OPTIMIZATION OF A MULTISTOREY-BUILDING BY OPTIMUM POSITIONING OF SHEAR WALL

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Abstract

The shear wall is a structural element which is used to resist earthquake forces. These wall will consumptives shear forces & will prevent changing location-position of construction & consequently destruction. On other hand, shear wall arrangement must be absolutely accurate, if not, we will find negative effect instead. For example if the shear walls make an increase distance between mass centre and hardness centre, we cannot expect a good tensional behavior from the structure. In case of mass centre and hardness centre coincide with each other, at that time the distance of shear wall from the mass centre also plays an important role in the shear contribution of the shear wall. The bending moment, shear force, torsion, axial force contribution by rest of the structural element and the ultimate design of all the structural components also affected by that. A study has been carried out to determine the optimum Structural configuration of a multistory building by changing the shear wall locations radically. Four different cases of shear wall position for a 10 storey residential building with keeping zero eccentricity between mass centre and hardness centre have been analyzed and designed as a space frame system by computer application software, subjected to lateral and gravity loading in accordance with IS provisions.

Keywords: *Shear walls, Lateral loading, Zero eccentricity, Stresses, Design configuration.*

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1. INTRODUCTION

Constructing the Shear wall in tall, medium and even short buildings will reinforce the significantly and either more economic than the bending frames. By the Shear walls, we can control the side bending of the structure, much better than other elements like closed frames and certainly the shear walls are more flexible than them. However, on many occasions the design has to be based on the off center position of the Lift and stair case walls with respect to the center of mass. The design in these cases results into an excessive stresses in most of the structural members, unwanted torsional moments and sways. Design by coinciding Stiffness center and mass of the building is the ideal for a structure. In this case there is no eccentricity, but as per IS 1893(1):2002 the minimum eccentricity is to be considered. The lateral force in a wall due to rotational moment is given by,

$$Fir = \frac{kiri}{\sum kiri^2} (Fe_d)$$

Where, ki = Stiffness of Shear wall "i"

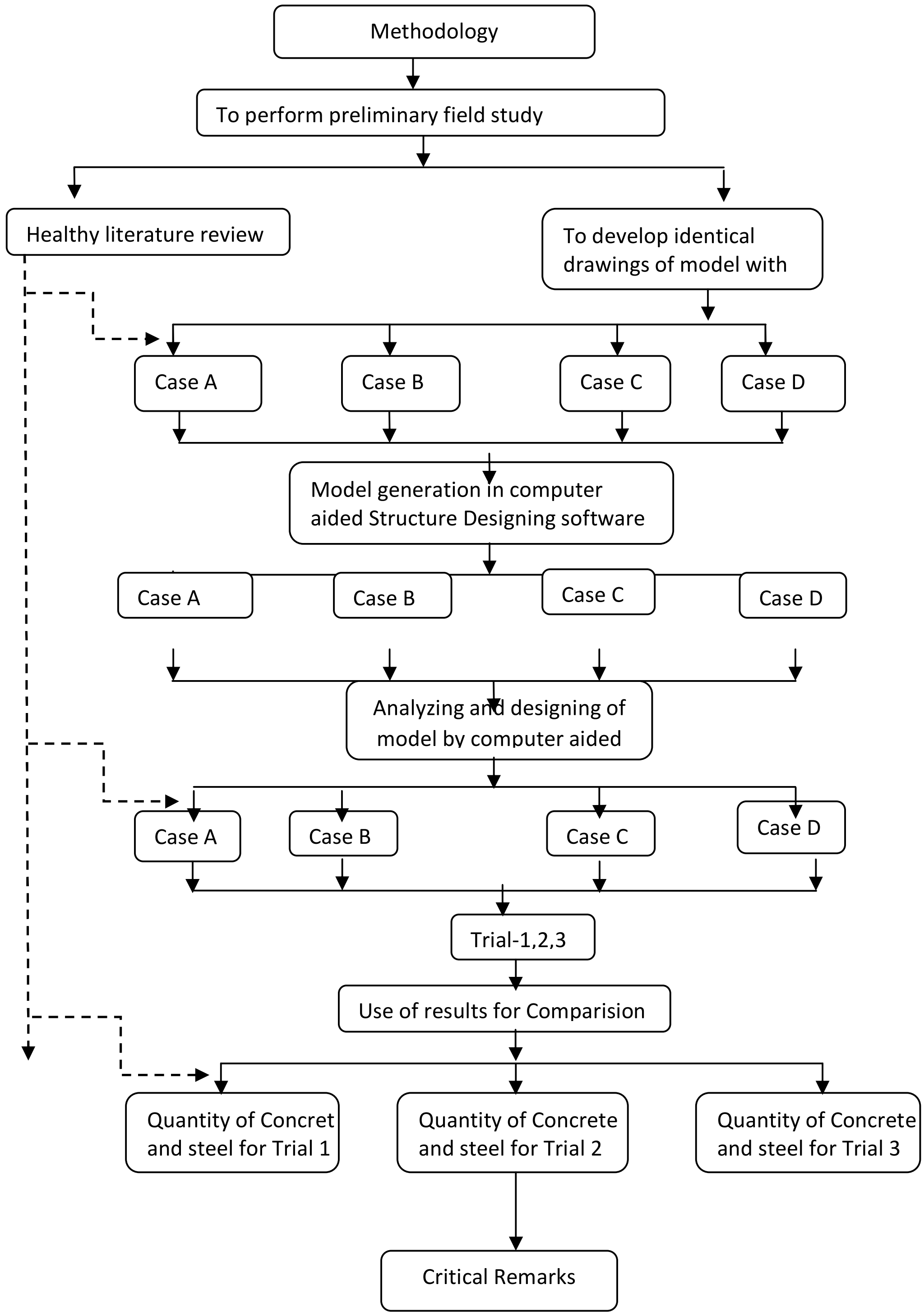
ri = Radial distance of shear wall "i"

F = Design Shear force

ed = Design eccentricity

From the above equation, it is observed that the distance of any shear wall from the centre of stiffness increases, the Shear generated in the Shear wall is decreased. The distance of Shear wall from the Centre of Stiffness is also an important Criteria for the Stresses generated in the Structural members and overall behavior of the whole structure.

