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Analysis and Design of Residential Building Using ETABS

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Abstract: The most common reinforced concrete construction is the building (planned for residential, institutional or commercial use. It is therefore instructive to look at its structural system and its load transmission mechanism in detail. Any structure is made up of structural elements (load carrying, such as slabs, beams and columns) and non-structural elements (such as partitions, false ceilings, doors). The structural elements, put together, constitute the 'structural system'. Its function is to resist effectively the action of gravitational and environmental loads, and to transmit the resulting forces to the supporting ground, without significantly disturbing the geometry, integrity and serviceability of the structure.

I. INTRODUCTION

The economical execution of a concrete structure depends more on the overall layout of the structure with respect to the construction feasibility and cost (called construct ability) than on its theoretical analysis. This knowledge regarding economy is generally acquired only through experience and study of projects already carried out. On the other hand, the structural safety of the individual member depends primarily on the theoretical analysis and design. The best way to ensure this safety is to design the structure according to the relevant codes of practice and construct the structure

According to accepted practice. As civil engineers will be called upon to carry out design of structures to be constructed as well as analyze (or review) structures already constructed, they should be familiar with the current codes and methods of design and analysis.

A. Engineering Structure and Structural Design

An engineering structure is an assembly of members or elements transferring the load and providing a form, space, an enclosure and or a cover to serve the desired function. The structural design is a science and art of designing, with economy and elegance. A durable structure is one, which can safely carry the forces and can serve the desired function satisfactorily during its service life span. The objective of structural design is to plan a structure, which meets the basic requirements of structural design and are as follows:

- Serviceability.
- Safety.
- Durability.
- Economy.
- Aesthetic beauty.
- Feasibility, practicability and acceptability.

B. Basic Requirements for Structural Design

A creative sense, imagination, understanding and keen observation of structures in nature, scientific knowledge of various aspects of structures, understanding of the various structural phenomenon on basis of statistical and experimental data, and finally, the backing of vast experience from the past, are some of the qualities, required for a structural engineer.

C. Design Process

The process of structural design consists of the following UNITS,

Unit 1

This stage involves the determination of the following:

- Type of structure (like load bearing or framed).
- Form of structure (like slab- beam, grid or shell).
- Geometry and layout, which include determination of positioning of columns, beams and soon.

Unit 2

This stage also involves information necessary from the client. The information required is as follows:

- Resources available
- Importance of the structure and aesthetic requirements.
- Function of structure.
- Expected life.

Unit 3

It involves analysis of the structure for the determination of internal design forces (like Bending moment and shear force) in the members and behavior of structures under the action of these forces.

Unit 4

This stage involves the determination of sizes of members, amount and detailing of reinforcement for resisting the design force. This stage forms the core and substance of design.

Unit 5

This stage involves preparation of working, drawing, giving sizes of the members, detailing of the reinforcements, preparing bar bending schedules and schedule of quantities giving specifications of material notes and special instruction, if any.

D. Loads

The design of a building has two aspects,

1. Functional Aspects:

Functional aspect takes into consideration the purpose for which the building is used. It is dealt by the architects.

2. Structural Aspects:

Structural aspects ensure safety of the building. It is taken care of by structural engineers. In the structural aspect it is ensured that the building is structurally safe and also economical. The occupants of the building should feel safe with regard to their uses and their properties. For convenience, we may separate the structural system into two load transmission mechanisms, viz. gravity load resisting and lateral load resisting, although, in effect, these two systems are complementary and interactive. As an integrated system, the structure must resist and transmit all the effects of gravity loads and lateral loads acting on it to the foundation and ground below.

The various loads to which a building is subjected to are given below;

1. Dead loads.
2. Live loads.
3. Wind loads.
4. Seismic loads.

In the present building model is analyzed and designed for the gravity loads alone.

