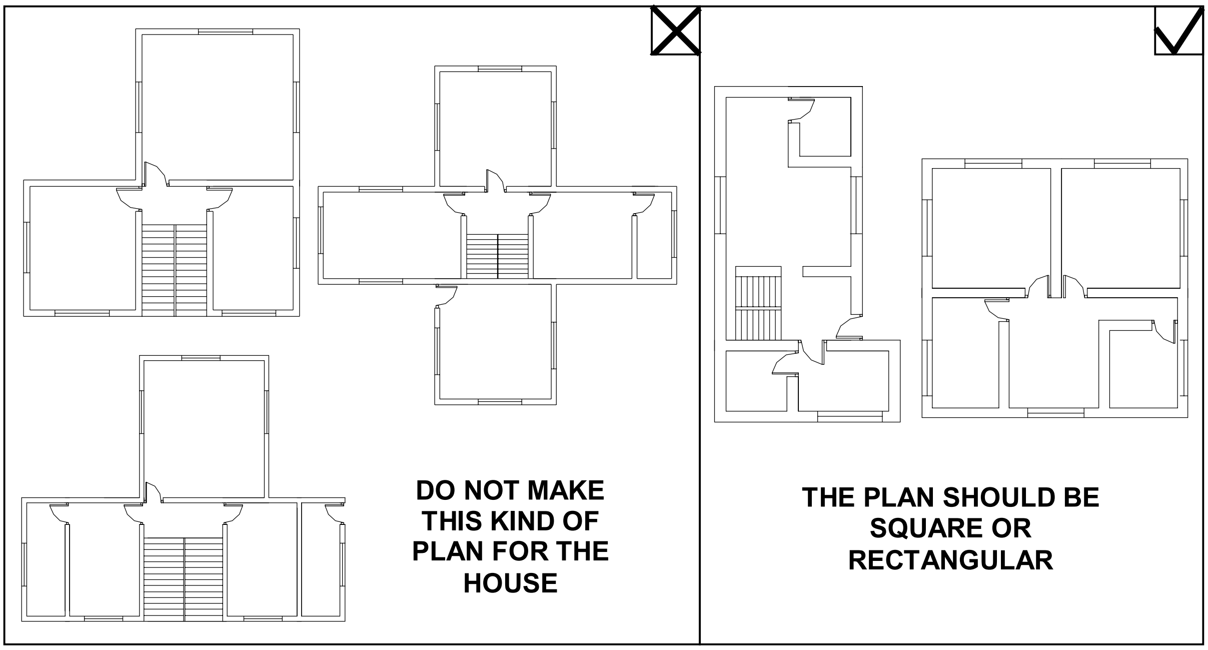


Fig. 6

2. A symmetrical building about both axes with a compact plan-form is more stable than a zigzag plan, having empty pockets. The latter is more prone to wind/ cyclone related damages (Fig.7).

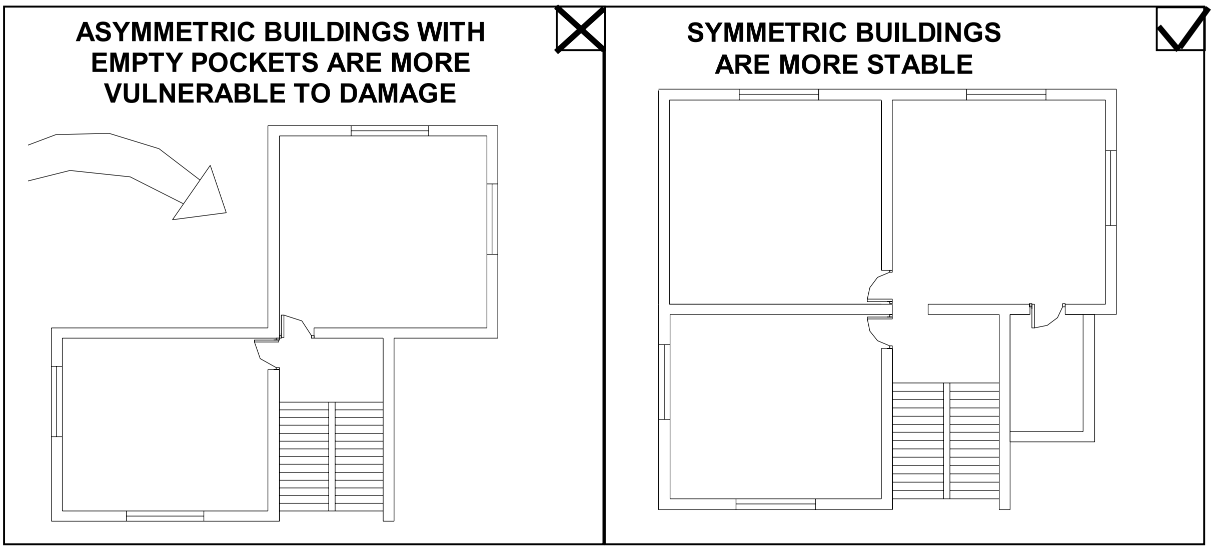


Fig. 7

3. In case of locating a group of buildings, a cluster arrangement should be chosen in preference to row type buildings (Fig.8).