1.1 Methodology



2. Analytical Study

2.1 Problem Statement

2.1.1 General

- The Building will be used for residential Purpose. So that there are 115 mm thick interior walls and 230 mm exterior walls are considered.
- For simplicity in analysis, no balconies used in the building.
- At ground floor, slabs are not provided and the floor will directly rest on ground.
- The main beams rest centrally on columns to avoid local eccentricity.
- Center line dimensions are followed for analysis and design.

2.1.2 Data of the Example

A typical building (G+8) having three various position of shear wall and one without shear wall having following data

Floor to Floor height = 3000mm
Height of Plinth = 450mm above ground level.

Depth of Foundation = 2100mm below ground level.

External Walls =230 mm
Internal Walls =115 mm

2.1.4 Imposed Loads

Roof: Roof Finish = 1.5 KN/m2
Live Load = Variable parameter
Floor: Floor Finish = 1.0 KN/m2
Live Load = Variable parameter

2.1.5 Earthquake Load

EQ load generation method = Response Spectrum Method
Seismic Zone = Zone 3
Soil Type =Medium Soil
Percentage Damping =5 %
Modal Combination method =SRSS

2.1.6 Materials

Concrete = M20,
Steel: Main & Secondary = Fe 415
Unit Weight of Concrete = 25 KN/m2
Unit Weight of Bricks Masonry = 19 KN/m2
Design Basis: =Limit State Method based on IS: 456-2000

2.1.3 Typical Drawing of Each Case

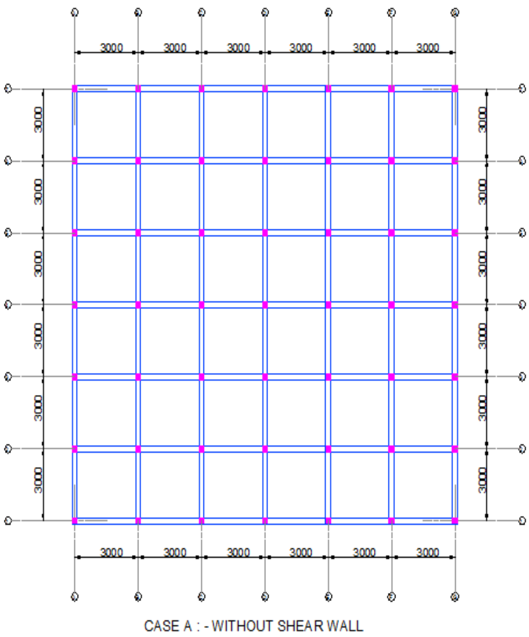


Fig 1 :- Location of shear wall in case A

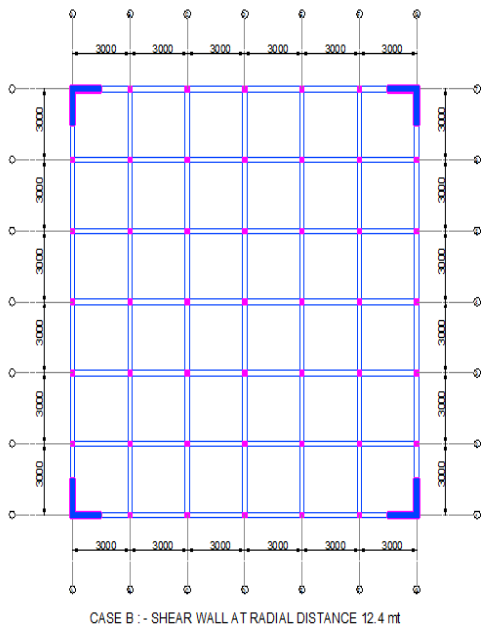


Fig2 :- Location of shear wall in case B

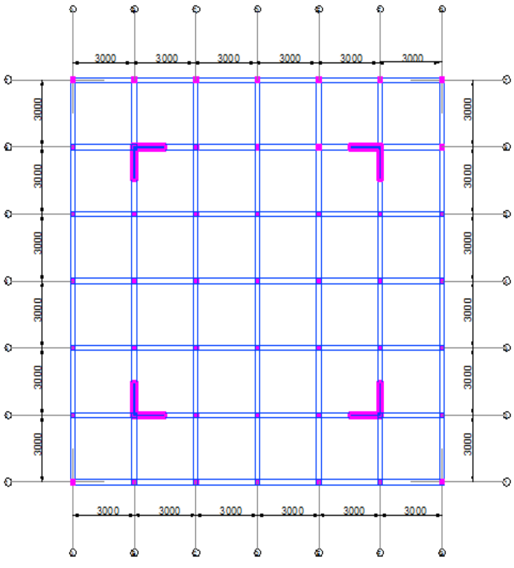


Fig 3:- Location of shear wall in case C

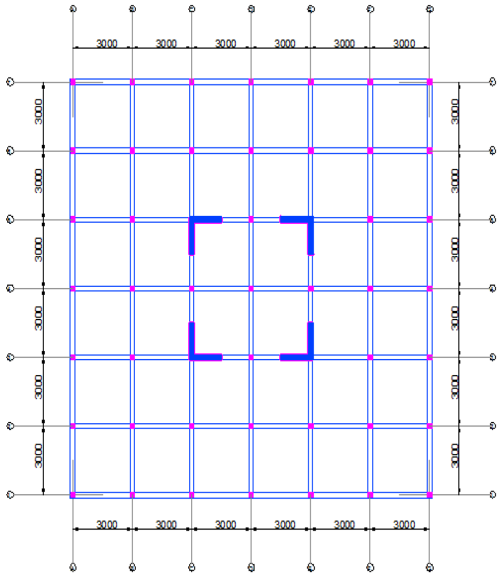


Figure 4:- Location of shear wall in case D

2.1.7 Trial cases of Variable Parameter

2.1.7.1 Trial:-1

- Live Load = 2 KN/m2
- Preliminary Beam Size = 230 x 450 mm

2.1.7.2 Trial:-2

- Live Load = 2 KN/m2
- Preliminary Beam Size = 230 x 300 mm

2.1.7.3 Trial:-3

- Live Load = 3 KN/m2
- Preliminary Beam Size = 230 x 300 mm

2.2 Major Design Consideration

2.2.1 Loads

A building is subjected to the following loads during its service life.

