

Cost Comparison of Earthquake Resistant Single Storey Masonry House with its Non Engineered and RCC Framed Counterparts

By

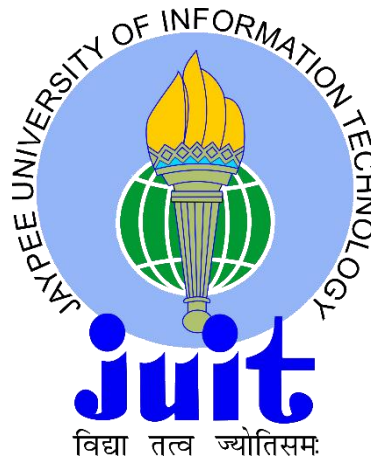
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***“THE BIGGEST FAILURE IN LIFE
IS THE FAILURE TO LEARN
FROM YOUR MISTAKES”***

-Shri Jaiprakash Gaur ji

CERTIFICATE

This is to certify that the work entitled “**Cost Comparison of Earthquake Resistant Single Storey Masonry House with its Non Engineered and RCC Framed Counterparts**” submitted by **Sarthak Vashishtha (111605), Apurv Kansal (111623), Vijay Pal Singh Gill (111681)** in partial fulfilment for the award of degree of Bachelor of Technology in Civil Engineering of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

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This project report gives a detailed description of the study work done on the project topic **“Cost Comparison of Earthquake Resistant Single Storey Masonry House with its Non Engineered and RC Framed Counterparts”** in the final year for the partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering, under the supervision of Mrs Poonam Dhiman.

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ABSTRACT

To begin with a proper cost estimation of a non-engineered brick masonry house using the rates provided in DSR 2012 (Delhi Schedule of Rates) provided by CPWD was prepared. Then by using simple techniques given in IS 13828:1993 (Improving earthquake resistance of low strength masonry buildings), this non engineered brick masonry house was converted into an earthquake resistant brick masonry house. Cost estimation of this house was done. For the final part of the project, the house was converted into a RCC framed house and again cost was estimated. The results were drawn on comparing the cost and safety factor of all the three counterparts.

CHAPTER 1
INTRODUCTION

Is your building safe from an earthquake? This is a question that everybody should be concerned about. Many earthquakes have taken place in India and its neighboring countries taking countless lives and leading to thousands of collapsed buildings.

1.1 What is Earthquake?

Earthquake is noticeable shaking of the Earth, Which can be violent enough to destroy buildings and can also kill thousands of people. The seismic activity of area refers to the frequency, type and size of earthquake experienced.

1.2 How it affect Masonry Houses?

The extent of damage caused but an earthquake does not only depend upon its magnitude but also the type of construction practices followed in a particular region. For example an earthquake in Tokyo or Los Angeles may result in the damage to only a few buildings but the results can be highly catastrophic in Mumbai or in Delhi.

Masonry Buildings are brittle structures. Ground vibrations during earthquake causes inertia forces in the building. The forces travel from roof and walls to foundations. The walls are most vulnerable to damage caused by horizontal forces due to earthquake.

The codes of practice on earthquake resistant design (IS4326:1993), earthquake resistance of earthen buildings (IS 13827:1993), Earthquake resistance of low strength masonry buildings (IS 13828:1993), ductile detailing of reinforced concrete structures (IS 13920:1993) and seismic strengthening of buildings (IS 13935) were published almost simultaneously to meet the urgency of seismic design of buildings.

By providing reinforced concrete bands at plinth, lintel, roof levels can protect your house from collapsing by forces generated during earthquake.

If you are planning to invest in a new building this report will help you to make your simple masonry house into an earthquake resistant building with minimal increase in your budget.

Figure 1 show how non engineered masonry house behave during earthquake.

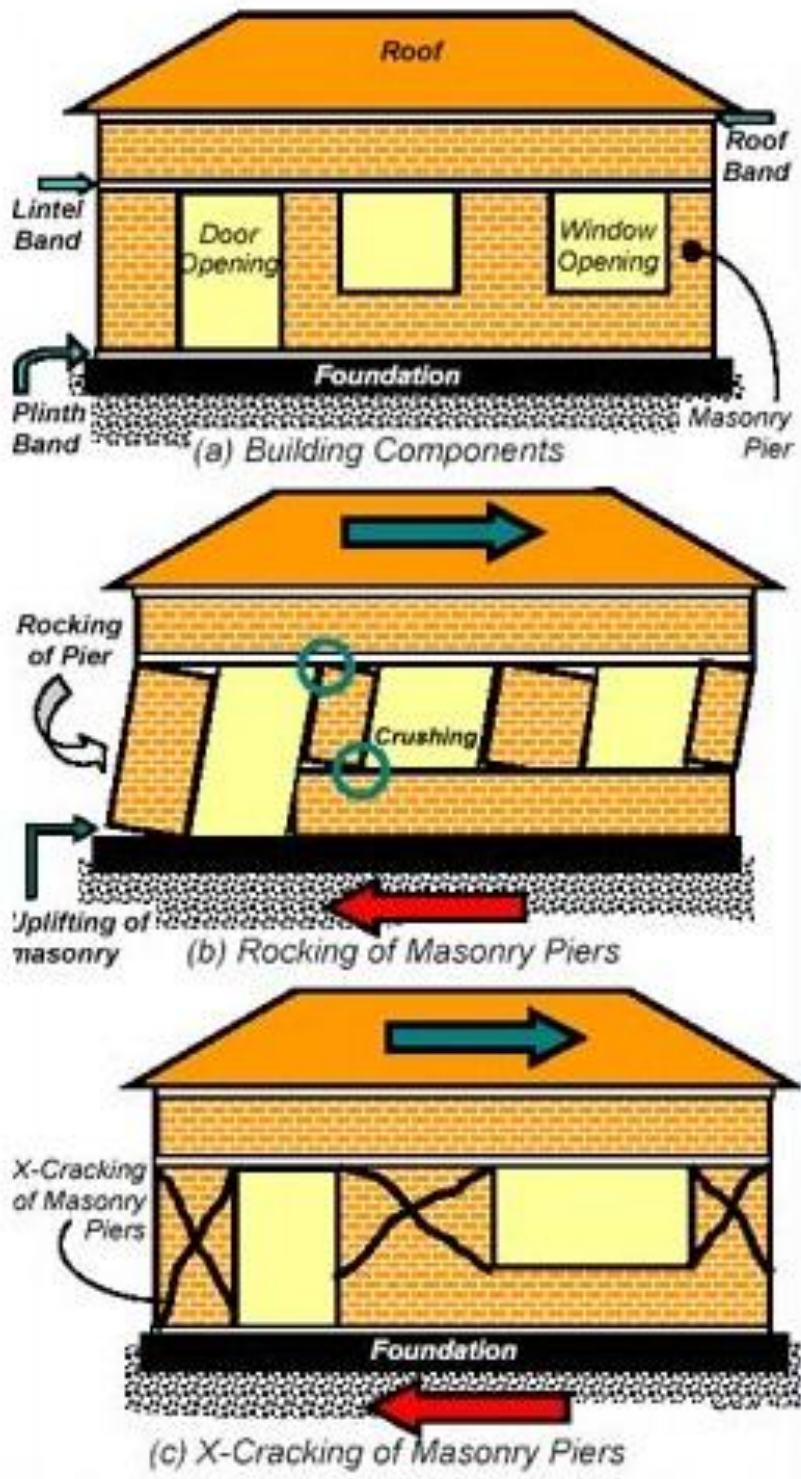


Fig 1:- Masonry House during Earthquake

CHAPTER 2

**NON-ENGINEERED SINGLE
STOREY MASONRY HOUSE**

2.1 Location Detail

This house is constructed in Earthquake Zone IV i.e. Delhi NCR, India. Following conditions were taken into account:-

- Unit weight of Soil:- 22kN/m^3
- Bearing Capacity of Soil:- 180kN/m^2
- Cohesion:- 15kN/m^2

