HIMACHAL PRADESH

PUBLIC WORKS DEPARTMENT

No. PWD- S.E. D-III - Safety Guidelines/2017- 517-37 Dated: 15-9-17

From:-

Engineer- in-Chief,
H.P.P.W.D Shimla-2.

To

The Chief Engineer,
(i) Mandi Zone,H.P.P.W.D. Mandi.
(ii) Shimla Zone H.P.P.W.D. Shimla
(iii) Kangra Zone ,H.P.P.W.D. Dharamshala.
(iv) Hamirpur Zone, H.P.P.W.D. Hamirpur.

Subject:- Hazards Safety Guidelines for Buildings in Himachal Pradesh.

As you are aware that as per performance audit requirement on Disaster preparedness, hazards safety guidelines were to be prepared. Copy of Hazards Safety Guidelines for Buildings in Himachal Pradesh which has been prepared / compiled by H.P.P.W.D. is being sent through email for taking further necessary action.

Engineer-in-Chief,
Himachal Pradesh PWD Shimla-2.

Copy for information and necessary action to:-

1) The Deputy Secretary(Rev-DM) to the Govt. of Himachal Pradesh.
2) All the Superintending Engineers in H.P.P.W.D.
3) Nodal Officer I.T. Nirman Bhawan, for uploading guidelines on Departmental web site.

Engineer-in-Chief,
Himachal Pradesh PWD Shimla-2.

HAZARDS SAFETY

GUIDELINES

FOR BUILDINGS

IN

HIMACHAL PRADESH

INDEX

Introductory:

Himalayan Region including **HIMACHAL PRADESH** falls in geologically unstable parts of the country & some devastating Earthquakes have already occurred there. A major part of the Peninsular India has also been visited by strong Earthquake. According to the studies made in India for Earthquake forces, the country has been divided into five Zones as per severity of the Earthquake. The Himachal Pradesh falls in zone IV & V i.e. most severely effective areas

It is endeavored to insure that as far as possible the structures are able to respond without structural damage to shocks of moderate intensities & without total collapse to shocks of heavy intensities of Earthquakes. While it is intended for Earthquake resistant design of normal structure, it has to be emphasized that in case of special structures, the detailed investigation should be undertaken as per the various BIS & other relevant codes applicable in this region.

Earthquake can cause damage not only on account of the shaking which results from them but also due to other change effects like land slides, floods, fires and disruption to communication. It is therefore important to take necessary precautions in the design of the structures so that they are safe against such secondary effects also. As such a comparatively Geologically stable site should be preferred and as far as possible fire proof building material should be used in the construction.

Apart from the design aspect, the building has to be constructed also with due care to sound engineering practices. For this purpose **reference can be made to**
IS- 4326 as amended from time to time.

The analysis for the special types of structures has to be made as per the provisions of the relevant BIS Codes & Research and Development work being carried out by various agencies like Department of Earthquake Engineering, University of Roorkee. The relevant BIS codes to be referred are:

i) I.S. 456-2000 amended as latest.

II) I.S.800-2007 amended as latest.

iii) I.S. 875-1987 amended as latest.

iv) I.S 1893-2002 amended as latest.

v) I.S 4326-1993 amended as latest.

vi) I.S 13920-1993 amended as latest.

iv) National Building Code and many other relevant I.S. codes.

Buildings being constructed in H.P can be broadly classified as under:

i) Masonry buildings in bricks as well as in stones.
ii) Buildings of Timber Structures.
iii) Buildings of Steel Structures.
iv) Buildings of R.C.C framed structures.

The old practice of construction of Buildings in Dhajji wall & dry stone masonry with wooden braces at suitable intervals are now obsolete & are now very rarely constructed. For larger size sheds as well as Godowns, **steel frames structure can be constructed and analized as special type of structures.**

In addition to above it is felt that the following also need special consideration while planning / designing the building:

1) A comparatively stable site for construction need to be selected so that it does not give away during Earthquake.

2) While designing/ construction certain simple precautions should be taken such as suitably proportion diagonal Bracings in vertical panels of steel and concrete structures. There might be cases of less importance & relatively small structures for which no analysis need to be made, provided certain simple precautions are taken in the construction. For example, suitably proportioned diagonal bracings in the vertical panels of steel & concrete structures add to the resistance of frames to withstand Earthquake forces. **Similarly in highly seismic areas, construction of type which entails heavy debris & consequent loss of life & property, such as masonry, particularly mud masonry & rubble masonry, should be avoided** in preference to construction of a type which is known to withstand seismic effects better **I** such as construction in light weight material and well braced timber framed structures.

3) Projections *I* cantilevers a s far as possible should be avoided.

4) Constructions should be carried out as per sound engineering practices as detailed further below.

5) Building materials used should be fire proof.

6) The Building should be so architecturally designed that it should be well braced.

7) The structure should be ductile as far as possible.

<u>I.Masonry Structures</u>

The Bureau of Indian standards has published a National Building Code for construction of various types of Buildings. For masonry Buildings, the various special references have been made for design as well as constructions to match with sound Engineering practices. Ordinarily the masonry building should be designed keeping in the provisions as detailed in SEC -IV of National Building Code for masonry works.

In addition to above ordinary design, the special design for Earthquake resistant be also made as per Para- 7 of the SECTION -IV Masonry works of National Building Code. The Earthquake resistant provisions as far as possible are explained as under:

Masonry construction

1 General- From the numerous observations of damage it appears that unreinforced brick. composite constructions and adobe houses are not the suitable forms of construction in seismic areas since these have large weight and almost no lateral strength or ductility . Besides, workmanship is yet another factor which effects its performance and hence emphasis should be given on good quality of workmanship in order to achieve best results in this material. The basic advantage of this construction lies in the fact that it is possible to use the same elements to perform a variety of functions which in a framed building have to be provided for separately which consequent compilation in detailed construction. This form thus simultaneously provides the structure subdivision of space, thermal and acoustic insulation, fire and other weather protection. Therefore, finding effective methods of improving their earthquake resistance for a vast majority of people throughout the world. For closer examination, building components could be studied separately also to establish where each one lacks strength and should be strengthened. The following paragraphs discuss the behavior of such buildings in detail and make a review of the methods of strengthening such buildings against seismic forces.