2.2.1.1 Dead Load

The dead loads in a building shall compromise of the weight of all the walls, partition walls, floors and roofs and shall include the weight of all the other permanent constructions in the building.

2.2.1.2 Live Load

Live loads are also called the superimposed loads and include all the moving or variable loads, due to people or occupants, their furniture, temporary stores, machinery etc. Live loads on floors shall compromise of all loads other than the dead loads. The various live loads acting on the different floors are given in IS 875: 1998

2.2.1.3 Earthquake Load

EQ load acts on the structure during earthquake. It will act horizontally on the structure. It is also called as seismic force.

2.2.2 Methods of Analysis

There are three methods for building analysis which have been used for the analysis of reinforced concrete structure viz. Plane grid method, Plane frame method, and Space frame method.

Space frame method is the most accurate and desirable method for analysis. This method is difficult to adopt for manual calculations, but is most suitable for computer-aided analysis.
In the Space frame method, the stiffness of columns is taken into account for analysis. Beams are designed as continuous beams with fixity at end supports. Columns will be designed for axial load and moments in X and Y directions. Footing shall also be designed for biaxial bending.

2.2.3 Design Philosophies

There are three design philosophies which have been used for the design of reinforced concrete structure viz. working stress method, Ultimate load method, Limit sate method.

At present the IS 456-2000 recommends the use of limit state method of design. However it has also retained the working stress method of design. A brief introduction about limit state method is represented below.

2.2.3.1 Limit State Method (IS 456-2000)

It is based on the concept as to achieve an acceptable probability that the structure will not become unserviceable in its lifetime. Hence this method is based on its philosophy that the structure should be able to withstand safely the working load throughout its life and also satisfy the serviceability requirement. In the design the following limit states are examined:

Limit State of Collapse:

It corresponds to the maximum load carrying capacities and it violation implies failure but do not mean complete collapse. This limit state corresponds to: Flexure, Compression, Shear and torsion.

Limit State of Serviceability:

It corresponds to the development of excessive deformation. This state corresponds to Defection on cracking and vibration.

2.2.4Design of Building Components

A brief description about the various components of the building (Super and Substructure) along with the method of analysis and design is presented in following articles.

2.2.4.1 Slabs

Slabs may be classified a one way slabs or two-way slabs based up on the aspect ratio. When the aspect ratio (ly/lx)>2. It is designed as one-way slab. However it is designed as two way slab when aspect ratio is ≤2.

- One way slab are designed as a beam considering one meter width of slab.
- Two way slabs are further classified into nine types as given in IS 456:2000 based on boundary conditions.
- The two way slabs are divided in middle strips and edge strips and designed accordingly.

2.2.4.2 Beams

These are the basically flexural member on which the slab rest. The beam is supported on columns to which they transmit the loads. Beams can have square, rectangular or flanged (T or L-shaped) cross-sections. With respect to the reinforcement provided. Beams can be singly reinforced or doubly reinforced.

2.2.4.3 Column

These are the vertical skeletal structural elements which may be rectangular, square, circular etc. in their cross-sectional shapes. The size of the section is governed by effective length of the column and loads acting on it, which in turn depend on the type floor system, spacing of columns, number of storey etc. The column is generally designed to resist axial compression combined with uni-axial or Bi-axial bending moments that are induced by frame action. It is also advisable to reduce the unsupported length of the columns by providing appropriate tie beams-otherwise they may have to be designed as slender columns.

2.2.4.4 Footing

These are the elements provided at the ground level to transfer the load of column to the soil. The design of footing is carried out with flexure, one way shear and two way shear consideration. The area of footing is provided based on the soil bearing capacity.

2.2.4.5 Shear wall

Shear walls are vertical elements in the lateral-force-resisting system that transmits lateral forces from the diaphragm above to the diaphragm below, or to the foundation. Shear walls may also be bearing walls in the gravity-load system, or they may be components in a dual system framed so as to resist only lateral loads.
Walls may be subjected to both vertical (gravity) and horizontal (wind or earthquake) forces. The horizontal forces are both in plane and out-of-plane. When considered under their in-plane loads, walls are called shear walls; when considered under their out-of-plane loads, they are called normal walls. Walls will be designed to withstand all vertical loads and horizontal forces, both parallel to and normal to the flat surface, with due allowance for the effect of any eccentric loading or overturning forces generated.

In this analyasis all the elements are analyzed and designed by space frame method and limit state method respectively by use of computer aided software "STRUDS 2008"

2.3 Calculation of R.C.C. Design

2.3.1 Analysis Process

Methods of analysis for a multistory structure are:

1) Approximate methods
    - Substitute frame method
    - Portal frame method

- cantilever frame method

2) Computer Methods
   - Matrix methods – Flexibility Matrix , Stiffness Matrix methods
   - Finite Element methods
   - Finite difference methods

Among all the above methods most accurate method is computer aided software. For computer analysis and design of structures various software are available in the market like STRUDS 2008, STADD PRO V8i, ETABS, and ANSYS etc.
The analysis of the whole project is done by computer aided software "STRUDS 2008".The modeling, analysis and design process for the structure is done by this software in three modes. The procedure of analysis in STRUD 2008 is as follows:

2.3.1.1 Pre-Processing Mode

This process consists of the following procedure:

1) File opening and preferences setting.
2) Creation of various types of slabs with varying supporting conditions.
3) Locating Columns.
4) Specifying Boundary conditions.
5) Enter material and Section properties
6) Generating walls in the floor plan.
7) Observing Entities.
8) Attaching external loads.
9) Copying the floor plans.
10) Editing the floor plans.
11) Analyzing the building structure.

