# Detailed Analysis and Design of Slab-Wall System and Column-Beam System Concrete Building

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*Abstract*---In the present scenario the high raised concrete buildings are increasing day-by-day in construction field. Construction became one of the significant sectors of Indian economy and is the major part of the development. For growing population the speed of construction needs to be given greater importance especially for large housing projects. The typical floor plan in a structural system of high raised concrete buildings can be easily done by slab-wall form compared to column-beam system. The behavior of the building under gravity and lateral loads is analyzed by using STADD.Pro V8i software for G+8 building. Comparisons with analytical results show that high base shear and deformation in column-beam system than slab-wall system concrete building.

**Keywords:** gravity and lateral loads, slab-wall, column-beam, base shear, deformation.

## I. INTRODUCTION

Now a day's Indian population is getting increased day by day and second largest country in the world regarding population. Future development leads to increased demand for housing; to overcome this India desperately need to plan for acquisition of land and rapid creation of dwelling units. The progress made by the construction industry of any country could be considered as the index of development of that country.

The traditional mode of construction for individual houses comprising load bearing walls with an appropriate roof above or reinforced concrete framed structure construction with infill masonry walls would be totally inadequate for mass housing construction industry in view of the rapid rate of construction. Further, such constructions are prone to poor quality control even in case of contractors with substantial resources and experience.

For undertaking mass housing works, it is necessary to have innovative technologies which are capable of fast rate construction and are able to deliver good quality and durable structure in cost effective manner.

### A. Slab-wall system and column-Beam system

Slab-wall system buildings are built in many countries such Japan, Italy and other countries. The main components of this system are walls and flat plate slabs, where in-situ concrete is poured into two half-box forms to shape loading walls and floor slabs simultaneously. Generally in 24hrs, residential units can be rapidly built up. For this reason, slab-wall system buildings are an attractive system for medium high-rise buildings having respective plan.

Column-Beam system is normal type of construction of buildings in this the pace of construction is slow due to step by step completion of different stages of activity, column and beams with partition brick walls is used for construction.

Balkaya and Kalkan in 2004 studied the relevance of R-Factor and Fundamental period for seismic design of tunnel form buildings, experimental results show good correlation and lead future credibility to propose equation for its use in practice [1]. Yuksel and Kalkan (2006) in his report, experimental investigation on the inelastic seismic behaviour of box type form buildings are presented [2]. Tavafoghi and Eshghi in 2008 described about the seismic behaviour of tunnel form concrete building structures [3]. Dhanashri and Desai in 2012 had done the comparative analysis of conventional formwork and tailor made formwork on the basis of cost and time parameter [4].

### B. Building Plan

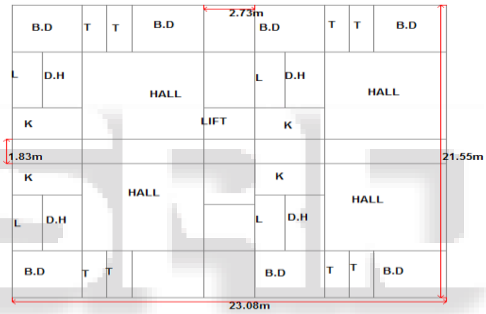


Fig.1: Plan of the building

### C. Dimensions

| | | |
|---|---|---|
| HALL | = | $6.315 \times 6.23\ m^2$ |
| B.R (Bed room) | = | $3.6 \times 3.2 m^2$ |
| D.H (Dining hall) | = | $2 \times 4 m^2$ |
| K (Kitchen) | = | $3.6 \times 3.2\ m^2$ |
| T (Toilet) | = | $1.2 \times 3.2\ m^2$ |
| L (Lobby) | = | $1.6 \times 4\ m^2$ |

## II. METHODOLOGY

- Preparation of architectural plan.
- Modelling of structure by box type form and frame in STADD.ProV8i.
- Application of gravity and lateral loads.
- Analysing the structure to understand the behaviour.
- Cost comparative study.

### A. Units of Measurement

Units of measurements used in analysis and design shall be SI units.

### B. Description of Structure

The size of the building is 23.079 m length and 21.549 m width at ground floor level (As per architectural drawings).

No of floor = Ground + 8 floors
Floor heights = 3.0m
Total height of the building = 27m (from ground floor to top floor level)

*1) Case I: Column-Beam System Concrete Building*

*a) Building modeling for analysis*

The column-beam system building is modeled in STADD Pro as a space frame.

