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The Relative Research on Planning, Modelling, and Analysis of G+6 Residential Buildings with and without Multi-level Car Parking Facility

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Abstract: ***In India, normally the proposed buildings are either residential or commercial cum residential. Generally, the parking is provided in the basement of the buildings or open to the sky, based on the availability of space. But there are some cases due to the high cost of land, it is not possible to provide an open space parking facility. On the other hand, parking facilities are very critical in metropolitan cities like Mumbai, Kolkata, Chennai, Delhi, etc. Due to the high number of vehicles on the roads. In some places due to the non-availability of the parking, the people had to face issue in their day to day work and some times had to pay fine for illegal parking. In this project, the crisis of the parking facilities is kept in mind and relative research is done to check whether it can be adapted in the cities of India or not to minimize the issues. And also the analysis of structures is done to check the stability of the structures.***

Keywords: G+6 Building, Multi-level Car Parking, Multi-storey, Modelling and Analysis, Relative Research, Hydraulic Lift.

I. INTRODUCTION

One of the major problems in a country like India is the rapid increase in population, lack of spaces, especially in metropolitan cities. Due to the lack of land space and high cost, it is preferred to build multi-storied buildings. On the other hand, every year millions of cars and motorcycles are sold in India, causing parking issues, especially in metropolitan cities. The problem can be minimized by constructing multi-level car parking in a multi-storied residential building[1]. The multi-level car parking maximizes the utilization of space and maintains an easy traffic flow on the road. The main aim of constructing a multi-storied building is to ensure that the structure of the building is safe and economical against all loading conditions and prevent any type of failure. The centralized hydraulic lift is used in the multi-level car parking area for easy vertical transportation of the car from one level to another and preventing any confusion among the cars. The presence of a ramp and lift facility maintains the proper flow of traffic inside the parking zone. The building is planned in such a way that it maintains proper air circulation throughout the building.

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The building with a multi-level car parking facility is considered as Building I whereas the building without a multi-level car parking facility is considered as Building II.

II. PLANNING AND LOAD CALCULATION

A G+6 residential building with a multi-level car parking facility; till the second floor, is analyzed and results (moments and shear forces) are compared with another residential G+6 building with car parking on the ground floor. Table I shows the different parameters for the respective buildings as mentioned below. The analysis of both buildings is carried out in STAAD. Pro [2][3]. The planning of the building is based on NBC vol 1 and vol 2. These parameters mentioned below are used to carry out the planning and analysis of the structures.

Table I. Parameters for Planning (Site Description)

Description	*Details*
Area of Land	1327.14 sq.m
Width of Road	24.994 m
Permissible Floor Area Ratio (FAR)	3.0
Permissible Ground Coverage (50 %)	663.57 sq.m
Permissible Covered Area	1327.14 × 3.0 = 3981.4 sq.m
Permissible Height	1.5 × (24.994 + 6) = 46.5 m
No. of Stories	G+6 (7 Storied)
Each Floor Height	2.9 m
Total Proposed Height	20.3 m
Grade of Concrete	M30
Grade of Steel	415 Grade
Proposed Land Area Coverage	560 sq.m (42.2 %)
Open to Sky	767.138 sq.m (57.8 %)
Column Dimension	600 mm × 250 mm
Beam Dimension	250 mm × 400 mm
Overall Slab Thickness	150 mm thick
No of Levels in Multi-Storey Car Parking	3 (Ground to 2nd floor)

The floor height of the building is considered to be 2.9 m. The total number of floors in the buildings is seven. Thus the total height is 20.3 m which is under the permissible height.