II. PROJECTOBJECTIVE

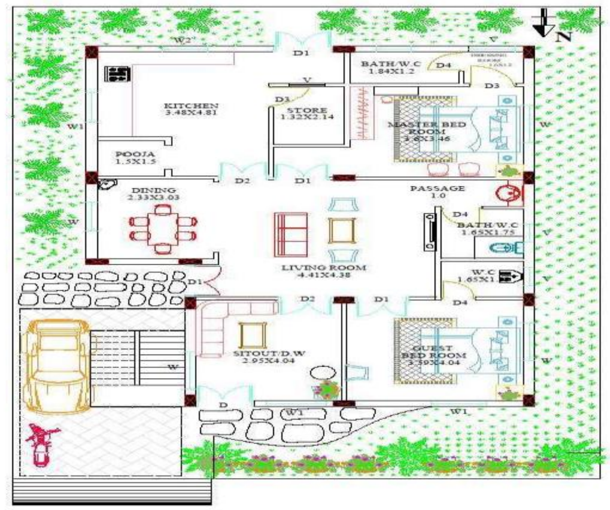
The present report incorporates the design process to establish the overall design philosophy to be adopted in the analysis and design. This report clearly communicate the designer understanding and client Requirements .It will give details of occupancy, materials, foundations, type of analysis, codes that will be used for design of structure.

A. Building Description

The project work has been taken up to plan and design of a residential building.

This project consists of only ground floor and first floor may be constructed in later stages.

In design all slabs are taken as continuous slabs. In our project all 230mm thick walls are non-load bearing walls and partition walls 150mm thick are constructed between rooms. The staircase is provided outside the building. The effective span is taken as per IS 456- 2000, dead loads and live loads are taken. As per IS-875-1984, area of steel Calculated by IS 456-2000, SP-16, Concrete mix design as per IS 10262:2009 and steel detailing drawings as per SP-34 All the structures are designed by Limit state method.

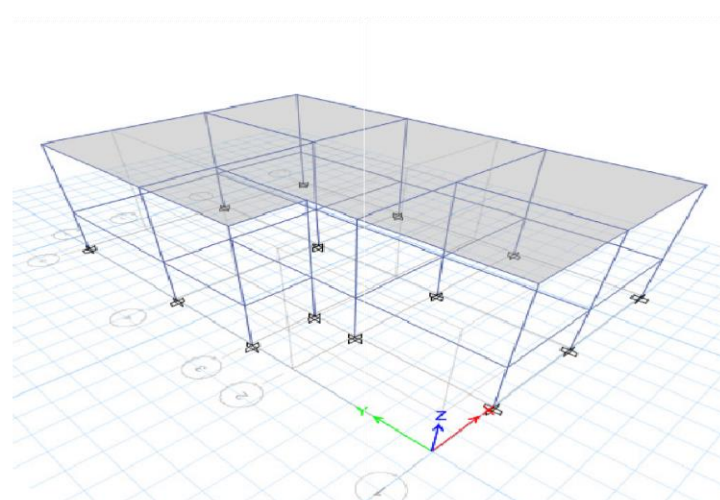


III. MODELLING

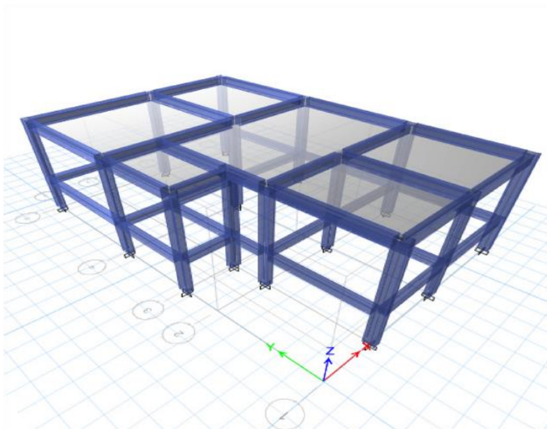
The structure is idealized as a 3-D space Frame model using the software packages ETABS version v9.7.0. The masonry wall is used as filler wall and not cast monolithically with structure. Hence this is not modeled in the analysis In this packages slab loads are applied as a floor door Slab loads are applied as a floor loads.

- Wall loads are applied as UDL on beams. Self- weight is added in the software to have member loads.