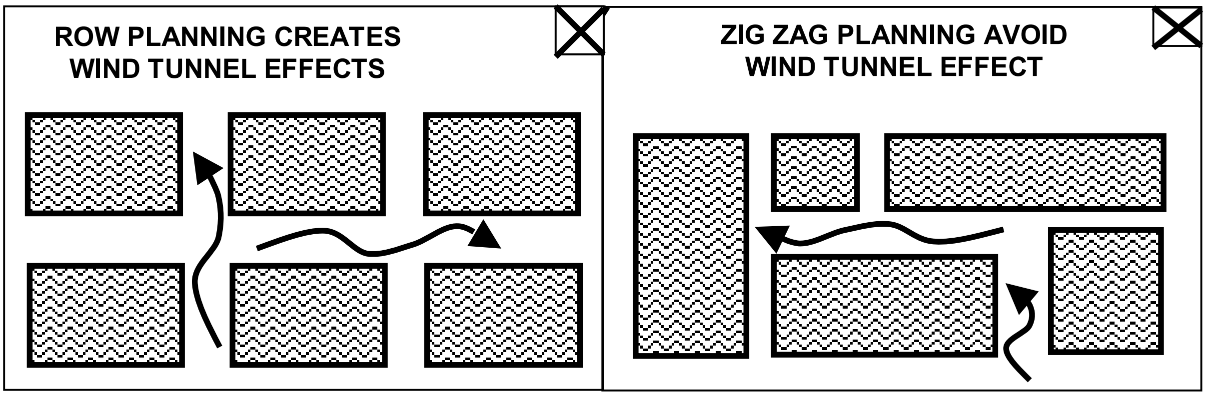


Fig - 8

4. The buildings should be oriented in such a manner that the shorter span length of the wall faces the sea (Fig.9).

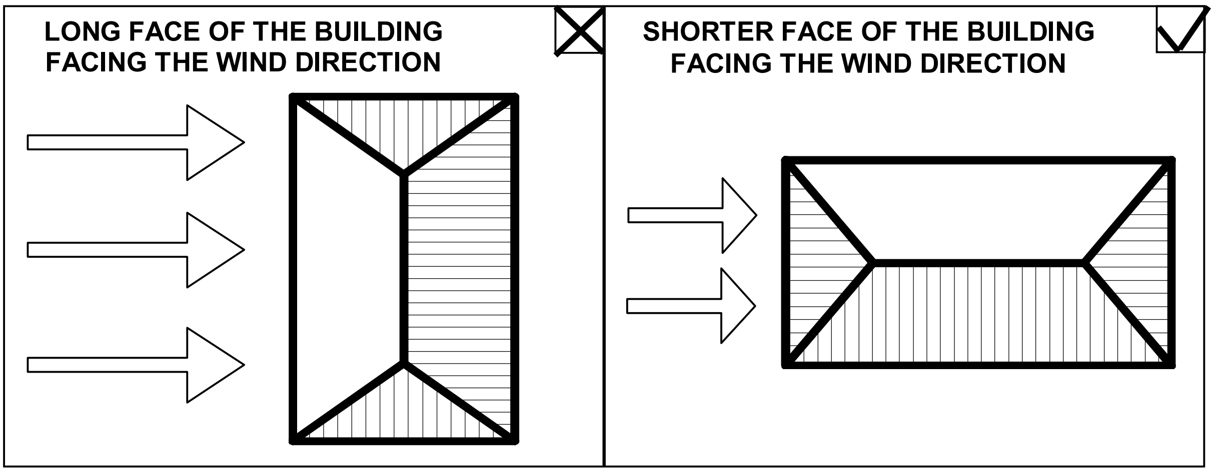


Fig.9

5. Aspect Ratio of the building (Length to Width ratio of the building) should not be greater than 3.
6. Ornamental architecture involving large cornices, vertical or horizontal cantilever

projection, fascia stones and the like should be avoided.

7. The opening in the building will encourage flooding. Hence large openings on the seaside should be avoided.

B. Desirable

1. The plan of the building could be square or rectangle from functional point of view. Near circular shape may give the least obstruction to wind or floodwaters.
2. The individual or twin type units are to be adopted in preference to multistoried or high-rise development to facilitate the day-to-day activities of fishers subject to availability of land.
3. The plinth area of each dwelling unit should be about 23 Sq.mt. (250 Sq. ft.) to 28 Sq.mt. (300 Sq.ft.)

3.0 CONSTRUCTION OF DWELLING UNITS

3.1 SOIL INVESTIGATION

A. Essential Requirements

1. In relocated village sites, it will be essential to carry out soil exploration using bore logs for soil classification and for determining Standard Cone Penetration Values.
2. Depth of water table should be recorded for each site by boring or by enquiries for dry as well as monsoon seasons.
3. Buildings should be founded only on soils of sufficient safe bearing capacity. It should not be constructed on loose sands and soft clays saturated with water susceptible for liquefaction. It is desirable that information about soil type be obtained and estimates of Safe Bearing Capacity made available from records of past constructions in the area or by proper soil investigation.
4. The soil should be tested to know the allowable bearing capacity at a grid spacing of 100m x 100m.

B. Desirable

1. Poor soils can be improved by proper ground improvement techniques.

3.2 FOUNDATION

A. Essential Requirements

1. Buildings can have shallow foundation on stiff sandy soil.
2. The Tsunami recently caused saturation of soil significantly. It has affected the safe bearing capacity of the soil. When there is risk of scouring due to storm surge minimum depth of foundation 1.5m below natural ground level may be provided in coastal regions.

In other regions it can be 1m. The receding tides have a tendency to scour the soil below the foundation. Hence the soil protection work around the building in the form of a raised ground must be considered (Fig.10).

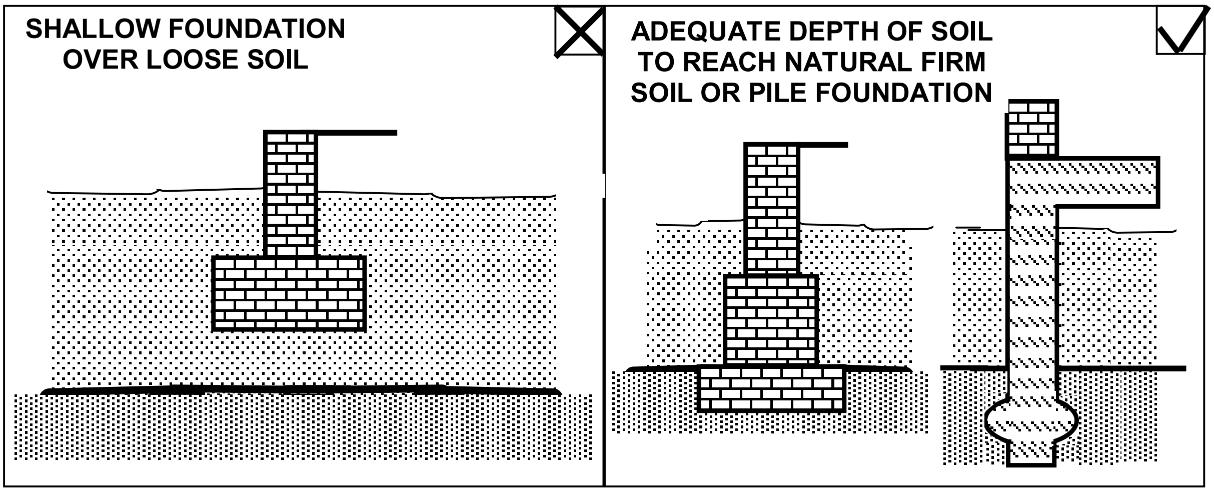


Fig.10

3. Where a building is constructed on stilts, these stilts should be properly braced in both the principal directions. This will provide stability to the complete building under lateral loads. Knee braces can be preferred to full diagonal bracing so as not to obstruct the passage of floating debris during tidal surge/ tsunami.
4. The depth of footing in the soil should go below the level of shrinkage cracks in clayey soils (Fig.10).
5. In firm soil conditions, individual or strip type foundation can be used.
6. It should have a firm base of lime or cement concrete of minimum proportion (1:4:8) with requisite width of two and half times the thickness of wall (not less than 0.8m) over which the construction of the footing may start (Fig.11). The minimum depth of foundation should be as indicated in Fig.12.