The dimension of the column is considered to be 600 mm × 250 mm. And the dimension of the beam is considered to be 250 mm × 400 mm. The overall slab thickness is considered as 150 mm. The thickness of the slab can be varied from 150 mm to 175 mm depending on the increment of the variable load [4]. The Floor Area Ratio (F.A.R) is considered as 3.0. The above values (FAR, permissible ground coverage, etc) are based on the rules authorized by metropolitan authority. The values mentioned in Table II are based on IS 875 (Part - 1): 1987, which is the Code for Design of Dead Load (DL), and IS 875 (Part - 2): 1987, which is the Code for Design of Imposed Load (LL). And also the wind load is considered as 4 kN/m^{2,} which is acting laterally on the buildings. The factor of safety (FOS) is considered as 1.5. The ultimate load (UL) is calculated as (Dead Load + Live Load + Floor Finish) × FOS.

Table II. Detailed Load Calculation

Load Calculation of Building I and Building II	
Load Type	***Value***
Dead Load (DL)	3.75 kN/m^2
Imposed Load (LL)	2.5 kN/m^2
Floor Finish	0.6 kN/m^2
Factor of Safety (FOS)	1.5
Ultimate Load	**10.275 kN/m^2**

Fig 1. and Fig 2. represent the front elevation of building with multi-level car parking and building without multi-level car parking facility respectively.

Fig 1. Front Elevation of Building with Multi-level Car Parking (Building I)

Fig 2. Front elevation of building without multi-level car parking (Building II)

The parking layout of the Multi-level car parking (Building I) is shown in Fig 3. In this figure, the 4 m wide passage is provided which is enough for two cars to pass by simultaneously [5]. There is a certain uniqueness that is followed in this parking – a) The ramp is provided for the cars to climb up the floors i.e from the ground to first or from first to second. B) The centralized hydraulic lift is for bringing the vehicles down to from any floor to the ground floor. i.e from second to ground or from first to ground. This type of uniqueness was possible to adapt to this type of building because of the less no. of apartments. This type of system is beneficial where the building is located in a very crowded place and it's not possible to get parking in that locality. The arrow determines the path to be followed by the cars while entering and exiting the multi-level car parking.

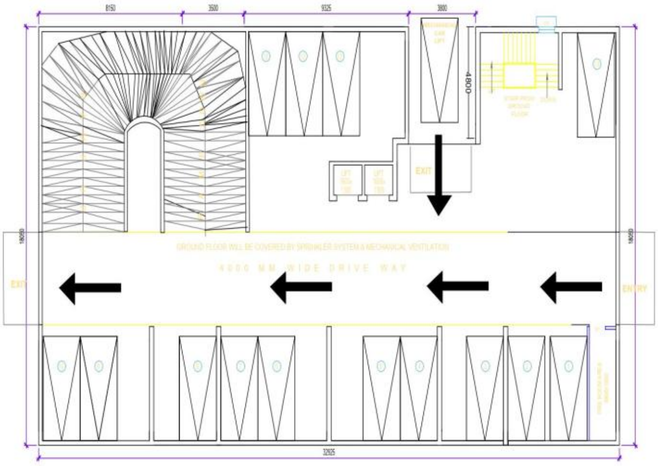

Fig 3. The layout of Multilevel Car Parking (Building I)

In Fig 4. the layout of the ground floor car parking of Building II is shown. In this layout, the provision for two passenger lift, staircase are also provided, similar to Fig 3. But there is no provision for a ramp or hydraulic car lift as this is a single floor (ground) car parking. Similarly, the arrow determines the path to be followed by the cars while entering and exiting the car parking. They are provided for each car parking is 12 sqm. The width of the passage is 4 m.