A. Model of the Structure

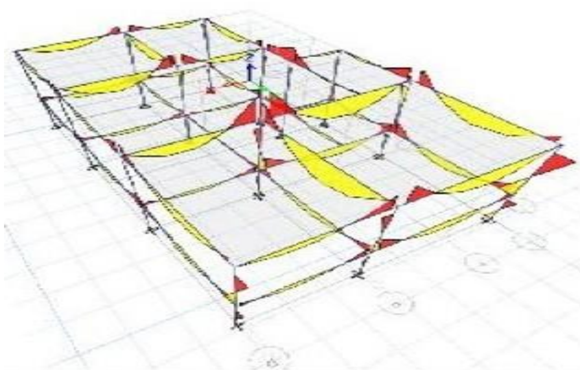


B. 3d Frame Generated In ETABS

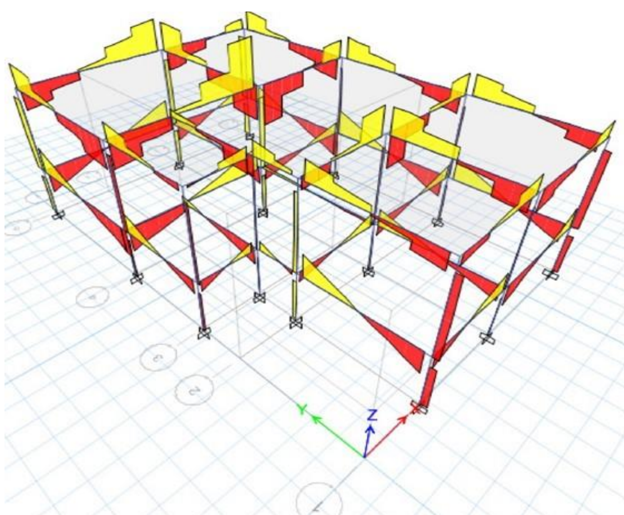


IV. RESULTS OF ANALYSIS BYETABS

A. Envelop Bending Moment Diagram



B. Envelop Shear Force Diagram



V. DESIGN OF STRUCTURAL ELEMENTS

Load Consideration

For safer side we considered SUPER IMPOSED DEAD LOAD also and all the load values are rounding up to higher value.

A. Typical Design Of Slabs

Design of Sit out Room Slab

Room size = 2.91mx3.96m

Live load = 2.5 kN/mm^2

Bearing of slab = 230 mm

Grade of Concrete fck =30N/mm^2

Grade of steel, fy =500N/mm^2

Effective cover = 25 mm

Span to depth ratio,

$K_t = 3.477$

SLAB DESIGN AND REINFORCEMENT DETAILS

SL NO	ROOM	DIMENSION OF SLAB	BENDING MOMENTS in KN/m			%age of Steel	Ast in mm²	REQUIRED SPACING in mm	PROVIDED SPACING
1	KITCHEN	4.91mX4.6m	-ve	X	15.16	0.17	249	315	10mmØ @300mm c/c
				Y	14.51	0.15	230	340	10mmØ @300mm c/c
			+ve	X	11.35	0.12	176	440	10mmØ @300mm c/c
				Y	10.81	0.12	176	440	10mmØ @300mm c/c
2	MASTER BED ROOM	3.55mX4.6m	-ve	x	11.77	0.13	194	400	10mmØ @300mm c/c
				y	8.26	0.09	140	560	10mmØ @300mm c/c
			+ve	x	8.76	0.09	140	560	10mmØ @300mm c/c
				y	6.15	0.07	105	740	10mmØ @300mm c/c
3	DINING	1.77mX3.04m	-ve	x	3.83	0.07	105	740	10mmØ @300mm c/c
				y	2.23	0.07	105	740	10mmØ @300mm c/c
			+ve	x	2.87	0.07	105	740	10mmØ @300mm c/c
				y	1.66	0.07	105	740	10mmØ @300mm c/c
4	GUEST BED ROOM	3.55mx3.96m	-ve	x	9.48	0.11	158	490	10mmØ @300mm c/c
				y	8.35	0.09	140	560	10mmØ @300mm c/c
			+ve	x	7.15	0.08	123	630	10mmØ @300mm c/c
				y	6.22	0.07	105	740	10mmØ @300mm c/c
5	SIT OUT	2.91X3.96m	-ve	x	7.67	0.11	136	575	10mmØ @300mm c/c
				y	5.70	0.09	111	703	10mmØ @300mm c/c
			+ve	x	5.77	0.11	106	740	10mmØ @300mm c/c
				y	4.25	0.07	105	740	10mmØ @300mm c/c
6	LIVING ROOM	6.69mX4.38m	-ve	x	15.80	0.22	295	265	10mmØ @260mm c/c
				y	10.36	0.18	213	367	10mmØ @300mm c/c
			+ve	x	12.07	0.17	231	339	12mmØ @200mm c/c
				y	7.85	0.13	154	505	12mmØ @200mm c/c