*b) Loads on Building*

Dead loads are calculated on the basics of unit weights of materials specified for construction or on the unit weight of materials given in the design criteria.

*c) Primary Loads*

(1) Self Weight

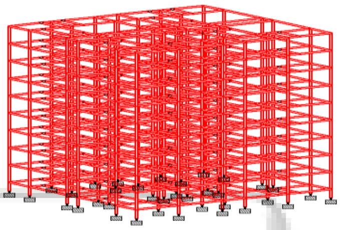

Fig.2: Due to self-weight

Self-weight of the RC columns and beams are calculated automatically based on the geometry by the software and is included in the analysis.

(2) Dead Loads

Floor finishes 0.050 × 20 = 1kN/m$^2$
Slab thickness 0.125 × 25 = 3.125kN/m$^2$
Total = 4.125 kN/m$^2$
Member load on 230 mm thickness wall = 0.230 × 20×2.55
= 11.73kN/m$^2$
Member load on 115mm thickness wall = 0.115 × 20 × 3
= 6.9kN/m$^2$
Member load on parapet wall = 0.115 × 20 × 1
= 2.3kN/m$^2$
Extra load on toilets room = 3kN/m$^2$

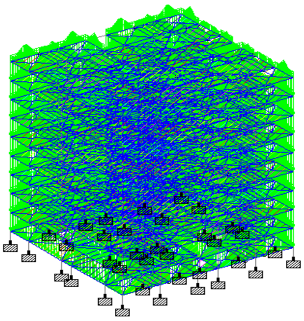

Fig.3.Due to dead load

(3) Live Loads

Live loads (Ref. IS: 875, Part-2)
Living area (all rooms, kitchens, toilet and bath rooms)
= 2.0kN/m$^2$
Balconies, corridors and staircases
= 3.0 kN/m$^2$
Terrace
= 1.5kN/m$^2$

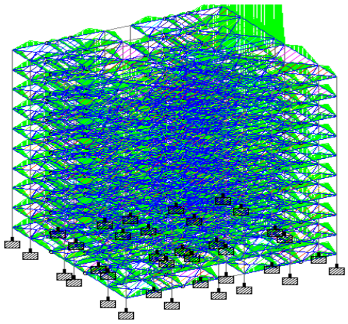

Fig.4: Due to live load

*d) Column and beam dimensions*

Table 1: Column sizes

| Column no: | Size |
|---|---|
| R1 | 750×300 |
| R5 | 300×750 |
| R7 | 0.8×0.35 |
| R8 | 0.6×0.3 |
| R9 | 0.3×50.8 |
| R10 | 0.3×0.6 |

Table 2: Beam sizes

| Beams | Size |
|---|---|
| R2 | 450*230 |
| R3,R4 | 500*230 |
| R6 | 750*300 |

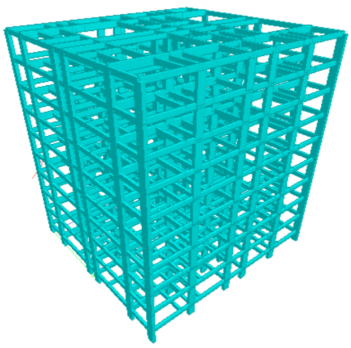

Fig.5: 3D view of column-beam system concrete building

*e) Design Imposed Loads for Earthquakes Force Calculation*

a. For various loading classes as specified in IS 875 (Part 2), the earthquake force shall be calculated for the full dead load plus the percentage of imposed load as given in Table 3.

b. For calculating the design seismic forces of the structure, the imposed load on roof need not be considered.

Table 3: Percentage of Imposed Load to be considered in Seismic Weight Calculation

 

| Imposed Uniformity Distributed Floor Load Loads ( kN/ $m^2$ ) | Percentage of Imposed |
|---|---|
| Up to and including 3.0 | 25 |
| Above 3.0 | 50 |

(1) Joint weights

Minimum joint weight = 5.25 KN (Force in Y direction)

Maximum joint weight = 307.774 KN (Force in Y direction)

(2) Seismic Loads

The structure is located in zone II of seismic map of India. The seismic loads on the structure are calculated as per IS1893-2002(Part 1) and response spectrum method is adopted for the seismic analysis

*Seismic Loads* (ref. IS: 1893(part-1)2002)