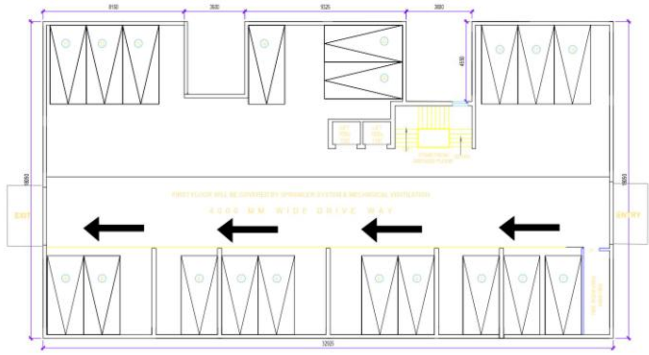

Fig 4. The layout of Ground Floor Car Parking (Building II)

III. ANALYSIS AND RESULT

The structural analysis of the G+6 building with and without a multi-level car parking facility is done using STAAD Pro. The moments, shear forces, and deflections of the critical columns (Column I, Column II) and critical beams (Beam I, Beam II) of both the buildings are analyzed, studied, and compared. Both the buildings in the configuration have seven numbers of stories.

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The elements are considered as critical because of the highest bending moment acting on that element (horizontal or vertical). During the analysis, the add beam method has been used in STAAD Pro [6]. to frame the structure. In Fig 5, the red portion shows the critical beam (Beam I) in Building I. The Bending Moment Diagram (BMD), Shear Force Diagram (SFD), and the Deflection Diagram of Beam I are shown in Fig 6. And the maximum values are further tabulated in Table III.

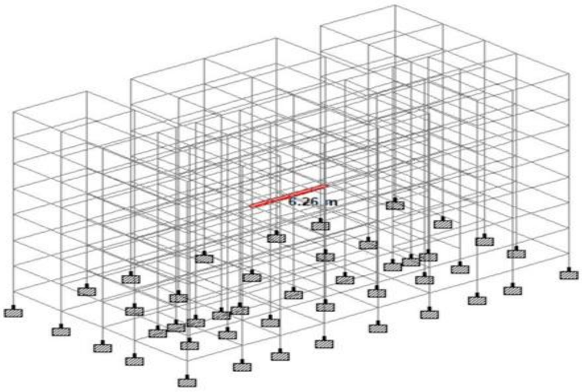

Fig 5. Red Portion shows the Beam I (Building I)

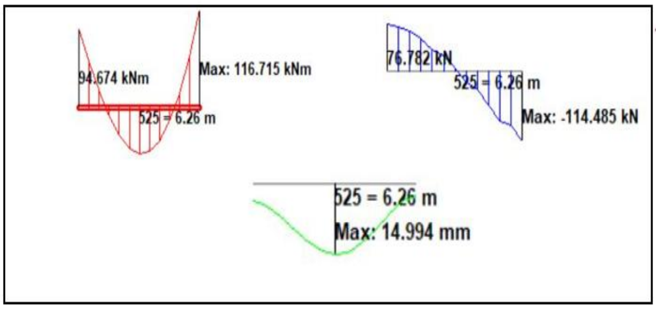

Fig 6. BMD, SFD, and Deflection Diagram of Beam I (Building I)

Table III. BM, SF, and Deflection of Beam I (Building I)

S.NO.	DESCRIPTION	VALUES
1.	Maximum BM	116.715 kNm
2	Maximum SF	-114.485 kN
3	Maximum Deflection	14.994 mm

In Fig 7, the red portion shows the critical column (Column I) in Building I. The Bending Moment Diagram, Shear Force Diagram, and the Deflection Diagram of Column I are shown in Fig 8. And the maximum values are further tabulated in Table IV.

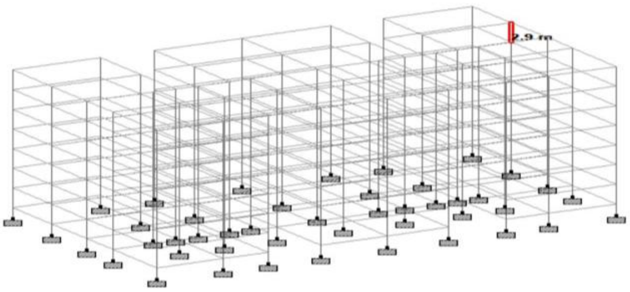

Fig 7. Red Portion shows the Column I (Building I)