2.2 Plan of House

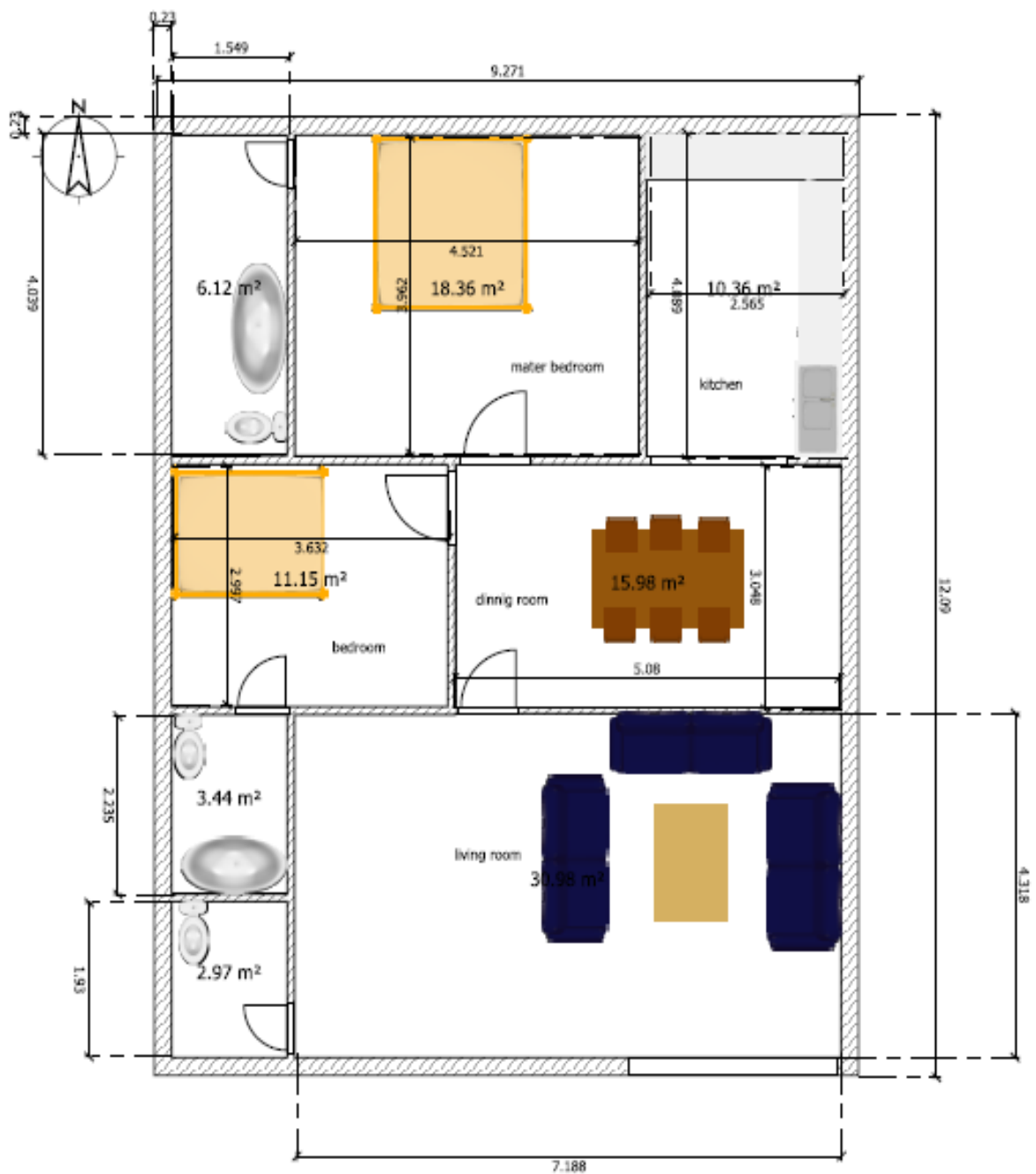


Fig 2:- Plan of House

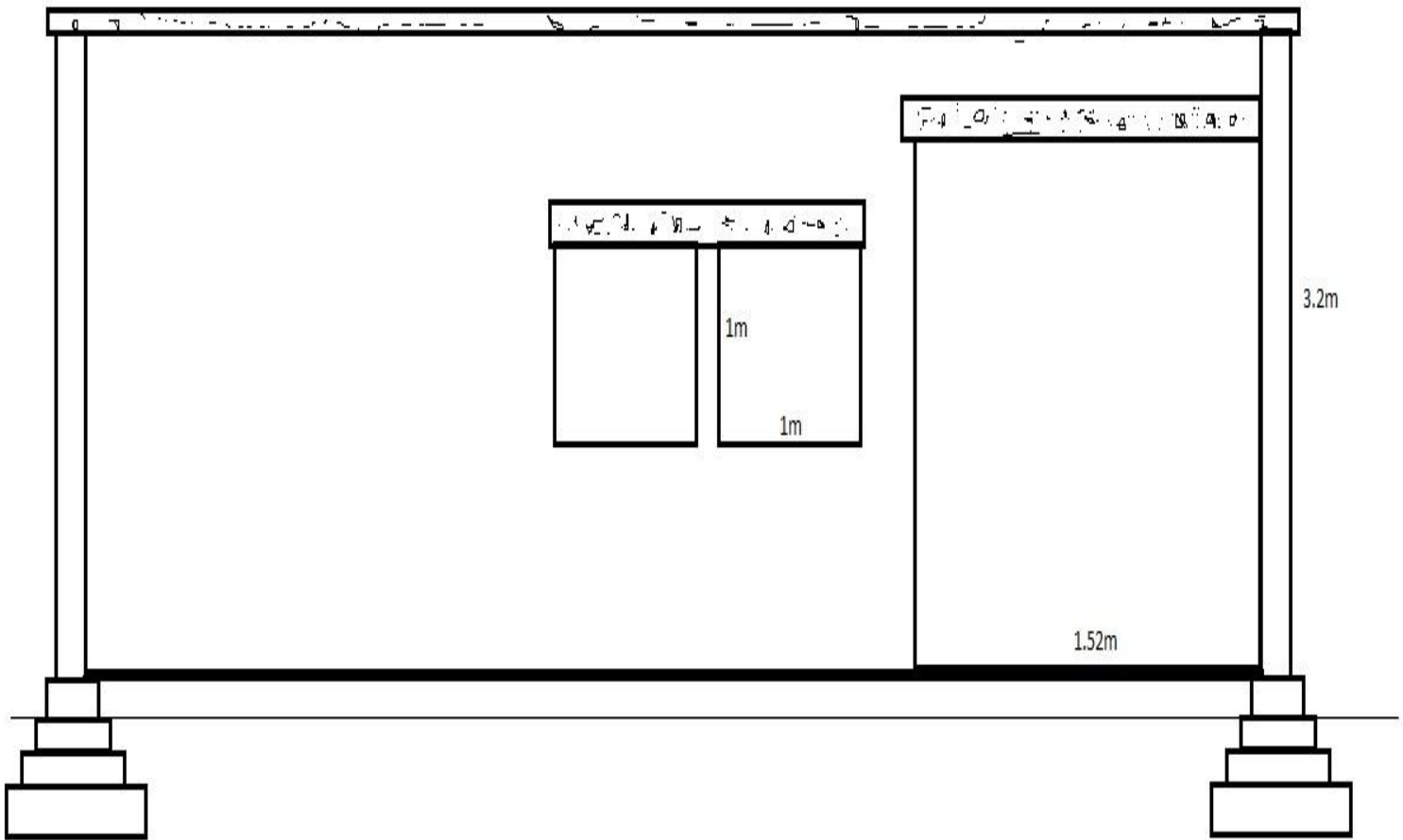


Fig 3: Front View of single Storey Brick masonry house

2.3 Foundation Design

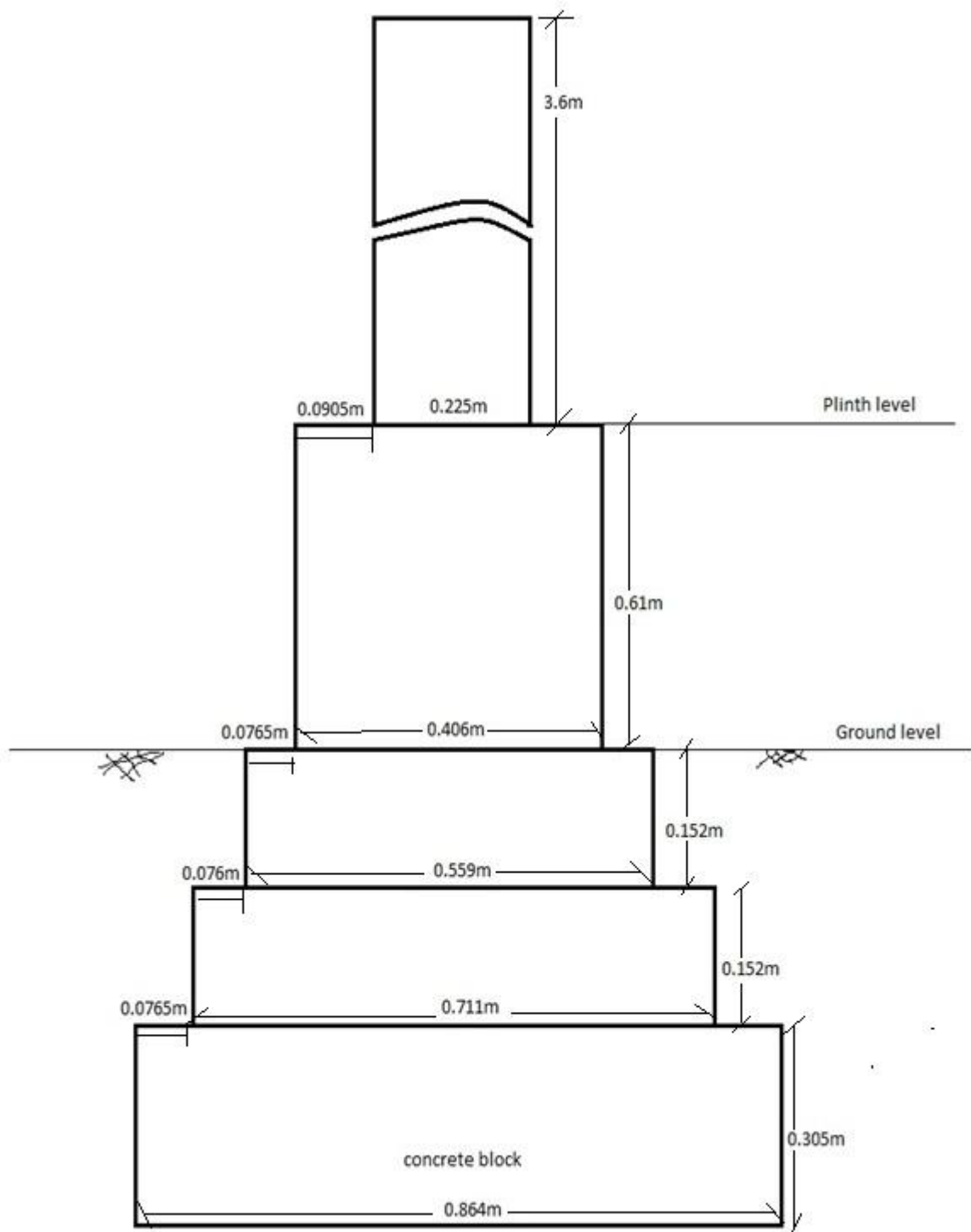


Fig 4:- Design of footing

2.4 Components and Specifications

Concrete Work:

M15 (1:2:4 i.e. 1 cement: 2 coarse sand: 4 aggregates) grade of concrete is used in foundation for lying concrete block.

Brick Work:

- **Sub-Structure**

Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in foundation and plinth by cement paste 1:6 (1 Cement: 6 coarse sand).

- **Super-Structure**

Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes by cement paste 1:6 (1 cement: 6 coarse sand).

RCC Work:

Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centring, shuttering, finishing and reinforcement, with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).

Marble Work:

Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facials and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.

Wood and PVC Work:

- Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required diameter & length (hold fast lugs or dash fastener shall be paid for separately) with Second Class Teak Wood.
- Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.

- Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete.
- Providing and fixing aluminium handles ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc. complete of size 125mm.
- Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.
- Providing and fixing aluminium hanging Twin Rubber door stopper ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc.

Steel Work:

- Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal diameter 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm diameter round headed screws, one lock at the corners. Clamp shall be made of 12mm diameter M.S. bar bent to shape as per standard drawing.
- Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.

Flooring:

- Cement concrete flooring 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry but excluding the cost of nosing of steps etc. complete of 40 mm thick with 20 mm nominal size stone aggregate.
- Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand), including grouting the joints with white cement and matching pigments etc.

Finishing:

- 12 mm cement plaster of mix 1:4 (1 cement: 4 coarse sand)

2.5 Cost Estimation of House (Part 1)

S.No.	Item No. of DSR	Description	Unit	Quantity	Rate	Cost (in INR)
Civil Work						
1	1	Earth Work				
	1.1	Earth work in excavation by mechanical means (Hydraulic excavator) / manual means over areas (exceeding 30cm in depth. 1.5m in width as well as 10 sqm on plan) including disposal of excavated earth, lead upto 50m and lift upto 1.5m, disposed earth to be levelled and neatly dressed.				
	1.1.1	All kinds of soil	cum	22.041	129.35	2851.00335
2	2	Supplying and filling in plinth with sand under floors, including watering, ramming, consolidating and dressing complete	cum	2.099	749.3	1572.7807
3	3	Concrete Work				
	3.1	1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size)				
			cum	11.02	4514.05	49744.831
	3.2	Providing and laying damp-proof course 50mm thick with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20mm nominal size).				
			sqm	12.2	254.7	3107.34

4	4	R.C.C.				
	4.1	Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centering, shuttering, finishing and reinforcement, with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	cum	17.916	5494.55	98440.3578
5	5	Brick Work				
	5.1	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in foundation and plinth in:				
	5.1.1	Cement mortar 1:6 (1 cement : 6 coarse sand)	cum	8.9219	3316.55	29589.92745
	5.2	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes in :				
	5.2.1	Cement mortar 1:6 (1Cement:6 coarse sand)	cum	45.19	3876.15	175163.2185

6	6	Marble Work				
	6.1	Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facias and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.				
	6.1.1	Granite of any colour and shade				
	6.1.1.1	Area of slab over 0.50 sqm	sqm	5.654	3083.4	17433.5436
7	7	Wood Work and PVC Work				
	7.1	Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required dia & length (hold fast lugs or dash fastener shall be paid for separately).				
	7.1.1	Second class teak wood	cum	0.4557	85813.3	39105.12081
	7.1.2	Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.				
	7.1.2.1	35 mm thick including ISI marked Stainless Steel butt hinges with necessary screws.	sqm	19.979	1578.3	31532.8557

7.2	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete				
7.2.1	Fixed to openings /wooden frames with rawl plugs screws	kg	120	98.2	11784
7.3	Providing and fixing aluminium extruded section body tubular type universal hydraulic door closer (having brand logo with ISI, IS : 3564,embossed on the body, door weight up to 36 kg to 80 kg and door width from 701 mm to 1000 mm), with double speed adjustment with necessary accessories and screws etc. complete.	each	7	981.75	6872.25
7.4	Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.				
7.4.1	Size 40mm	each	7	137.75	964.25
7.5	Providing and fixing aluminium handles ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete :				
7.5.1	125 mm	Each	7	62.5	437.5
7.6	Providing and fixing aluminium hanging door stopper ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete				
7.6.1	Twin rubber stopper.	each	7	71.55	500.85

8	8	Steel Work				
	8.1	Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal dia 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm dia. round headed screws, one lock at the corners. Clamp shall be made of 12mm dia M.S. bar bent to shape as per standard drawing.	Each	8	117.45	939.6
	8.2	Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.				
	8.2.1	M.S. Tube	kg	1670	150	250500
9	9	Flooring				
	9.1	Cement concrete flooring 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry, but excluding the cost of nosing of steps etc. complete.				
	9.1.1	40 mm thick with 20 mm nominal size stone aggregate	sqm	99.36	280.05	27825.768

9.2	Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more (thickness to be specified by the manufacturer), of 1st quality conforming to IS : 15622, of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand),including grouting the joints with white cement and matching pigments etc. complete	sqm	130.25	931.5	121327.875
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10	10	Finishing			
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10.1	12 mm cement plaster of mix				
10.1.1	1:4 (1 cement: 4 coarse sand)	Sqm	524.04	132.1	69225.684
10.2	White washing with lime to give an even shade : New work (three or more coats)	Sqm	524.04	11.75	6157.47
10.3	Distempering with oil bound washable distemper of approved brand and manufacture to give an even shade				
10.3.1	New work (two or more coats) over and including water thinnable priming coat with cement primer	sqm	139.18	64.65	8997.987

Total					954074.2129
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CHAPTER 3

**RECOMMENDATIONS AND
CLAUSES FROM *IS 13828:1993* AND
*IS 1893:1984***

3.1 IS 13828 (IMPROVING EARTHQUAKE RESISTANCE OF LOW STRENGTH MASONRY BUILDING -GUIDELINES)

- Projecting parts should be avoided as far as possible. If the projecting parts cannot be avoided, they should be properly reinforced and firmly tied to the main structure.
- Ceiling plaster should preferably be avoided. When it is unavoidable, the plaster should be as thin as possible.
- In order to minimize torsion, the building should have a simple rectangular plan
- Precautions should be taken to keep the rain water away from soaking into the wall so that the mortar is not softened due to wetness. An effective way is to take out roof projections beyond the walls by about 500 mm.
- The fired bricks should have a compressive strength not less than 3.5 MPa. Strength of bricks and wall thickness should be selected for the total building height.
- The mortar should be cement-sand (1:3) or clay mud of good quality.
- The minimum wall thickness shall be one brick in one storey construction and one brick in top storey and 1.5 brick in bottom storey of up to three storey constructions. It should also not be less than 1/16 of the length of wall between two consecutive perpendicular walls.
- The height of the building shall be restricted to the following, where each storey height shall not exceed 3.0 m.
- Door and window openings in walls reduce their lateral load resistance and hence should preferably be small and more centrally located.
- Figure 5 shows recommendations for masonry house in IS 13828:1993

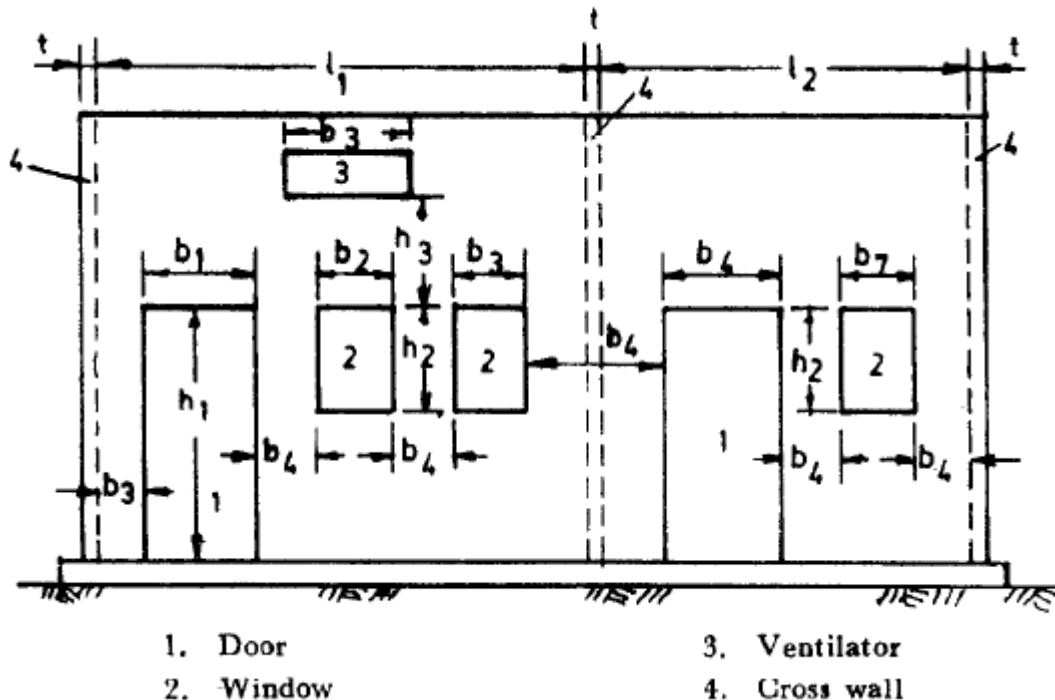


Fig 5:- Recommendations of IS 13828:1993

**Table 2 Size and Position of Openings
in Bearing Walls (see Fig. 4)**
(Clauses 8.4.1 and 8.4.3)

Description	Building Category	
	A, B & C	D
i) Distance b_5 from the inside corner of outside wall, <i>Min</i>	230 mm	600 mm
ii) Total length of openings, ratio; <i>Max</i> : ($b_1 + b_2 + b_3$) / l_1 or ($b_6 + b_7$) / l_2		
— one storeyed building	0.46	0.42
— 2 & 3 storeyed building	0.37	0.33
iii) Pier width between consecutive openings b_4	450 mm	560 mm
iv) Vertical distance between two openings one above the other, h_3 , <i>Min</i>	600 mm	600 mm