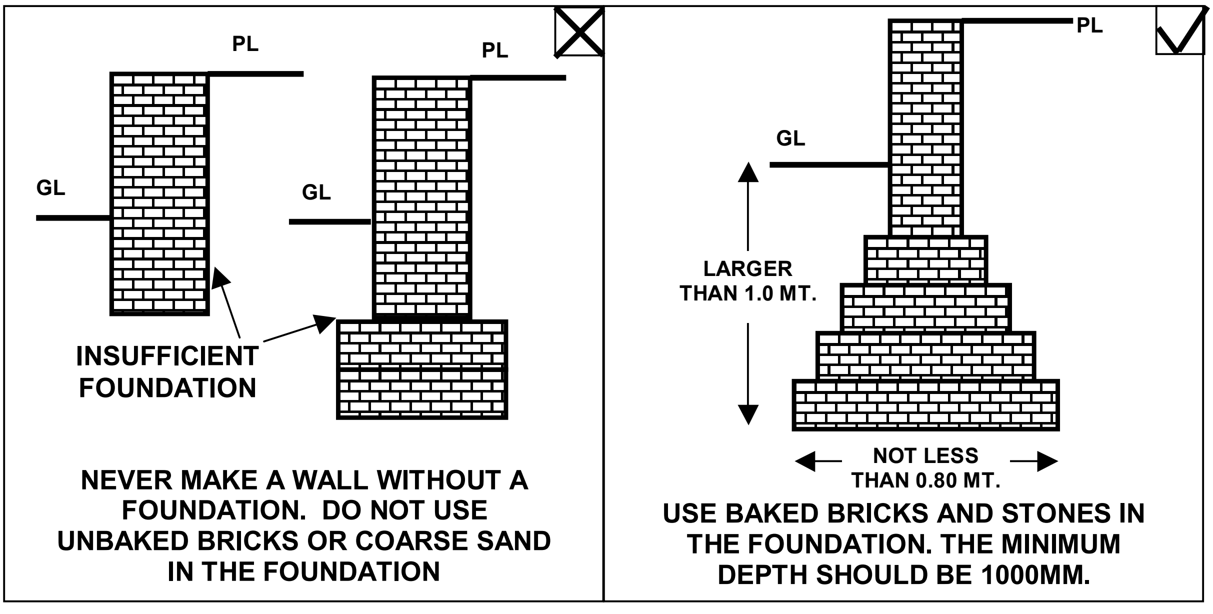


Fig.11

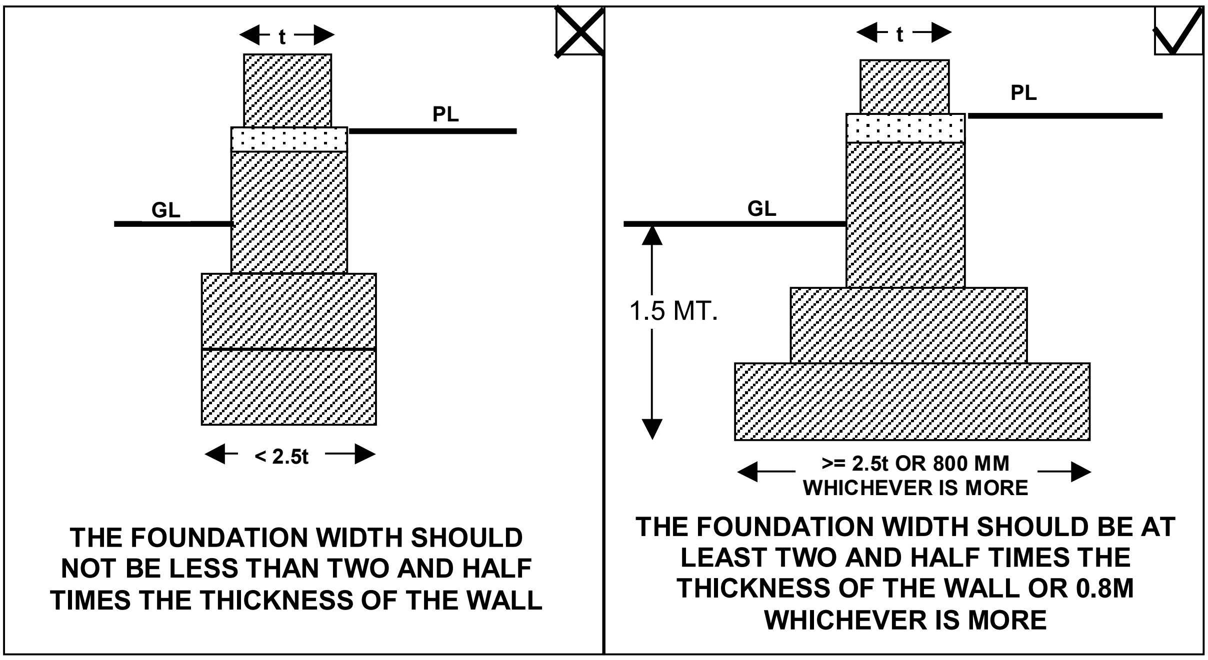


Fig. 12

7. It will be desirable to connect the individual reinforced concrete column footings by means of RC beams below natural ground level. These bands will be intersecting at right angles and form an integral housing unit. The ground beam should be in one level and be connected continuously.
8. The vertical reinforcement at corners and jambs of doors and windows should emanate from ground level beam.
9. Horizontal beam at ground level or plinth level must be provided. It is desirable to provide the same at both the places (Fig.13)

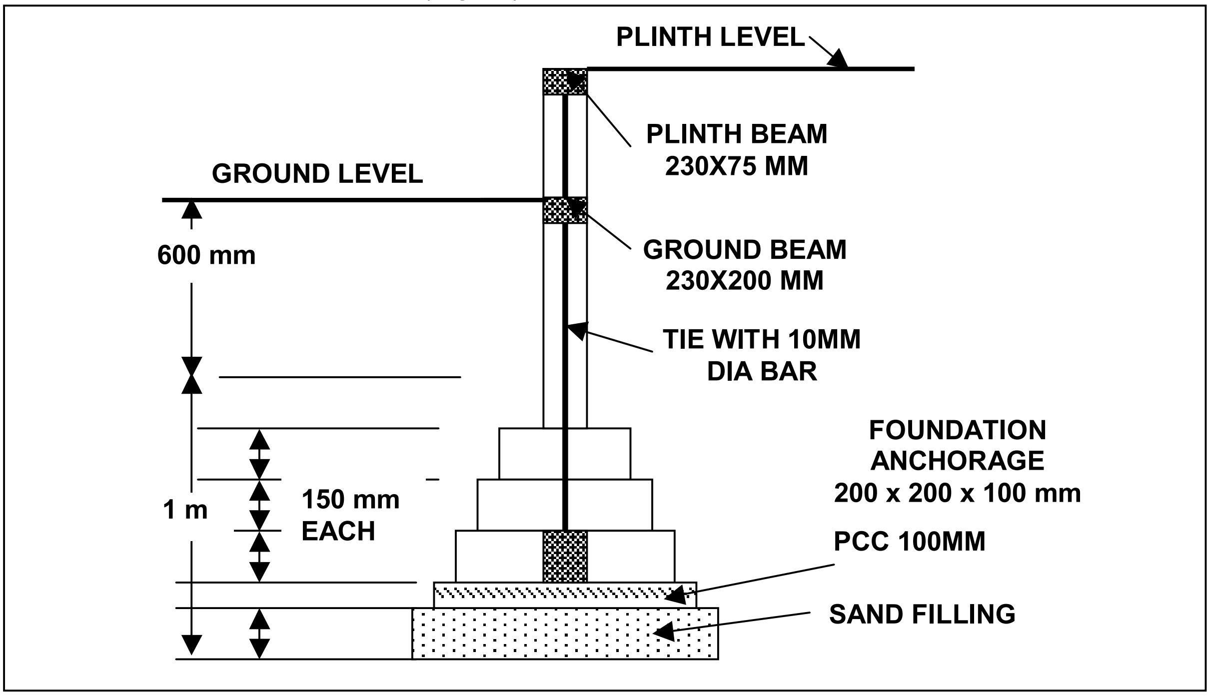


Fig.13

10. All the vertical bars should have a minimum 'L' bend length of 45 cm (1.5 feet).

11. The plinth height should be not less than 0.6m feet above natural ground level or as per topography requirement.
12. In case of strip footing a RC band of 100mm thickness to the width of the brick masonry should be provided all along the portion and connected to the RC band or slab provided at bottom of foundation of minimum cross section 100 x 100 mm.

B. Desirable

1. Continuous reinforced concrete footings are considered to be most effective from earthquake considerations as well as to avoid differential settlements under normal vertical loads and loss of contact during flooding. Hence they are preferable. They offer better resistance to scouring.
2. In case of soft soil or filled up soil where the safe bearing capacity near Ground level is very less, pile of single under ream or double under ream should be provided.
3. Where the foundation is on rock, it shall be excavated at least to a depth of 50 mm to provide a key for the foundations.