2.3.1.2 Post Processing Mode

Analysis report is obtained in this mode. Report of post processing mode can be generated are

a) Elemental result
   1) Shear force

Bending moment
Axial force

   2) Torsion

b) Nodal result
   1) Deflection
   2) Reaction

2.3.2 Design Process

Design of each components of multistoried structure has been done by using computer aided software STRUD 2008 in the following way,

a) Setting of Design parameters for
   1) Slab
   2) Beam
   3) Column
   4) Footing
   5) Shear wall
b) Design of each components one by one
c) Design data reports
   1) Design schedules for each component

2.3.3 Quantity Estimation

In this software the quantity of each R.C.C. components has been provided with quantity of concrete and quantity of steel separately.
Quantity reports of structure has been obtain by software for following components

1) Slab quantity
2) Beam quantity
3) Column quantity
4) Footing quantity

3. Result and Discussion

3.1 Results

3.1.1 Trial:-1

- Live Load = 2 KN/m2
- Preliminary Beam Size = 230 x 450 mm

3.1.1.1 Beam

Table 1: Quantity of concrete in beam (trial 1)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	26.082	25.081	25.185	25.288
2	26.082	25.702	25.737	26.030
3	26.082	25.116	24.840	24.961
4	26.082	24.978	24.840	24.909
5	26.082	24.840	24.840	24.909
6	26.082	24.840	24.840	24.840
7	26.082	24.840	24.840	24.840
8	26.082	24.840	24.840	24.840

9	26.082	24.840	24.840	24.840
10	26.082	24.840	24.840	24.840
TOTAL(m3)	**260.82**	**249.917**	**249.642**	**250.297**

Table 2: Quantity of steel in beam (trial 1)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	2772.227	2675.430	3032.986	3175.756
2	2930.800	3232.510	3825.537	3962.128
3	2102.556	2332.150	2675.695	2711.517
4	2033.926	2367.998	2801.699	2750.90
5	1967.653	2382.478	2825.914	2719.660
6	1930.262	2341.676	2814.228	2659.814
7	1927.452	2310.357	2750.929	2579.280
8	1920.258	2279.415	2668.587	2489.191
9	1920.258	2205.625	2637.418	2411.293
10	1920.258	2060.936	2469.929	2343.405
TOTAL(kg)	**21425.693**	**24188.575**	**28502.922**	**27874.944**

3.1.1.2 Column

Table3: Quantity of concrete in column (trial 1)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	13.296	10.941	10.630	10.706
2	15.642	14.336	14.336	13.466
3	13.814	11.894	11.041	10.201
4	11.219	9.972	9.360	9.207
5	10.607	9.054	7.830	8.059
6	8.159	7.525	7.141	7.414
7	7.776	7.776	7.141	7.414
8	7.776	7.776	7.141	7.414
9	7.776	7.776	7.141	7.414
10	7.776	7.776	7.141	7.414
TOTAL(m3)	**103.840**	**92.286**	**88.904**	**87.343**

Table 4: Quantity of steel in column (trial 1)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	2169.89	2053.460	1847.690	1706.140
2	2649.42	2348.740	2242.250	2035.620
3	2200.99	1821.400	1840.930	1914.840
4	2181.70	1774.620	1752.490	1628.250
5	1896.10	1587.010	1454.840	1535.240
6	1641.19	1399.060	1188.940	1227.260
7	1173.51	1079.690	1077.710	1078.950
8	1173.51	1085.610	1079.690	1080.920
9	1184.61	1094.730	1092.510	1091.540
10	1217.90	1122.100	1114.460	1118.160
TOTAL(kg)	**17399.38**	**15451.290**	**14691.530**	**14416.920**

3.1.1.3 Footing

Table 5: Quantity of concrete in footing (trial 1)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	62.867	48.069	45.629	45.240
TOTAL(m3)	**62.867**	**48.069**	**45.629**	**45.240**

Table 6: Quantity of steel in footing (trial 1)

QUANTITY OF steel (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	1677.47	1265.413	1203.913	1178.789
TOTAL(kg)	**1677.47**	**1265.413**	**1203.913**	**1178.789**

3.1.1.4 Shear Wall

Table 7: Quantity of concrete in shear wall (trial 1)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	4.59	4.59	4.59
2	--	5.4	5.4	5.4
3	--	5.4	5.4	5.4
4	--	5.4	5.4	5.4
5	--	5.4	5.4	5.4
6	--	5.4	5.4	5.4
7	--	5.4	5.4	5.4
8	--	5.4	5.4	5.4
9	--	5.4	5.4	5.4
10	--	5.4	5.4	5.4
TOTAL(m3)	--	**53.19**	**53.19**	**53.19**

Table 8: Quantity of steel in shear wall (trial 1)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	663.33	993.52	812.44
2	--	513.11	770.00	682.3
3	--	171.78	413.56	342.44
4	--	171.78	171.78	171.78
5	--	171.78	171.78	203.78
6	--	171.78	171.78	203.78
7	--	171.78	171.78	203.78
8	--	171.78	171.78	203.78
9	--	171.78	171.78	171.78
10	--	235.78	171.78	171.78
TOTAL(kg)	--	**2614.68**	**3379.54**	**3167.64**

3.1.2 Trial:-2

- *Live Load = 2 KN/m2*
- *Preliminary Beam Size = 230 x 300 mm*

3.1.2.1 Beam

Table 9: Quantity of concrete in beam (trial 2)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	17.388	17.595	19.665	16.870
2	17.388	20.441	19.665	17.491
3	17.388	17.595	17.181	16.767
4	17.388	17.595	17.181	16.870
5	17.388	17.595	17.181	16.767
6	17.388	17.565	17.181	16.767
7	17.388	16.560	16.560	16.663
8	17.388	16.560	16.560	16.360
9	17.388	16.560	16.560	16.560
10	17.388	16.560	16.560	16.560
TOTAL(m3)	173.88	**157.061**	**174.294**	**167.675**

Table 10: Quantity of steel in beam (trial 2)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	3717.462	3123.434	3032.986	3509.906
2	4024.229	3672.450	3032.986	4547.092
3	2191.105	2354.751	2763.507	2824.756
4	2135.395	2358.587	2868.484	2915.473
5	2090.489	2369.129	2877.104	2849.714
6	2011.030	2343.593	2808.405	2748.934
7	1898.195	2751.080	2889.675	2625.218
8	1848.690	2317.591	2782.623	2501.200
9	1758.512	2225.688	2646.002	2372.185
10	1572.402	1796.802	2388.273	1996.810
TOTAL(kg)	**23168.447**	**25017.105**	**28090.045**	**28891.278**