Fig 6:- Table 2 of IS 13828:1993

- Figure 6 is Table 2 in IS 13828 which show Size and Position of Openings in Bearing Walls.
- Openings in any storey shall preferably have their top at the same level so that a continuous band could be provided over them including the lintels throughout the building.
- All buildings to be constructed of masonry shall be strengthened by the methods as specified for various categories of buildings
- Figure 7 is table 3 in IS 13828 which show strengthening Arrangements Recommended for Low Strength Masonry Building

**Table 3 Strengthening Arrangements
Recommended for Low Strength
Masonry Buildings**
(Clause 8.5.1)

Building Category	Number of Storeys	Strengthening to be Provided
(1)	(2)	(3)
A	1 and 2 3	c, f b, c, f, g
B	1 and 2 3	b, c, f, g b, c, d, f, g,
C	1 2 and 3	b, c, f, g b, c, d, f, g
D	1 and 2	b, c, d, f, g

Strengthening Method

- b — Lintel band (see 8.5.2)
- c — Roof band and gable band where necessary (see 8.5.3 and 8.5.4)
- d — Vertical steel at corners and junctions of walls (see 8.5.7)
- f — Bracing in plan at tie level of pitched roofs (see 5.2.2.2)
- g — Plinth band where necessary (see 8.5.6)

Fig 7:- Table 3 of IS 13828:1993

- Lintel band is a band provided at lintel level on all internal and external longitudinal as well as cross walls except partition walls.
- Roof band is a band provided immediately below the roof or floors. Such a band need not be provided underneath reinforced concrete or reinforced brick slabs resting on bearing walls, provided that the slabs cover the width of end walls fully.
- Plinth band is a band provided at plinth level of walls on top of the foundation wall, this is to be provided where strip footings of masonry (other than reinforced concrete! or reinforced masonry) are used and the soil is either soft or uneven in its properties as frequently happens in hill tracts. This band serves as damp proof course as well.
- The band should be made of reinforced concrete of grade not leaner than M15 or reinforced brickwork in cement mortar not leaner than 1:3. The bands should be of the full width of the wall, not less than 75 mm in depth and should be reinforced with 2 HSD bars 8 mm diameter land held in position by 6 mm diameter bar links, installed at 150 mm apart.
- Figure 8 shows detail reinforcement of bands provided on Roof, Lintel and Plinth level.

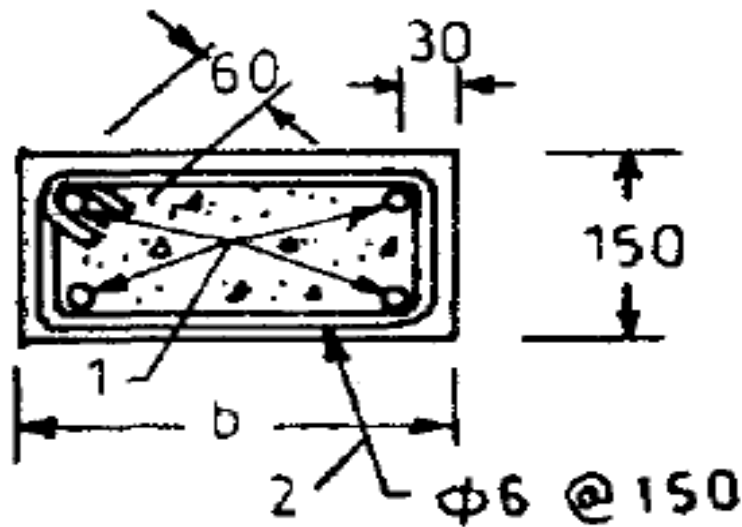


Fig 8:- Detail Reinforcement of Bands provided in house

- Vertical steel at corners and junctions of walls which are up to 350 mm thick should be provided. For walls thicker than 350 mm, the area of the bars should be proportionately increased.
- The vertical reinforcement should be properly embedded in the plinth masonry of foundations and roof slab or roof band so as to develop its tensile strength in bond. It should pass through the lintel bands and floor slabs or floor level bands in all storeys. Bars in different storey may be welded or suitably lapped.
- Figure 9 is table 4 in IS 13828 which show Vertical steel Reinforcement in Low Strength Masonry Walls.

Table 4 Vertical Steel Reinforcement in Low Strength Masonry Walls

(Clause 8.5.7)

No. of Storeys	Storey	Diameter of HSD Single Bar; in mm, at Each Critical Section for			
		Category A	Category B	Category C	Category D
One	—	Nil	Nil	Nil	10
Two	Top	Nil	Nil	10	10
	Bottom	Nil	Nil	10	12
Three	Top	Nil	10	10	10
	Middle	Nil	10	10	12
	Bottom	Nil	12	12	12

NOTES

1 The diameters given above are for HSD (High Strength Deformed) bars with yield strength 415 MPa. For mild-steel plain bars, use equivalent diameters.

2 The vertical bars should be covered with concrete of M15 grade or with mortar 1 : 3 (cement-sand) in suitably created pockets around the bars (see Fig. 10 & 11). This will ensure their safety from corrosion and good bond with masonry.

3 For category B two storey stone masonry buildings, see note under Table 3.

Fig 9:- Table 4 of IS 13828:1993

3.2 **IS 1893:1984** (CRITERIA FOR EARTHQUAKE DESIGN OF STRUCTURE)

- For the purpose of specifying the earthquake resisting features, the buildings, have been categorized in five categories A to E, as given in Table 1, based on the value of Q_h , given by:

$$Q_h = Q_o B I$$

Q_h = design seismic coefficient for the building,

Q_o = basic seismic coefficient for the seismic zone

I = importance factor applicable to the building

B = soil foundation factor

- For Zone IV $Q_o = 0.05$ (Using table 2)
- For houses $I = 1$ (Using table 4)
- For soft soil and Unreinforced Strip Foundations $B = 1.5$ (Using table 3)
- Therefore $Q_h = 0.075$
- With $0.06 < Q_h < 0.08$, the building can be classified as 'Category C'

3.3 Foundation Design

Recommendations from Planning & Designing of Residential Buildings – Y.N. Raja Rao and Y. Subramanum

- The Thickness of concrete bed should not be less than 15cm. It generally varies from 20 to 30 cm. The projection of concrete bed varies from 10 to 15 cm but it should not be more than the thickness i.e., the depth of concrete.
- The courses of footings are generally 10 to 30 cm in depth. The offsets provided are usually 5 cm for brick masonry.
- The general thumb rules followed are as follows.

Width of super-structure wall	:	T
Width of foundation concrete	:	2T+30 cm
Width of bottom most course of footings	:	2T
Depth of concrete block	:	2/3T
- These types of footings are most commonly used ones and are economical as compared to other types of foundations for ordinary types of buildings.
- Structure in soils with moderate bearing capacity can be safely constructed with this type of foundation.

CHAPTER 4

**EARTHQUAKE RESISTANT SINGLE
STOREY MASONRY HOUSE**

4.1 Changes in plan according to IS Codes

- Thickness of outer walls have been increased from 0.225m to 0.45m and of inner wall from 0.1m to 0.225m.
- Three Bands – Plinth, Lintel, Roof band is provided of width 0.15m.
- Height of walls have been reduced from 3.2 m to 2.9 m
- Size of windows have been reduced from 1X1m to 0.7X0.7m.
- No Ceiling plaster has been done.
- Proper placing of windows and doors have been done.