Structure Action of Building Elements- Buildings responds to ground motion like all other structures and attract inertia forces depending on their stiffness and damping characteristics. Following this, the roof tends to separate from supports, the roof covering tends to be dislodged and walls tends to tear apart. If unable to do so, the walls tend to shear off diagonally in the direction of motion. In case of filler walls in reinforced concrete or timber frame, these may fall out of the frame unless properly tied to the frame. In this section, however, only load bearing wall type constructions are discussed. For this, some of the basic ideas must be understood first. The walls which resist forces in their own planes will be referred to as shear walls and those in perpendicular direction as cross walls. It is thus clear that in a building the same walls could act as shear walls or cross walls depending on direction of earthquake motion. Referring to figure- 2, for the x direction of motion, walls B act as shear walls while of the resistance against the collapse of wall A as well. Wall A acts as vertical slab supported on two vertical sides and bottom and subjected to inertia force of its own mass. Near the edges, the wall will have bending moments in the horizontal plane for which brick work has little strength. This may result in cracking and separation of the walls. If, however, a horizontal bending moment is introduced at a suitable level in wall A and continued in wall B, the tension in the horizontal plane may be taken care of. Tension on account of vertical bending may generally get relieved due to self-weight and can be made to take care of bending tensions. The same will be true for wall B when ground motion is in Y direction. **Thus the horizontal bending member is a very desirable provision in such buildings. Such a member is called a runner or a band and depending on its location it may be called a roof band, lintel band, or gable band.**

The roof slab transfers inertia force at top of the walls causing shearing and overturning forces in them. Major portion of this load Is taken up by the shear walls on account of their large in plane stiffness compared to the cross walls. However, the slab must have enough strength in bending in horizontal plane to be able to transfer the force in aforesaid manner. **Reinforced concrete on reinforced brick slabs would normally possess this but other types of roof/floor, such as brick-tile covering or timber planks-joists floors, must be connected together and fixed to walls suitable to achieve this purpose.** Shear walls should of course be able to take the shear of this slab in addition to its own inertia forces and should be designed safe for the bending and normal stresses resulting from such forces.

In the barrack type construction, the roof trusses rest on walls ‘A’ while the walls 'B' are gabled to receive the purlins (see Fig.3). In such cases**, the trusses must be anchored in the walls by the 'holding down bolts' and the walls 'A' must be treated as vertical cantilevers. Also a band may be necessary to transfer the horizontal forces. Alternately, diagonal bracing may be provided at the main tie level extending from one gable end to the other.**

The above structural behavior leads to the following requirements of structure safety of brick building against earthquake forces:

a) A free walls must be designed as vertical cantilever.

b) Shear walls must resist forces transferred to it by its deformation.

c) Roof/floor elements must be tied together and be capable of transferring their inertia forces to the walls; and

d) Walls must be effectively tied together to avoid separation to joints due to shaking. Horizontal bands may be provided for this purpose at suitable places.

Behavior of Brick Shear Walls- Shear walls are the main elements resisting the lateral forces in a building. In fact, the strength of such walls determines the lateral load carrying capacity of the building. However, their strength depends on a number of factors which are sometimes very difficult to take into account in a theoretical analysis. The main source of error and uncertainty is the workmanship. With this difficult parameter playing an important part in the strength of a shear wall, any effort to use the more sophisticated methods may appear to be an exercise in futility. Simpler approaches were therefore, suggested in which a masonry wall was treated as a series piers formed by the opening in a shear wall (see Fig.4). For calculating stresses in such piers, it is assumed that the rotational component of deformations of the portion above and below the openings are small as compared to those of the piers between the openings and are neglected. The points of contra flexure are assumed at the mid height of such piers and the forces (the lateral shear) are shared among the piers such that their tops deflect by equal amount. The deflection of each pier is calculated by assuming the ends to be restrained against rotation.

The total horizontal shear in a wall will, therefore, be distributed in the various piers in proportion to their shear stiffness. This shear causes bending moment equal to Vh /2 at the top and bottom sections of the pier. Also, there would be overturning forces in these piers on account of this horizontal force in addition to the direct stresses due to the dead load of the building above the lintel level. The total stress σ is given by $\sigma = \sigma_b + \sigma_d + \sigma_o$

in which σb is the stress due to bending, *σd is* the stress due to the dead load and σo is the stress due to the overturning forces. Such computations should be made along each axis of the building for reversible earthquake force. If the combined stress *σ* exceeds the ultimate strength of brickwork in tension, cracking would occur. The sections of the piers should either be designed such that tension does not appear or else provision should be made for reinforcing the section at such crucial points.

Sections along the jambs of openings and the corners in a shear wall have been identified as the vulnerable points in the walls. **Since the ordinary brickwork has very little strength in tension, it may seem essential that such wall sections be strengthened by reinforcing steel in vertical direction, particularly in active seismic zones. Taking a clue from here,** the efficiency of such strengthening measures was examined and experimental study of house models was carried out. The various strengthening measures studied included vertical steel at corners, vertical steel at jambs and their combinations with the lintel band. It was found that the strength of models increased many folds with the introduction of these methods. Further, it became very clear that such measures would not allow the entire building to collapse during an earthquake. The quantity of such reinforcing steel would naturally depend on the number of storeys in a building and on the severity of the zone. **With these methods, it is possible to go up to four storeyed construction**. The Code provides for such special measures in detail. Special features of design and construction for earthquake resistance masonry buildings, in Zones III, IV and V are also covered in IS: 1905-1980.

1.1 Materials- In view of the explanation given under 1 **the Code recommends good quality bricks, and prohibits the use of sun dried bricks. It also permits use of squared stone masonry or random rubble masonry brought to courses at regular intervals of 60 cm and also hollow concrete block masonry which possesses adequate strength as laid down in the relevant standards.**

1.2Mortar- Since strength of masonry building is largely dependent upon the strength of mortar used, it is recommended in the Code that **only those mortars which possess adequate strength characteristics be used in construction. If a reinforcing bar is used in masonry, it is desirable to have richer material around itto ensure proper bond. For this purpose, either 1:4 cement-sand mortar or M10 or M15 grade concrete is recommended for use.**

2 Walls

2.1 The Code recommends that load bearing masonry walls should not be more than 15 m total height or four storeys. Moinfar(1972) from his experience on observations of earthquake damage to brick masonry buildings in Iran has reported that for ordinary workmanship and quality of building materials **the height of dwelling should not exceed three storeys, preferably two, and under no circumstances should the total height of the dwelling exceed 11m including the height of the parapet.**Random rubble masonry (brought to courses at 60 cm vertical intervals) is recommended only up to 2 storeys or (8mtr in height) in view of its poor performance observed during the past earthquakes.