3.3 Walling

A. Essential Requirements

1. All external walls or wall panels must be designed to resist the out of plane lateral pressures adequately. For this, the walls should be sufficiently buttressed by the transverse walls or pilasters. The lateral load due to wind/ tidal surge/ tsunami should finally be resisted either by walls lying parallel to the lateral force direction (by shear wall action) or by RC frames to which the panel walls are fixed using appropriate Reinforcement such as Seismic Bands at window sill and lintel level. This will avoid collapse due to out of plane forces.
2. A small building enclosure with properly interconnected walls is preferable. Buildings having long wall should be avoided (Fig.14).

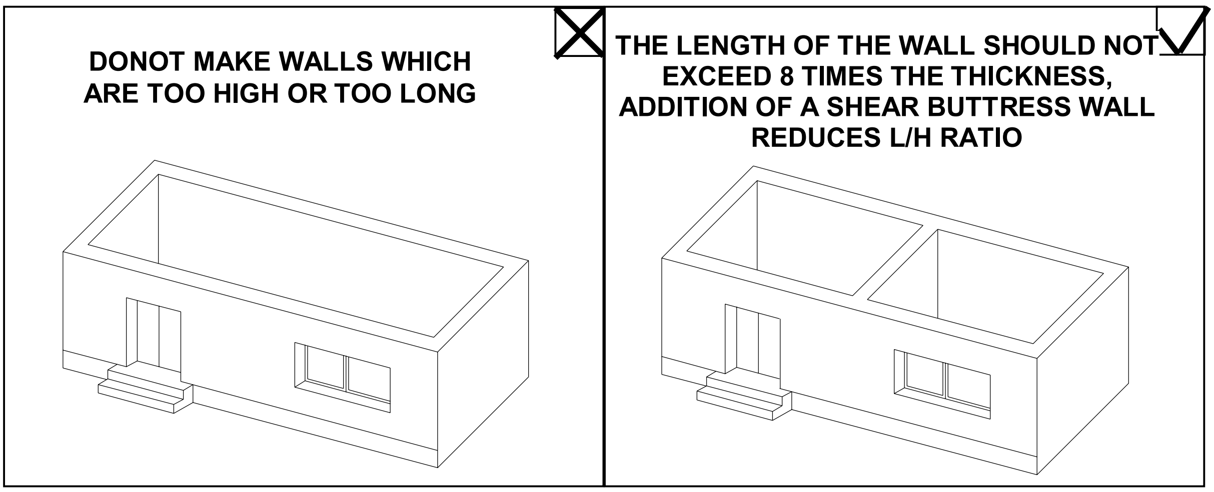


Fig.14

3. It is necessary to reinforce walls by means of horizontal reinforced concrete bands and vertical reinforcing tie members having reinforcing bars as suggested for earthquake resistance. This will make the building act as an integral unit under lateral forces (Fig.15)