4.2 Plan of House

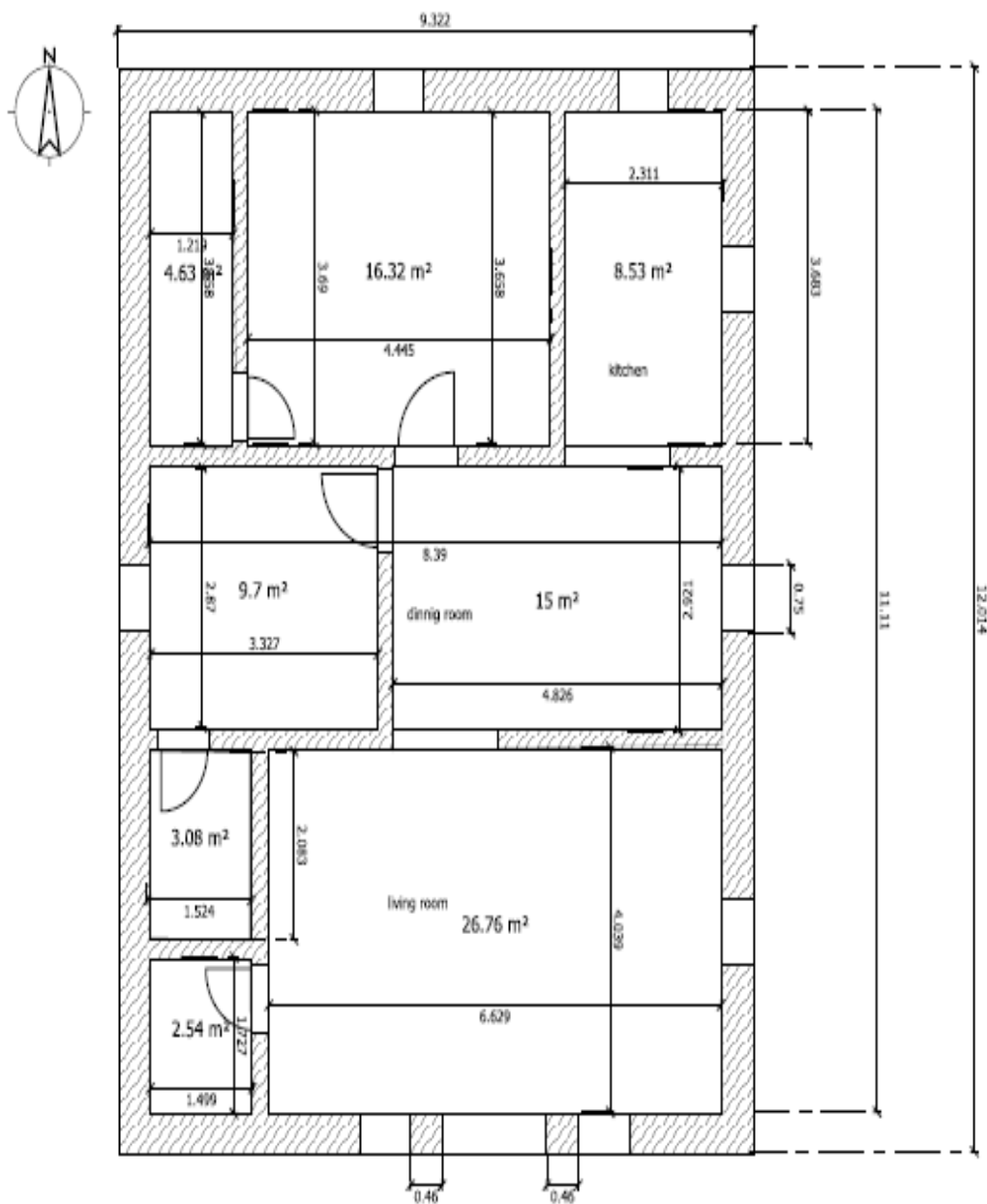


Fig 10:- Plan of House

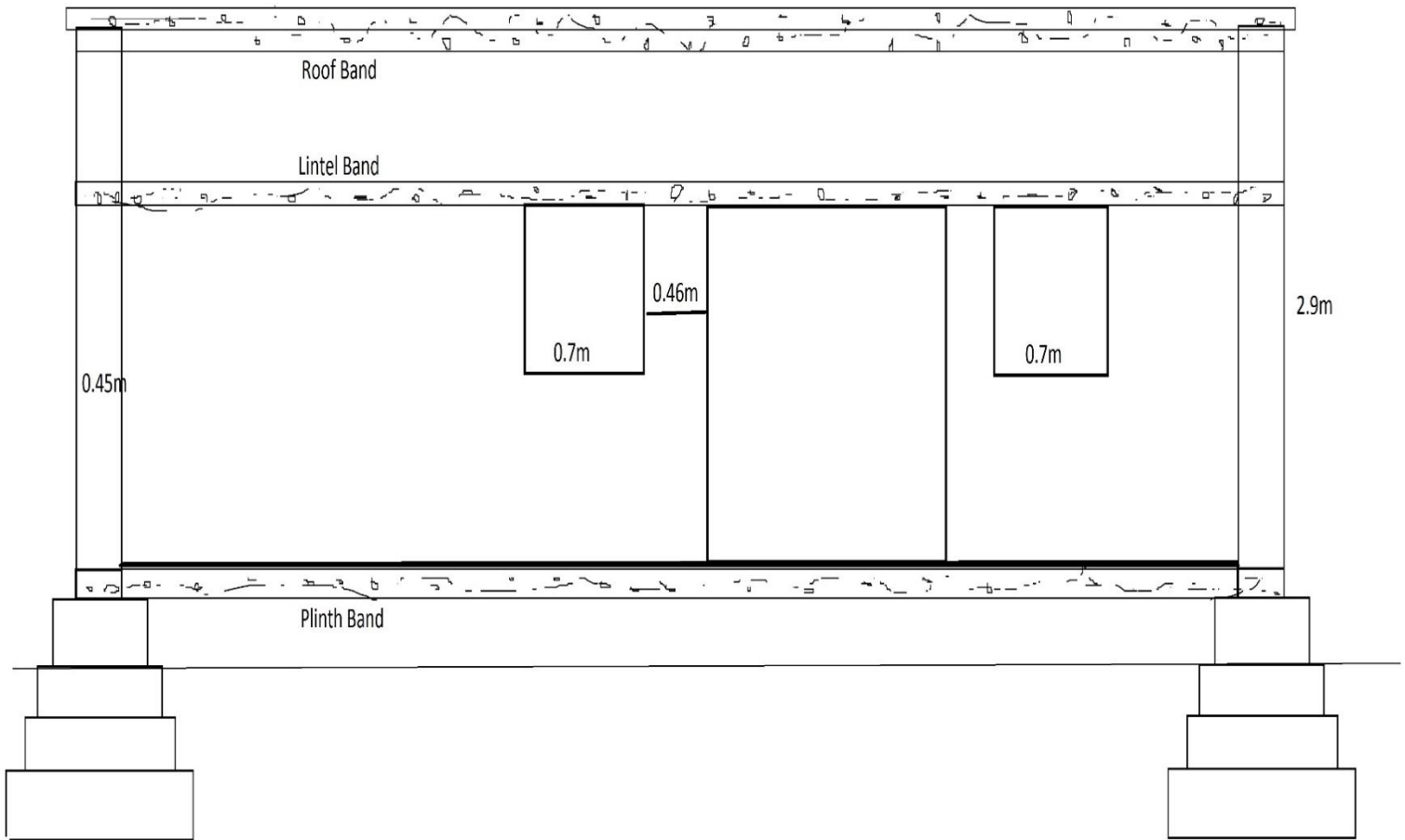


Fig 11:- Front View of house showing all three bands

Area of house = **112 square meters.**

4.3 Foundation Design

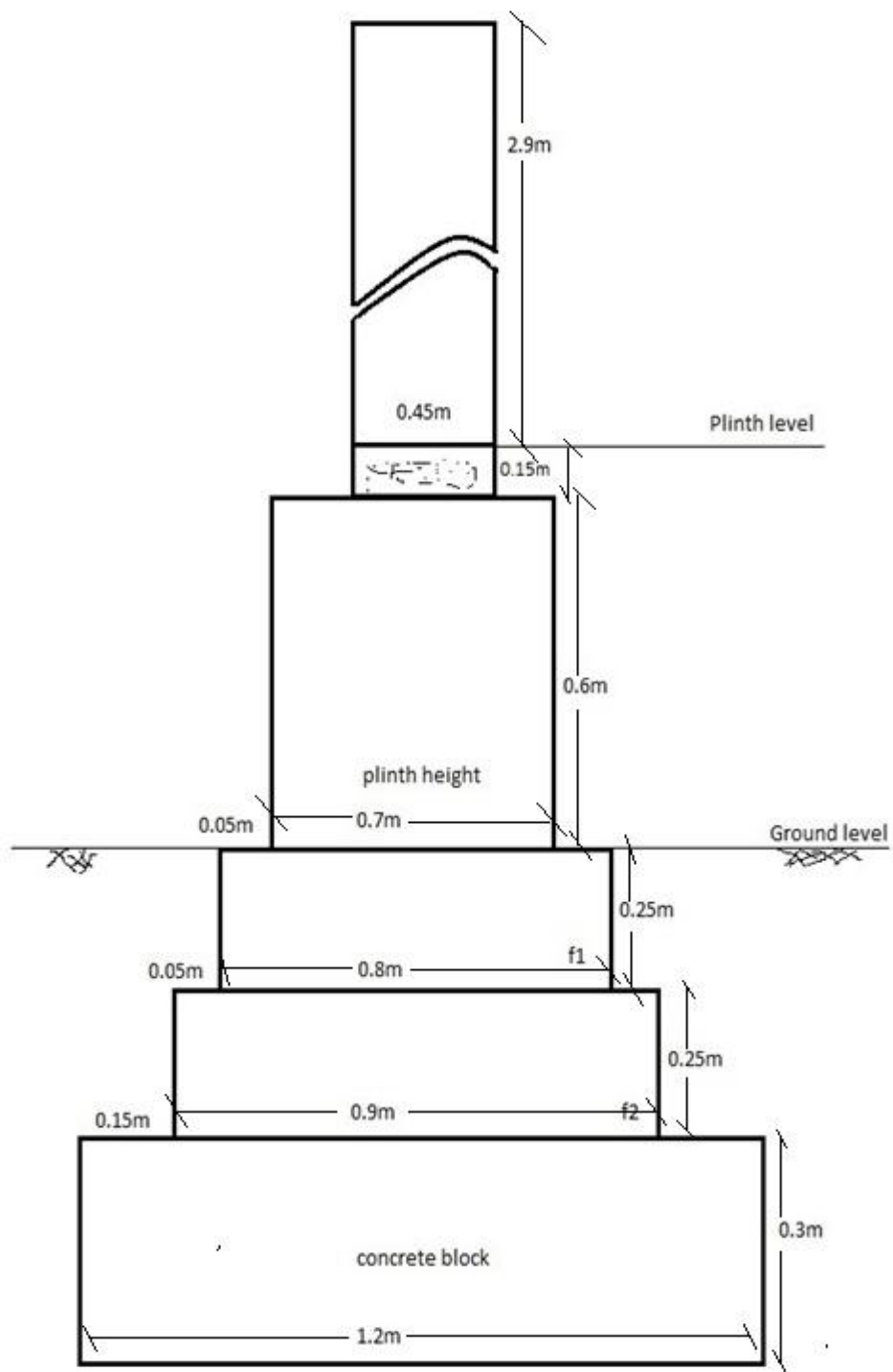


Fig 12:- Design of Foundation

4.4 Components and Specifications

Concrete Work:

M20 (1:1.5:3 i.e. 1 cement: 1.5 coarse sand: 3 aggregates) grade of concrete is used in foundation for lying concrete block.

Brick Work:

- **Sub-Structure**

Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in foundation and plinth by cement paste 1:3 (1 Cement: 3 coarse sand).

- **Super-Structure**

Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes by cement paste 1:3 (1 cement: 3 coarse sand).

RCC Work:

Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centring, shuttering, finishing and reinforcement, with 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size).

Marble Work:

Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facials and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.

Wood and PVC Work:

- Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required diameter & length (hold fast lugs or dash fastener shall be paid for separately) with Second Class Teak Wood.
- Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.
- Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete.
- Providing and fixing aluminium handles ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc. complete of size 125mm.
- Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.
- Providing and fixing aluminium hanging Twin Rubber door stopper ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc.

Steel Work:

- Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal diameter 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm diameter round headed screws, one lock at the corners. Clamp shall be made of 12mm diameter M.S. bar bent to shape as per standard drawing.
- Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.

Flooring:

- Cement concrete flooring 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry but excluding the cost of nosing of steps etc. complete of 40 mm thick with 20 mm nominal size stone aggregate.
- Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand), including grouting the joints with white cement and matching pigments etc.

Finishing:

- 12 mm cement plaster of mix 1:4 (1 cement: 4 coarse sand)

4.4 Cost Estimation of House (Part 2)

S.No.	Item No. of DSR	Description	Unit	Quantity	Rate	Cost (in INR)
Civil Work						
1	1	Earth Work				
	1.1	Earth work in excavation by mechanical means (Hydraulic excavator) / manual means over areas (exceeding 30cm in depth. 1.5m in width as well as 10 sqm on plan) including disposal of excavated earth, lead upto 50m and lift upto 1.5m, disposed earth to be levelled and neatly dressed.				
	1.1.1	All kinds of soil	cum	39.2256	129.35	5073.83136
2	2	Supplying and filling in plinth with sand under floors, including watering, ramming, consolidating and dressing complete	cum	7.1505	749.3	5357.86965
3	3	Concrete Work				
	3.1	1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size)	cum	14.7096	4850	71341.56
	3.2	Providing and laying damp-proof course 50mm thick with cement concrete 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20mm nominal size).	sqm	0	254.7	0

4	4	R.C.C.				
	4.1	Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centring, shuttering, finishing and reinforcement, with 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size).	cum	31.5367	5494.55	173279.975
5	5	Brick Work				
	5.1	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in foundation and plinth in:				
	5.1.1	Cement mortar 1: 3(1 cement : 3 coarse sand)	cum	34.52	3500	120820
	5.2	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes in :				
	5.2.1	Cement mortar 1:3 (1Cement:3 coarse sand)	cum	46.47	3976.15	184771.6905

6	6	Marble Work				
	6.1	Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facials and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.				
	6.1.1	Granite of any colour and shade				
	6.1.1.1	Area of slab over 0.50 sqm	sqm	5.654	3083.4	17433.5436
7	7	Wood Work and PVC Work				
	7.1	Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required dia & length (hold fast lugs or dash fastener shall be paid for separately).				
	7.1.1	Second class teak wood	cum	0.45606	85813.3	39136.0136
	7.1.2	Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.				

7.1.2.1	35 mm thick including ISI marked Stainless Steel butt hinges with necessary screws.	sqm	16.48	1578.3	26010.384
7.2	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete				
7.2.1	Fixed to openings /wooden frames with rawl plugs screws	kg	100	98.2	9820
7.3	Providing and fixing aluminium extruded section body tubular type universal hydraulic door closer (having brand logo with ISI, IS : 3564,embossed on the body, door weight up to 36 kg to 80 kg and door width from 701 mm to 1000 mm), with double speed adjustment with necessary accessories and screws etc. complete.	each	7	981.75	6872.25
7.4	Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.				
7.4.1	Size 40mm	each	7	137.75	964.25
7.5	Providing and fixing aluminium handles ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete :				
7.5.1	125 mm	Each	15	62.5	937.5

7.6	Providing and fixing aluminium hanging door stopper ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete				
7.6.1	Twin rubber stopper.	each	7	71.55	500.85

8 8 Steel Work

8.1	Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal dia 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm dia. round headed screws, one lock at the corners. Clamp shall be made of 12mm dia M.S. bar bent to shape as per standard drawing.	Each	8	117.45	939.6
8.2	Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.				
8.2.1	M.S. Tube	kg	1670	150	250500

9 9 Flooring

9.1	Cement concrete flooring 1:2:4 (1cement : 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry but excluding the cost of nosing of steps etc. complete.				
9.1.1	40 mm thick with 20 mm nominal size stone aggregate	sqm	85.56	280.05	23961.078

9.2	Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more (thickness to be specified by the manufacturer), of 1st quality conforming to IS : 15622, of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand),including grouting the joints with white cement and matching pigments etc. complete	sqm	108	931.5	100602
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10	10	Finishing			
10.1	12 mm cement plaster of mix				
10.1.1	1:4 (1 cement: 4 coarse sand)	Sqm	425.894	132.1	56260.5974
10.2	White washing with lime to give an even shade : New work (three or more coats)	Sqm	526.094	11.75	6181.6045
10.3	Distempering with oil bound washable distemper of approved brand and manufacture to give an even shade				
10.3.1	New work (two or more coats) over and including water thinnable priming coat with cement primer				
		sqm	118.494	64.65	7660.6371
TOTAL					1108425.235

CHAPTER 5

**EARTHQUAKE RESISTANT SINGLE
STOREY RCC FRAMED HOUSE**

5.1 Changes in plan

House is reconstructed and is made RCC Framed House which has 18 Columns and 25 Beams.

