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FIELD PRACTICING MANUAL

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English Version

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Government of NWFP
Pakistan

AND ALLAH SETTLED HOUSES A DWELLING PLACE FOR YOU (AL-QURAN)

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PREFACE

On October 8, 2005 a disastrous earthquake in the history of Pakistan having 7.6 Magnitude on Richter scale struck the northern parts of Pakistan and Kashmir. According to the Government resources, almost 80,000 people died, thousands were injured and millions became homeless.

Government of NWFP made a comprehensive plan for the resettlement of these people. University of Engineering & Technology Peshawar was given a task to prepare a manual consisting of guidelines and recommendations for framing regulations to ensure earthquake resistant construction. This Field Practicing Manual or Guidelines for standard construction is reflection of the same. In this manual, efforts have been made to simplify instructions for earthquake resistant construction and construction materials. This booklet would almost be equally beneficial for the site Engineers, Contractors and masons INSHALLAH.

CONTENTS

1. CONSTRUCTION MATERIALS

1.1 Cement:

i. Fresh cement is like a fine powder which is commonly available in sealed bags. On opening the bag, cement starts absorbing moisture from the air and with the passage of time, small and large lumps are formed Fig.1, which results in the decline of cement strength. So the cement bag once opened should be used as soon as possible.

Fig.1 Lumps in cement

ii. The lumps in cement also appear if the sealed bags are placed for a longer time. This is major indication of old cement and its use should be avoided.

iii. Always use good quality cement. Avoid the use of poor quality cement.

iv. Test can be carried out to assess the strength of the cement. This facility is available in all the Engineering Universities and in most of the construction related Government/non Government Institutions throughout Pakistan.

1.2 Sand, Khaka and Gravel:

i. Sand, Khaka and gravel should be free from dust and waste residuals. In the presence of these, the strength of concrete and mortar decreases.

ii. Always prefer machine crushed gravel. Fig.2

Fig.2 Machine Crushed Gravel

iii. The gravel should be well graded containing fine and coarse aggregates. Concrete prepared with same size of gravel is comparatively poor in strength.

iv. The size of the gravel for concrete should be less than 3/4" (19mm).

v. A material like coarse sand obtained from the crush machine during the process of stone crushing is called khaka. A dust free khaka can be used safely in the wall masonry.

1.3 Water:

i. Drinking water should be used in concrete and mortar. The use of contaminated water reduces the strength significantly.

1.4 Bricks:

i. Always use A-class bricks in wall masonry (Fig. 3)

ii. All the bricks should be of the same size.

iii. The bricks should be properly burnt and there should be no damage or deformed edges or sides.

Fig.3 First Class Bricks

iv. The quality of the bricks can be assessed by striking two bricks with each other. In case of A-class bricks, ringing noise is produced. Moreover, if it is dropped from a height of 4 feet on hard soil, it does not break. (Fig.4 and Fig.5).

Fig.4 Striking of two bricks with each other

Fig.5 Dropping of brick from 4 feet height

1.5 Concrete Block:

i. Ratio not more than 1:6:12 (1 part cement, 6 parts sand and 12 parts gravel) may be used in the blocks for wall masonry. The block prepared with the ratio of sand and gravel more than aforementioned would be very weak the use of which can prove to be dangerous (Fig.6).

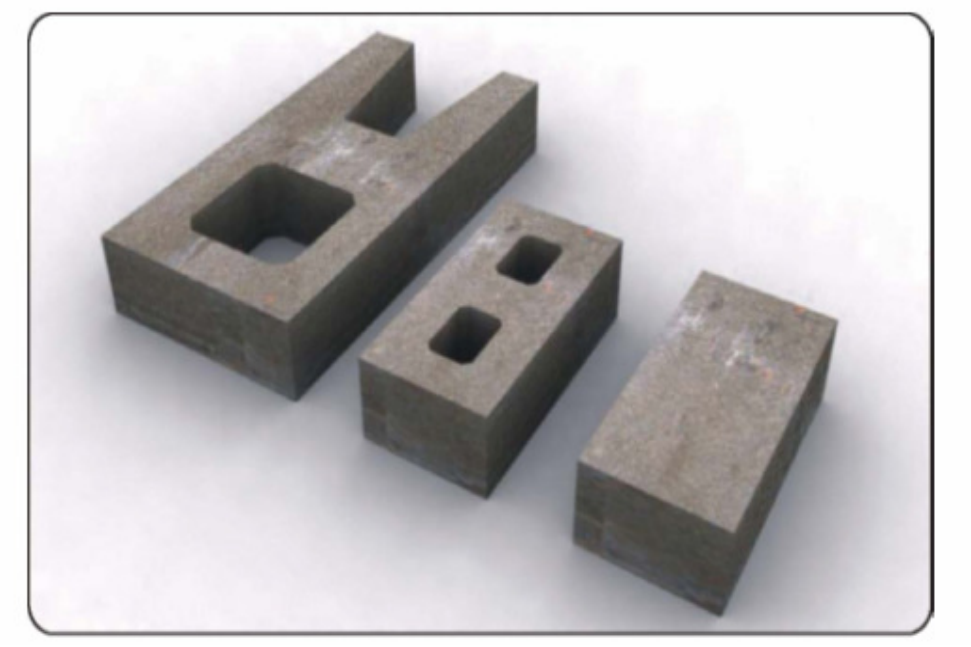

Fig.6 Concrete Block

ii. The amount of water in the aforementioned concrete used for the blocks should not exceed 8 number measure of 5 Kg tin for each cement bag of 50 Kg (Fig.7). Remember use of excess water in the concrete is very dangerous.

iii. Cracked, deformed and broken edged blocks should not be used.

Fig.7 Five Kg oil tin to measure water for mortar and concrete

1.6 Stone:

i. If it is desired/specified to use stones in wall masonry then it should be in square shape of appropriate size obtained from the mountains.

ii. Use of boulders obtained from streams and rivers should be avoided as the walls of these stones causes huge loss during earthquake.

1.7 Steel:

i. Oil and rust free steel should be used. If a large quantity of steel is to be used, its quality should be got tested from a recognized institute. All the Engineering Universities and construction related most of Government and non Government Institutions have this facility (Fig.8).

Fig.8 Material testing machine

1.8 Mortar:

i. Cement, sand and water for use in the mortar should be according to the instructions described in the previous pages.

ii. Constituents of the mortar i-e cement, sand or khaka should be mixed in dry mode and after mixing two to three times, add water gradually and remix.

iii. Water should not be added in one so that cement mixed water may not waste as runoff during mixing.

iv. Mortar should be prepared on a clean and metal led floor.

v. Use of water in mortar should be appropriate so as to make its use easier. Remember that excess water reduces the strength of the mortar significantly.

vi. After mixing of cement and sand, addition of water makes it glue like slurry which is commonly known as mortar. As if glue is not used immediately, it is dried and turns to waste. Likewise, if mortar is not used within almost one hour, will be dried like glue and wasted. So the time limit of one hour is very much important. The use of such mortar in the wall masonry proves harmful during earthquake.

vii. Some masons get the mortar prepared in large quantity and use it for hours which is a wrong way. The right thing is to prepare only that quantity of mortar which could be used within an hour.

viii. The mortar for the masonry should be of the ratio 1:6 (1 part cement and 6 parts sand/Khaka). Mortar prepared with 1 part cement three parts sand and three parts Khaka can also be used. It is notable that use of excess quantity of sand and khaka in the mortar causes reduction in strength of the wall.

ix. The ratio of mortar for plastering should be one part cement and three parts sand. The wall should be wet at saturation level before plastering.