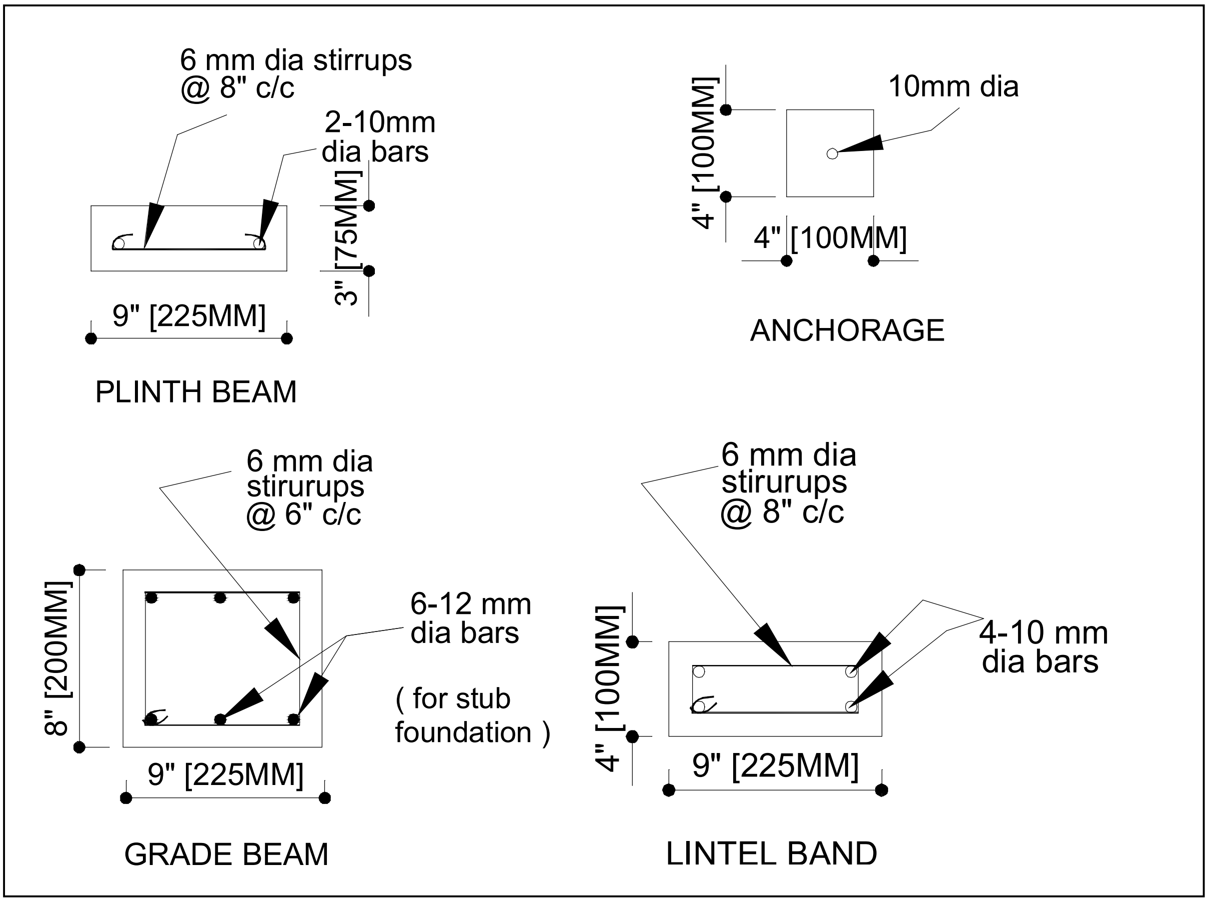


Fig.15

4. The thickness of the load bearing walls should not be less than 200 mm (Fig.16).

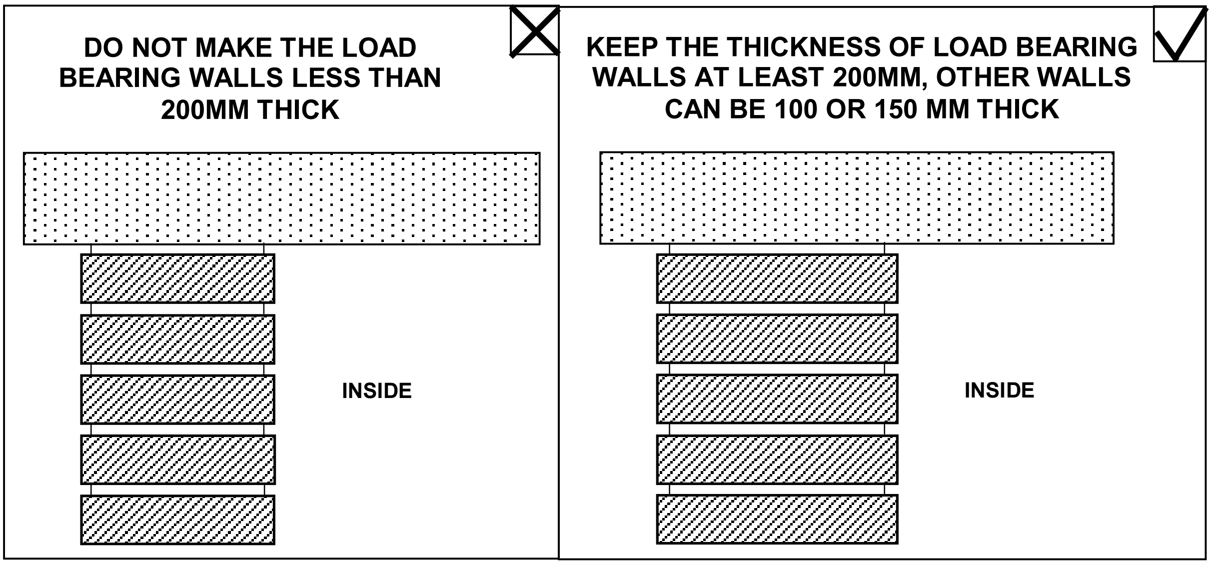


Fig.16

5. Since tensile and shear strength are important for lateral resistance of masonry walls, use of mud or very lean mortars should be avoided. A mortar mix leaner than 1:6 by volume or equivalent in strength should not be used.
6. For achieving full strength of masonry, the usual bonds specified for masonry should be followed so that the vertical joints are broken properly from course to course (Fig.17).

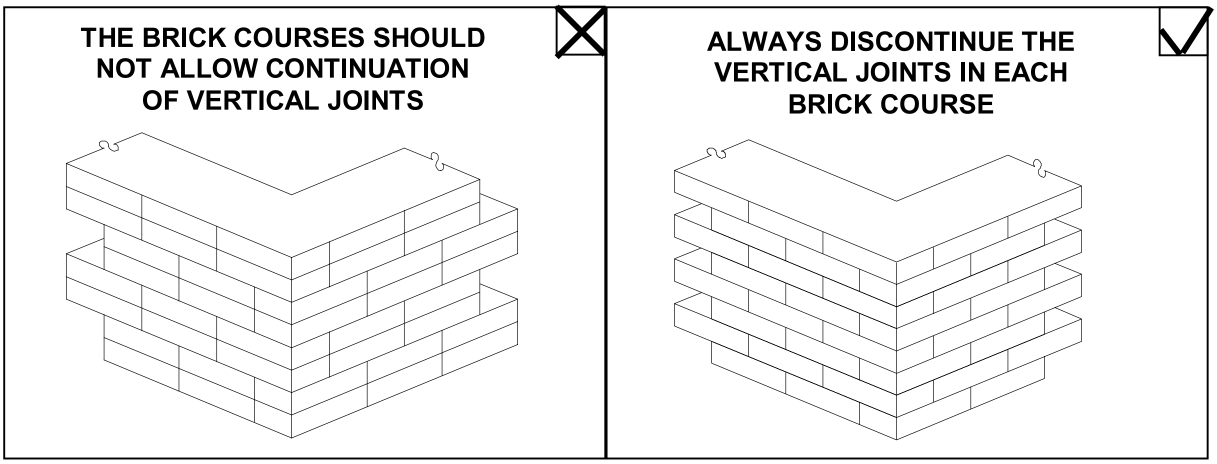


Fig.17

7. The toothed joints in masonry work should be avoided since they are hollow & weak mostly.
8. To obtain full bond, it is necessary to make a sloping (stepped) joint by making the corners first to a height of 600mm and then building the wall in between them. Otherwise the toothed joint should be made in both the walls alternately in lifts of about 45cm.
9. For framed building, the necessary principles of Anchorage, Bracing and Connectivity and continuity must be maintained.
10. The reinforcing bars in corners and jambs of opening should be surrounded by concrete of size 100x100 mm of grade M 20 or more (Fig.18).

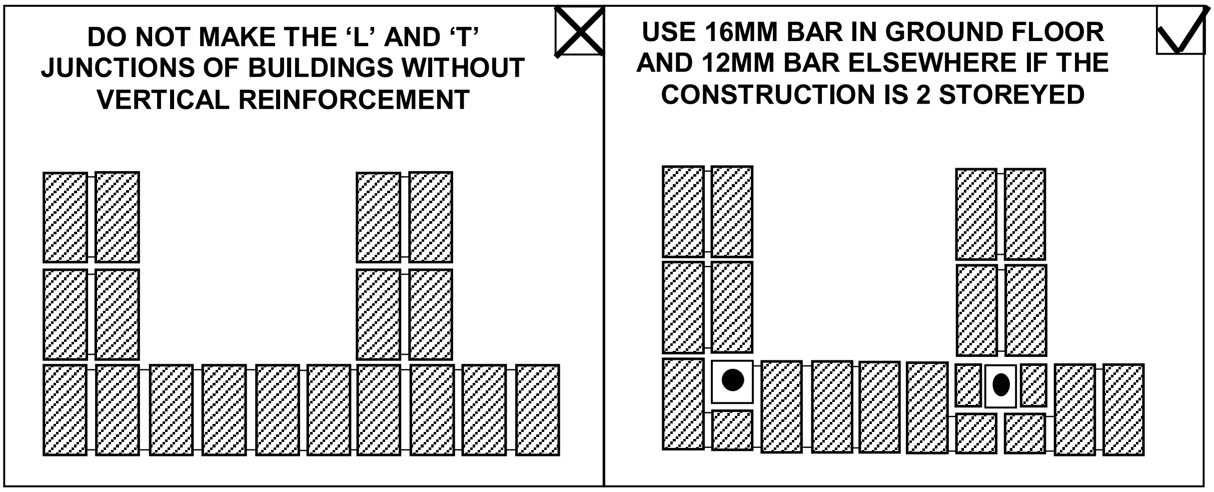
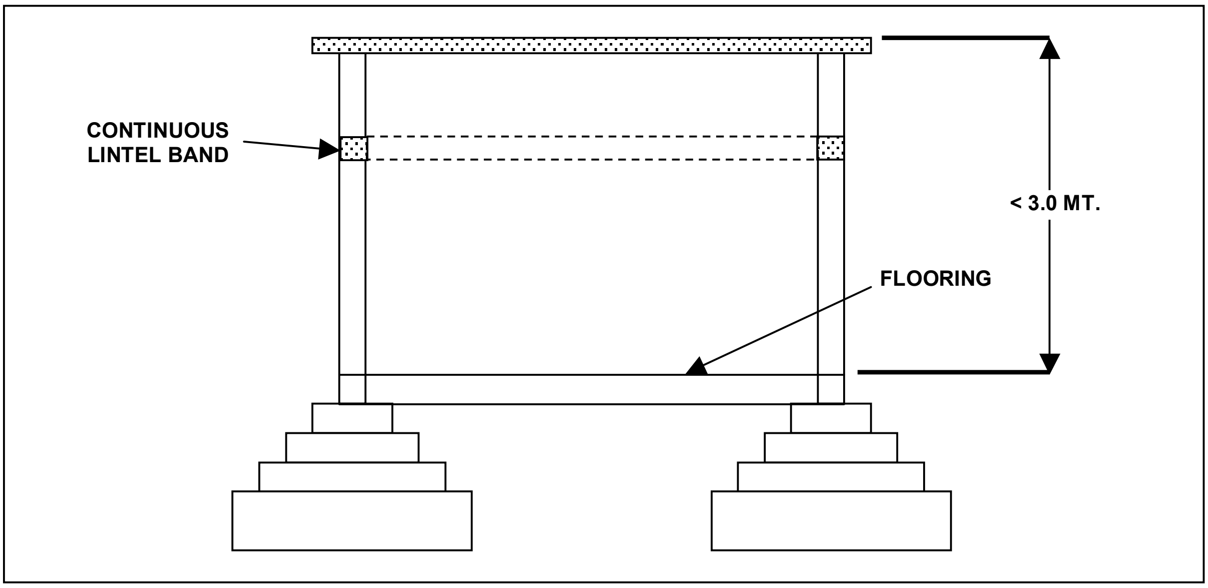


Fig. 18

11. Plastering with 1:5 is a must for the brickwork to protect the bricks from salinity.



12. The wall thickness should be not less than 230 mm (9”) and the wall height should be not less than 2.8m (9 feet) for flat roof slab.
13. Continuous lintel has to be provided for the partition wall also and height of floor should be less than 3000mm (Fig. 19 and Fig. 20).