5.2 Plan of House

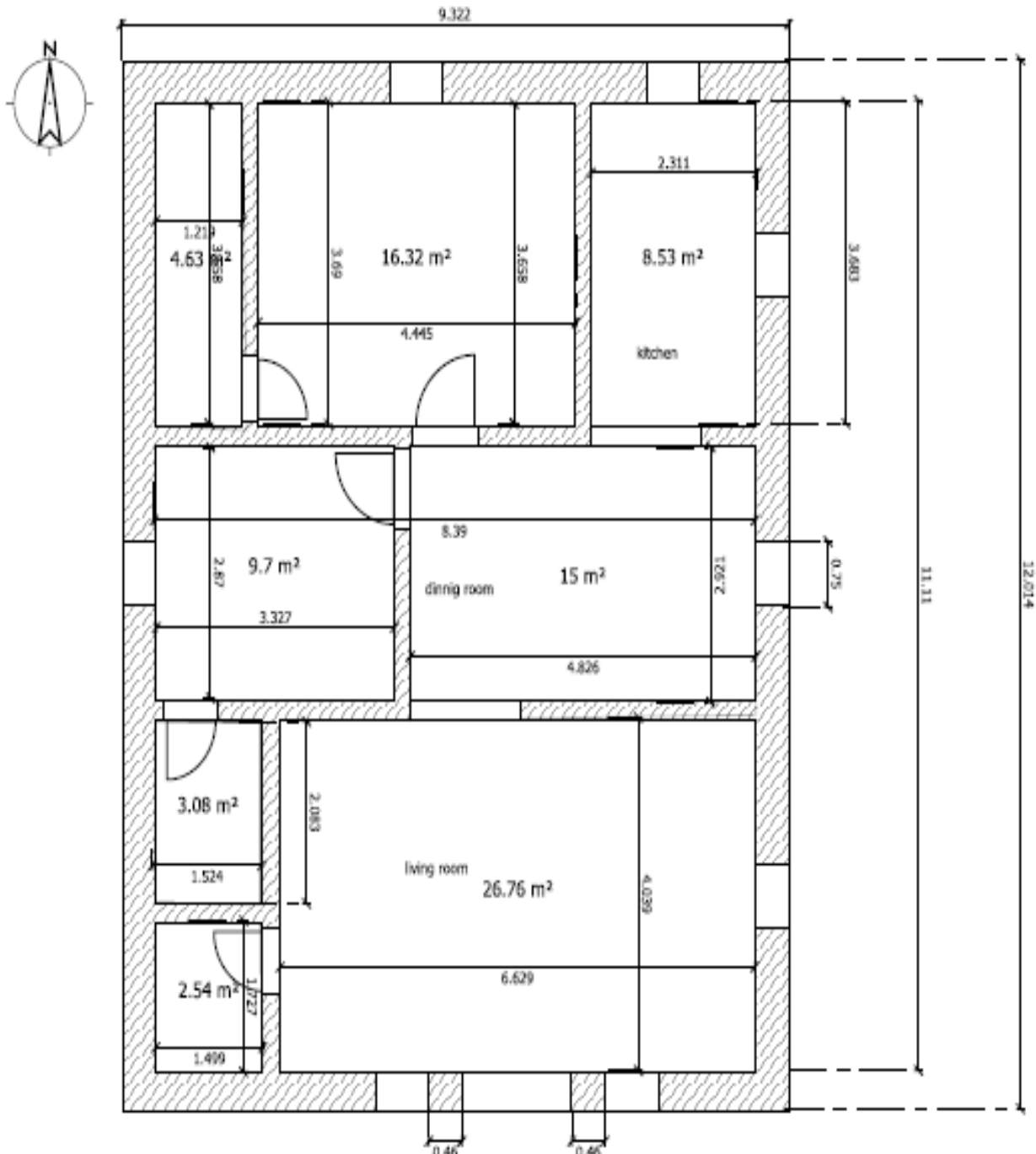


Fig 13:- Plan of House

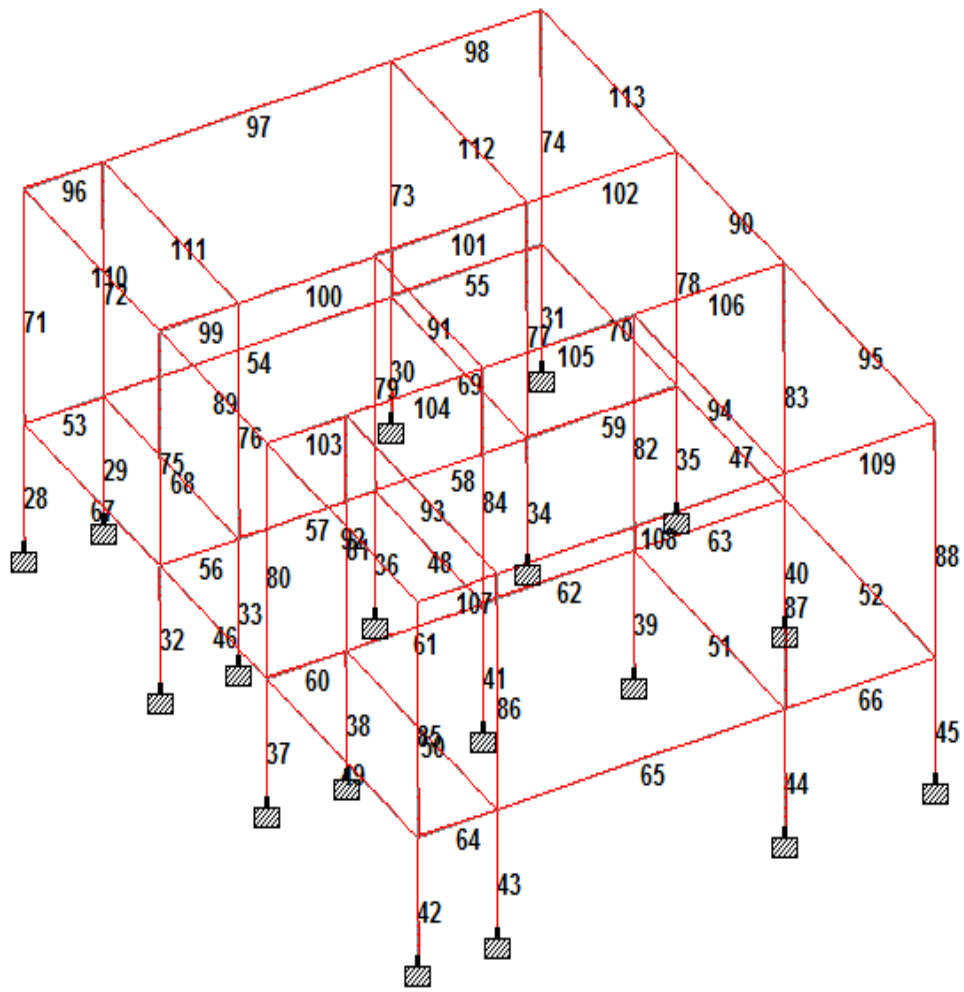


Fig 14:- 3D Isometric view of RCC Framed House

5.2 Load Cases provided in RCC Framed house

5.2.1 Dead Load

Dead Load was calculated according to Indian Standard code of practice for Dead Load (other than Earthquake) for Buildings and Structures, IS 875 (Part 1).

5.2.2 Live Load

Live Load was calculated according to Indian Standard code of practice for Design Load (other than Earthquake) for Buildings and Structures, IS 875 (Part 2).

5.2.3 Earthquake Load

Earthquake Load was calculated according to Indian Standard Criteria for Earthquake Resistant Design of Structures, IS 1893.

5.2.4 Load Combinations

Figure 15 shows load Combinations which were taken in StaddPro V8i.

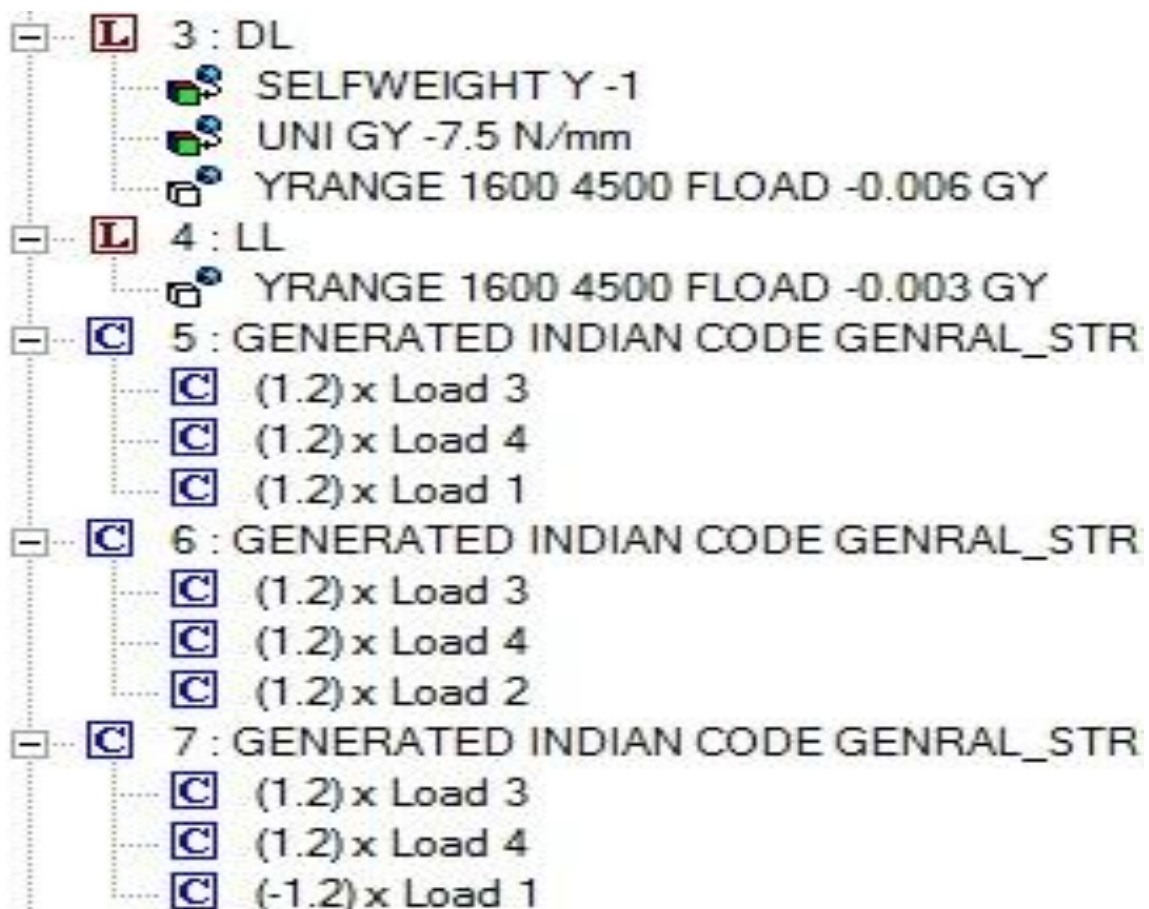




Fig 15:- Load case provided in RCC Framed Structure

5.3 Design of Slab

Slab has been designed according to largest area of slab i.e. critical slab

Depth of slab = 200mm

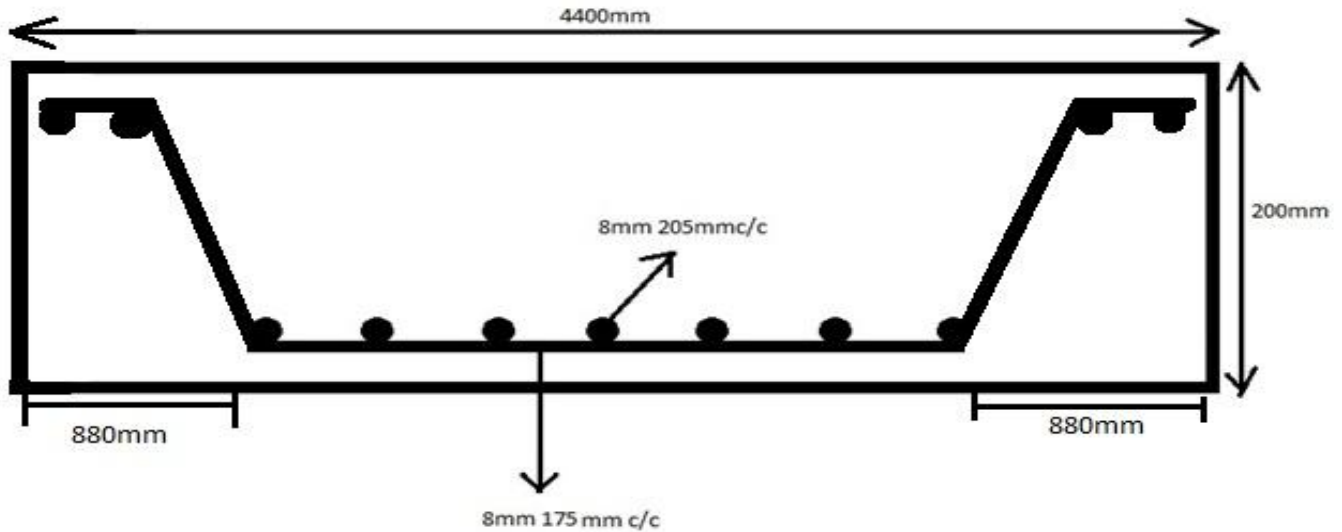


Fig 16: Detail Reinforcement of Slab



Fig 17:- Torsion Reinforcement in Slab

5.4 Design of Beam

After Analysing RCC Framed House, 7 different beam designs were designed according to their area of reinforcement in entire structure of dimensions 400mm X 300mm (Depth X Width).

Beams are grouped according to their type in below table 1

Table 1: Grouping of Members according to design of Beam

Group number	Member number
1	96,98,89,110,111,113,99,102,100,101,91,90,103,104,105,106,92,109,107
2	97
3	112
4	93
5	94
6	95
7	108

5.4.1 Design of Beam of Group 1

Longitudinal Tension Reinforcement: 3#10mm Bars

Longitudinal Compression Reinforcement: 4# 10 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

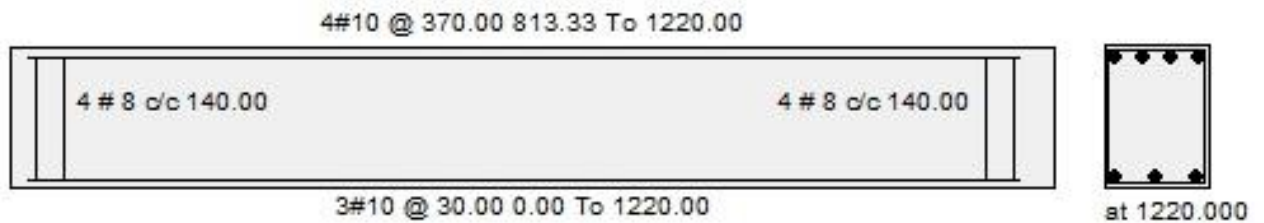


Fig 18:- Design of beam of Group 1

5.4.2 Design of Beam of Group 2

Longitudinal Tension Reinforcement: 3#12mm Bars

Longitudinal Compression Reinforcement: 3# 16 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

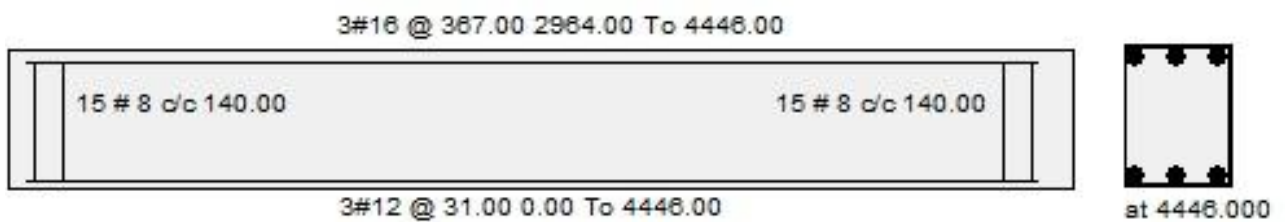


Fig 19:- Design of beam of Group 2

5.4.3 Design of Beam of Group 3

Longitudinal Tension Reinforcement: 3#16mm Bars

Longitudinal Compression Reinforcement: 4# 10 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