1.9 Concrete:

i. Cement, sand, gravel and water for concrete should be according to the above mentioned instructions.

ii. The constituents of the concrete should be mixed with the mixer machine (Fig.9). In case of non availability of the machine, dry constituents should be mixed three to four times with the help of shovels and after that gradually add water and remix properly.

Fig. 9 Concrete aggregates mixing machine

iii. The concrete in columns, beams and slab should be of the ratio 1:2:4 (1 part cement, 2 parts sand and 4 parts gravel).

iv. The optimum quantity of water may be used for making good quality concrete. The quantity of water should not be more than 5 to 6 tin (5 kg empty oil tin) for one bag of cement (50Kg) in the concrete prepared for columns, beams and slab. If gravel and sand is already wet, then reduce the amount of water. Remember the use of excess water is extremely harmful for concrete strength.

v. A simple way to assess the quantity of water in the concrete is that if it is taken in hand and pressed, good quality concrete cement slurry does not flow out of the fingers (Fig.10).

Fig.10 Pressing of concrete in hand

vi. After properly mixing cement, sand and gravel when water is added, cement make glue like slurry. Glue if not used immediately, dries and is wasted. Likewise concrete if not used within an hour dries and is wasted. So it is important that concrete should be used within an hour after water is added otherwise the beams, columns and slabs made with this concrete will be weak in strength.

vii. If the concrete has to be dropped from a height, it should not be more than 6 feet because it leads to segregation of concrete which causes reduction in strength. (Fig.11).

Fig.11 Falling of concrete from a height

viii. Concrete should be compacted with the help of vibrator after adding each layer of 6 to 12 inches (Fig.12). Remember that strength of vibrator compacted concrete is much more than that of otherwise. If vibrator is not available, concrete should be compacted with steel rod.

ix. Keep continued curing of columns, beams and slabs made of concrete for 14 days.

Fig.12 Vibrator

2. WALL MASONRY

2.1 Brick Masonry;

i. Always use A- class bricks for wall masonry.

ii. Cement, sand or cement, sand and khaka mortar can be used for masonry work.

iii. Thickness of mortar between two brick courses should not be more than 3/8" in any case. Thicker the mortar layer, weaker the masonry work would be. (Fig.13).

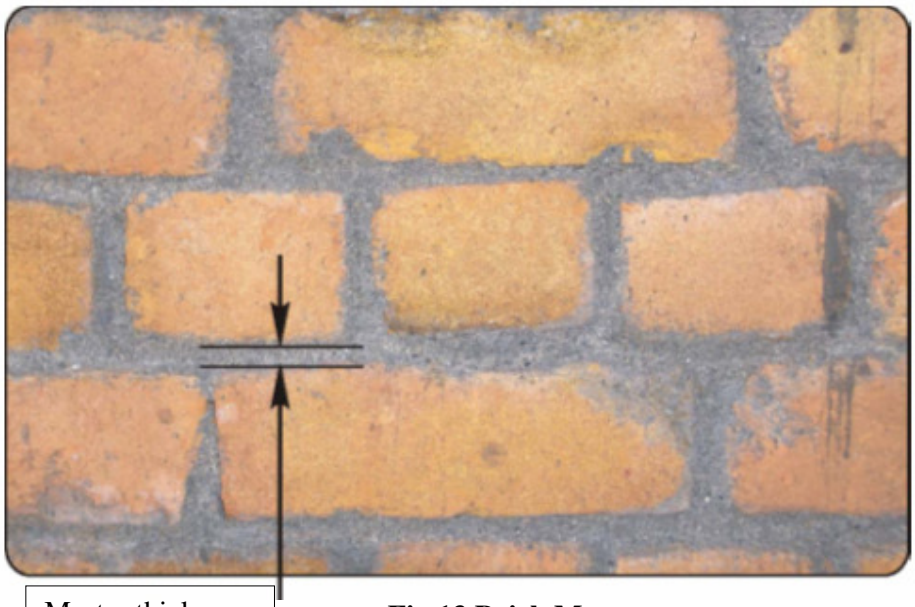

Fig.13 Brick Masonry

iv. Soak the bricks in water for 1 to 2 hours before their use. In this way, bricks do not absorb moisture from mortar and the brick mortar adhesiveness increases (Fig.14).

v. Use of old bricks should be avoided. If it is unavoidable, then those should be cleaned properly. It should be free from any type of dust/mortar.

vi. Minimum 7 days curing is required for masonry work. Use drinking water for curing. Remember improper curing may reduce the strength of wall significantly.

vii. Curing of plaster should also be carried out for 7 days**.**

Fig.14 Soaking of bricks in water before use

2.2 Block Masonry:

i. Always use good quality blocks for the masonry.

ii. Cement, sand or cement sand and khaka mortar can be used for the masonry work.

iii. Maximum thickness of mortar between two courses should not be more than 3/8". Thicker the mortar layer, weaker the masonry work would be.

iv. Minimum 7 days curing is required for masonry work. Use drinking water for curing. Remember improper curing may reduce the strength of wall significantly.

2.3 Stone Masonry:

i. Well chiseled and well shaped squared stones should be used. Use of un- chiseled stones is extremely dangerous because strong grip does not develop with mortar.

ii. In a 15 inch thick wall install 15 inch through stone after every three to four feet (Fig.15). This will provide a homogeneous bond with other stones and will strengthen the wall. Always keep the length of the through stones equal to the thickness of the wall.