3.1.2.2 Column

Table 11: Quantity of concrete in column (trial 2)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	13.296	11.874	12.185	11.887
2	16.008	15.554	15.554	15.341
3	14.910	13.970	12.140	12.963
4	13.446	13.238	11.041	10.858
5	11.525	11.316	10.584	10.767
6	11.525	11.316	09.972	10.690
7	07.776	10.016	08.748	08.671
8	07.776	09.403	08.059	08.059
9	07.776	09.403	08.059	07.600
10	08.082	09.403	08.059	08.136

TOTAL(m3)	**112.122**	**115.493**	**104.402**	**104.974**

Table 12: Quantity of steel in column (trial 2)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	2482.22	3976.700	2002.500	1827.04
2	3319.08	2965.530	2873.540	1868.10
3	2347.13	2094.710	2068.410	1997.40
4	2139.91	2059.060	1989.230	2119.35
5	1992.30	1960.880	1888.160	1807.48
6	1881.07	1849.660	1809.730	1731.25
7	1778.99	1814.280	1776.420	1987.83
8	1173.51	1587.580	1448.730	1349.86
9	1222.95	1488.660	1250.990	1337.38
10	1231.47	1636.960	1646.460	1340.35
TOTAL(kg)	**19568.63**	**19669.970**	**18707.230**	**18084.03**

3.1.2.3 Footing

Table 13: Quantity of concrete in footing (trial 2)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	60.341	46.945	47.211	45.801
TOTAL(m3)	**60.341**	**46.945**	**47.211**	**45.801**

Table 14: Quantity of steel in footing (trial 2)

QUANTITY OF steel (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	1680.016	1287.765	1326.009	1300.167
TOTAL(kg)	**1680.016**	**1287.765**	**1326.009**	**1300.167**

3.1.2.4 Shear Wall

Table 15: Quantity of concrete in shear wall (trial 2)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	4.590	4.590	4.590
2	--	5.400	5.400	5.400
3	--	5.400	5.400	5.400
4	--	5.400	5.400	5.400
5	--	5.400	5.400	5.400
6	--	5.400	5.400	5.400
7	--	5.400	5.400	5.400
8	--	5.400	5.400	5.400
9	--	5.400	5.400	5.400
10	--	5.400	5.400	5.400
TOTAL(m3)	--	**53.19**	**53.19**	**53.19**

Table 16: Quantity of steel in shear wall (trial 2)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	993.49	993.52	1294.99
2	--	770.00	769.60	547.18
3	--	314.00	413.56	242.89
4	--	171.78	171.78	171.78
5	--	171.78	171.78	203.78
6	--	171.78	171.78	203.78
7	--	171.78	171.78	242.89
8	--	171.78	171.78	203.78
9	--	171.78	171.78	203.78
10	--	171.78	171.78	171.79
TOTAL(kg)	--	**3279.97**	**3379.64**	**3486.74**

3.1.3 Trial:-3

- *Live Load = 3 KN/m2*
- *Preliminary Beam Size = 230 x 300 mm*

3.1.3.1 Beam

Table 17: Quantity of concrete in beam (trial 3)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	17.388	16.560	16.560	16.560
2	17.388	16.870	17.181	16.663
3	17.388	16.560	16.560	16.560
4	17.388	16.560	16.560	16.560
5	17.388	16.560	16.560	16.560
6	17.388	16.560	16.560	16.560
7	17.388	16.560	16.560	16.560
8	17.388	16.560	16.560	16.560
9	17.388	16.560	16.560	16.560
10	17.388	16.560	16.560	16.560
TOTAL(m3)	**173.880**	**165.91**	**166.221**	**165.703**

Table 18: Quantity of steel in beam (trial 3)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	3409.881	2016.202	1973.808	2031.858
2	3715.175	2570.800	2647.202	2706.889
3	2122.567	1944.847	2218.602	2186.091
4	2081.692	2055.334	2345.550	2250.877
5	2057.334	2096.149	2418.503	2291.698
6	1979.012	2121.062	2448.692	2308.634
7	1930.206	2119.877	2438.504	2331.549
8	1893.578	2108.370	2445.335	2293.049
9	1823.225	2067.440	2462.595	2292.016
10	1573.728	1776.462	2346.312	2038.324
TOTAL(kg)	22586.398	**20876.543**	**23745.103**	**22730.985**

3.1.3.2 Column

Table 19: Quantity of concrete in column (trial 3)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	13.296	11.354	10.319	11.627
2	15.642	13.970	12.872	13.572
3	13.812	11.894	11.102	10.567
4	11.219	9.972	9.757	9.895
5	10.607	9.360	8.442	8.442
6	8.465	7.830	7.524	7.141
7	7.776	7.141	7.141	7.141
8	7.776	7.141	7.141	7.141
9	7.776	7.141	7.141	7.141
10	7.776	7.141	7.141	7.141
TOTAL(m3)	**104.145**	**92.944**	**88.398**	**89.808**

Table 20: Quantity of steel in column (trial 3)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	2323.87	2049.77	1951.030	1627.15
2	2591.19	2247.33	2231.62	1866.91
3	2312.21	1968.04	1906.04	2074.78
4	2148.64	1829.47	1804.31	1684.06
5	1806.66	1595.34	1520.93	1558.01
6	1649.51	1405.41	1298.22	1287.81
7	1284.74	1188.94	1139.51	1077.71
8	1173.51	1077.71	1077.71	1077.71
9	1173.51	1077.71	1077.71	1077.71
10	1173.51	1077.71	1077.71	1077.71
TOTAL(kg)	**17673.35**	**15517.43**	**15084.79**	**14409.56**

3.1.3.3 Footing

Table 21: Quantity of concrete in footing (trial 3)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	66.548	56.888	50.479	50.331
TOTAL(m3)	**66.548**	**56.888**	**50.479**	**50.331**

Table 22: Quantity of steel in footing (trial 3)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
FOOTING LEVEL	1802.823	1527.548	1347.562	1331.036
TOTAL(kg)	**1802.823**	**1527.548**	**1347.562**	**1331.036**

3.1.3.4 Shear Wall

Table 23: Quantity of concrete in shear wall (trial 3)

