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

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Abstract: Construction is one of the significant sectors of Indian economy and is an integral part of the development. Today India's urban population is the second largest in the world and its future development leads to increased demand for housing to cope with this problem India should desperately need to plan for acquisition of land and rapid creation of dwelling units. Construction is a complex process involving basically the areas of Architectural planning, Engineering & Construction. There is growing realization today that speed of construction needs to be given greater importance especially for large housing projects. This is not only essential for the faster turnover of equipment and investment – leading possible to the reduction in the housing cost but also for achieving the national objective of creating a large stock to overcome shortest possible time. Fortunately, some of the advanced technologies catering to faster speed of construction are already available in the country. For e.g. Prefabrication, autoclaved blocks, slab-wall system of construction etc. This thesis describes the detailed analysis and design of slab-wall system and column-beam system in concrete building. At present construction the typical floor plan in a structural system of high raised concrete building's can be easily done by slab-wall form compared to column-beam system and the behavior of the building under gravity and lateral loads is analyzed by using STAAD. 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 in concrete building.

Introduction

General

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. Several systems are adopted at different places in the world; eventually the systems which are reasonably economical and easy for operation with skilled labor are useful in India. Certain systems are in vogue and more and more contractors are trying to bring in new technologies.

Structural design in an art of science of designing, with economy and elegance, a safe serviceable and durable structure. The process of designing commences with the planning of the structure, primary to meet the functional requirements of the user. The requirements delivered by the client may not be well defined and may be vague also but it is the work of the designer to understand the needs and design the structure accordingly. The functional requirements and economy of the structure for its intended use over the life span of the structure are intended to by the structural designer.

Probably the largest single investment one makes in his life is on house. Therefore, most careful attention should be given to all the aspects of designing it. A house is a shelter in which human beings live. A building used for dwelling purposes is known as residential building, house, bungalow, apartments & even cottages fall in the category of residential buildings. With rapid increase in population & availability of modern amenities, large numbers of people are opting for modern and well furnished apartments. Apartment is usually a set of rooms constructed solely for the purpose of residence for tenancy. It may be a single bed room or unit of bed rooms.

Location is one of the factors that most directly affect the price of a building. It's easier for an apartment complex to afford a desirable location than for a single homeowner. Cost is one of the important in construction of residential building. Because of many of the other advantages of living in an apartment; the cost for rent is usually quite a bit lower than the monthly mortgage cost for a homeowner.

Planning

Building planning is mostly done by architects. But even Engineers some time have to perform this job. Hence knowledge of building planning in its broad prospective is essential for all the civil engineers. There may be two conditions of planning for a architect or Engineer. First one is when site plan is given and second one is when site plan is yet to be decided. In the later case, architect can show his full competence by suitably selecting the site, orientation, planning and designing the building.

Plans are a set of drawings or two dimensional diagrams used to describe a place or object, or to communicate building or fabrication instructions. Usually plans are drawn or printed on paper, but they can take the form of a digital file.

Plans are often for technical purposes such as architecture, engineering, or planning. Their purpose in these disciplines is to accurately and unambiguously capture all the geometric features of a site, building, product or component. Plans can also be for presentation or orientation purposes, and as such are often less detailed versions of the former. The end goal of plans is either to portray an existing place or object, or to convey enough information to allow a builder or manufacturer to realize a design.

The term "plan" may casually be used to refer to a single view, sheet, or drawing in a set of plans. More accurately, plan refers to an orthographic projection looking down on the object, such as in a plan view or floor plan.

Need of High Rise Structure

Buildings that are higher than 60 meters are defined as "high-rise building" in Japan. Unlike other common structures, high-rise buildings must observe its regulations that are strictly defined. With our high engineering skills and extensive experience, we have engaged in designing high-rise buildings around the world for decades. Utilizing the latest technologies, KKE proposes the best system for high-rise buildings that will reduce earthquake and wind risks at reasonable cost

The present trend in housing is construction of high rise residential apartments. Hyderabad is a rapidly developing city. As the cost of land is high, construction of high rise apartments is an urgent need of the town.

Load Transferring Mechanism in High Rise Structure

Slabs are the main structural components, which directly exposed to the live loads in a structure, whether it is high rise structure or a load bearing structure. In case of high rise structure the loads from the slabs is transferred to the beams and in turn to the columns, which are resisting on a footing. The footing transfers the load to the soil there by the load is safely transferred to the earth. Where as in case of load bearing structures the loads from the slabs is directly transferred to the load bearing walls, which in turn transferred to the earth through isolated footings. This present project is the design of such high rise structure which is practically viable.