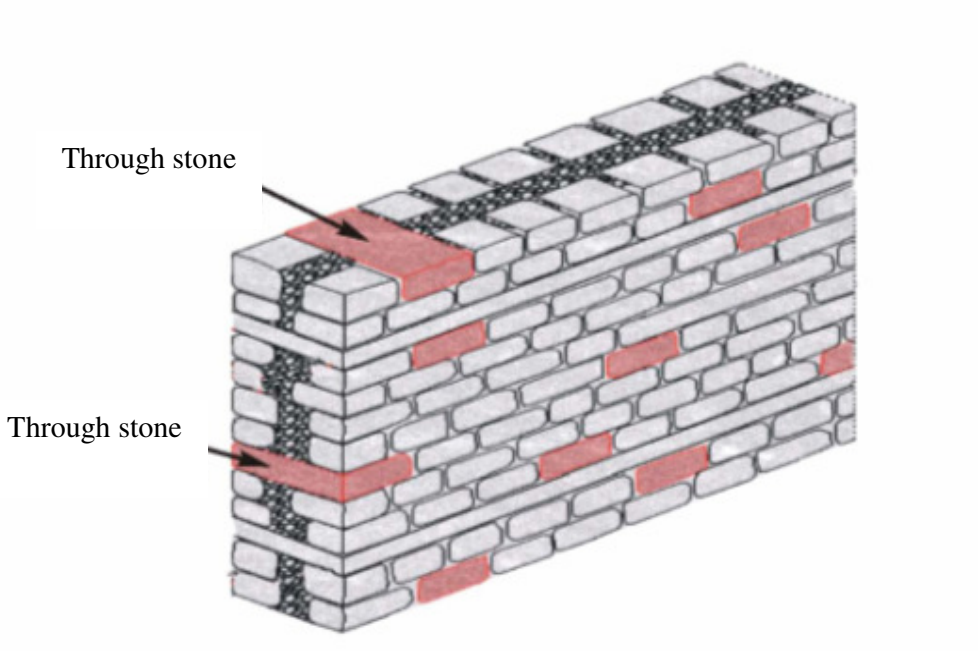

Fig.15 Stone Masonry

3. INSTRUCTIONS FOR EARTHQUAKE RESISTANT BUILDINGS

3.1 Brick, Block and Stone masonry Buildings

i. The plan of the building should be square or rectangular.

ii. For rectangular plan the length of building should be less than 4 times of its width.

iii. Thickness of wall should not be less than 9" and 15" for brick masonry and stone masonry respectively.

iv. Keep number and size of windows, doors and ventilators in the building to a minimum. Remember more the doors and windows in the walls of building, more the dangerous it would be during earthquake.

v. It is extremely important to provide concrete beams at different levels in the walls to make the bricks, blocks or stones constructed buildings earthquake resistant. (Fig.16)

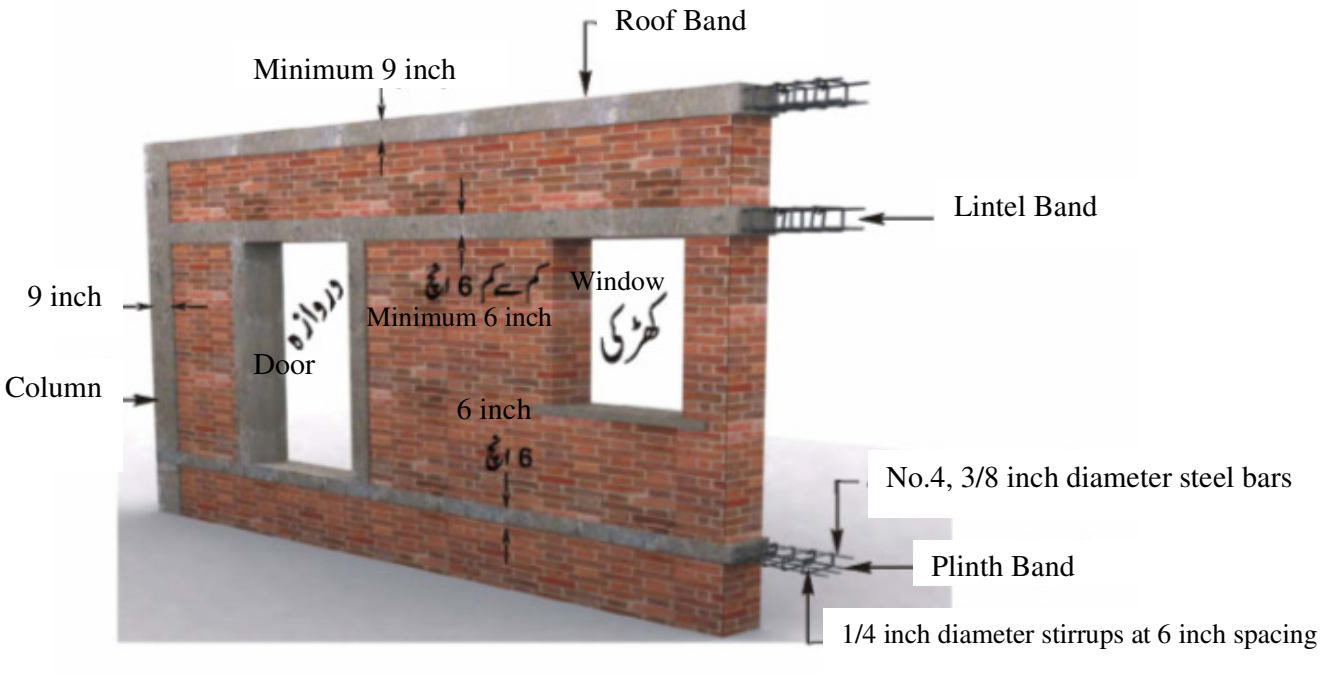

Fig. 16 Bands at different levels of a wall

vi. Three types of beams have been shown in Fig.16. The beam at the floor level is usually called as Plinth Band or Plinth beam. The beam at the doors and windows level is called lintel band or lintel beam while the beam at the roof level is called roof band or roof beam.

vii. The beam at windows and doors level is very essential. It must be kept in mind that beam should not only cover the windows or doors but should also be provided throughout the walls length as shown in Fig.16. Beam should also be provided on those walls which don't have windows or doors. The lintel beam on all the walls should be connected as shown in Fig.17.

Fig.17 Columns at the corners of rooms of Building

viii. Severe damages to the corners of the buildings have been observed during earthquake. Hence it is better to provide concrete columns on each corner of the room. In addition to this, 1/4 inch diameter, 3 feet long two steel rods should be provided in the corners of walls after each 2 feet height. The details of strengthening of corners have been shown in Fig.18.

ix. Roof slab should be properly tied with roof beam or roof band.

x. It should be kept in mind that distance of doors and windows should not be less than 2 feet from the corners of the walls.