QUANTITY OF CONCRETE (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	4.59	4.590	4.590
2	--	5.40	5.400	5.400
3	--	5.40	5.400	5.400
4	--	5.40	5.400	5.400
5	--	5.40	5.400	5.400
6	--	5.40	5.400	5.400
7	--	5.40	5.400	5.400
8	--	5.40	5.400	5.400
9	--	5.40	5.400	5.400
10	--	5.40	5.400	5.400
TOTAL(m3)	--	**53.19**	**53.19**	**53.19**

Table 24: Quantity of steel in shear wall (trial 3)

QUANTITY OF STEEL (FLOOR WISE)				
FLOOR NO.	**CASE A**	**CASE B**	**CASE C**	**CASE D**
1	--	653.52	993.52	812.44
2	--	514.00	770.00	682.30
3	--	171.78	413.56	342.44
4	--	171.78	171.78	171.78
5	--	171.78	171.78	203.78
6	--	171.78	171.78	203.78
7	--	171.78	171.78	203.78
8	--	171.78	171.78	203.78
9	--	171.78	171.78	171.78
10	--	235.78	171.78	171.78
TOTAL(kg)	--	**2605.75**	**3379.53**	**3167.64**

3.2 Discussion

3.2.1 Trial: - 1

Table 25:- Quantity of concrete & steel in beam (trial 1)

QUANTITY OF CONCRETE & STEEL IN BEAM (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	260.82	21425.693
B	249.917	24188.575
C	249.642	28502.922
D	250.297	27874.944

Table 26:- Quantity of concrete & steel in column (trial 1)

QUANTITY OF CONCRETE & STEEL IN COLUMN (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	103.840	17399.38

B	92.286	15451.290
C	88.904	14691.530
D	87.343	14416.920

Table 27:- Quantity of concrete & steel in footing (trial 1)

QUANTITY OF CONCRETE & STEEL IN FOOTING (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	62.867	1677.47
B	48.069	1265.413
C	45.629	1203.913
D	45.240	1178.789

Table 28:- Quantity of concrete & steel in shear wall (trial 1)

QUANTITY OF CONCRETE & STEEL IN SHEAR WALL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	---	---
B	53.19	2614.68
C	53.19	3379.54
D	53.19	3167.64

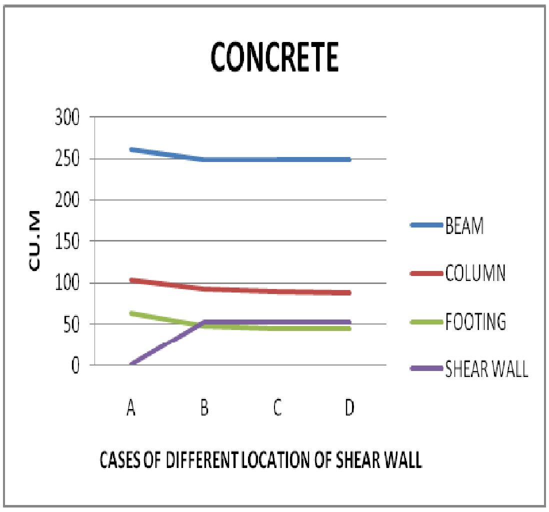


Fig 5 :- Comparision of quantity of concrete of each component case wise (trial 1)

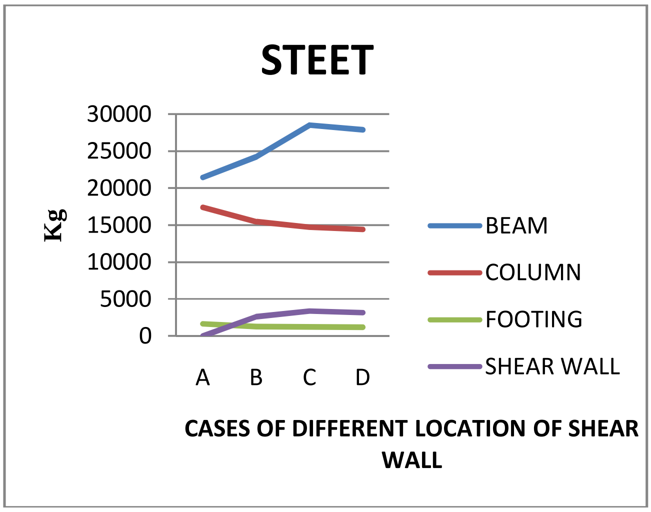
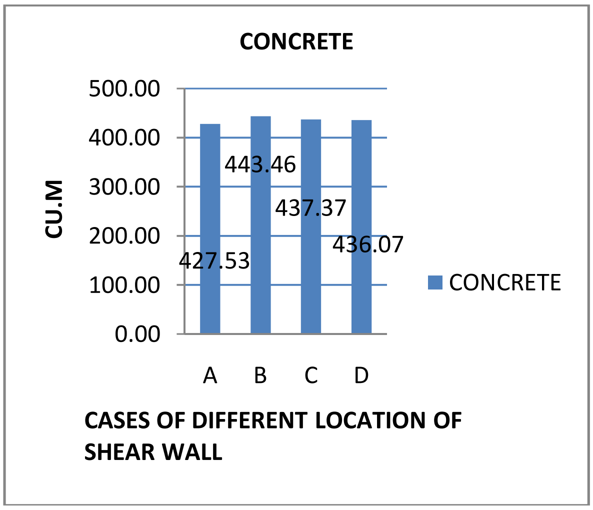


Fig 6:- Comparision of quantity of steel of of each component case wise (trial 1)

Tab**le 29:-** Total quantity of concrete & steel (trial 1)

TOTAL QUANTITY OF CONCRETE & STEEL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	427.527	40502.543
B	443.462	43519.958