Horizontal seismic coefficient, Ah = Z I $S_A$ /2R g

Zone factor, Z = 0.10 (Zone II, Hyderabad)

Importance factor, I = 1 (General building)

Response Reduction factor, R = 3 (Table.7)

Fundamental natural period of vibration 0.09h / Sort (d)

Length of the building = 23.079 m

Width of the building = 21.549 m

Height of the building = 28.5 m

Time period Along X-direction TX = 0.534 m

Time period Along X-direction TZ = 0.552 m

Response acceleration coefficient, $S_a$/g = 2.50 (medium soil)

Horizontal seismic coefficient, Ah = 0.0416

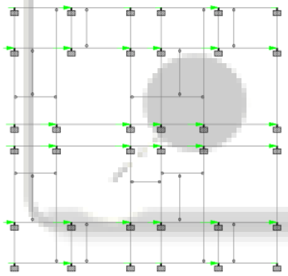

Fig.6: Earth quake loads in x-direction

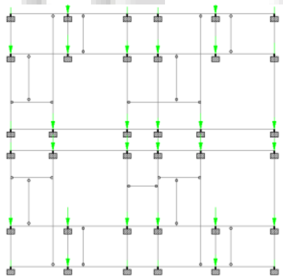

Fig.7: Earth quake loads in y-direction

*f) WIND LOADS (Ref.IS:875, Part-3)*

Basic wind speed, $V_P$ = 44 m/s (Hyderabad)

Risk c0-efficient, K1 = 1.0 (general building)

Terrain, height & structure size factor (Category-2& Class - B)

$K_2$ = 0.98 (up to 10m Height)

$K_2$ = 1.02 (10m to 15m Height)

$K_2$ = 1.05 (15m to 20m Height)

$K_2$ = 1.10 (20m to 30m Height)

Topography factor, $K_3$ = 1.0

Design wind velocity, Vz (N/m = Vb ×$K_1$ ×$K_2$ ×$K_3$

Design wind pressure, $P_z$ = 0.6 $V_z^2$

$P_z$ = 1.11 kN/$m^2$

$P_z$ = 1.21 kN/$m^2$

= 1.28 kN/$m^2$

$P_z$ = 1.40 kN/$m^2$

The wind loads are applied in all four directions from ground floor to top $_{level}$ in the STADD building model

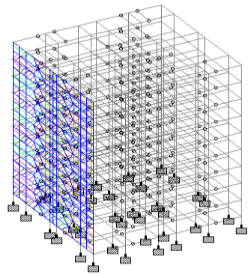

Fig.8: WL-X direction

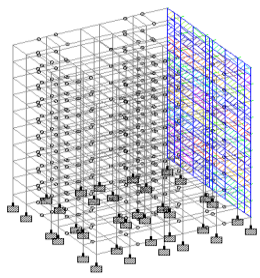

Fig.9: WL-XN direction

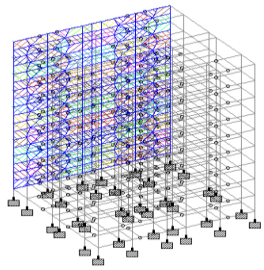

Fig.10: WL-Z direction

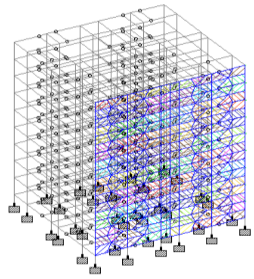

Fig.11: WL-ZN direction

*g) Load Combinations*

The basic load combinations of the primary loads considered in the analysis are shown below.

LOAD COMB 9: 1.5(DL+LL)

LOAD COMB 10: 1.2(DL+LL+EQ (+X))

LOAD COMB 11: 1.2(DL+LL+EQ (+Z))

LOAD COMB 12: 1.2(DL+LL+EQ (-X))

LOAD COMB 13: 1.2(DL+LL+EQ (-Z))

LOAD COMB 14: 1.5(DL+EQ (+X))

LOAD COMB 15: 1.5(DL+EQ (+Z))

LOAD COMB 16: 1.5(DL+EQ (-X))

LOAD COMB 17: 1.5(DL+EQ (-Z))

LOAD COMB 18: 0.9DL+1.5EQ (+X)

LOAD COMB 19: 0.9DL+1.5EQ (+Z)

LOAD COMB 20: 0.9DL+1.5EQ (-X)

LOAD COMB 21: 0.9DL+1.5EQ (-Z)