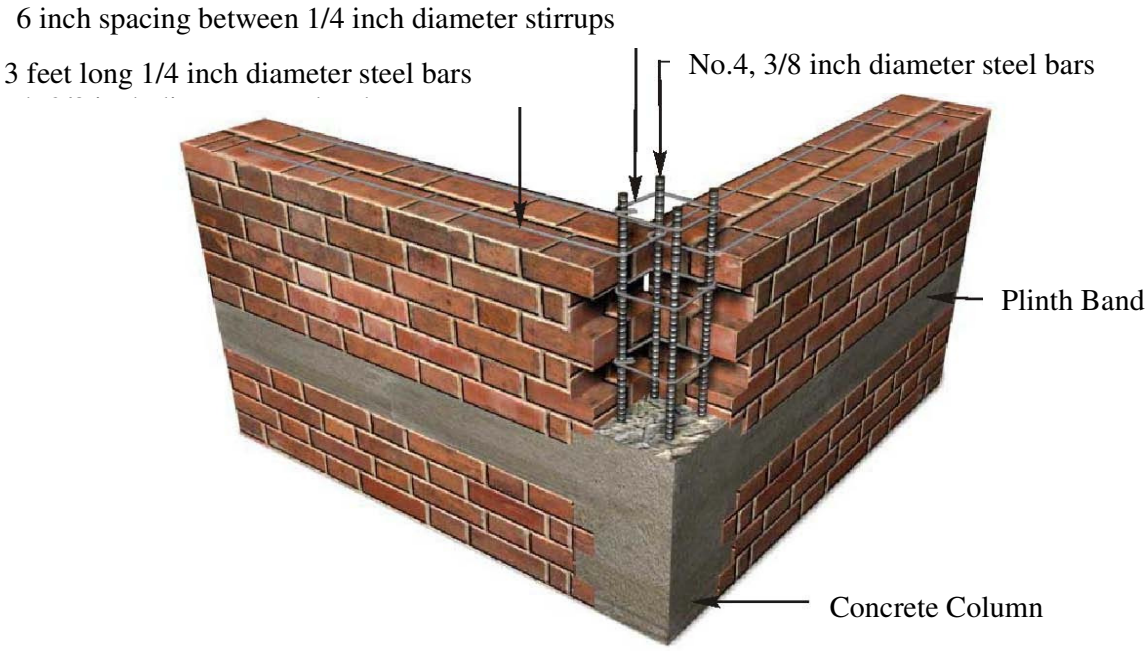

Fig.18 Column and steel rods at the corner of wall

3.2. Reinforced Cement Concrete Buildings

i. Hook of the steel stirrups in beams and columns should be at an angle of 135^0 Fig.19.

ii. Hooks of the consecutive stirrups should be at the opposite corners Fig.19.

iii. Lap should be provided in the middle height of the column Fig.20.

iv. Lap of the beam should be within the quarter length of the beam Fig.20.

v. The distance between the two stirrups at the lap portion should be 3 to 4 inches. Fig.20.

vi. Distance between two stirrups near joints should be 3 to 4 inches. Fig.20

vii. Hook must be given at the end of the beam Fig.20.

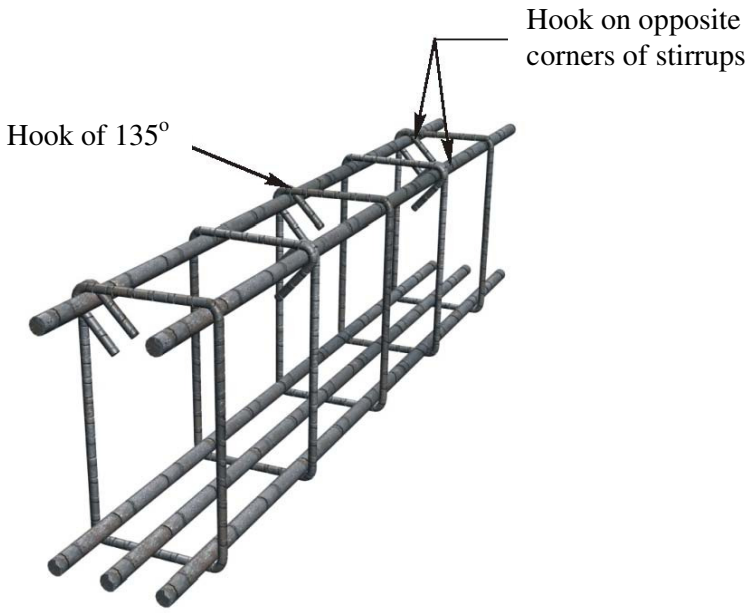

Fig.19 Hook on opposite corners of stirrups

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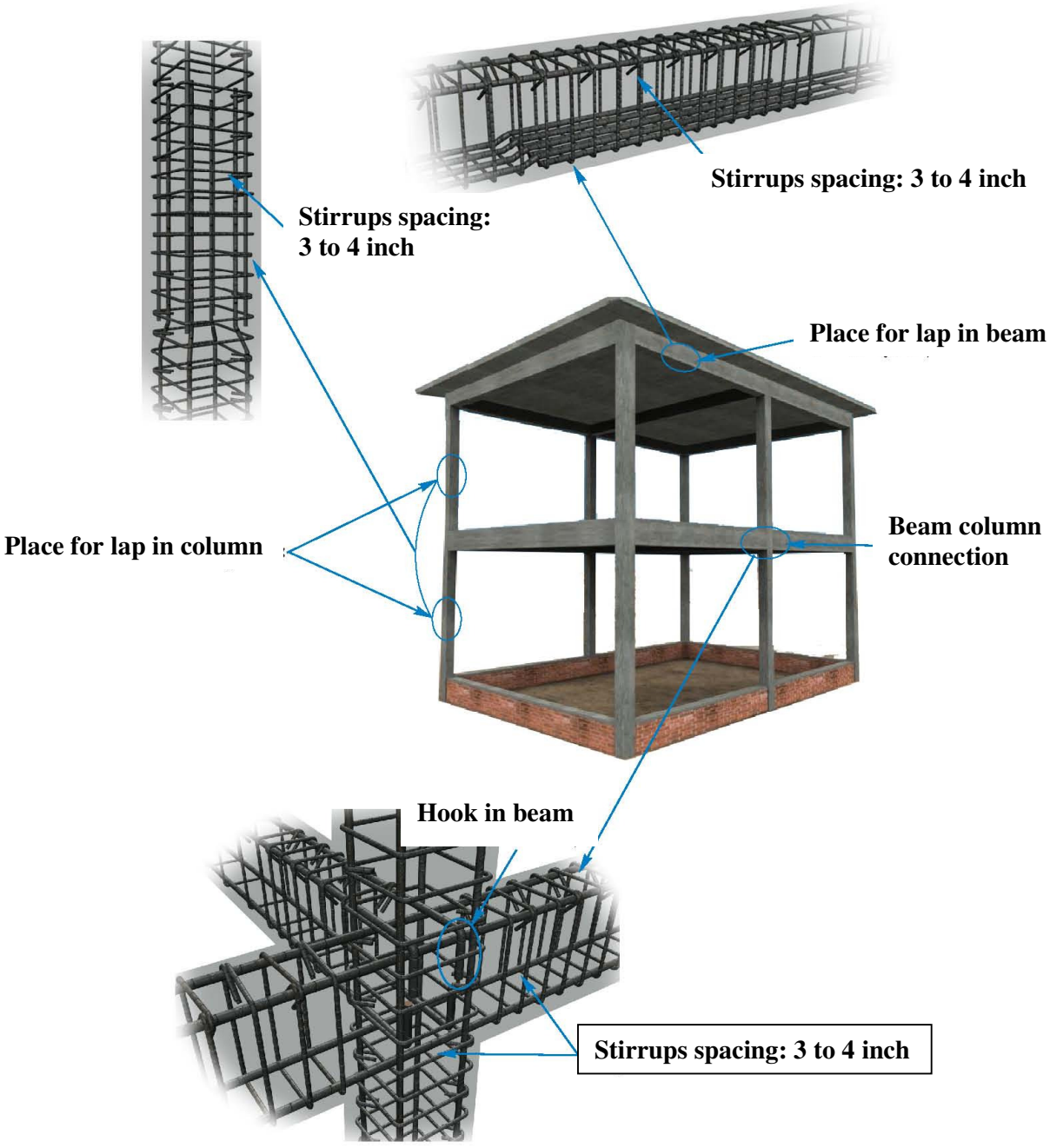


Fig.20 Details of lap and beam column connection

viii. Length of the Lap in slab, column and beam should be according to the following table.