Hence, Design is safe.

A.Design of Beams

Assuming simply supported beam

Size of beam = 230mmx450 mm

Clear span =4.38m fck = 30N/mm^2
effective cover 40 mm
d = D - e_c
=450-40
=410mm
Check for deflection:
Percentage steel provided,
P_t =0.59%
Stress in steel at service load,
f_s = 0.58f_y(Astreq / Astpro)

=0.58X500X $\frac{498.47}{565.48}$
= 252.38 N/mm^2
Read out modification factor (K_t) from curve (from fig.4 of IS 456:2000) for

f_s = 252.38 N/mm^2 and P_t = 0.59 values.

K_t = 1.15

$$\left[\frac{l}{d}\right]_{max} = 20k_t = 20X\ 1.15 = 23$$
$$\left[\frac{l}{d}\right]_{provided} = \frac{4490}{410} = 10.95$$
$$\therefore \left[\frac{l}{d}\right]_{max} > \left[\frac{l}{d}\right]_{provided}$$

C. Design of Column

Axial load= 510 kN/m
fck = 30N/mm^2
fy= 500 N/mm^2
P_u= PX1.5 = 510X1.5= 765 kN
P_u= 0.4fckXACX+0.67XASC
A= A_C+A_{SC}
A_C=0.992A
<u>PITCH</u>
Pitch = 200mm

5.1.6.1 COLUMN DESIGN AND REINFORCEMENT DETAILS

COLUMN	P in Kn	P_{prov} in kN	P_u in kN	Ag_{req} in mm^2	Ag_{prov} in mm^2	A_{sc} in mm2	A_c in mm2	NO OF BARS	LATERAL TIES
C1	149	150	225	15428	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C2	268	270	405	27770	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C3	165	170	255	17484	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C4	161	160	240	16457	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C5	370	370	555	37713	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C6	288	290	435	29828	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C7	90	90	135	9257	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C8	236	235	352.5	24205	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C9	340	340	510	34970	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C10	510	510	765	52455	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C
C11	309	310	465	31885	87400	699	86700	#4-16mm Ø #2-12mm Ø	2L-8mmØ @200mm C/C

Hence, Design is Safe.

D. Design of Stair Case

Vertical distance between the floor = 3.2m
Characteristic strength of concrete (f_{ck}) = 30 N/mm^2

Steel(fy)=500N/mm
Assume,
Rise =160mm
Thread=230mm
height =3.2m
D=150mm

∴ Height to fetch flight=3/2=1.6m
Rise =160mm=0.16m

Spacing for 10mm Ø bar,

$$\text{Spacing} = \frac{\pi d^2/4}{Ast} \text{X}1000$$

$$= \frac{\pi 1\ ^2/4}{180} \text{X}1000$$

= 436.33mm

Hence, Design is Safe.

VI. CONCLUSIONS

The following conclusions are drawn from this work are as follows

1. The way of extracting the Information from the architectural Drawing for the purpose and of analysis design.
2. Learnt about the orientation of columns with respect to gridline.
3. Learnt about the importance and concept of load combinations considered in analysis and design.
4. The way of grouping of various Structural members based on results that are obtained from the analysis.
5. Learnt about the interpretation of various results like forces and moment switch Comes as a output from using the analysis software ETABS.

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