2.2 The load bearing walls must be straight and symmetrical in plan so that torsional shears are avoided or minimized.

2.3 A free standing wall is recommended to have a factor of safety of 1.5 in overturning in view of the importance of such walls.

2.4 During an Earthquake shaking, infills in framed building will behave according to its physical connection with the frames. The infills usually add to the stiffness & strength of a building if bonded properly with the frame. It is, therefore, recommended in the code that the bonding should be done properly either by suitable mortar or dowels. If this is not achieved, the infills would behave just like a free standing wall. In either situation, the infill should be checked for safety against inertia force acting on its own mass as provided in 2.3 or 2.4 of the code.

3 Opening in bearing walls

3.1 to 3.6 **Openings divide a bearing wall into a series of piers** whose strength determines the strength of the wall element. Analysis has shown that sections around jambs of openings are the vulnerable sections & must be safeguarded. **It is also seen that the larger the opening, smaller is the strength of the wall**. Also the strength of wall depends upon the placing of opening in the wall. **The more central location of opening leads to a higher strength &higher the opening higher is the strength**. In view of these, the code recommends certain specifications as regards the size and placing of openings in load bearing walls.

If openings do not comply with the recommendations made in the previous subclauses, the code recommends **strengthening of openings by providing steel at jambs or by framing the opening in reinforced concrete** .

It also suggests that as far as possible **all openings in a storey should have their top at the same level to facilitate provision of continuous reinforced concrete band all round the building.**

3.7 Projecting parts are always potential hazards during an earthquake and, therefore, these must be well anchored in reinforced masonry and concrete.

3.8Observations in past earthquakes have shown that **use of arches to span across openings is a source of weakness and must be avoided unless steel ties are provided.**

4 Strengthening arrangements

4.1 This is the most important operative clause of the code. It specifies the strengthening measures to be adopted in case of masonry buildings for which design seismic coefficient is worked out first in accordance with provisions of IS-1893-1975. It maybe recalled that design seismic coefficient is worked out on the basis of seismic zone, soil foundation factor (b) & importance factor (I).

Depending upon the value of design seismic coefficient, the strengthening arrangements vary – higher seismic coefficient inviting more elaborate provisions compared to those for lower coefficients. **Basically the following six provisions are specified:**

a) Masonry mortar (see explanatory 1.2)

b) Lintel band all round to tie up the building.

c) Roof band (and gable band in case of sloping roofs)

d) Vertical steel at corner and junctions of walls to take up tension which occurs at these points.

e) Vertical steel in jambs of openings (see explanatory 3.6): and

f) Bracing in plan at tie level (see explanatory 4.4.2.2).

(b), (c) & (d) are explained in the following subclauses.

4.2 to 4.5 **Bands or Runners**-Lack of proper connection between various elements of the buildings, like walls or between walls and roof (or floor), has often resulted in damage to masonry building during Earthquakes. As explained in Para1, **runners or bands of reinforced concrete or reinforced brickwork provided in all the load bearing walls at different levels together with vertical reinforced concrete elements which are not necessarily load bearing, provide excellent connections for the building to act as one unit under Earthquake motion**, thus increasing considerably its resistance and minimizing damage**.**

Locating the runners at lintel and/ or roof level is recommended depending upon the seismic intensity, type of construction and soil strength. The various bands may be made in M20 or richer concrete. **A minimum thickness of 7.5 cm and width equal to thickness of the wall is recommended.**

One steel bar near each face of the wall is recommended in the reinforced concrete wall. In reinforced brickwork, the reinforcement may be provided in two consecutive courses with two bars near each face of the wall so that the total area of the steel is the same as in reinforced concrete band. That is, with the number of bars doubled, the diameter of bars may be reduced to 70% for obtaining the same total steel area. The joints in reinforced brickwork containing the steel bars should be increased so as to have a minimum mortar cover of 5mm around the bar.

In case of sloping roofs, the roof band is made continuous over the gable

ends of the end wall below the purlins. Obviously, the specifications for the gable band, roof band and lintel band are, therefore, the same.

In case of structures where design seismic coefficient works out more than 0.08 (due to importance of the structure or soil foundation system), these bands are provided with more reinforcement as given in Table1 of the code.

Roof band is not required in case of reinforced concrete or reinforced brick slabs which are continuous over the whole building or between crumpled sections, if any, and cover the width of the walls fully as they have a binding action on the walls and are also capable of transmitting their inertia force to the shear walls.

Runners/ bands at any level should also be continuous at the corners and junctions of the wall. The gable band should be continuous with the roof band at tie level. Typical details for continuity are shown in Fig.5.

4.6 Horizontal runners may not be much effective by themselves in increasing the lateral resistance of buildings. Vertical steel at corners and jambs of openings provides much greater strengthening, particularly in combination with the horizontal steel reinforcement bars in runners.

By reinforcing these critical sections alone, brick buildings two to four storeys are strengthened sufficiently at a small extra cost and without additional skill required in construction to escape collapse even under most severe earthquake forces. The recommendation of the code are based on this cost consideration rather than to no damage criterions.

If the design seismic coefficient is greater than 0.08, all building (1 to 4 storey) must be reinforced by vertical steel. The quantity of steel in case specified in Tabel-5 of the code. The details of providing the vertical steel in brickwork hollow blocks & stone masonry at corners, T-sections & jambs of the opening are also illustrated in Fig.6, 7, 8 & 9 of the code.

3 TIMBER CONSTRUCTION

3.0 Timber is often used for structural work particularly in hilly regions as also for temporary constructions. It is well known that timber has poor weather resistance and it is liable to seasonal changes, cracks and warping.

3.1 Earthquake forces attracted by a structure is proportional to its weight. Also it is well known that failure occurs on account of tension in structures as was explained in 1 on masonry. A suitable material for earthquake resistance would, therefore, be one in which the strength per unit weight is higher. Timber has a high strength to unit weight ratio and is, therefore, very suitable for earthquake resistance construction.

3.2 Timber is not as so strong as other materials of constructions, namely masonry or reinforced concrete & although it has high strength per unit weight its construction is generally advised to restrict to two storeys in seismic areas.

3.3 Quiet often fire breaks out following an earthquake on account of electric short circuiting, kitchen fire etc, and for this reason the code recommends that attention should also be paid to fire safety in timber construction.

3.4 In order to insure an initiated action by the structure during an earthquake, it is necessary to make the superstructure rigid by appropriate techniques so that it behaves a one unit during vibration. Therefore attention must be paid to suitable construction detailing of junctions of the members and the wall panels since the rigidity is very intimately associated with such detailing.