Fig.19

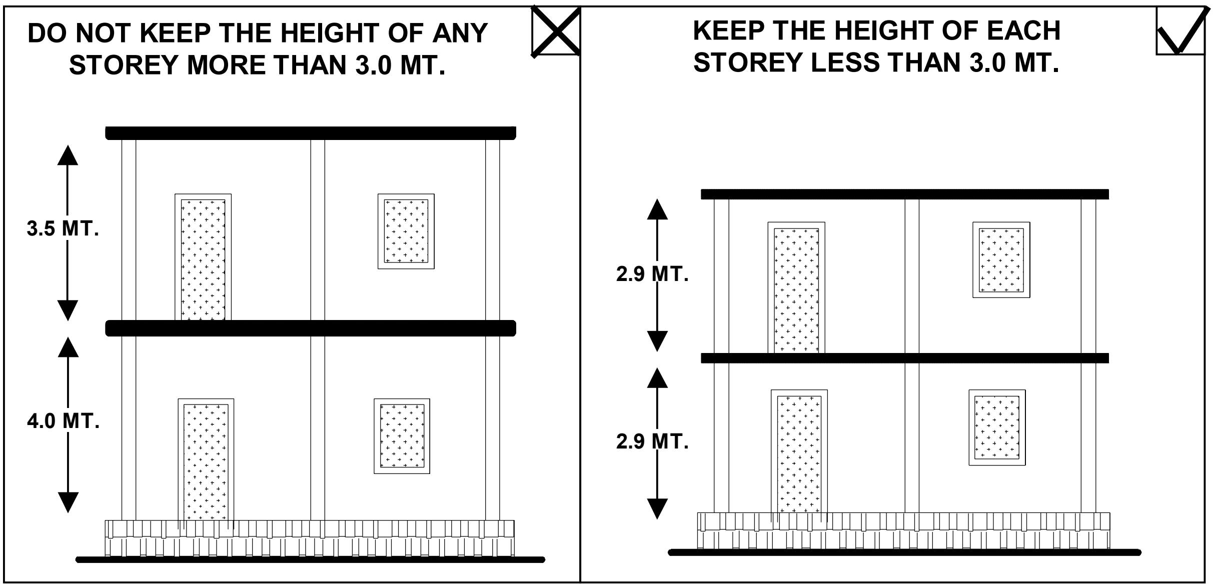


Fig. 20

B. Desirable

1. First class bricks of strength not less than 45 kg/ sq.cm may be used. If the building is of single storey, brick strength of 35 kg/ sq.cm can be used.
2. Masons may be trained before actual execution

3.4 Roofing

A. Essential Requirements

1. Minimum of 100mm thick concrete of M20 concrete should be provided.

2. Vertical reinforcement bars should be tied and anchored in the roof slab.
3. A roof band is to be provided within the roof slabs above the wall having minimum of 2 rods provided within the slab.
4. There should be a weathering course and a pressed tile layer on the top of the roof.
5. Cantilevers are to be well anchored to protect them from earthquake damage (Fig.21)

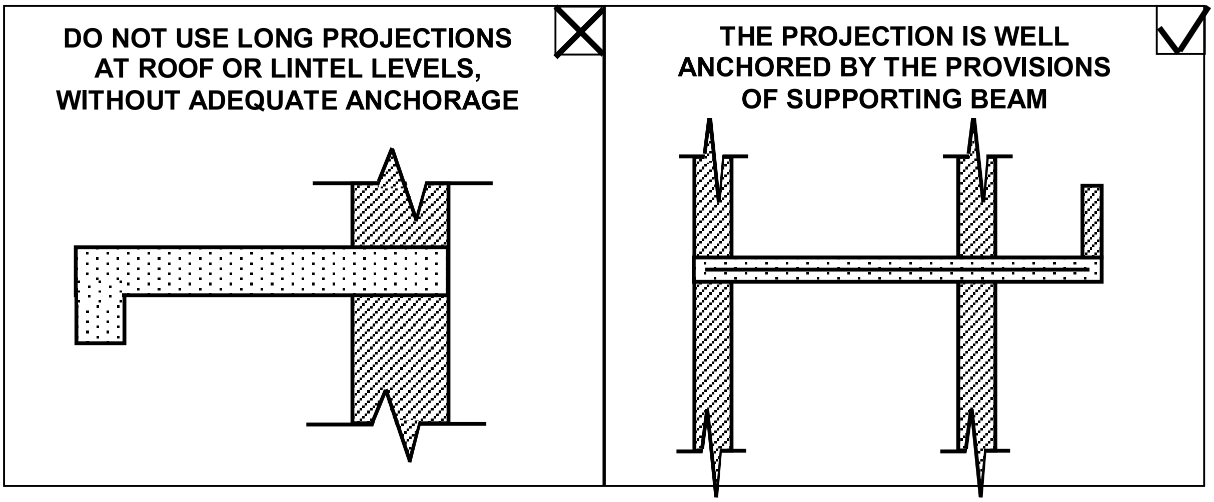


Fig.21

B. Desirable

1. A flat RCC roof is preferable to the gable type roof.
2. Light weight (G.I or AC sheets) low-pitched roofs should either be avoided or strongly held down to purlins. Pitched roofs with slopes in the range of 22^o to 30^o i.e., pitch of 1/5 to 1/3.5 of span will reduce suction on roofs and facilitate quick drainage of rainwater.
3. A gentle slope provided for the flat roof will enable quick drainage of rainwater.

3.5 Openings

A. Essential Requirements

Openings in general are areas of weakness and stress concentration, but are needed for lighting and ventilation.

1. The openings should be avoided in walls facing the sea.
2. Openings to be located away from the corners by a clear distance equal to at least 1/4 of the height of opening or 60cm which ever is more (Fig.22).