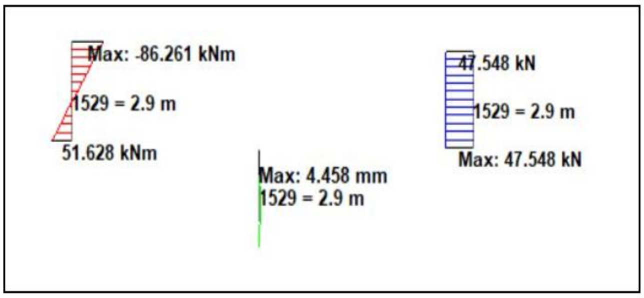

Fig 8. BMD, SFD, and Deflection Diagram of Column I (Building I)

Table IV. BM, SF, and Deflection of Column I (Building I)

S.NO.	DESCRIPTION	VALUES
1.	Maximum BM	-86.261 kNm
2	Maximum SF	52.810 kN
3	Maximum Deflection	2.90 mm

In Fig 9, the red portion shows the critical beam (Beam II) in Building II. The Bending Moment Diagram, Shear Force Diagram, and the Deflection Diagram of Beam II are shown in Fig 10. And the maximum values are further tabulated in Table V. The values are to be further used for designing of Structural Elements (Slab, Beam, Column).

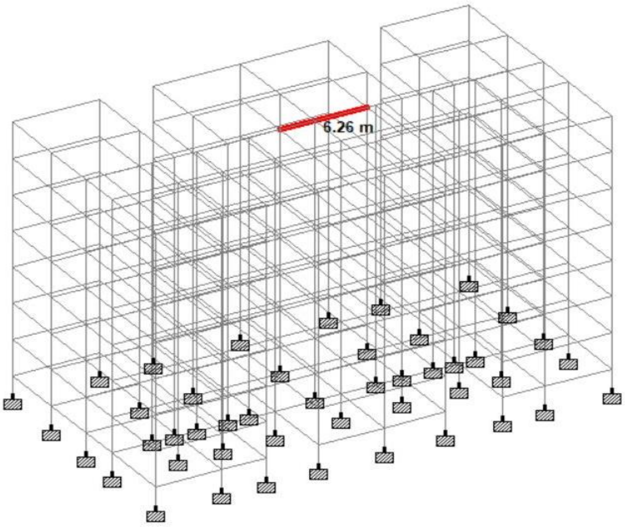

Fig 9. Red Portion shows the Beam II (Building II)

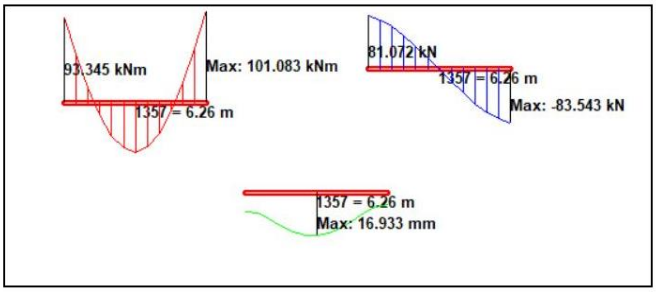

Fig 10. BMD, SFD, and Deflection Diagram of Beam II (Building II)

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Table V. BM, SF, and Deflection of Beam II (Building II)

S.NO.	DESCRIPTION	VALUES
1.	Maximum BM	101.083 kNm
2	Maximum SF	-83.543 kN
3	Maximum Deflection	16.933 mm

In Fig 11, the red portion shows the critical column (Column II) in Building II. The Bending Moment Diagram, Shear Force Diagram, and the Deflection Diagram of Column II are shown in Fig 12. And the maximum values are further tabulated in Table VI.