3.5 FOUNDATIONS

3.5.1 TO 3.5.2.2 For timber buildings, it must be insured that the structures remains intact all the time for which the code recommends that the **portion of the building below the plinth level must be constructed in masonry or concrete.** This is desirable in view of the fact that timber may deteriorate and rot if taken underground. The superstructure may or may not be rigidly connected to the plinth masonry. Experience from past earthquakes has shown that building note fixed with the foundation escape collapse although they could move sideways. The code also suggests appropriate details of connection of columns with the foundation masonry in case it is desirable to have the superstructures rigidly fixed into the plinth masonry /concrete foundation. In case of small buildings, however the code permits the vertical poles to be embedded in to the Ground.

3.6.1 **Stud wall construction** and brick nogged timber frame construction are generally adopted in practice while construction are generally adopted in practice while constructing buildings in timber. The code recommends appropriate size of structural members for use in these two types of construction. These dimensions are based on an estimate of earthquake forces expected in the various seismic zones and the minimum sizes indicated in the code corresponds to the expected earthquake forces in zone V.

3.7 Stud wall construction

3.7.1 to 3.7.10 In this form of construction , the timber studs and corner posts are framed into sills, top plates and wall plates. Horizontal studs and diagonal members are used to stiffen the frame against lateral forces. The joints must be covered by suitable steel strap. The wall cladding can be of timber boards. The code recommends the minimum size of the studs and diagonal bracings depending on the seismic coefficient for two categories of timber, namely ,Class I and Class II as defined in IS:883-1970.

3.8 Brick Nagged Timber Frame

This form of construction consists of intermediate verticals, columns, sills, wall plates, horizontal nagging members and diagonal members framed into each other and the space between the remaining members is filled with tight fitting masonry. The minimum size of various timber elements to be used in this construction is specified in the code. The joints of the wall plate and the sill plate with studs must be covered with suitable steel straps.

3.9 CONNECTIONS BETWEEN TIMBER MEMBERS-

Cutting and notching are very important and significantly affect the strength of a member. For this reason, the Code recommends that notching or cutting should be limited to about 20mm in depth unless steel strips are provided to strength the notched face of the member to compensate for the loss of the material. Where it is necessary to cut or notch a member by about 40mm in depth, the steel reinforcing strips should be placed along the notch only. However, where the cut is more

than 40mm in depth or a member is completely cut through steel strips should be placed on both edges of the member.

3.10 Bridging and blocking –In order to provide rigidity to the timber frame, the code recommends cross bridging of wooden joist at every 3.5 m length. The code also recommends providing blocks at all bearings of such joists to block the space between joist.

In addition to the above the study on earthquake resistance forces have further been made by some agencies like Department of Earthquake Engineering , University of Roorkee ,HUDCO, CBRI etc. On the basis of their studies some Do’s & Don’ts have been framed for the guidance of layman particularly with reference to simple residential Earthquake resistant

Buildings. The illustrations based on Do’s & Don’ts framed as above are attached as per annexure –‘A’

II <u>R.C.C. Structures</u>

1) The analysis of RCC framed structure is quite complex and need special care keeping in view the importance of the building. The buildings immediately required after the Earthquake such as Hospital, Telephone exchange Buildings, other buildings linked with communication & the building of public gatherings like Cinema hall, Market complex etc. need to be given a better considered importance.

2) The Provision to be considered for the analysis of RCC framed structures have been given in detail in Bureau of Indian standard code IS 456-& IS 1893. The design of the structure has to be essentially based on these codes.

3) During construction the quality control for RCC has to be insured as per provision of IS-456 & NBC

4) Sound Engineering practices as per NBC & IS 4326 amended time to time should be adhered to meticulously.

5) The material to be used i.e. cement, steel & aggregate should adhere to quality control as specified in relevant BIS codes & as approved by Engineer –in –Charge .

6) The most important is the association of well qualified Civil Engineers during planning, design & execution of the work. The execution has to be done under the supervision of well qualified Civil Engineer.

Worker Safety Measures in Construction

The fatal injury rate for the construction industry is higher than the national average for all industries.

Potential hazards for workers in construction include:

- Falls (from heights);
- Trench collapse;
- Scaffold collapse;
- Electric shock and arc flash/arc blast;
- Failure to use proper personal protective equipment; and
- Repetitive motion injuries.

Hazards & Solutions

For construction, standard most frequently included in hazards are:

1. Scaffolding
2. Fall protection (scope, application, definitions)
3. Excavations (general requirements)
4. Ladders
5. Head protection
6. Excavations (requirements for protective systems)
7. Hazard communication
8. Fall protection (training requirements)
9. Construction (general safety and health provisions)
10. Electrical (wiring methods, design and protection)

Scaffolding

Hazard: When scaffolds are not erected or used properly, fall hazards can occur. Construction workers frequently work on scaffolds. Protecting these workers from scaffold-related accidents would prevent a large no. of injuries and fatalities each year.

Solutions:

- Scaffold must be sound, rigid and sufficient to carry its own weight plus four times the maximum intended load without settling or displacement. It must be erected on solid footing.
- Unstable objects, such as barrels, boxes, loose bricks or concrete blocks must not be used to support scaffolds or planks.

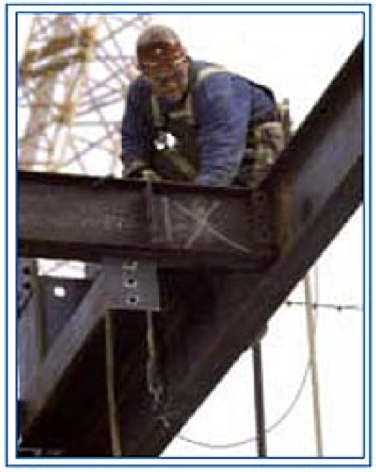
- Scaffold must not be erected, moved, dismantled or altered except under the supervision of a competent person.
- Scaffold must be equipped with guardrails, mid rails and toe boards.
- Scaffold accessories such as braces, brackets, trusses, screw legs or ladders that are damaged or weakened from any cause must be immediately repaired or replaced.
- Scaffold platforms must be tightly planked with scaffold plank grade material or equivalent.
- A "competent person" must inspect the scaffolding and, at designated intervals, reinspect it.
- Rigging on suspension scaffolds must be inspected by a competent person before each shift and after any occurrence that could affect structural integrity to ensure that all connections are tight and that no damage to the rigging has occurred since its last use.
- Synthetic and natural rope used in suspension scaffolding must be protected from heat-producing sources.
- Employees must be instructed about the hazards of using diagonal braces as fall protection.
- Scaffold can be accessed by using ladders and stairwells.
- Scaffolds must be at least 10 feet from electric power lines at all times.