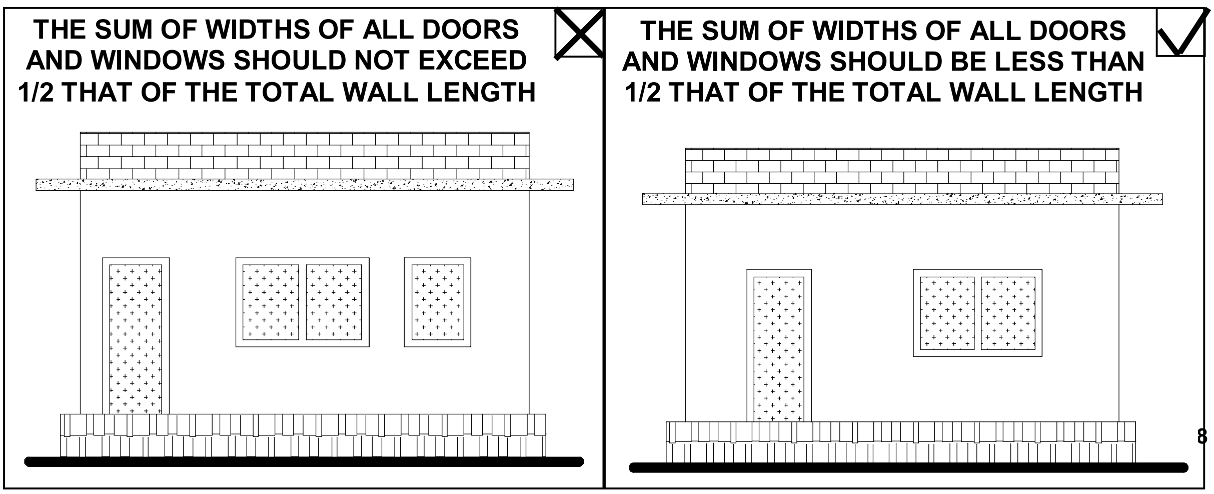


Fig.22

3. The total length of openings not to 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.
4. The horizontal distance (pier width) between two openings should be not less than 50% the height of the shorter opening but also not less than 60cm (Fig.23).

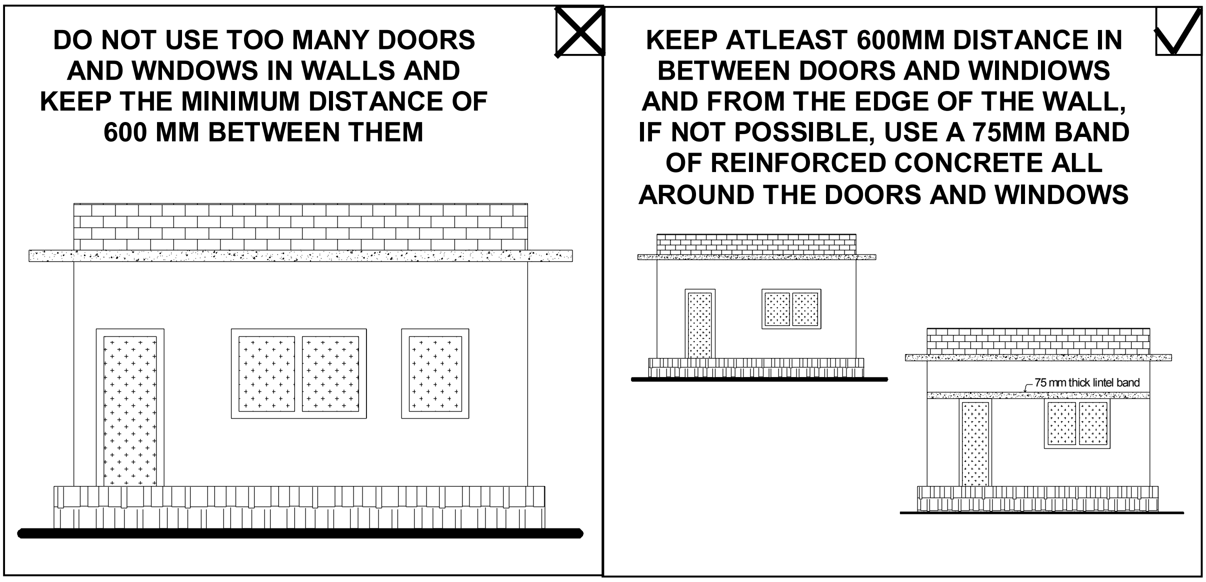


Fig.23

5. The vertical distance from an opening to an opening directly above should not be less than 60cm and not less than 1/2 of the width of the smaller opening.

B. Desirable

1. The materials for doors & windows should be wood or pre-cast concrete. The use of iron, steel window or door should be avoided from corrosion point of view.
2. It is desirable to provide reinforced bands or ties around the openings and the window frame should be well anchored in the wall (Fig.24).

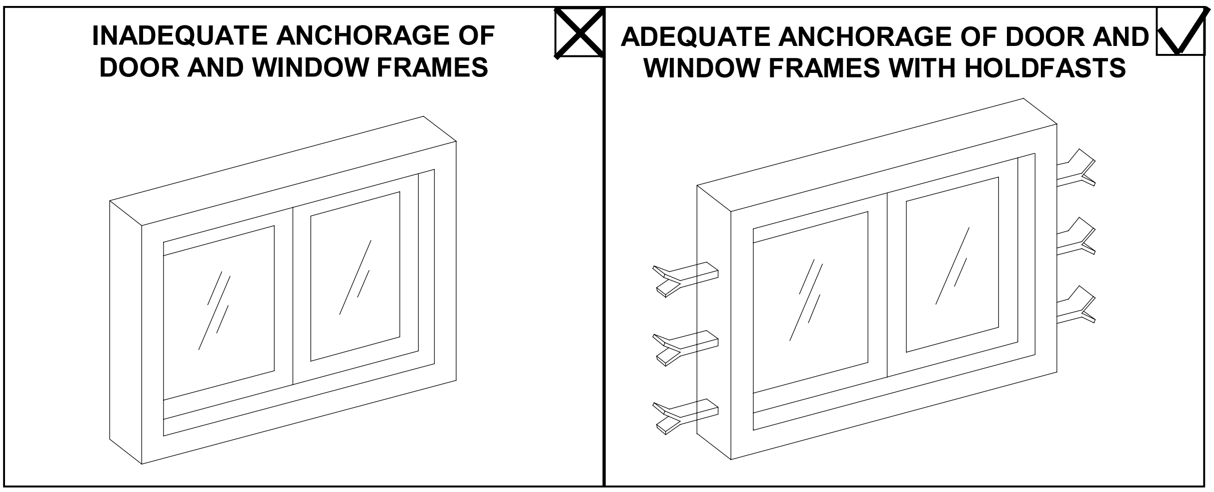


Fig.24

3.6 Flooring

A. Essential Requirements

1. The soil below the floor should be well compacted.
2. If the floor length is more than one and half times the width, a divider-reinforced band may be provided over the compacted soil base.

B. Desirable

1. The flooring is preferable to be made with a hard metal concrete base over well-compacted soil.

3.7 Drainage

1. The rainwater should not be allowed to weaken the foundation due to water logging problems. It is preferable to provide an apron around the building.
2. The wastewater from kitchen and bath should be disposed off properly through the drain.
3. Roof top rainwater harvesting system is to be provided.

4.0 Quality control

1. The construction as well as curing should be done only with good quality of water.
2. The PCC in foundation of 1:4:8 should be made over well-compacted soil.
3. The cement mortar not leaner than the minimum grade 1:6 should only be used for construction of brick work (Fig.25).