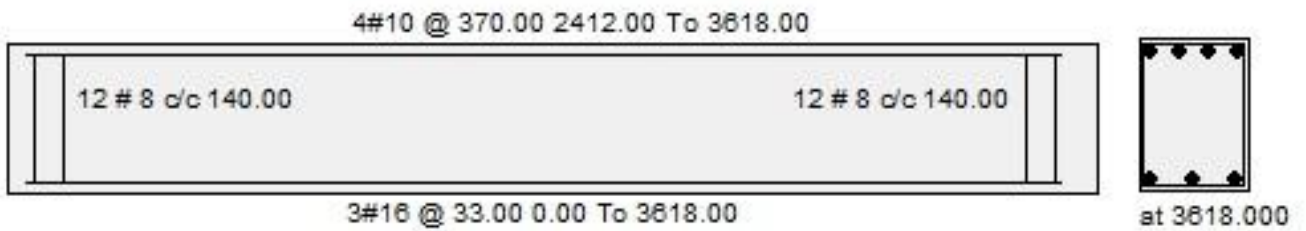


Fig 20:- Design of beam of Group 3

5.4.4 Design of Beam of Group 4

Longitudinal Tension Reinforcement: 5#10mm Bars

Longitudinal Compression Reinforcement: 4# 12 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

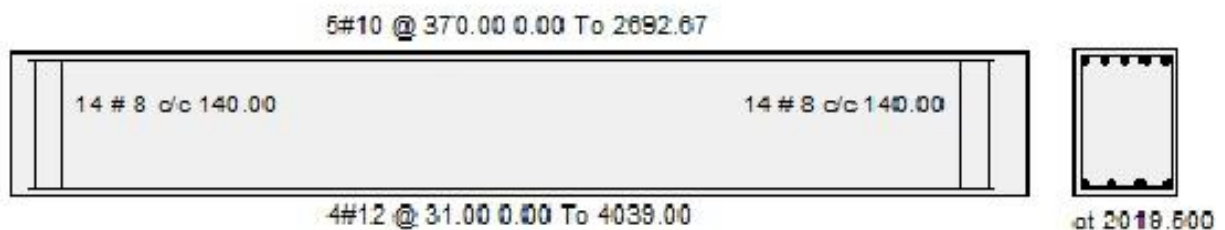


Fig 21:- Design of beam of Group 4

5.4.5 Design of Beam of Group 5

Longitudinal Tension Reinforcement: 7#10mm Bars

Longitudinal Compression Reinforcement: 5# 10 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

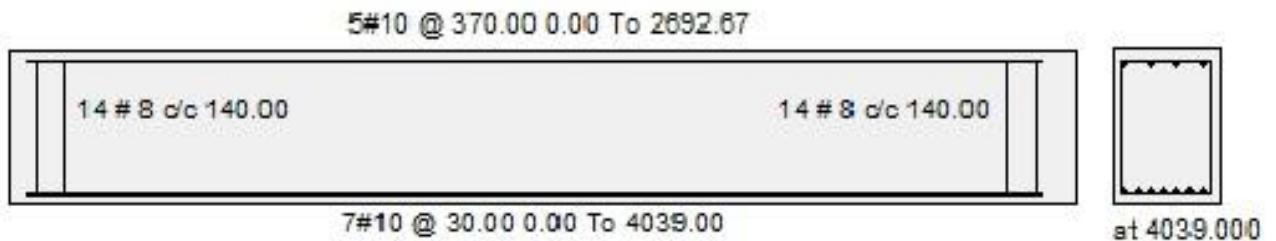


Fig 22:- Design of beam of Group 5

5.4.6 Design of Beam of Group 6

Longitudinal Tension Reinforcement: 4#10mm Bars

Longitudinal Compression Reinforcement: 4# 10 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm



Fig 23:- Design of beam of Group 6

5.4.7 Design of Beam of Group 7

Longitudinal Tension Reinforcement: 3#12mm Bars

Longitudinal Compression Reinforcement: 4# 12 mm Bars

Stirrups reinforcement: 8mm c/c 140 mm

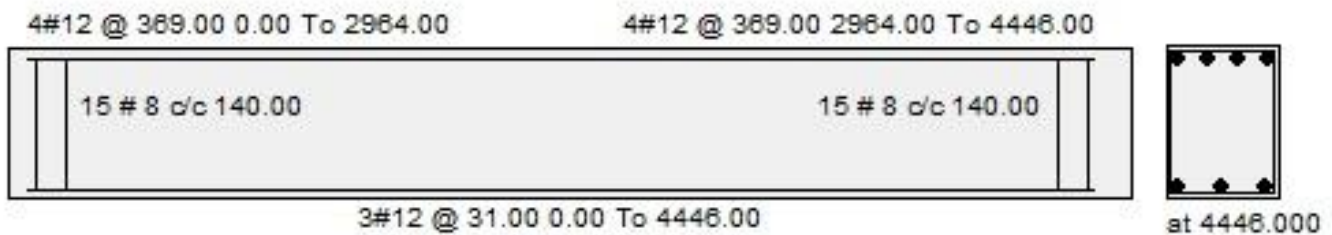


Fig 24:- Design of beam of Group 7

5.5 Design of Columns

After Analysing RCC Framed House, 2 different column designs were designed according to their area of reinforcement in entire structure of dimensions 300mm X 300mm.

Columns are grouped according to their type in below table 2

Table 2:- Grouping of Members according to design of Column

Group number	Member Number
1	71,28,73,30,82,39,80,37
2	72,85,29,74,31,75,32,76,33,79,36,77,34,78,35,83,40,84,41,81,38,85,42,86,42,87,44,88,45

5.5.1 Design of Column of Group 1

Reinforcement in Column: 4# 12mm diameter

Shear reinforcement in Column: 8mm @ 190 mm c/c

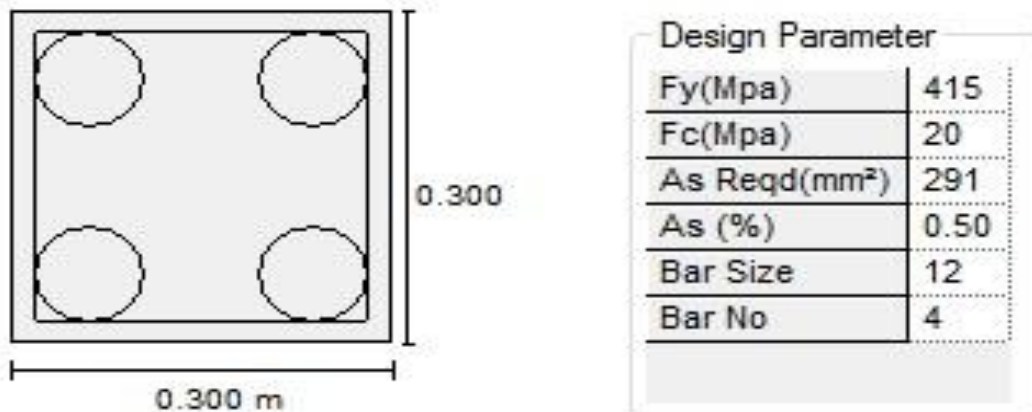


Fig 25:- Design of Column of Group 1

5.5.2 Design of Column of Group 2

Longitudinal reinforcement in Column: 4# 16mm diameter

Shear reinforcement in Column: 8mm @ 225 mm c/c

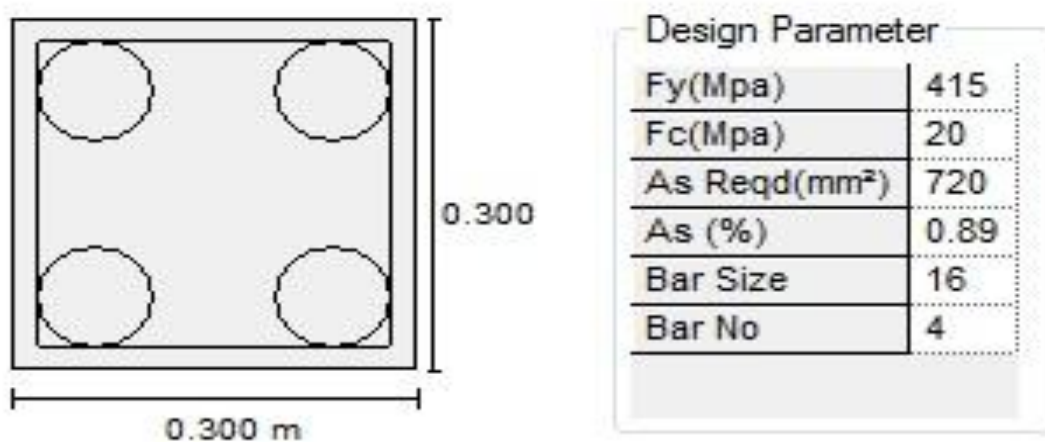


Fig 26:- Design of Column of Group 2

5.6 Design of Plinth Beam

After Analysing RCC Framed House, 2 different plinth beam designs were designed according to their area of reinforcement in entire structure of dimensions 300mm X 300mm (Depth X Width).

Table 3:- Grouping of Members according to design of Plinth Beam

Group Number	Member Number
1	54,65
2	53,55,67,68,70,59,58,57,56,46,48,47,63,62,61,60,49,50,51,52,66,64

5.6.1 Design of Plinth Beam of Group 1

Longitudinal Tension Reinforcement: 4#10mm Bars

Longitudinal Compression Reinforcement: 3# 12 mm Bars

Stirrups reinforcement: 8mm c/c 120 mm

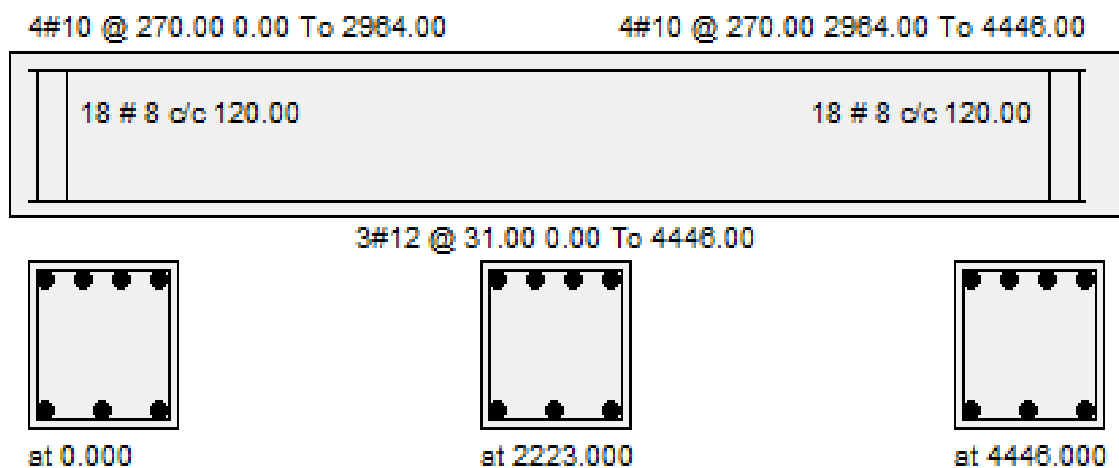


Fig 27:- Design of plinth beam of Group 1

5.6.1 Design of Plinth Beam of Group 2

Longitudinal Tension Reinforcement: 3#10mm Bars

Longitudinal Compression Reinforcement: 3# 12 mm Bars

Stirrups reinforcement: 8mm c/c 120 mm

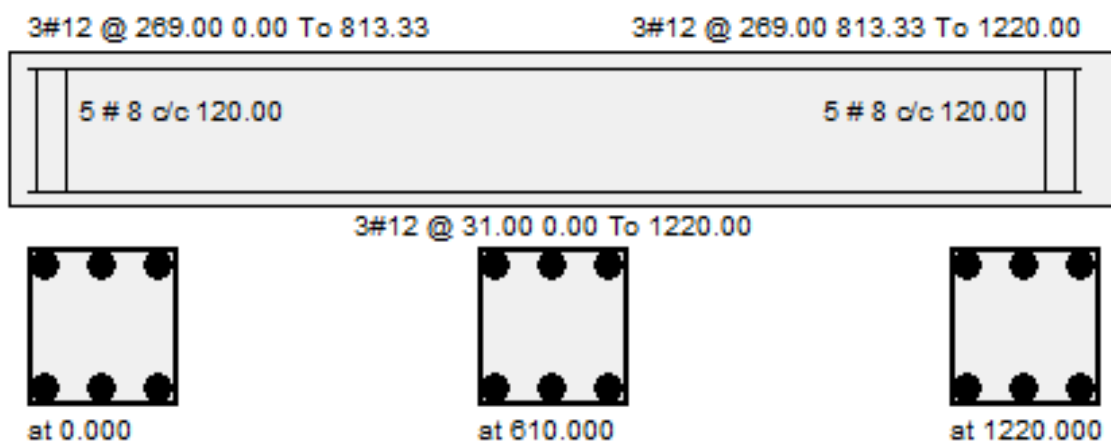


Fig 28:- Design of plinth beam of Group 2

5.7 Design of Footing

After Analysing RCC Framed House, 2 different types of footings (Isolated & Combined) were designed according to their area of reinforcement and spacing between columns.