Fall Protection

Hazard: Falls consistently account for the greatest number of fatalities in the construction industry. A number of factors are often involved in falls, including unstable working surfaces, misuse or failure to use fall protection equipment and human error. Using guardrails, fall arrest systems, safety nets, covers and restraint systems can prevent many fatalities and injuries from falls.

Solutions:

- Consider using aerial lifts or elevated platforms to provide safer elevated working surfaces;
- Erect guardrail systems with toe boards and warning lines or install control line systems to protect workers near the edges of floors and roofs;
- Cover floor holes; and/or
- Use safety net systems or personal fall arrest systems (body harnesses).



Ladders

Hazard: Ladders and stairways are another source of injuries and fatalities among construction workers.

Solutions:

- Use the correct ladder for the task.
- Have a competent person visually inspect a ladder before use for any defects such as:
  - Structural damage, split/bent side rails, broken or missing rungs/steps/cleats and missing or damaged safety devices;
  - Grease, dirt or other contaminants that could cause slips or falls;
  - Paint or stickers (except warning labels) that could hide possible defects
- Make sure that ladders are long enough to safely reach the work area.
- Mark or tag ("Do Not Use") damaged or defective ladders for repair or replacement, or destroy them immediately.
- Never load ladders beyond the maximum intended load or beyond the manufacturer's rated capacity.
- Be sure the load rating can support the weight of the user, including materials and tools.
- Avoid using ladders with metallic components near electrical work and overhead power lines.

Stairways

Hazard: Slips, trips and falls on stairways are a major source of injuries and fatalities among construction workers.

Solutions:

- Stairway treads and walkways must be free of dangerous objects, debris and materials.
- Slippery conditions on stairways and walkways must be corrected immediately.
- Make sure that treads cover the entire step and landing.
- Stairways having four or more risers or rising more than 30 inches must have at least one handrail.

Trenching

Hazard: Trench collapses also cause many fatalities and injuries during construction.

Solutions:

- Never enter an unprotected trench.
- Always use a protective system for trenches feet deep or greater.
- Employ a registered professional engineer to design a protective system for trenches 20 feet deep or greater.
- Protective Systems:

- Sloping to protect workers by cutting back the trench wall at an angle inclined away from the excavation not steeper than a height/depth ratio of 1.5 :1, according to the sloping requirements for the type of soil.
- Shoring to protect workers by installing supports to prevent soil movement for trenches that do not exceed 20 feet in depth.
- Shielding to protect workers by using trench boxes or other types of supports to prevent soil cave-ins.

- Always provide a way to exit a trench--such as a ladder, stairway or ramp--no more than 25 feet of lateral travel for employees in the trench.
- Keep spoils at least two feet back from the edge of a trench.
- Make sure that trenches are inspected by a competent person prior to entry and after any hazard-increasing event such as a rainstorm, vibrations or excessive surcharge loads.

SLOPING. Maximum allowable slopes for excavations less than 20 ft. (6.09 m) based on soil type and angle to the horizontal are as follows:

TABLE V:2-1. ALLOWABLE SLOPES

Soil type	Height/Depth ratio	Slope angle
Stable Rock (granite or sandstone)	Vertical	90º
Type A (clay)	3/4 :1	53º
Type B	1:1	45º

(gravel, silt)		
Type C (sand)	1.5:1	34º
Type A (short-term) (For a maximum excavation depth of 12 ft.)	1/ 2:1	63º

Hazard: Significant and serious injuries may occur if cranes are not inspected before use and if they are not used properly. Often these injuries occur when a worker is struck by an overhead load or caught within the crane's swing radius. Many crane fatalities occur when the boom of a crane or its load line contact an overhead power line.

Solutions:

- Check all crane controls to insure proper operation before use.
- Inspect wire rope, chains and hook for any damage.
- Know the weight of the load that the crane is to lift.
- Ensure that the load does not exceed the crane's rated capacity.
- Raise the load a few inches to verify balance and the effectiveness of the brake system.
- Check all rigging prior to use; do not wrap hoist ropes or chains around the load.
- Fully extend outriggers.
- Do not move a load over workers.
- Barricade accessible areas within the crane's swing radius.
- Watch for overhead electrical distribution and transmission lines and maintain a safe working clearance of at least 10 feet from energized electrical lines.

Hazard Communication

Hazard: Failure to recognize the hazards associated with chemicals can cause chemical burns, respiratory problems, fires and explosions.

Solutions:

- Maintain a Material Safety Data Sheet (MSDS) for each chemical in the facility.
- Make this information accessible to employees at all times in a language or formats that are clearly understood by all affected personnel.

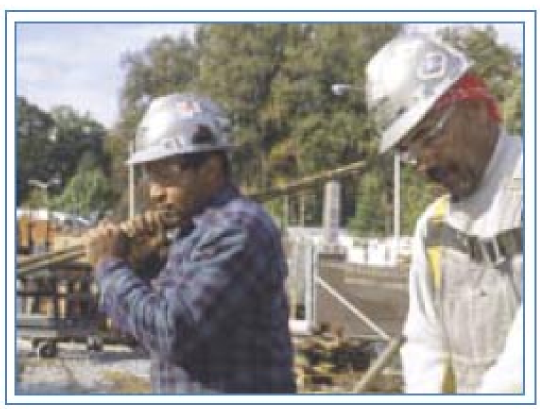
- Train employees on how to read and use the MSDS.
- Follow manufacturer's MSDS instructions for handling hazardous chemicals.
- Train employees about the risks of each hazardous chemical being used.
- Provide spill clean-up kits in areas where chemicals are stored.
- Have a written spill control plan.
- Train employees to clean up spills, protect themselves and properly dispose of used materials.
- Provide proper personal protective equipment and enforce its use.
- Store chemicals safely and securely.

Head Protection

Hazard: Serious head injuries can result from blows to the head.

Solution:

- Be sure that workers wear hard hats where there is a potential for objects falling from above, bumps to their heads from fixed objects, or accidental head contact with electrical hazards.



Safety Checklists

The following checklists may help to take steps to avoid hazards that cause injuries, illnesses and fatalities. As always, be cautious and seek help if you are concerned about a potential hazard.

Personal Protective Equipment (PPE)

Eye and Face Protection

- Safety glasses or face shields are worn anytime work operations can cause foreign objects getting into the eye such as during welding, cutting, grinding, nailing (or when working with concrete and/or harmful chemicals or when exposed to flying particles).