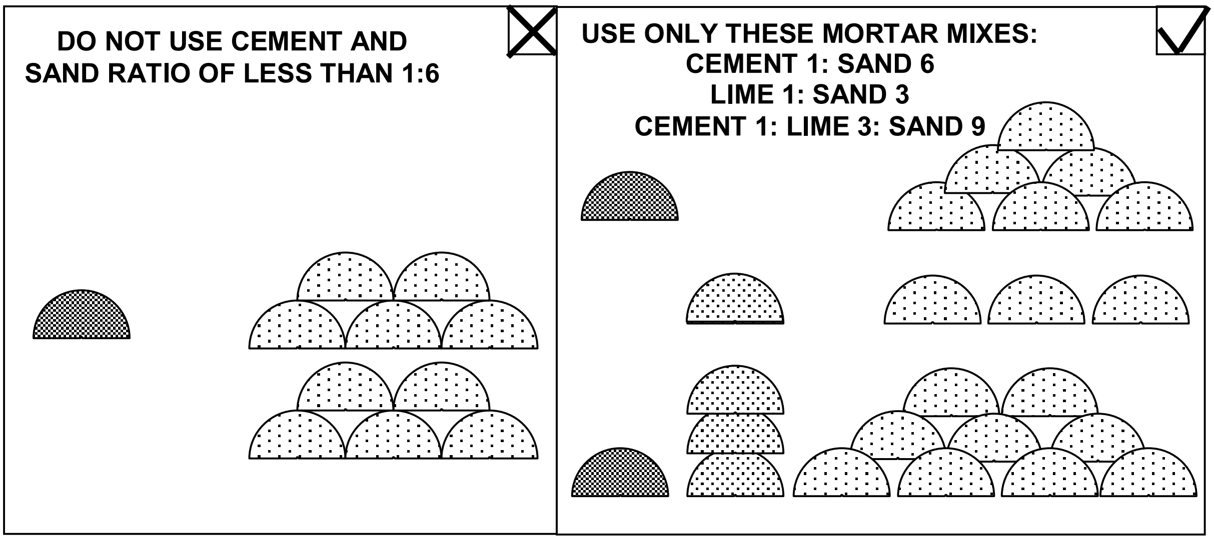


Fig.25

4. The reinforcement bars should be properly detailed. i.e., bent with proper hooks at ends of the beams and bands with adequate anchorage.
5. The thickness of band should be not less than 75mm with 2 rods of 10 mm diameter and tied with properly detailed hooks / bends.

6. Concrete work of 1: 1.5: 3 and water/ cement (w/c) should not exceeding 0.4 should be used in coastal area. It is preferable to use Pozzolana cement instead of Ordinary Portland Cement (OPC) and Corrosion Resistant Steel (CRS) bars instead of Cold Twisted Deformed (CTD) bars in coated steel.
7. The cover to the reinforcement bars in beams and slabs should be maintained as per ISI codes. In any case a minimum cover of 20mm should be ensured.
8. Due inspection should be made for ensuring quality control during concrete construction.

A. __Measuring Materials__

In non-engineered reinforced concrete constructions, the proportions of concrete mix are usually kept 1:1.5:3 by volume of cement: sand: aggregate. The aggregate may be in the form of river shingle, or crushed stone, of maximum 20mm size. A 50kg cement sack has a nominal volume of 0.0317m3. It will be best to make the concrete mixture using whole bags of cement. For measuring sand and aggregate, a wooden box with handles having a volume equal to one sack of cement will be most appropriate as well as convenient to use. Such box can also be made of steel sheets.

B. __Mixing Materials__

Where mixing is done manually without using a power driven mixer, it should be done on an impervious platform, say, using iron sheets or cemented floor. For making a mix of 1:1.5:3, three boxes of aggregates should first be measured and flattened on the platform, then 1.5 boxes of sand should be spread on the aggregate and finally one full sack of cement opened on top. The material should first be mixed thoroughly in dry state so as to obtain uniform color and then water should be added. The quantity of water should be enough to make a soft ball of the mixed concrete in hand. A little wetter mix is better for hand compaction and drier mix where vibrator is used for compaction. The quantity of water used should be limited to ensure a w/c ratio of not more than 0.4 in coastal areas and 0.5 in other areas.

C. __Formwork__

Wooden formwork with well-formed surface and joints between planks should be used. Use of water resistant plywood for the skin of the formwork will give very good surface finish for the concrete. It is preferable to use steel formwork for the roof slab.

D. __Placing of Reinforcement__

While placing reinforcing bars, the following recommendations must be ensured. Minimum clear cover to the reinforcement: 20 mm to the bars in slabs, 25mm to bars in beams and columns. In large columns, say 450mm in size, the cover should be 40mm. For achieving proper cover, a simple and effective method is to make cement mortar cover blocks of required size and install them between the bars and formwork. Tying with bars with thin binding wire will ensure that the cover blocks do not get dislodged during concreting. The following points should be ensured

- Tying of longitudinal bars with transverse bars and stirrups and links at each crossing with soft binding wire. The end of binding wire should be turned inwards so that it does not touch the formwork.
- Minimum overlap in bars: 45 times the diameter of the bar for Plain mild steel and 60 times the diameter for high strength deformed bar. The overlapping portion should be wound with binding wire.
- Shape of links and stirrups: the ends of bars should be hooked by bending through 180º for straight bars and 135º in case of stirrups.

E. Casting and Compacting Concrete

The concrete should normally be cast in one continuous operation so as to avoid discontinuity of more than one hour. Mixed concrete should not be allowed to stay on the platform for more than 45 minutes and must be placed in the forms and compacted continuously. Hand compaction must be done by poking through the freshly placed concrete. Simply leveling the surface with trowels will leave voids in the concrete mass. It may be mentioned that lack of compaction results in large reduction in concrete strength, hence utmost attention should be given to this factor. For the poking rod, a 16mm diameter rod about 50cm long may be used. In framed structure vibration of concrete during its placement is essential.

F. Curing of Concrete

Concrete work requires water-curing for a minimum of 14 days to gain adequate strength. Otherwise, the gain of strength is poor and concrete becomes brittle. Concrete slabs may be kept under water by ponding of water over it. This can be achieved by making earthen barriers around the edges. Columns should be kept covered with wet empty gunny bags.

ANNEXURE A

List of IS Codes for further reference

1. Published by Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110 002, Tel: +91 11 23230131, Fax: +91 11 23234062 email : info@bis.org.in ,Web: www.bis.org.in/
    a. IS: 1893-1984 : Criteria for earthquake resistant design of structures" (Fourth Revision)
    b. IS: 4326-1993 : Earthquake resistant design and construction of buildings – code of practice" (Second Revision)
    c. IS: 13828-1993 : Improving Earthquake Resistance of low strength Masonry buildings guidelines"
2. Produced by The International Association For Earthquake Engineering, Tokyo; "Guidelines for Earthquake resistant Non-engineered construction" A.S. ARYA, et al, Oct. 1986, reprinted by Indian Society of Earthquake Technology, Roorkee – 247667
3. Produced by Building Materials and Technology Promotion Council, Core 5 -A, First Floor , India Habitat Centre, Lodi Road, New Delhi- 110 003. Tel: +91 11 24638096, Fax: +91 11 24642849, e-mail: info@bmtpc.org , Web: http://www.bmtpc.org/
    a. Improving Earthquake Resistant Buildings – guidelines by Arya A.S. et. al– 1999
    b. Improving Wind/Cyclone Resistant Buildings - guidelines by Arya A.S. et. al – 1999
    c. Reconstruction and New Construction of Buildings in Chamoli earthquake affected areas of Uttar Pradesh" by Arya, A.S. January 2000
4. Earthquake Resistant Construction and Seismic Strengthening, Govt. of India, Maharastra Emergency Rehabilitation Program. Revenue and Forest Department, Mumbai, India.
5. IS 13920-1993, Ductile Detailing of Reinforced Concrete Structures subject to Seismic forces – code of practice, Bureau of Indian Standards, N Delhi, India
6. Bureau of Indian Standards: IS 456-2000- Code of Practice for Plain and Reinforced Concrete.

ANNEXURE B

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