C	437.365	47777.905
D	436.07	46638.293



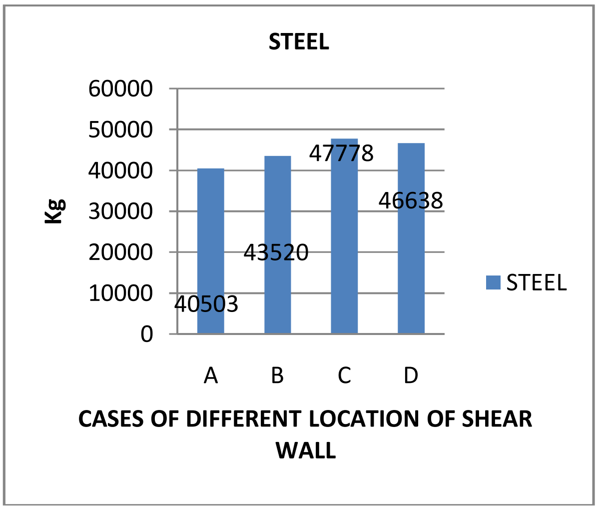


Fig 7:- Comparision of total quantity of concrete case wise (trial 1)

Fig 8:- Comparision of total quantity of steel case wise (trial 1)

3.1.2 Trial: - 2

Table 30:- Quantity of concrete & steel in beam (trial 2)

QUANTITY OF CONCRETE & STEEL IN BEAM (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	173.88	23168.447
B	157.061	25017.105
C	174.294	28090.045
D	167.675	28891.278

Table 31:- Quantity of concrete & steel in column (trial 2)

QUANTITY OF CONCRETE & STEEL IN COLUMN (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	112.122	19568.630
B	115.493	19669.097
C	104.402	18707.230
D	104.974	18084.030

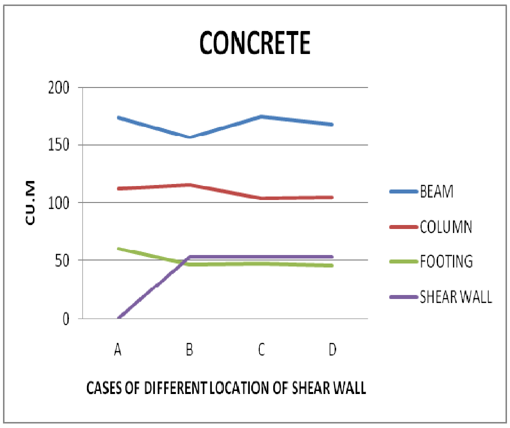
Table 32:- Quantity of concrete & steel in footing (trial 2)

QUANTITY OF CONCRETE & STEEL IN FOOTING (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	60.341	1680.016
B	46.945	1287.765

C	47.211	1326.009
D	45.801	1300.167

Table 33:- Quantity of concrete & steel in shear wall (trial 2)

QUANTITY OF CONCRETE & STEEL IN SHEAR WALL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	---	---
B	53.19	3279.97
C	53.19	3378.64
D	53.19	3166.74



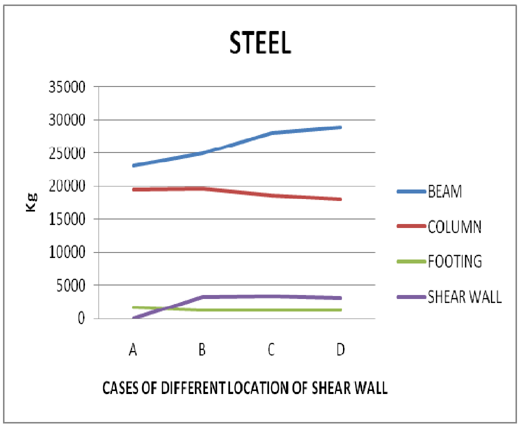


Fig 9:- Comparision of quantity of concrete of each component case wise (trial 2)

Fig 10:- Comparision of quantity of steel of each component case wise (trial 2)

Table 34:- Total quantity of concrete & steel (trial 2)

TOTAL QUANTITY OF CONCRETE & STEEL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	346.343	44417.093
B	372.689	49253.937
C	379.097	51502.924
D	371.64	51442.215

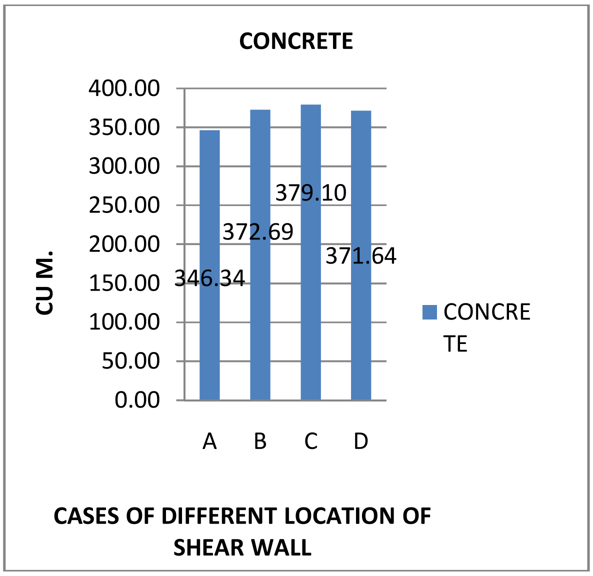


Fig 11:- Comparision of total quantity of concrete case wise (trial 2)

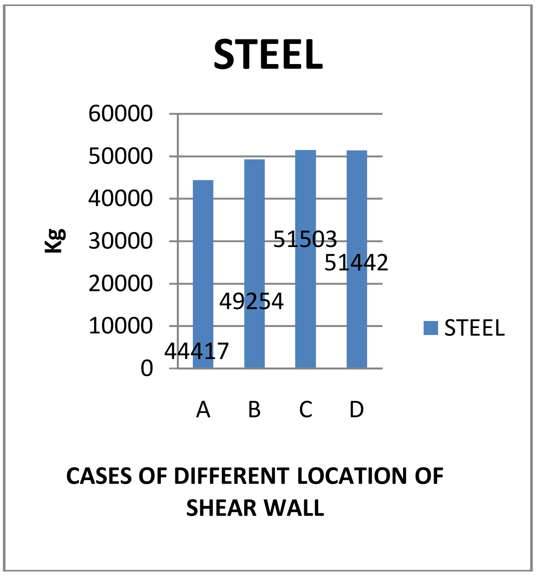


Fig 12:- Comparision of total quantity of concrete case wise (trial 2)