- Eye and face protectors are selected based on anticipated hazards.
- Safety glasses or face shields are worn when exposed to any electrical hazards including work on energized electrical systems.

Foot Protection

- Construction workers should wear work shoes or boots with slip-resistant and puncture-resistant soles.
- Safety-toed footwear is worn to prevent crushed toes when working around heavy equipment or falling objects.

Hand Protection

- Gloves should fit snugly.
- Workers wear the right gloves for the job (for example, heavy-duty rubber gloves for concrete work, welding gloves for welding, insulated gloves and sleeves when exposed to electrical hazards).

Head Protection

- Workers shall wear hard hats where there is a potential for objects falling from above, bumps to their heads from fixed objects, or of accidental head contact with electrical hazards.
- Hard hats are routinely inspected for dents, cracks or deterioration.
- Hard hats are replaced after a heavy blow or electrical shock.
- Hard hats are maintained in good condition.

Scaffolding

- Scaffolds should be set on sound footing.
- Damaged parts that affect the strength of the scaffold are taken out of service.
- Scaffolds are not altered.
- All scaffolds should be fully planked.
- Scaffolds are not moved horizontally while workers are on them unless they are designed to be mobile and workers have been trained in the proper procedures.
- Employees are not permitted to work on scaffolds when covered with snow, ice, or other slippery materials.
- Scaffolds are not erected or moved within 10 feet of power lines.
- Employees are not permitted to work on scaffolds in bad weather or high winds unless a competent person has determined that it is safe to do so.

- Ladders, boxes, barrels, buckets or other makeshift platforms are not used to raise work height.
- Extra material is not allowed to build up on scaffold platforms.
- Scaffolds should not be loaded with more weight than they were designed to support.
-

Electrical Safety

- Work on new and existing energized (hot) electrical circuits is prohibited until all power is shut off and grounds are attached.
- An effective Lockout/Tagout system is in place.
- Frayed, damaged or worn electrical cords or cables are promptly replaced.
- All extension cords have grounding prongs.
- Protect flexible cords and cables from damage. Sharp corners and projections should be avoided.
- Use extension cord sets used with portable electric tools and appliances that are the three-wire type and designed for hard or extra-hard service.
- All electrical tools and equipment are maintained in safe condition and checked regularly for defects and taken out of service if a defect is found.
- Do not bypass any protective system or device designed to protect employees from contact with electrical energy.
- Overhead electrical power lines are located and identified.
- Ensure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
- All electrical tools must be properly grounded unless they are of the double insulated type.
- Multiple plug adapters are prohibited.

Floor and Wall Openings

- Floor openings (12 inches or more) are guarded by a secured cover, a guardrail or equivalent on all sides (except at entrances to stairways).
- Toeboards are installed around the edges of permanent floor openings (where persons may pass below the opening).

Elevated Surfaces

- Signs are posted, when appropriate, showing the elevated surface load capacity.
- Surfaces elevated more than 48 inches above the floor or ground have standard guardrails.

- All elevated surfaces (beneath which people or machinery could be exposed to falling objects) have standard 4-inch toeboards.
- A permanent means of entry and exit with handrails is provided to elevated storage and work surfaces.
- Material is piled, stacked or racked in a way that prevents it from tipping, falling, collapsing, rolling or spreading.

Hazard Communication

- A list of hazardous substances used in the workplace is maintained and readily available at the worksite.
- There is a written hazard communication program addressing Material Safety Data Sheets (MSDS), labeling and employee training.
- Each container of a hazardous substance (vats, bottles, storage tanks) is labeled with product identity and a hazard warning(s) (communicating the specific health hazards and physical hazards).
- Material Safety Data Sheets are readily available at all times for each hazardous substance used.
- There is an effective employee training program for hazardous substances.

Crane Safety

- Cranes and derricks are restricted from operating within 10 feet of any electrical power line.
- The upper rotating structure supporting the boom and materials being handled is provided with an electrical ground while working near energized transmitter towers.
- Rated load capacities, operating speed and instructions are posted and visible to the operator.
- Cranes are equipped with a load chart.
- The operator understands and uses the load chart.
- The operator can determine the angle and length of the crane boom at all times.
- Crane machinery and other rigging equipment is inspected daily prior to use to make sure that it is in good condition.
- Accessible areas within the crane's swing radius are barricaded.
- Tag lines are used to prevent dangerous swing or spin of materials when raised or lowered by a crane or derrick.
- Illustrations of hand signals to crane and derrick operators are posted on the job site.
- The signal person uses correct signals for the crane operator to follow.

- Crane outriggers are extended when required.
- Crane platforms and walkways have antiskid surfaces.
- Broken, worn or damaged wire rope is removed from service.
- Guardrails, hand holds and steps are provided for safe and easy access to and from all areas of the crane.
- Load testing reports/certifications are available.
- Tower crane mast bolts are properly torqued to the manufacturer's specifications.
- Overload limits are tested and correctly set.
- The maximum acceptable load and the last test results are posted on the crane.
- Initial and annual inspections of all hoisting and rigging equipment are performed and reports are maintained.
- Only properly trained and qualified operators are allowed to work with hoisting and rigging equipment.

EARTHQUAKE SAFE CONSTRUCTION OF MASONRY BUILDINGS **Zone V**

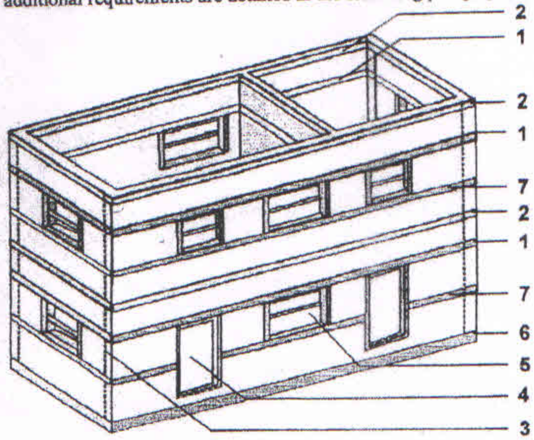
Simplified Guideline for ***All New Buildings*** in the ***Seismic Zone V of India***

Introduction:

As usual new construction of buildings under IAY, Prime Minister Rojgar Yojana and buildings under various other National and State schemes get started in the month of May. The Ministry of Home Affairs is keen that **All New Buildings** should be made earthquake resistant in the first instant so that we do not add to the stock of existing unsafe buildings. Since most of the buildings are constructed using brickwork or, solid hollow concrete blocks with flat roofs, very simple illustrated guidance is provided in the attached brochure for incorporating the earthquake resistant features suitable for seismic zone V.