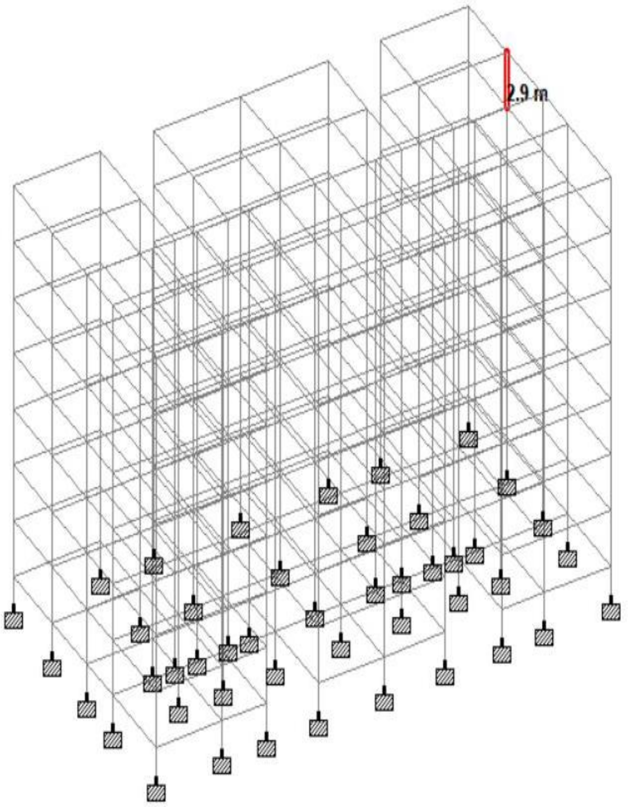

Fig 11. Red Portion shows the Column II (Building II)

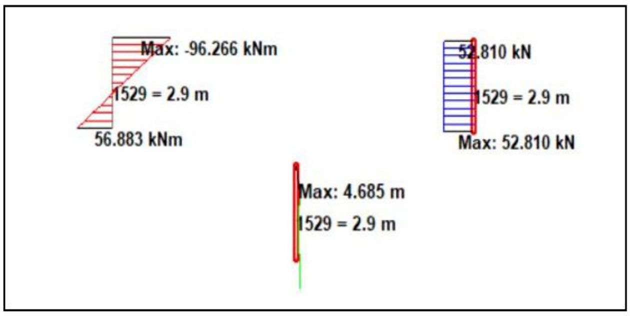

Fig 12. BMD, SFD, and Deflection Diagram of Column II (Building II)

Table VI. BM, SF, and Deflection of Column II (Building II)

S.NO.	DESCRIPTION	VALUES
1.	Maximum BM	-96.266 kNm
2	Maximum SF	52.810 kN
3	Maximum Deflection	2.90 mm

CRITICAL BEAMS: The graphical variations of bending moments, shear forces, and deflections in critical beams of Building I and Building II using bar chart are shown in Fig. 13. The graph is plotted between the building type (x-axis) versus the maximum values of critical beams (y-axis).

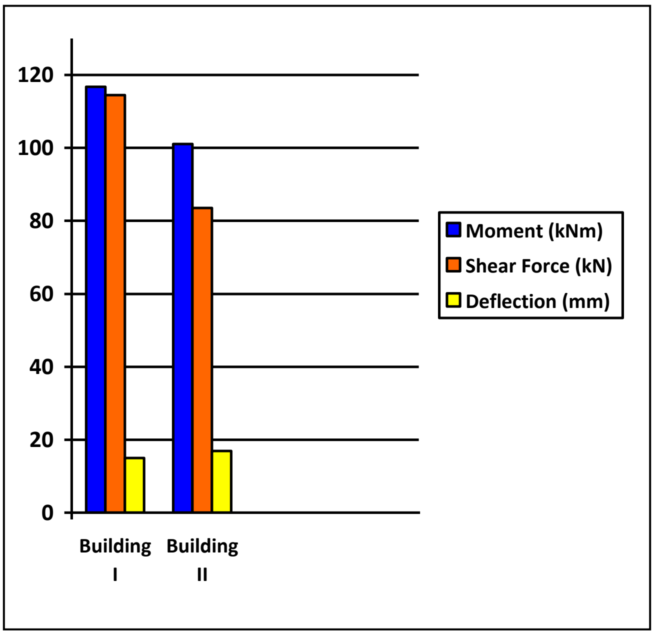

Fig. 13 Variation of Bending Moment, Shear Force, and Deflection of Critical Beams in Building I and Building II