3.1.3 Trial: - 3

Table 35:- Quantity of concrete & steel in beam (trial 3)

QUANTITY OF CONCRETE & STEEL IN BEAM (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	173.880	22586.398
B	165.710	20876.543
C	166.221	23745.103
D	165.703	22730.985

Table 36:- Quantity of concrete & steel in column (trial 3)

QUANTITY OF CONCRETE & STEEL IN COLUMN (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	104.145	17637.35
B	92.944	15517.13
C	88.398	15084.79
D	89.808	14409.56

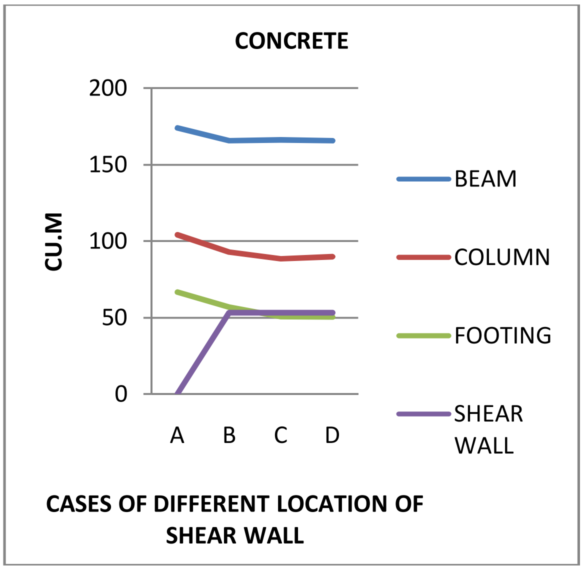
Table 37:- Quantity of concrete & steel in footing (trial 3)

QUANTITY OF CONCRETE & STEEL IN FOOTING (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	66.548	1802.823
B	56.888	1527.548
C	50.479	1347.562

D	50.331	1331.036

Table 38:- Quantity of concrete & steel in shear wall (trial 3)

QUANTITY OF CONCRETE & STEEL IN SHEAR WALL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	---	---
B	53.19	2605.75
C	53.19	3379.53
D	53.19	3167.64



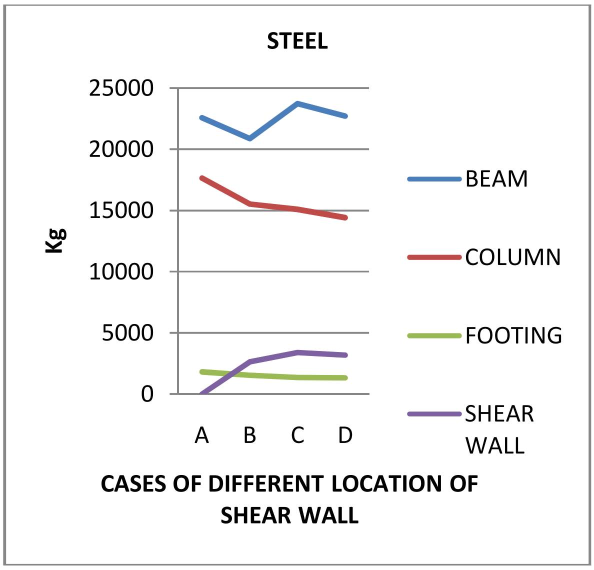


Fig 13:- Comparision of quantity of concrete of each component case wise (trial 3)

Fig 14:- Comparision of quantity of steel of each component case wise (trial 3)

Table 39:- Total quantity of concrete & steel (trial 3)

TOTAL QUANTITY OF CONCRETE & STEEL (CASE WISE)		
CASE	**QUANTITY OF CONCRETE (m3)**	**QUANTITY OF STEEL (Kg)**
A	344.573	42026.571
B	368.732	40526.971
C	358.288	43556.985
D	359.032	41639.221

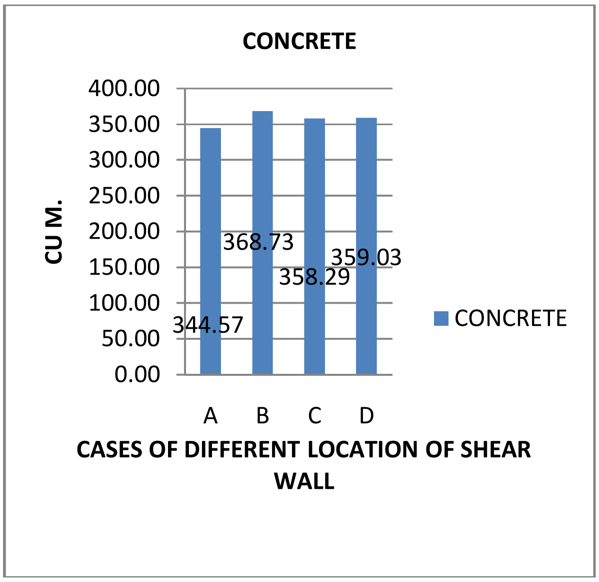


Fig 15:- Comparision of total quantity of concrete case wise (trial 2)

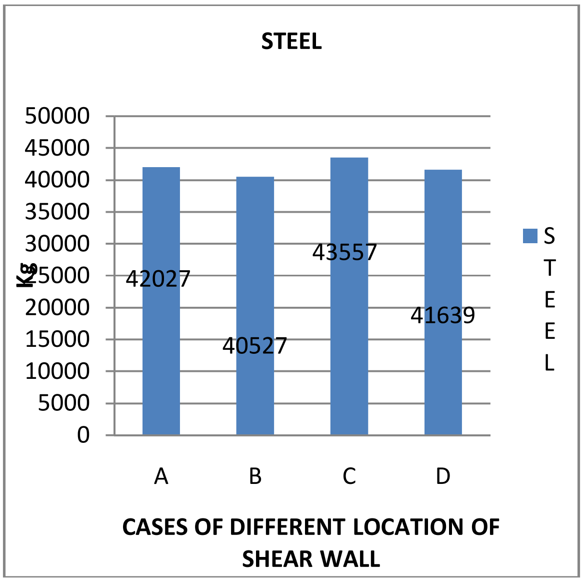


Fig 16:- Comparision of total quantity of concrete case wise (trial 2)

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