Code-Based Procedure for Seismic Analysis

Main feature of seismic method of analysis based on Indian standard 1893 (part 1): 2002 Seismic analyses of most of the structure are still carried out on the basis of lateral force assumed to be equivalent to the actual loading. The base shear which is the total horizontal force on the structure is cal calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of structure in terms of lateral forces according to code formula.

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. The loading in slab-wall system is transferred from slabs to walls. In slab-wall system the dead load is less compared to column-beam system.

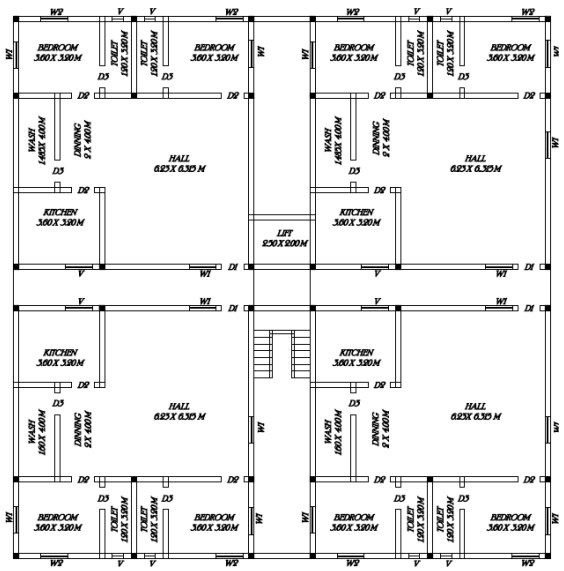
In slab-wall system the casting of whole structure and transverse walls done in a continuous operation, using controlled concrete mixers obtained from central batching, mixing plants and mechanically placed through concrete buckets using crane and compacted in leak proof moulds using high frequency vibrators. In this system, the walls and floors are cast together in one continuous operation in matter of few hours and in built accelerated curing overnight enable removal and re-use of forms on daily cycle basis. The Room Sized wall panels and the ceiling elements cast against steel plates have smooth finishing and the interiors have neat and clean lines without unsightly projections in various corners.

The walls and ceilings also have smooth even surfaces, which only need color or white wash. Textured or pattern colored concrete facia can be provided; this will need no frequent repainting. The efficiency in slab-wall system is around 87.5% (useful carpet area as % of plinth area)

Cement used in this system is more than that used in column-beam system and Steel requirement is more, as it is required for the shear wall construction. But shear wall construction increases. The walls and

ceiling being smooth and high quality concrete repairs for plastering and leakage's are not at all required frequently. In slab-wall system the maintenance cost is negligible.

Plan and Dimensions



Dimensions

Main door	D1	=	1×2.1	=	2.1m^2
Bed room and kitchen doors	D2	=	0.9×2.1	=	1.89m^2
Toilet and balcony doors	D3	=	0.75×2.1	=	1.575m^2
Hall Window	W1	=	1.5×1.5	=	2.25m^2
Bed room window	W2	=	1×1.5	=	1.5m^2
Ventilation window	V	=	0.75×0.6	=	0.45m^2

Description of Structure

The size of the building is 23.07 m length and 21.54 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)

Material Propoerties

For this thesis, M30 grade concrete was used. The grade of steel used for main reinforcement is Fe500 and shear reinforcement is Fe415.