CRITICAL COLUMNS: The graphical variations of bending moments, shear forces, and deflections in critical columns of Building I and Building II using bar chart are shown in Fig 14. The graph is plotted between the building type (x-axis) versus the maximum values of critical columns (y-axis).

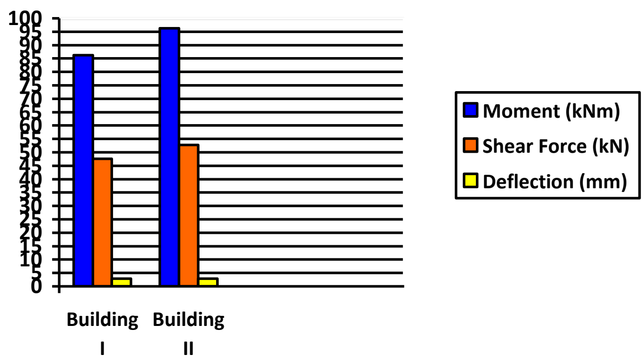

Fig. 14 Variation of Bending Moment, Shear Force, and Deflection in Critical Columns in Building I and Building II

3D MODELLING: Edificius v.X(d), an ACCA BIM software has been used to execute the 3D Modelling and is further rendered in a rendering software named V-Ray [7]. The 3D-Modelling of Building I and Building II are shown in Fig. 15 and Fig. 16 respectively.

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Fig. 15 3D-Modelling of Building I

Fig. 16 3D-Modelling of Building II

IV. CONCLUSION

To do the proper space management of the building a new type of planning is adopted in this project. Accordingly, different ideas are adopted from various references to achieve a remarkable building that will be economical, safe, and stable in terms of construction. The ramp and lift are used in the building for vertical transportation of cars from one floor to another. The building is planned in such a way so that it can provide maximum ventilation and reduces space management issues. The front setback of the building is considered as 6 m [8]. As per the Kolkata Municipal Corporation (KMC) and National Building Code (NBC) regulations, the permissible FAR is 3.0.The provided covered area is 3360 sq.m approx. which is less than the permissible covered area (3981.4 sq.m). Thus the proposed FAR is 2.5. If the permissible FAR of 3 is achieved in this land area, the total no. of floors of the building can be increased to G+7; one more floor can be constructed over each building. Thus the height of the floor will be increased to 23.2 m which is within the permissible height (46.5 m).

As per the analytical point of view,

- The deflection in columns is observed to be nearly the same for both the buildings and is within the permissible limit as per IS Code Books.
- Similarly, the deflection in beams is also observed to be nearly the same for both the buildings and is within the permissible limit as per IS Code Books.
- The moment in the column of Building I reduces by 11.6 % when compared to the moment in the column of Building II.
- The moment in the beam of Building I increases by 15.5 % when compared to the moment in the beam of Building II.
- The shear force in the column of Building I reduces by 11.1 % when compared with the shear force in the column of Building II.
- The shear force in the beam of Building I increases by 37.0 % when compared with the shear force in the beam of Building II.

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Kushal Jain, working as a designer and site engineer in a reputed construction company in Chhattisgarh, India. He has completed his B.Tech (Civil Engineering) from SRM Institute of Science and Technology (SRM IST), Kattankulathur, Tamil Nadu, India. He is a member of the American Society of Civil Engineers (ASCE).