5.7.1 Isolated Footing

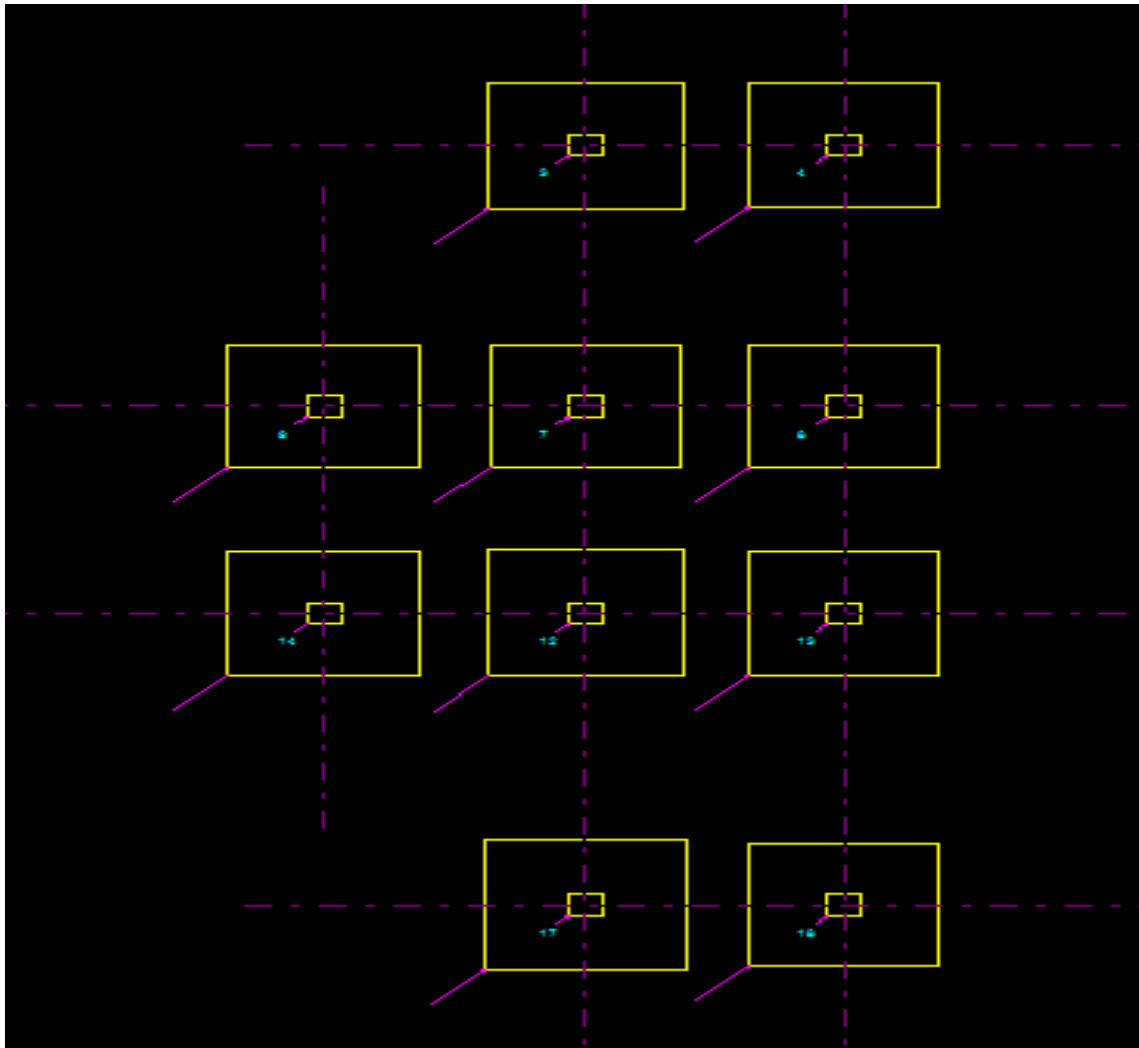


Fig 29:- Plan of Isolated Footings

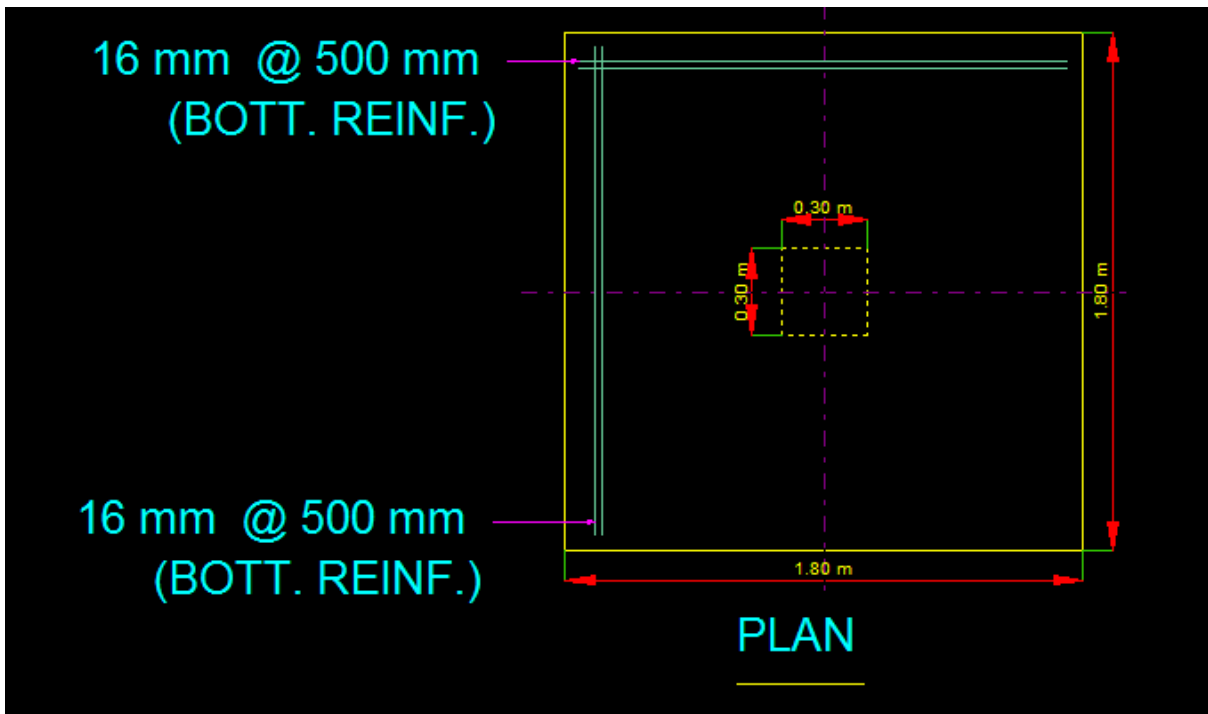


Fig 30:- Plan of footing

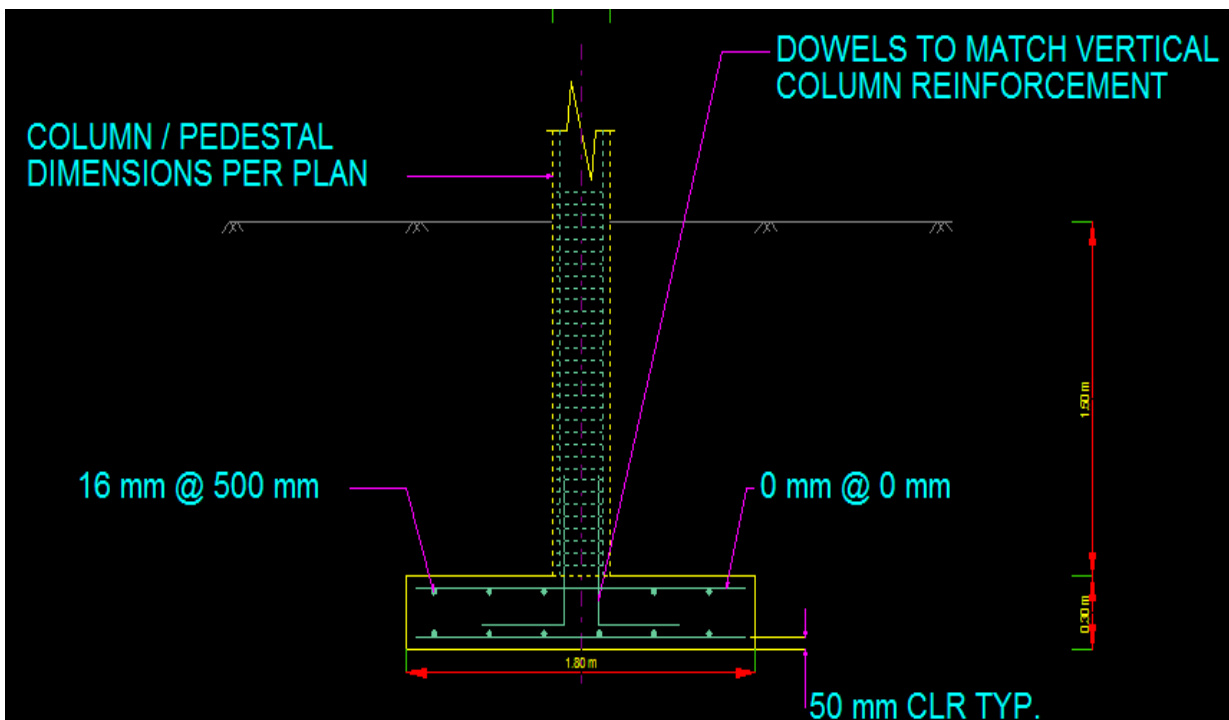


Fig 31:- Elevation of Isolated Footing

Summary of Isolated Footings

Table 4:- Detail Foundation Geometry and Footing Reinforcement

Footing No.	Group ID	Foundation Geometry		
		Length	Width	Thickness
-	-			
3	1	1.750 m	1.750 m	0.305 m
4	2	1.700 m	1.700 m	0.305 m
7	3	1.700 m	1.700 m	0.305 m
8	4	1.700 m	1.700 m	0.305 m
9	5	1.700 m	1.700 m	0.305 m
12	6	1.750 m	1.750 m	0.305 m
13	7	1.700 m	1.700 m	0.305 m
14	8	1.700 m	1.700 m	0.305 m
17	9	1.800 m	1.800 m	0.305 m
18	10	1.700 m	1.700 m	0.305 m

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
	Bottom Reinforcement(M _y)	Bottom Reinforcement(M _x)	Top Reinforcement(M _y)	Top Reinforcement(M _x)	Main Steel	Trans Steel
-						
3	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
4	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
7	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
8	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
9	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
12	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
13	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
14	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
17	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A
18	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	Ø16 @ 500 mm c/c	N/A	N/A