Column-Beam System Concrete Building

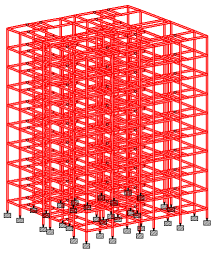


Fig: Due to self weight

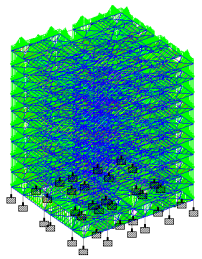


Fig Due to dead load

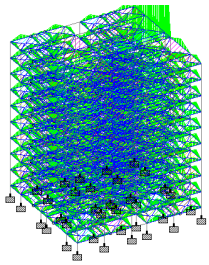


Fig: Due to live load

Load Combinations

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

LOAD COMB - 1.5(DL+LL)
LOAD COMB - 1.2(DL+LL+EQ(+X))
LOAD COMB -1.2(DL+LL+EQ(+Z))
LOAD COMB -1.2(DL+LL+EQ(-X))
LOAD COMB -1.2(DL+LL+EQ(-Z))
LOAD COMB -1.5(DL+EQ(+X))
LOAD COMB -1.5(DL+EQ(+Z))
LOAD COMB - 1.5(DL+EQ(-X))
LOAD COMB -1.5(DL+EQ(-Z))
LOAD COMB - 0.9DL+1.5EQ(+X)
LOAD COMB -0.9DL+1.5EQ(+Z)
LOAD COMB - 0.9DL+1.5EQ(-X)
LOAD COMB -0.9DL+1.5EQ(-Z)
LOAD COMB -DL+LL+WL(+X)
LOAD COMB -DL+LL+WL(+XN)
LOAD COMB -DL+LL+WL(+Z)
LOAD COMB - DL+LL+WL(+ZN)
LOAD COMB - DL+LL+WL(-X)
LOAD COMB - DL+LL+WL(-XN)
LOAD COMB -DL+LL+WL(-Z)
LOAD COMB -DL+LL+WL(-ZN)
LOAD COMB - DL+WL(+X)
LOAD COMB - DL+WL(+XN)
LOAD COMB - DL+WL(+Z)
LOAD COMB - DL+WL(+ZN)
LOAD COMB - DL+WL(-X)
LOAD COMB - DL+WL(-XN)
LOAD COMB - DL+WL(-Z)
LOAD COMB - DL+WL(-ZN)
LOAD COMB - DL+WL(+X)
LOAD COMB - DL+WL(+XN)
LOAD COMB - DL+WL(+Z)

LOAD COMB - DL+WL(+ZN)
LOAD COMB -DL+WL(-X)
LOAD COMB - DL+WL(-XN)
LOAD COMB -DL+WL(-Z)
LOAD COMB - DL+WL(-ZN)

Slab-Wall System Concrete Building

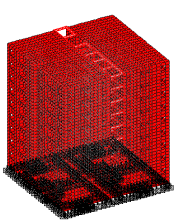


Fig: Due to self weight

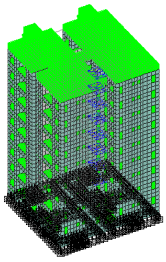


Fig: Due to dead load

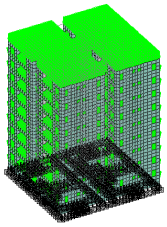


Fig: Due to live load

Load Combinations

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

LOAD COMB -1.5(DL+LL)
LOAD COMB - 1.2(DL+LL+EQ(+X))
LOAD COMB -1.2(DL+LL+EQ(+Z))
LOAD COMB -1.2(DL+LL+EQ(-X))
LOAD COMB - 1.2(DL+LL+EQ(-Z))
LOAD COMB - 1.5(DL+EQ(+X))
LOAD COMB - 1.5(DL+EQ(+Z))
LOAD COMB - 1.5(DL+EQ(-X))
LOAD COMB -1.5(DL+EQ(-Z))
LOAD COMB - 0.9DL+1.5EQ(+X)
LOAD COMB - 0.9DL+1.5EQ(+Z)
LOAD COMB - 0.9DL+1.5EQ(-X)
LOAD COMB - 0.9DL+1.5EQ(-Z)

Results And Discussions

With reference to the above mentioned slab-wall system and column-beam system analysis results are presented and compared in the Table 1.1 and 1.2.

Table: 1.1 Base shear values for column-beam system and slab-wall system concrete building

Direction	**Column-Beam (kN)**	**Slab-Wall (kN)**	**% Variation**
EQ-X	2553.75	1804.58	41
EQ-Z	2516.75	1778.41	41

Table: 1.2 Maximum displacement values for column-beam system and slab-wall system concrete building

Direction	Column-Beam (mm)	Slab-Wall (mm)	% Variation
EQ-X	36.24	1.29	27
EQ-Z	50.4	1.6	30
WL-X	7	1.23	5
WL-XN	7	0.3	22
WL-Z	10.62	0.43	24
WL-ZN	10.62	0.43	24

The below graphs shows that the deformation variation from ground floor to top floor level in slab-wall system and column-beam system concrete building.