LOAD COMB 22 DL+LL+WL (+X)

LOAD COMB 23 DL+LL+WL (+XN)

LOAD COMB 24 DL+LL+WL (+Z)

LOAD COMB 25 DL+LL+WL (+ZN)

LOAD COMB 26 DL+LL+WL (-X)

LOAD COMB 27 DL+LL+WL (-XN)

LOAD COMB 28 DL+LL+WL (-Z)

LOAD COMB 29 DL+LL+WL (-ZN)

LOAD COMB 30 DL+WL (+X)

LOAD COMB 31 DL+WL (+XN)

LOAD COMB 32 DL+WL (+Z)

LOAD COMB 33 DL+WL (+ZN)

LOAD COMB 34 DL+WL (-X)

LOAD COMB 35 DL+WL (-XN)

LOAD COMB 36 DL+WL (-Z)

LOAD COMB 37 DL+WL (-ZN)

LOAD COMB 38 DL+WL (+X)

LOAD COMB 39 DL+WL (+XN)

LOAD COMB 40 DL+WL (+Z)

LOAD COMB 41 DL+WL (+ZN)

LOAD COMB 42 DL+WL (-X)

LOAD COMB 43 DL+WL (-XN)

LOAD COMB 44 DL+WL (-Z)

LOAD COMB 45 DL+WL (-ZN)

Compressive strength of concrete (FC) = 30000 kN/$m^2$

Yield strength of main reinforcement steel = 500000 kN/$m^2$

Yield strength of shear reinforcement = 415000 kN/$m^2$

*2) Case II: Slab-wall System Concrete Building*

*a) Building modelling for analysis*

The slab-wall system building is modelled in STADD Pro as a space frame using plate elements.

*b) Loads on Building*

Dead loads are calculated on the basics of unit weights of materials specified for construction or on the unit weight of materials given in the design criteria.

*c) Primary Loads*

(1) Self Weight

Self-weight of the RC walls and slabs are calculated automatically based on the geometry by the software and is included in the analysis.

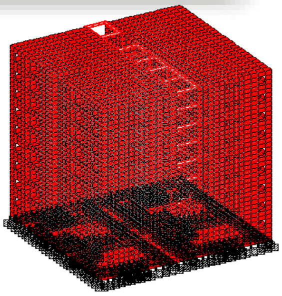

Fig.12: Due to self-weight

(2) Dead Loads

Floor finishes = 0.050 × 20 = 1kN/$m^2$

Extra load on toilets room = 3kN/$m^2$

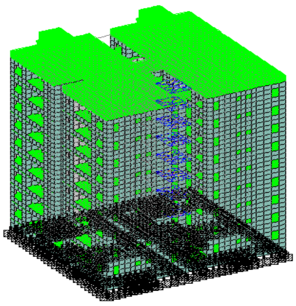

Fig.13; Due to dead load

(3) Live Loads

<u>Live loads</u> (Ref. IS: 875, Part-2)

Living area (all rooms, kitchens, toilet and bath rooms) = 2.0kN/$m^2$

Balconies, corridors and staircases = 3.0 kN/$m^2$

Terrace = 1.5kN/$m^2$

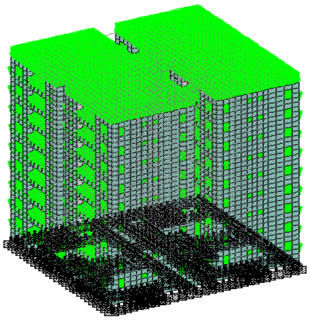

Fig.14: Due to live load

*d) Joint weights:*

Minimum joint weight = - 4.772kN (Force in Y direction)

Maximum joint weight = 68.159kN (Force in Y direction)