Diameter of Bar	Length of Lap in Roof slab	Length of Lap in Column/Beam	
	Grade-40	Grade-40	Grade-60
3/8”	16”	21”	21”
1/2”	21”	28”	28”
5/8”	26”	35”	35”
3/4”	-	42”	42”
1”	-	70”	70”
9/8”	-	80”	80”

ix. Clear cover between steel and concrete on the outer side should be according to the following table.

Roof Slab	3/4”
Beam/Column	1.5”
Foundation	3”

4. MISCELLANEOUS INSTRUCTIONS

4.1 Foundation:

i. Minimum foundation depth and width of one or two storey building should be 3 feet and 2.5 feet respectively.

ii. Some people use stone up to the plinth level for wall masonry. As explained earlier, if it is required to use stone in wall masonry, well chiseled and well square shaped mountainous stones should be used. Use of un- chiseled stones obtained from streams and rivers causes severe damage during earthquake. Thus use of these should be avoided. It is better to use good quality bricks or blocks instead of stones.

iii. Foundation details have been shown in Fig.21 which is satisfactory for one or two storey house. However if the soil bearing capacity is very low then RCC should be used in foundation as shown in Fig.22

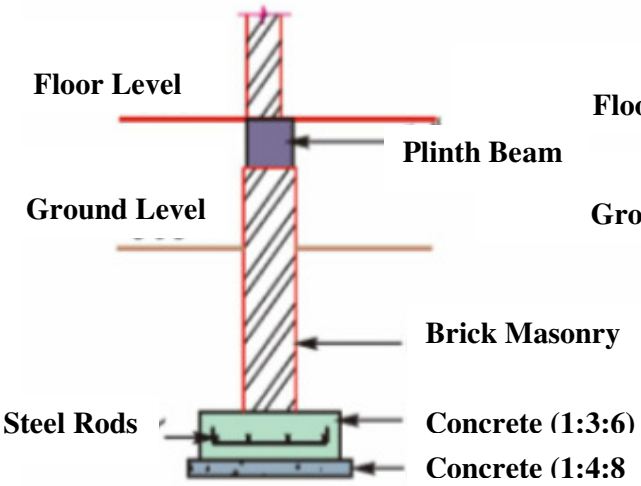


Fig.22 RCC Foundation

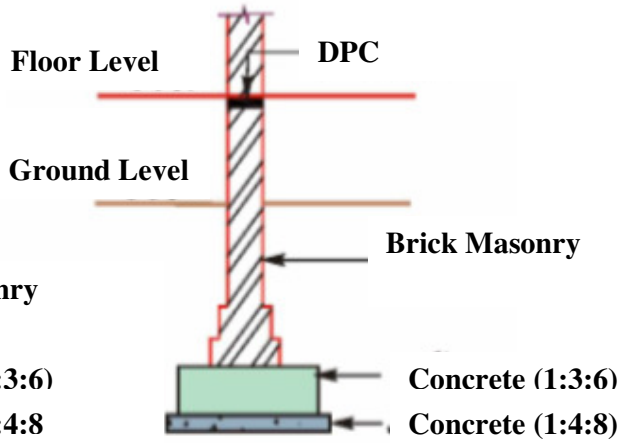


Fig.21 PCC Foundation

4.2 Framework:

i. As far as possible shuttering/framework should be of steel. Fig.25-26.

ii. There should be no hole in the shuttering so that cement slurry or concrete may not flow out.

iii. Surface of the shuttering should be clean and smooth.

iv. Shuttering should be so strong that it could bear the weight of the fresh concrete.

v. Shuttering beneath beam and roof slab should be provided for at least 14 days so that concrete gains its strength. However column shuttering can be removed after two days.

4.3 Steel mesh on the walls:

i. Collapsing of walls causes maximum causalities during earthquake. To protect the wall from collapsing, steel mesh should be fitted on the wall as shown in the figure. Remember that the mesh should be firmly tied with the columns and beams provided in the walls at different levels.