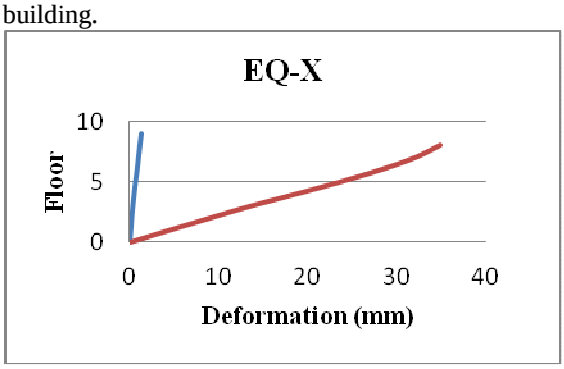


Fig. 1.1 Comparison of displacement in EQ-X direction

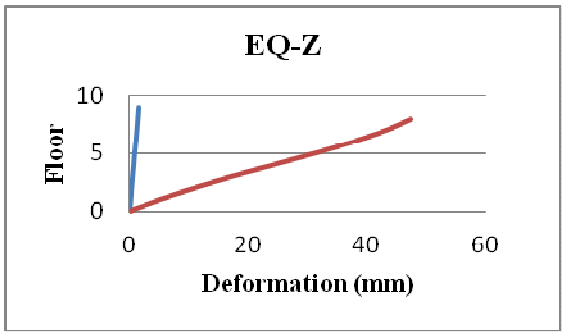


Fig. 1.2 Comparison of displacement in EQ-Z direction

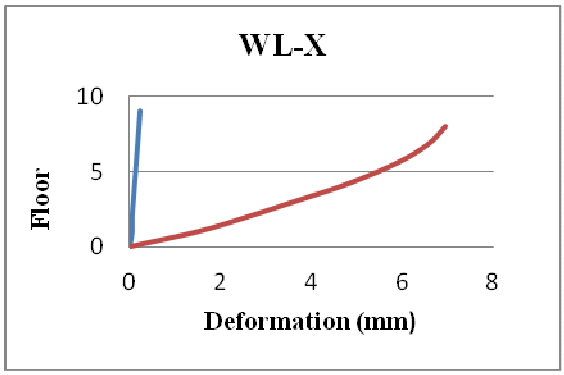


Fig. 1.3 Comparison of displacement in WL-X direction

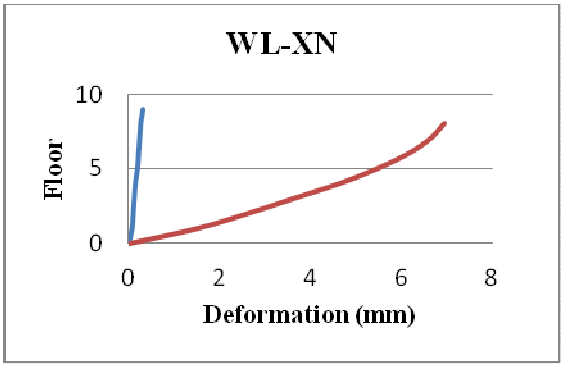


Fig. 1.4 Comparison of displacement in WL-XN direction

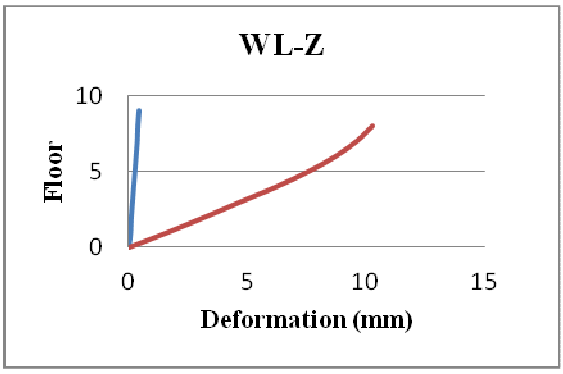


Fig. 1.5 Comparison of displacement in WL-Z direction

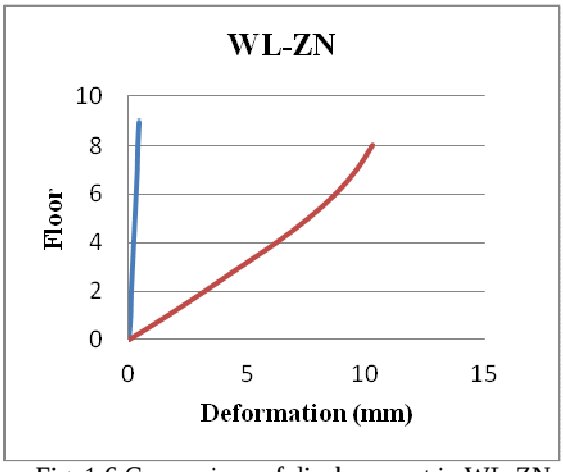


Fig. 1.6 Comparison of displacement in WL-ZN direction

Cost comparison between column-beam system and slab-wall system concrete building shown in Table 1.3 and 1.4.

Table: 1.3 Cost analyses in column-beam system concrete building

Material	**Cost (Rs)**
Steel (columns and beams)	32,66,760
Concrete (columns and beams)	37,43,100
Brick work (230mm wall)	41,41,961
Brick work (115mm wall)	18,74,812
Plastering (230mm wall)	32,18,535
Plastering (115mm wall)	14,99,850
Plastering (openings)	81,009
Shuttering (columns and beams)	1,17,333
Total cost = Rs 1,79,43,360	

Table: 1.4 Cost analyses in slab-wall system concrete building

Material (wall)	Cost (Rs)
Steel	26,90,806
Concrete	48,81,785
Shuttering	4,88,000
Total cost = Rs 80,60,591	

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 30% 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.
- Slab-wall system gives least cost for construction of high raised building

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