*e) Wall and slab dimensions*

Slab thickness = 0.125 mm

Wall thickness = 0.150 mm

*f) Wall Openings*

Main door = 1×2.1 =2.1$mm^2$

Bed room and kitchen doors = 0.9×2.1 =1.89$mm^2$

Toilet and balcony doors = 0.75×2.1 =1.575$mm^2$

Hall Window = 1.5×1.5 =2.25$mm^2$

Bed room window = 1×1.5 =1.5$mm^2$

Ventilation window = 0.75×0.6 =0.45$mm^2$

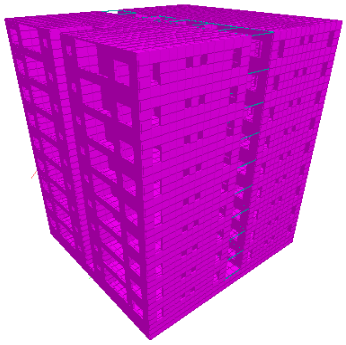

Fig.15: 3D view of slab-wall system concrete building

*g) Wind loads applied on plates as a plate load*

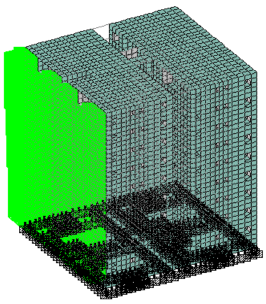

Fig.16: WL-X direction

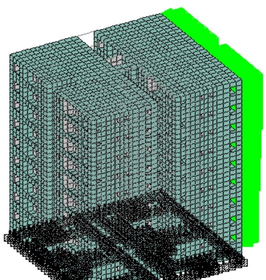

Fig.17: WL-XN direction

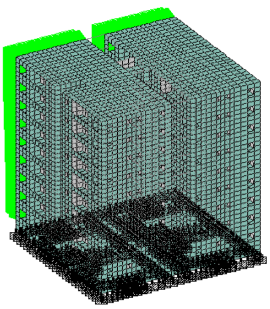

Fig. 18: WL-Z direction

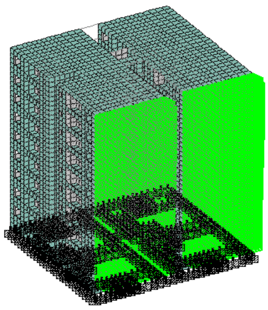

Fig.19: WL-ZN direction

*h) Load Combinations*

LOAD COMB - 9: 1.5(DL+LL)
LOAD COMB - 10: 1.2(DL+LL+EQ (+X))
LOAD COMB - 11: 1.2(DL+LL+EQ (+Z))
LOAD COMB - 12: 1.2(DL+LL+EQ (-X))
LOAD COMB - 13: 1.2(DL+LL+EQ (-Z))
LOAD COMB - 14: 1.5(DL+EQ (+X))
LOAD COMB - 15: 1.5(DL+EQ (+Z))
LOAD COMB - 16: 1.5(DL+EQ (-X))
LOAD COMB - 17: 1.5(DL+EQ (-Z))
LOAD COMB - 18: 0.9DL+1.5EQ (+X)
LOAD COMB - 19: 0.9DL+1.5EQ (+Z)
LOAD COMB - 20: 0.9DL+1.5EQ (-X)
LOAD COMB - 21: 0.9DL+1.5EQ (-Z)

## III. Results And Discussions

Comparison between slab-wall system and Column-Beam System Concrete Building

### A. *Base shear*

Table 1: Base shear values for column-beam and slab-wall system concrete building

| Direction | Column-Beam (Kn) | Slab-wall (kN) | % variation |
|---|---|---|---|
| EQ-X | 2533.754 | 1984.599 | 27.67 |
| EQ-Z | 2553.754 | 1955.837 | 29.55 |
| WL-X | 728.07 | 387.447 | 87.91 |
| WL-XN | 728.07 | 554.447 | 31.31 |
| WL-Z | 779.761 | 607.573 | 28.34 |
| WL-ZN | 779.761 | 607.573 | 28.34 |
| DL | 59062.2 | 45459.6 | 29.92 |
| LL | 9593.07 | 9126 | 5.12 |

### B. *Displacement*

Table 2: Maximum displacement values for column-beam and slab-wall system concrete building

| Direction | Column-beam (mm) | Slab-wall (mm) |
|---|---|---|
| EQ-X | 36.24 | 1.17 |
| EQ-Z | 50.4 | 1.5 |
| WL-X | 7 | 0.18 |
| WL-XN | 7 | 0.3 |
| WL-Z | 10.62 | 0.3 |
| WL-ZN | 10.62 | 0.3 |

## IV. Conclusion

This study deals with the analytical investigation of a structure subjected to gravity and lateral loads. Based on the results the following conclusions are drawn.

- The base shear of column-beam system is more than slab-wall system.
- The reduction in displacement of about 5-88 % is achieved using slab-wall.
- Reduction in displacement shows the capacity of slab-wall system in resisting earth quake loads than the column-beam system thereby minimizes the damage.

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