ii. Use 18 gauge steel wire mesh with 3/4 to 2 inch spacing. Fig.23-26

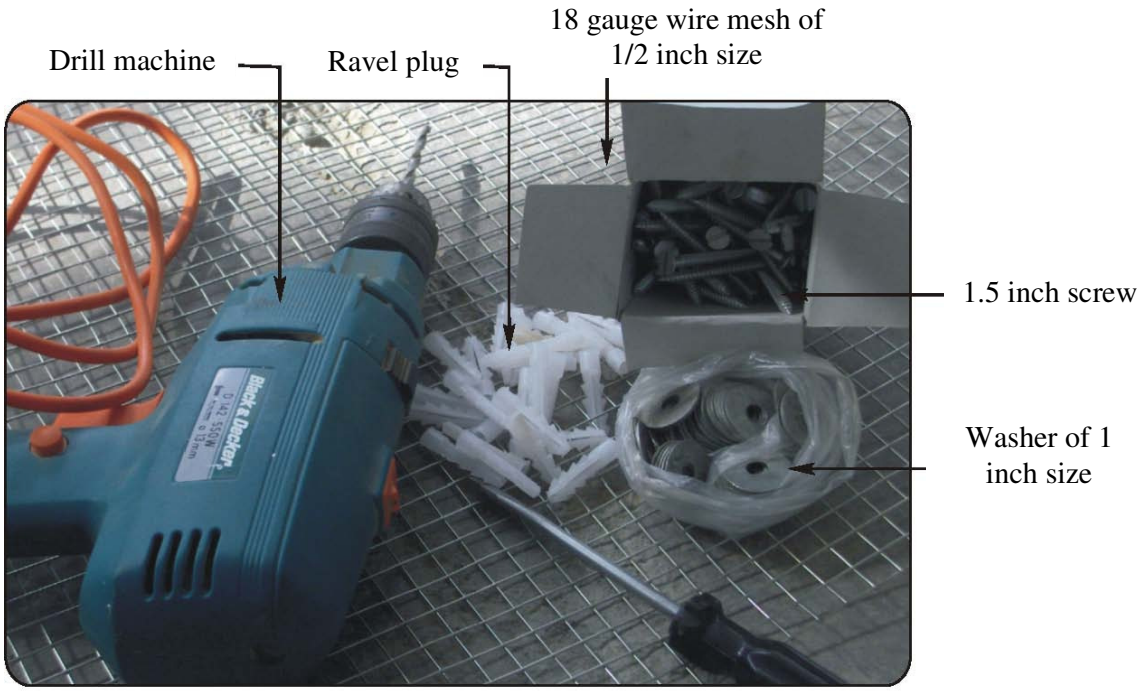


Fig.23 Accessories for wire mesh on the wall

Fig.24 Drilling for fixing the mesh

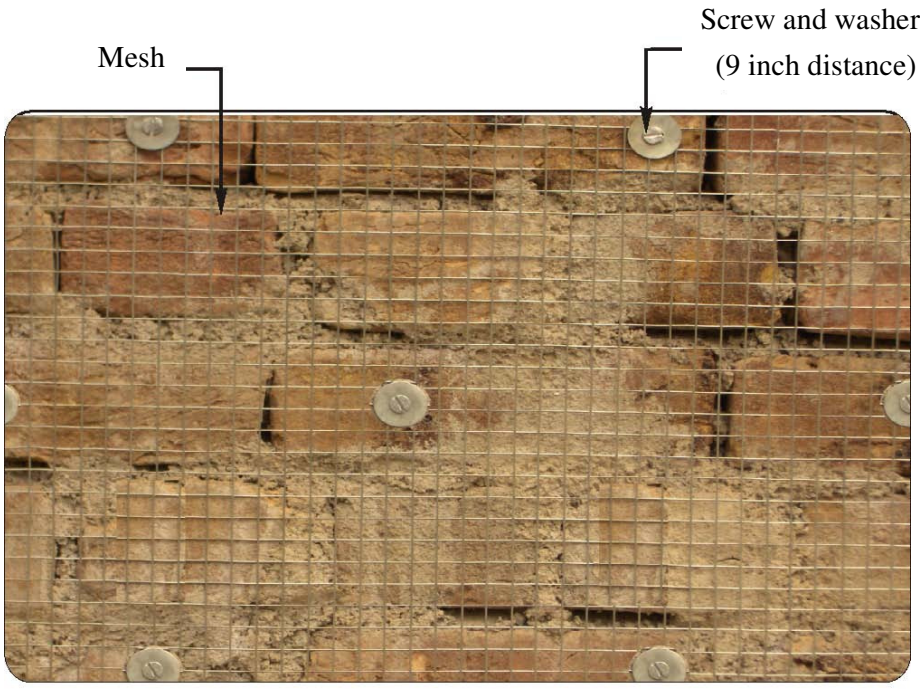


Fig. 25 Steel wire mesh on wall

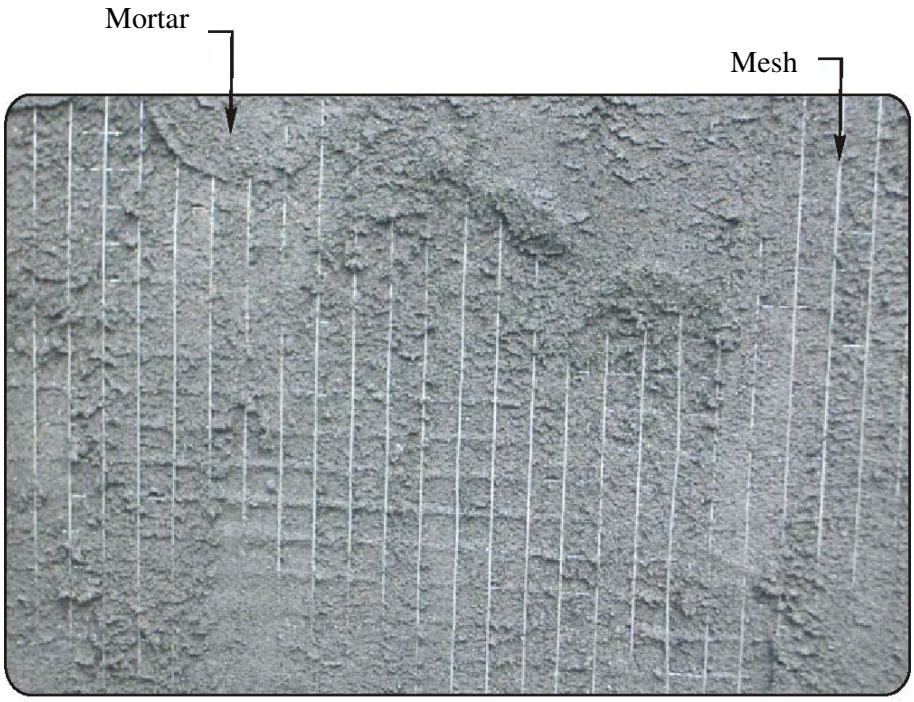
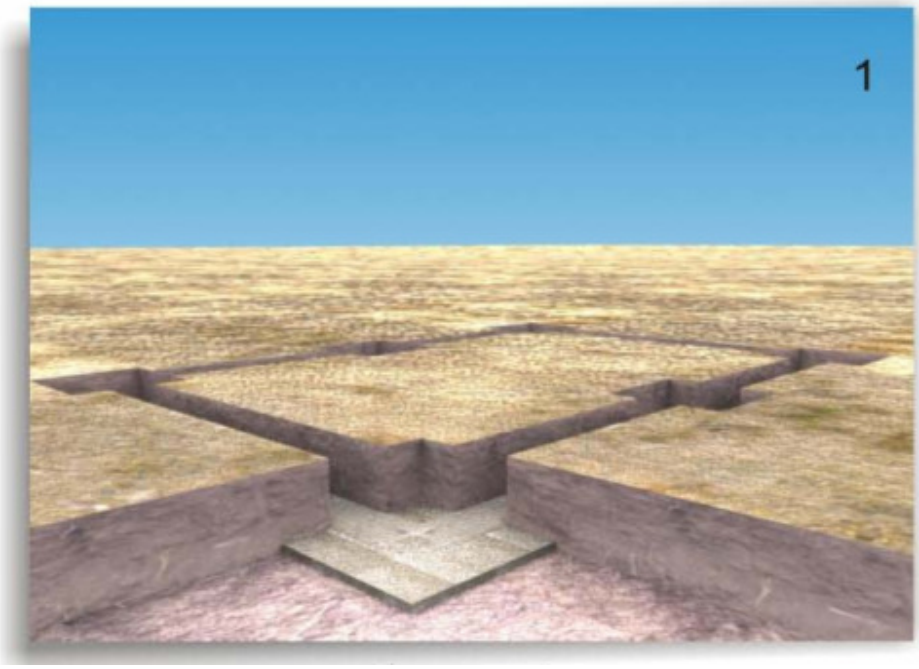
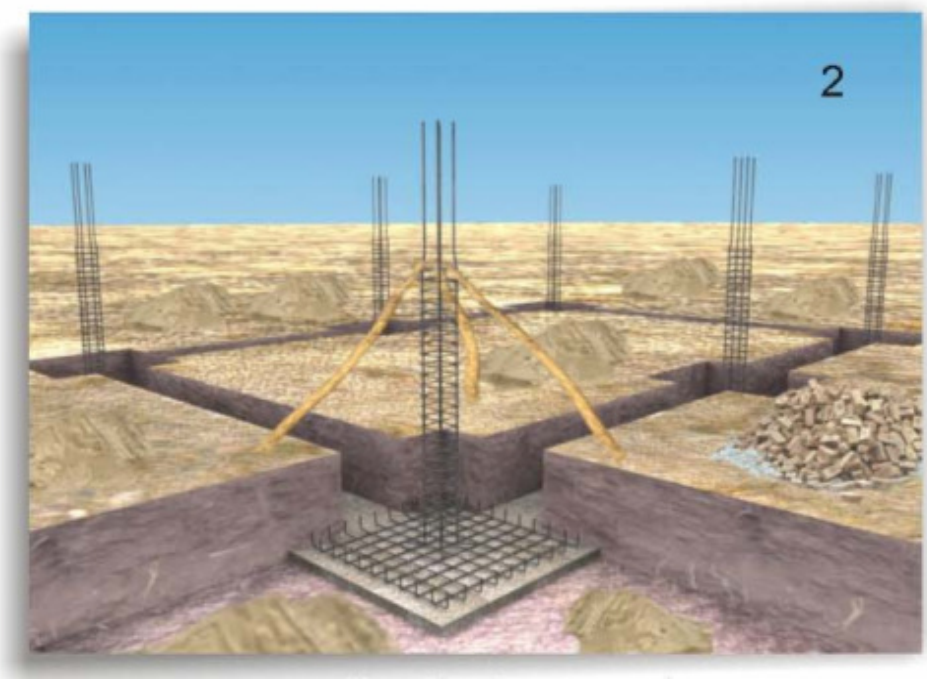