Essential Elements for Earthquake Safety[1]:

The essential elements required to make a building earthquake safe are as given in ***Figure 1.*** Some additional requirements are detailed in the following paragraphs.



1. **Lintel Band**
2. **Roof/ Floor Band**
3. **Vertical reinforcing bar at corner**
4. **Door**
5. **Window**
6. **Plinth Band**
7. **Window Sill Bands**

Figure – 1: Essential Internal Elements in Buildings for Earthquake Safety

1. **GOOD CEMENT MORTAR**:

The cement mortar should be used in the ratio of 1 part of cement with 4 parts of sand (1 sack of cement mixed with 4 equal sacks of sand).

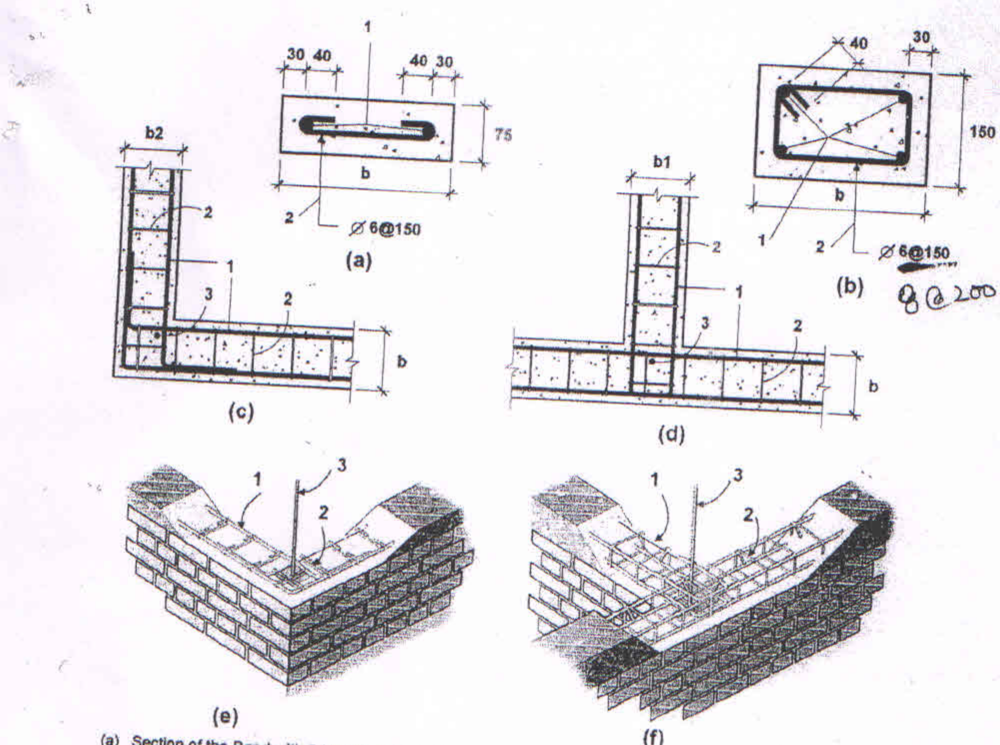
2. **HORIZONTAL SEISMIC BANDS**:

A seismic band consists of reinforced concrete flat runner through **all external and internal masonry walls** at the following levels in the building.

a. at the plinth level of the building
b. at the levels of lintels of doors and windows
c. at the ceiling level of roofs consisting of wooden joists or, prefabricated reinforced concrete beams or, planks. *(Such band will not be necessary if the roof consists of Reinforced Concrete or, Reinforced Brick slabs cast on the walls covering a minimum of 2/3 of the thickness of the wall.)*

The dimensions of the band and the reinforcement inside depend upon the length of the walls between the perpendicular cross walls. The table below ***(Table-1)*** shows the dimensions to be adopted for the seismic bands and the internal reinforcement details to be provided. The reinforcement and bending details of seismic bands are given in the ***Figure-2.*** Reinforcing bars will be of Fe 415 type [TOR or, High Yield Strength Deformed, i.e. HYSD bars]

[1] The details given here are extracted from IS: 4326-1993 **Code of Practice** as applicable to buildings with Brick/ Concrete block walls and R.C. flat slab roofs. Details not given here may be seen in the Code.



(a) Section of the Band with 2 longitudinal steel bars
(b) Section of the Band with 4 longitudinal steel bars
(c) Structural Plan at L- type wall junction
(d) Structural Plan at T- type wall junction
(e) 3 Dimensional view of the L - type wall junction
(f) 3 Dimensional view of the T - type wall junction

1. Longitudinal reinforcements
2. Lateral Ties
3. Vertical reinforcement at corners

b, b1, b2 Wall thickness

***Figure-2*: Reinforcement and Bending Details of Seismic Bands**

***Table-1*: Recommended size and longitudinal steel in Seismic Bands (Zone V)**

Internal length of wall	**Buildings of all types i.e., Residential buildings & Public Buildings** (Schools, Hospitals, Meeting Halls, Anganwadis, etc.)		
	Size of the band	No. of Bars	Dia *(mm)*
5 m or, less	10 cm x wall width	2	10
6 m	10 cm x wall width	2	12
7 m	15 cm x wall width	4	10
8 m	15 cm x wall width	4	12

3. VERTICAL REINFORCEMENT IN THE BRICK WALLS:

For earthquake safety in seismic zone V reinforcing bars have to be embedded in brick masonry at the corners of all the rooms and the side of the door openings. Window openings larger than 60 cm in width will also need such reinforcing bars (***Figure – 4***). The diameter of the bar depends upon the number of storeys in the building. The recommendations are given in ***Table-2***.

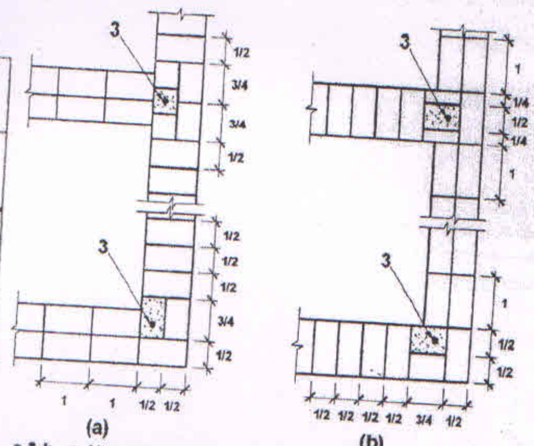
Providing the vertical bars in the brickwork and concrete blocks requires special techniques which could be easily learnt by the supervising engineers and masons will need to be trained.