5.7.2 Combined Footing

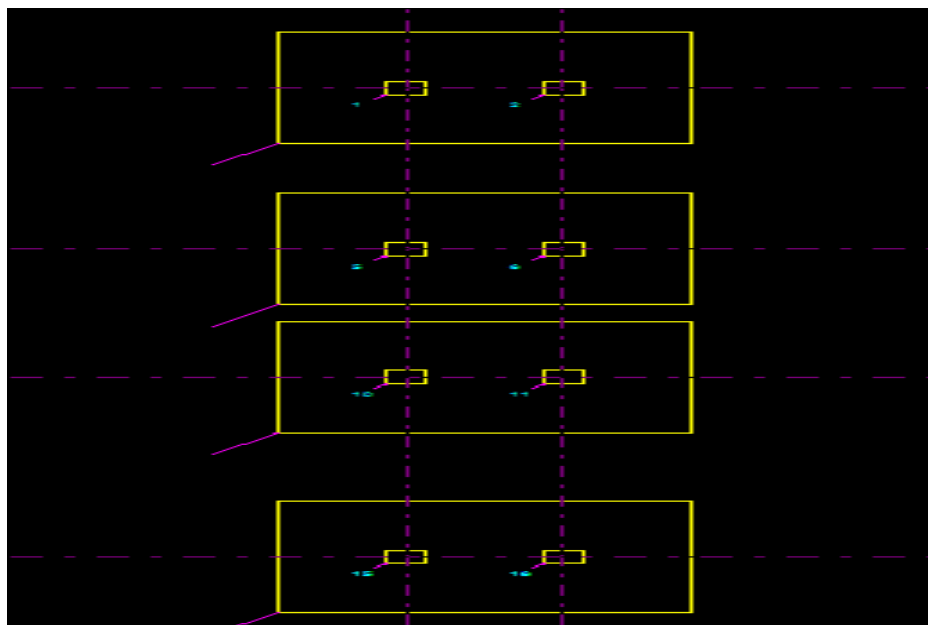


Fig 32:- Plan of Combined Footings

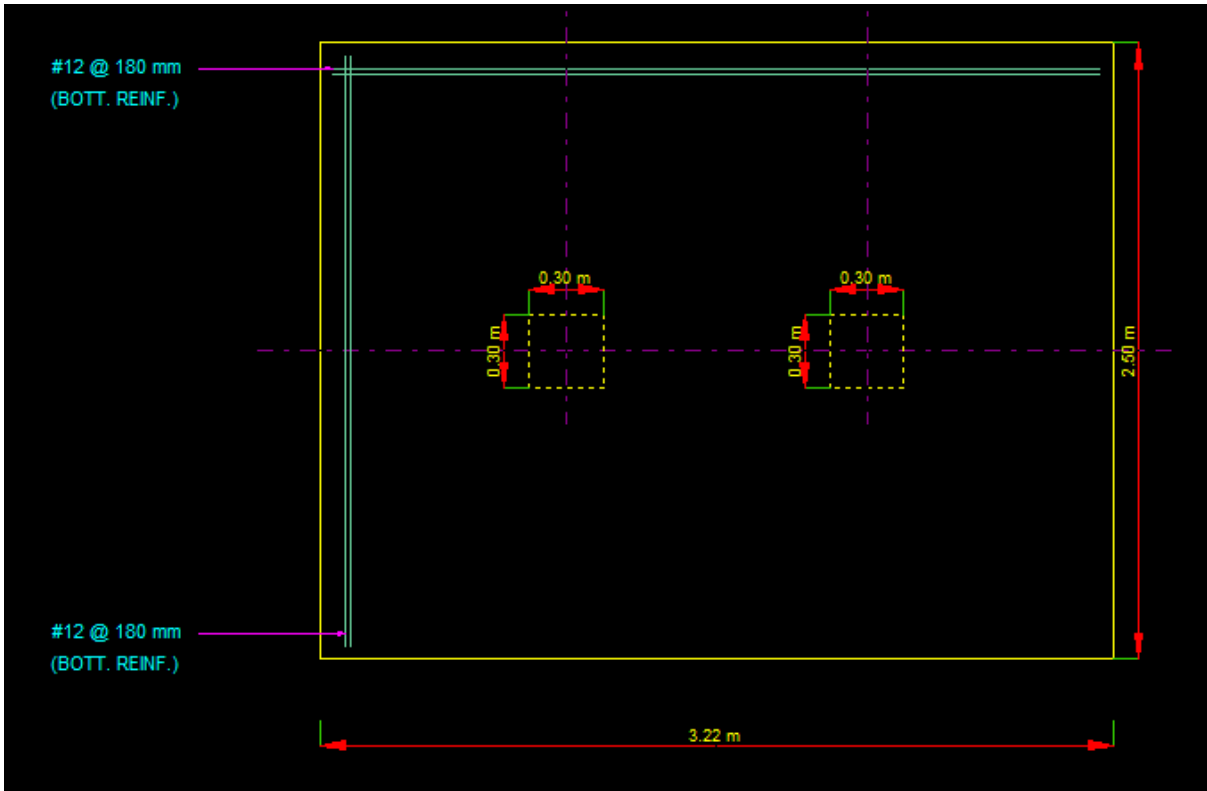


Fig 33:- Plan of combined footing

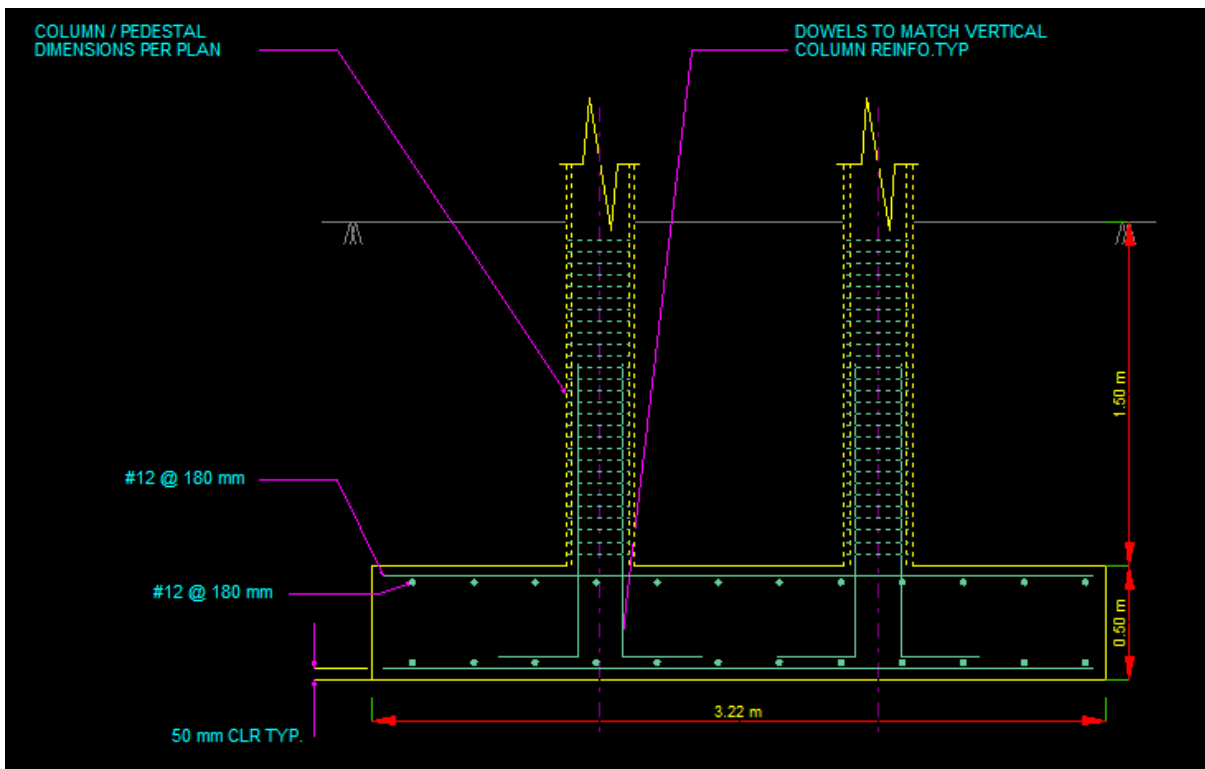


Fig 34:- Elevation of Combined Footing

Summary of Combined Footings

Table 5:- Detail Foundation Geometry and footing Reinforcement

Footing No.	Left Overhang (m)	Right Overhang (m)	Length (m)	Width (m)	Thickness (m)
1	1.000	1.000	3.220	2.500	0.500
2	1.000	1.000	3.220	2.500	0.500
3	1.000	1.000	3.220	2.500	0.500
4	1.000	1.000	3.220	2.500	0.500

Footing No.	Footing Reinforcement			
	Main Steel Top	Main Steel Bottom	Secondary Steel Top	Secondary Steel Bottom
1	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c
2	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c
3	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c
4	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c	Ø12 @ 180 mm c/c

CHAPTER 6
**COST ESTIMATION OF SINGLE
STORY RCC FRAMED HOUSE**

6.1 Components and Specifications

Brick Work:

Super-Structure

Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes by cement paste 1:6 (1 cement: 6 coarse sand).

RCC Work:

Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centring, shuttering, finishing and reinforcement, with 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size).

Marble Work:

Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facials and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.

Wood and PVC Work:

- Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required diameter & length (hold fast lugs or dash fastener shall be paid for separately) with Second Class Teak Wood.
- Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.
- Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete.
- Providing and fixing aluminium handles ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc. complete of size 125mm.
- Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.
- Providing and fixing aluminium hanging Twin Rubber door stopper ISI marked anodised transparent or dyed to required colour or shade with necessary screws etc.
- Wooden Partition walls @100mm

Steel Work:

- Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal diameter 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm diameter round headed screws, one lock at the corners. Clamp shall be made of 12mm diameter M.S. bar bent to shape as per standard drawing.
- Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.

Flooring:

- Cement concrete flooring 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry but excluding the cost of nosing of steps etc. complete of 40 mm thick with 20 mm nominal size stone aggregate.
- Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand),including grouting the joints with white cement and matching pigments etc.

Finishing:

- 12 mm cement plaster of mix 1:4 (1 cement: 4 coarse sand)

6.2 Cost Estimation of House (Part 3)

S.No.	Item No. of DSR	Description	Unit	Quantity	Rate	Cost (in INR)
Civil Work						
1	1	Earth Work				
	1.1	Earth work in excavation by mechanical means (Hydraulic excavator) / manual means over areas (exceeding 30cm in depth. 1.5m in width as well as 10 sqm on plan) including disposal of excavated earth, lead upto 50m and lift upto 1.5m, disposed earth to be levelled and neatly dressed.				
	1.1.1	All kinds of soil	cum	117.677	129.35	15221.51995
2	2	Supplying and filling in plinth with sand under floors, including watering, ramming, consolidating and dressing complete	cum	90.24	749.3	67616.832
3	3	R.C.C.				
	3.1	Reinforced cement concrete work in beams, suspended floors, roofs having slope up to 15° landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level, excluding the cost of centering, shuttering, finishing and reinforcement, with 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size).	cum	68.91	5823	401262.93
4	4	Brick Work				
	4.1	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes in :				
	4.1.1	Cement mortar 1:3 (1Cement:3 coarse sand)	cum	11.52	3976.15	45805.248

5	5	Marble Work				
	5.1	Providing and fixing 18mm thick gang saw cut mirror polished premoulded and prepolished) machine cut for kitchen platforms, vanity counters, window sills ,facias and similar locations of required size of approved shade, colour and texture laid over 20mm thick base cement mortar 1:4 (1 cement : 4 coarse sand) with joints treated with white cement, mixed with matching pigment, epoxy touch ups, including rubbing, curing, moulding and polishing to edge to give high gloss finish etc. complete at all levels.				
	5.1.1	Granite of any colour and shade				
	5.1.1.1	Area of slab over 0.50 sqm	sqm	5.654	3083.4	17433.5436
6	6	Wood Work and PVC Work				
	6.1	Providing wood work in frames of doors, windows, clerestory windows and other frames, wrought framed and fixed in position with hold fast lugs or with dash fasteners of required dia & length (hold fast lugs or dash fastener shall be paid for separately).				
	6.1.1	Second class teak wood	cum	0.45606	85813.3	39136.0136
	6.1.2	Providing and fixing ISI marked flush door shutters non decorative type, core of block board construction with frame of 1st class hard wood and well matched commercial 3 ply veneering with vertical grains or cross bands and face veneers on both faces of shutters.				
	6.1.2.1	35 mm thick including ISI marked Stainless Steel butt hinges with necessary screws.	sqm	16.48	1578.3	26010.384

6.2	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats, square or round bars etc. including priming coat with approved steel primer all complete				
6.2.1	Fixed to openings /wooden frames with rawl plugs screws	kg	100	98.2	9820
6.3	Providing and fixing aluminium extruded section body tubular type universal hydraulic door closer (having brand logo with ISI, IS : 3564,embossed on the body, door weight upto 36 kg to 80 kg and door width from 701 mm to 1000 mm), with double speed adjustment with necessaryaccessories and screws etc. complete.	each	7	981.75	6872.25
6.4	Providing and fixing special quality chromium plated brass cupboard locks with six levers of approved quality including necessary screws etc. complete.				
6.4.1	Size 40mm	each	7	137.75	964.25
6.5	Providing and fixing aluminium handles ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete :				
6.5.1	125 mm	Each	15	62.5	937.5
6.6	Providing and fixing aluminium hanging door stopper ISI marked anodised (anodic coating not less than grade AC 10 as per IS : 1868) transparent or dyed to required colour or shade with necessary screws etc. complete				
6.6.1	Twin rubber stoppr.	each	7	71.55	500.85
6.7	Wooden Partiton walls @100mm	sqm	46.43	2330	

7		7		Steel Work			
	7.1	Providing and fixing circular/ Hexagonal cast iron or M.S. sheet box for ceiling fan clamp of internal dia 140mm, 73mm height, top lid of 1.5mm thick M.S. sheet with its top surface hacked for proper bonding, top lid shall be screwed into the cast iron/ M.S. sheet box by means of 3.3mm dia. round headed screws, one lock at the corners. Clamp shall be made of 12mm dia M.S. bar bent to shape as per standard drawing.	Each	8	117.45	939.6	
	7.2	Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approved steel primer.					
	7.2.1	M.S. Tube	kg	1670	150	250500	
8		8		Flooring			
	8.1	Cement concrete flooring 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry, but excluding the cost of nosing of steps etc. complete.					
	8.1.1	40 mm thick with 20 mm nominal size stone aggregate	sqm	85.56	280.05	23961.078	
	8.2	Providing and laying rectified Glazed Ceramic floor tiles of size 300x300 mm or more (thickness to be specified by the manufacturer), of 1st quality conforming to IS : 15622, of approved make, in colours White, Ivory, Grey, Fume Red Brown, laid on 20 mm thick cement mortar 1:4 (1 Cement: 4 Coarse sand), including grouting the joints with white cement and matching pigments etc., complete	sqm	108	931.5	100602	

9	9	Finishing				
	9.1	12 mm cement plaster of mix				
	9.1.1	1:4 (1 cement: 4 coarse sand)	Sqm	273.8	132.1	36168.98
	9.2	White washing with lime to give an even shade : New work (three or more coats)	Sqm	526.094	11.75	6181.6045
	9.3	Distempering with oil bound washable distemper of approved brand and manufacture to give an even shade				
	9.3.1	New work (two or more coats) over and including water thinnable priming coat with cement primer	sqm	111	64.65	7176.15
				TOTAL		1165292.634

CHAPTER 7
CONCLUSIONS AND REFERENCES

7.1 Conclusions

The recent earthquakes in Nepal and India have left us in no doubt that earthquake resistant designs of buildings and houses are the need of the hour. Earthquake all around the world have claimed numerous lives. Through this project a new side of earthquake resistant design was discovered and it was learned that building earthquake resistant houses is neither difficult nor expensive.

When a non-engineered single story brick masonry house was constructed of an area of 1210 sq feet, the cost incurred came out to be **Rs 954074 (Rs 788.5/sq feet)**, later the same house was made earthquake resistant using provisions under IS 13828 : 1993 (Improving earthquake resistance of low strength masonry buildings) . The cost incurred for this house was **Rs 1108425 (Rs 916/sq feet)**, an increase of just **16.16%**. For the final part of the project, the same house was converted into a RCC framed house under the provisions of IS 456 (Plain and reinforced concrete), IS 1893 (Indian standard criterion for earthquake resistant design of structures), IS 875 part I (Indian standard code of practice for dead load) & part II (Indian standard code of practice for design load). The overall cost came out to be **Rs 1165292 (Rs 963.05/sq feet)** .As expected the cost increase was a mere **22.13%**.

At the end it is safe to presume that the added safety factor outweighs the extra cost incurred. Thus it is advised that no matter how small or casual the structure is, it should be made earthquake resistant, after all nature may not give us a second chance.

7.2 References

1. *Improving Earthquake Resistant of Low strength masonry buildings*, IS 13828:1993, Bureau of Indian Standards, New Delhi.
2. *Plain and Reinforced Concrete for Buildings-Code of Practice*, IS 456:2000, Bureau of Indian Standards, New Delhi.
3. *Indian Standard Criteria for Earthquake Resistant Design of structure*, IS 1893, Bureau of Indian Standards, New Delhi.
4. *Indian standard code of practice for Dead Load for Buildings and Structures*, IS 875 (Part 1), Bureau of Indian Standards, New Delhi.
5. *Indian Standard code of practice for Design Load for Buildings and Structures*, IS 875 (Part 2), Bureau of Indian Standards, New Delhi.
6. Y.N. Raja Rao, Y. Subramaniam, *Planning and Design of Residential Buildings*.
7. B.N. Dutta, *Estimation and Costing in civil Engineering*.
8. Shalimar Bagh Bill of Quantities.
9. Delhi Schedule of Rates 2012