Fig.26 Plastering on steel wire mesh

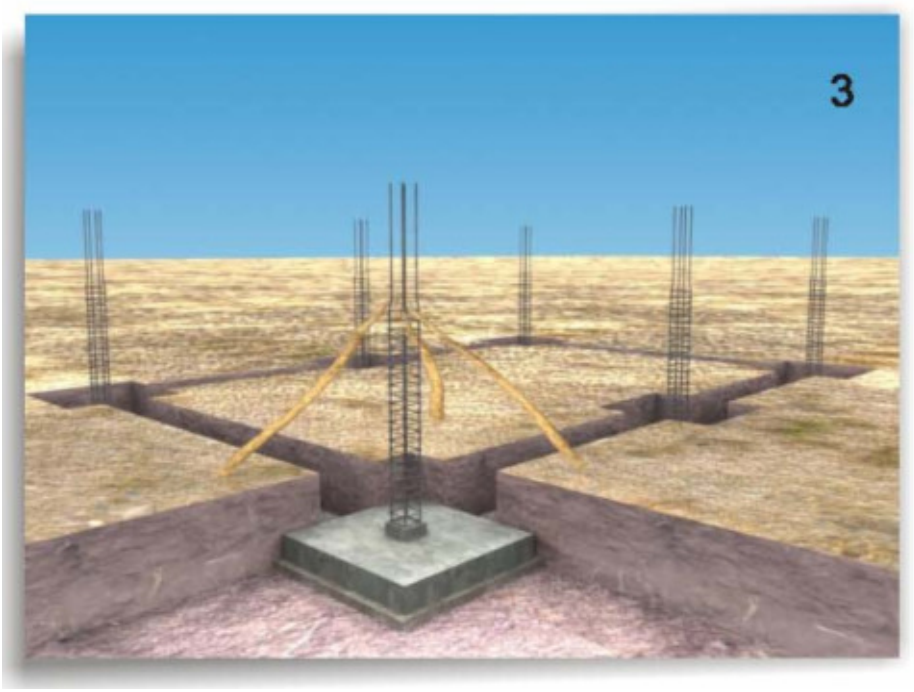
4.4 Phase wise Construction of Concrete Buildings



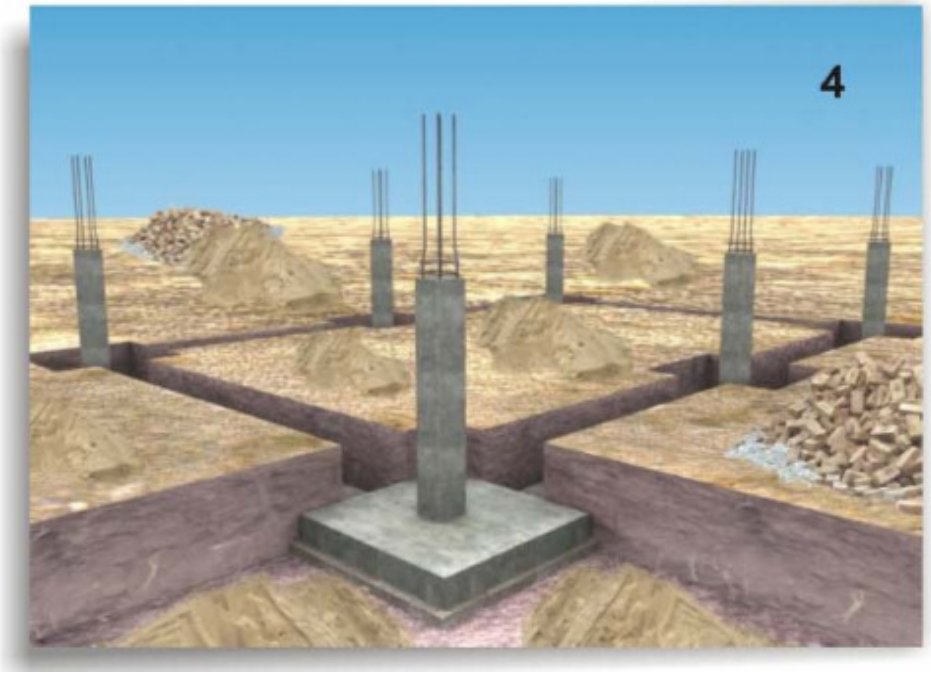
1. Spread concrete 1:4:8 in foundation after excavation having thickness 4 inch and smooth surface.