These vertical bars have to be started from the foundation concrete, will pass through all seismic bands where they will be tied to the band reinforcements using binding wire and embedded to the ceiling band/roof slab as the case may be using a 300 mm 90° bend. Sometimes the vertical bars will not be made in one full length. In that case the extension of the vertical reinforcement bars are required, an overlap of minimum of ***50 times** the bar diameter* should be provided. The two overlapped reinforcement bars should be tied together by using the binding wires.

***Table-2:* Recommended size of vertical steel in Seismic Bands (Zone V)**

Buildings of all types i.e., Residential buildings & Public Buildings * (Schools, Hospitals, Meeting Halls, Anganwadis, etc.)		
No. of storeys	Floor	Dia of Single HYSD(TOR) Bar at corners of room (mm)
One	-	12
Two	Top	12
	Bottom	16
Three	Top	12
	Middle	16
	Bottom	16

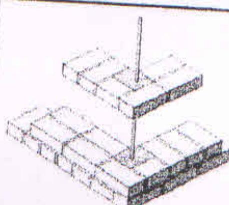
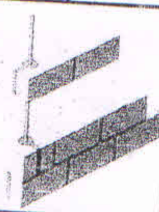
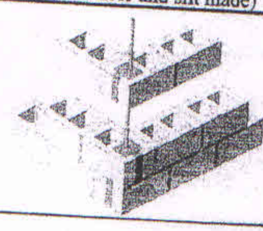
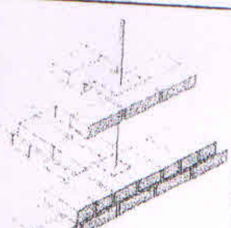
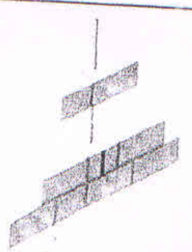
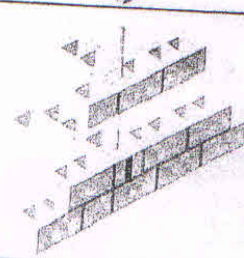
**** Building of four storey not permitted in Zone V.***



a & b : Alternate courses in one brick wall
1 : One brick length
½ : Half brick length
¼ : Quarter of a brick length
¾ : Three quarters of a brick length
3 : Vertical reinforcement bars with Concrete/ mortar filling in pocket of M20 grade (1:1½:3 nominal mix)

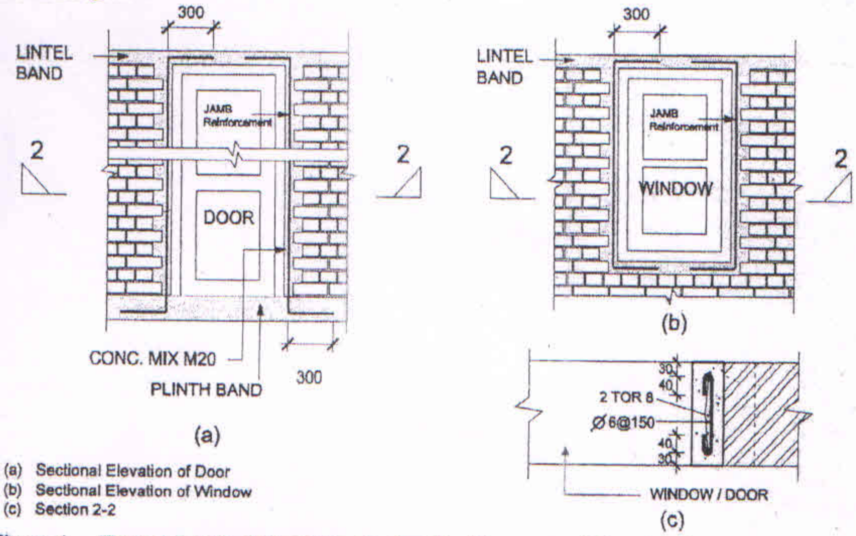
***Figure-3:* Typical Details of Providing Vertical Steel Bars in Brick Masonry**

***Table-3:* Recommended joint details with the vertical reinforcement at corner for masonry walls using different kind of materials**

Type of *Joint*	Corner reinforcement in case of *Brick Masonry*	Corner reinforcement in case of *Solid Concrete Block Masonry*	Corner reinforcement in case of *Hollow Concrete Block Masonry* (see the hole and slit made)
L- Joint			
T- Joint			

4. VERTICAL REINFORCEMENT AT JAMBS OF OPENINGS:

All door and window openings wider than 600 mm will have vertical reinforcement in jambs as shown in ***Figure-4.***



(a) Sectional Elevation of Door
(b) Sectional Elevation of Window
(c) Section 2-2

Figure-4: ***Typical Details of Providing Vertical Steel Bars around doors/windows***

5. FOUNDATION

Foundation width 'B' should be decided by the load coming on the foundation and the bearing capacity. Masonry width may be reduced by ½ times T in every step of 150 mm height.

NOTE:
In sandy soils with high water table within 8 m depth below ground level, which may get liquefied during earthquake of MSK intensity VIII to IX, pile foundation need to be used in consultation with the Structural/ Geotechnical Engineer.

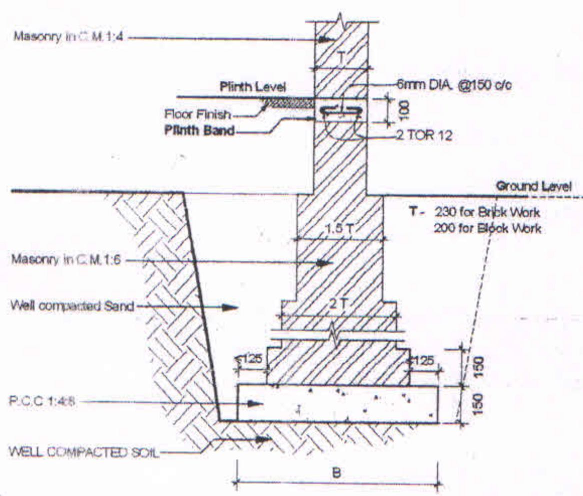


Figure-5: ***Foundation Detail with Plinth Band in Brick or, Concrete Block Masonry***

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