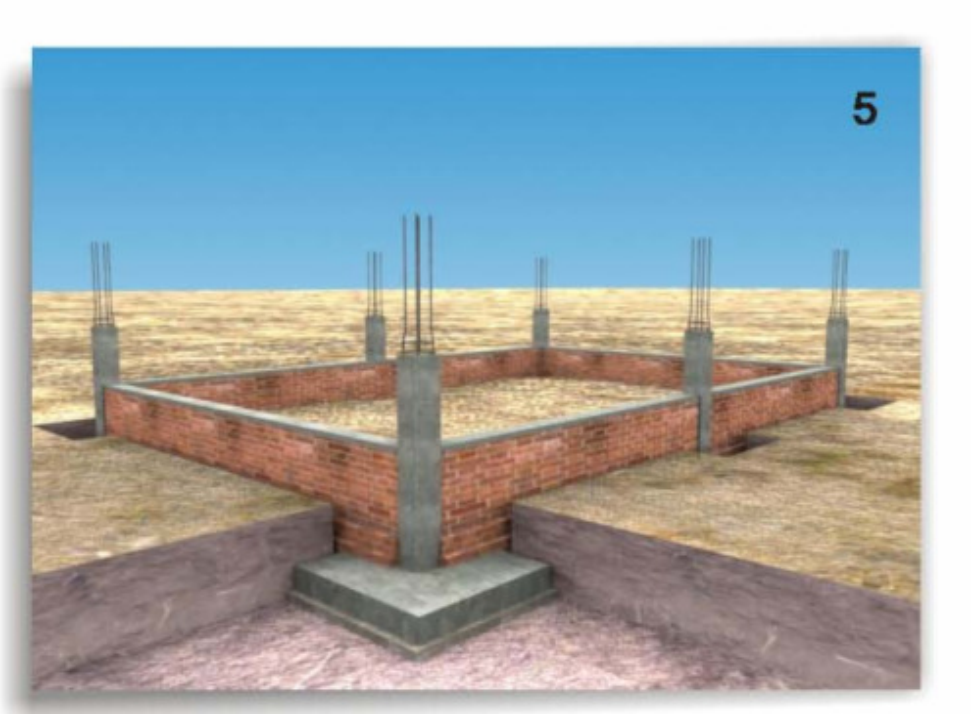
2. Tie the ends of foundation and column steel bars. The length of the steel bars in the column should be enough so that the lap comes in the middle of the height of the column. Support the bars in the column to stand at its original position.



3. Spread concrete in the foundation after fixing the framework and then place 3-4 inch thick starter of the column.

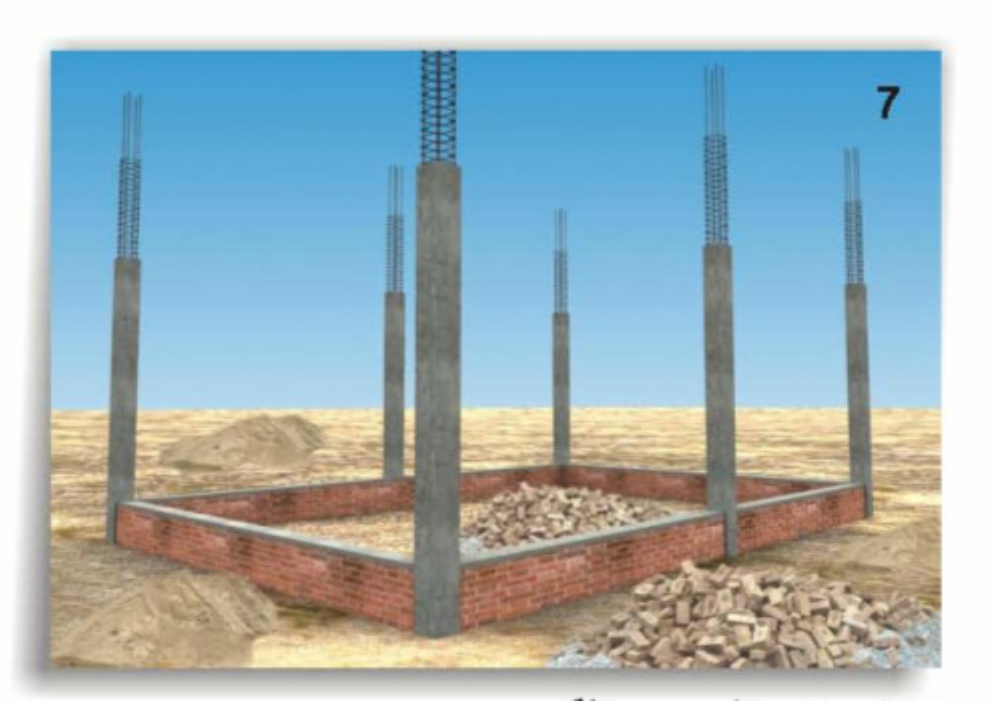


4. After fixing column framework, fill with concrete up to the lap level.



5. After placing the wall foundation, complete masonry to DPC level in between the columns.

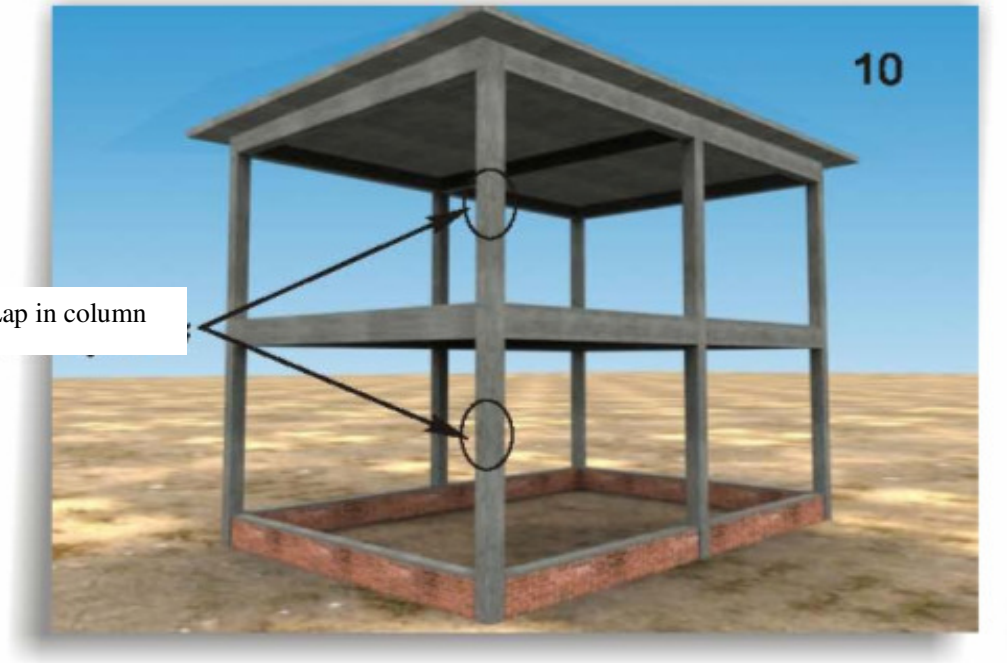
6. Tie the column bars by giving suitable lap. The length of the steel bars in the column should be enough so that the next lap comes in the middle of the height of 2nd floor.



7. After fixing framework, fill column with concrete up to 1st floor.

8. After fixing framework, tie the steel bars of beam and slab and try to fill with concrete simultaneously.

9. Fill concrete in the columns up to the lap level of 2nd floor after fixing framework.



10. Repeating the above steps, complete the remaining floors.

11. Complete wall masonry. Fix steel wire mesh on inner side of wall and plaster.

12. Fill concrete around the building to protect it from rain water.