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# Optimum Solution of Multi-Level Car Park for Different Structural System Considering Composite Slab in Steel Construction

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***Abstract*— The Multilevel car park is a unique type of building. In India, the metropolitan cities have started to build this type of structure to solve a parking problem in congested traffic area. In nearer future, the multilevel car parks become a need of the day. Present study is carried out with an objective to understand the various forms and the structural aspect of the multilevel car parks in India. Accordance with various structural systems, type of decking system also has been studied. In present study it is proposed to analysis and design the multi-level car park by adopting different structural system like 'moment resisting frame' and 'braced frame'. For this dissertation G+3 and G+6 -story car parking structure is considered. In braced frame 'x'-type and 'v'type bracing is selected. The car park is considered of steel structure with composite deck slab. Selected structure has self-park operational system with split-level functional type (staggered floor system). The analysis and design is carried out in accordance with the IS 800:2007 and IS 1893:2002(Part-1). Design of deck slab has been carried out using BS-5950 (Part-4) and Eurocode-4. Analysis has been done using STAAD.Pro v8i. Different parameters like displacement, bending moment, weight of member, base shear etc. are observed and comparison is made between moment resisting frame and braced frame. We have also considered mass asymmetric structure and analyzed.**

***Index Terms*—steel structure, Split level car parking, Mass Asymmetric Structure, STAAD PRO V8i**

## I. INTRODUCTION

Nowadays vehicular traffic in the metropolitan cities has been expanding at a very fast rate. It is now poised for greater growth as the country's economy enters take off stage. Many new companies have started manufacturing cars in India to cater market of Indian society. Today's scenario is more and more people can afford to buy cars. This upsurge in vehicles has created a big problem of parking particularly in congested commercial and office localities therefore concept of multilevel car parks has become a need of the day. The multi-storey car park is a exceptional style of building, one in which all elements of the structure are normally exposed to the environment. One must remember that these car parks must be completed quickly and without causing much hindrance to the busy traffic.

Due to lack of land availability in the metropolitan cities the horizontal parking facilities are not enough to serve the society, so it's solution is vertical parking – it's called as MULTILEVEL CAR PARKING.

## II. STRUCTURAL MODELLING ANALYSIS & DESIGN

For the present work, typical 3D model of multi level car parking structure has been taken, situated in Vadodara. A 3D view of the frame building is also shown in Fig. 1. In this problem only slabs and beams are composite while columns are built up of steel. Concrete wall of 1.2 m height & 150 mm thickness is used as outer periphery throughout the building acting as a barrier. No internal walls are considered as the building deals with the storage of vehicles. The building has been analyzed and designed for medium class soil, for earthquake zone III using Equivalent Static Method of Analysis. The same building has also been analyzed and designed with concrete members with minimal changes in the geometry. Designs are based as per the present Indian standard codal provisions. Limit state method in IS 800:2007 is referred for the design.

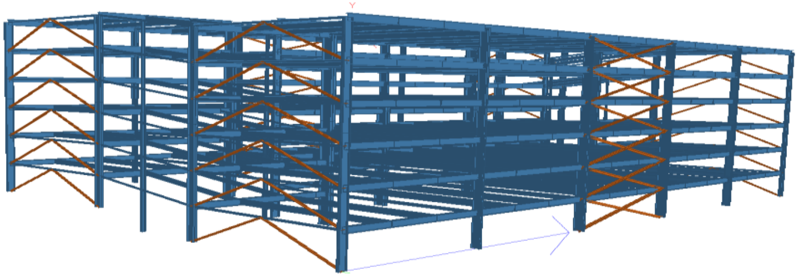

Fig.1 3D view of building

***Geometrical Data***

- Type of building : Car Parking Structure
- Location of building : Vadodara (Gujarat)

- Height of building from GL : 20.8 m
- Typical storey height : 3.2 m
- Dimensions of building :
- Length (L) : 50.00 m (in X– direction)
- Breadth (B) : 34.40 m (in Z – direction)
- Loading Data
- Dead Load (DL) at any typical floor level & roof level = 3.71 kN/m2
- Live Load (LL) at any floor level : 4.50 kN/m2
- Earthquake Load (EL)
- Zone factor : 0.16
- Importance factor : 1.0
- Response reduction factor = 4.0 (Concentric braced frame) 5.0 (Moment Resisting Frame)

## III. ASSUMPTION

Following are some assumptions made for general arrangement of building, analysis and design:

– Floor is made of reinforced cement concrete with steel deck acting as form work and bottom reinforcement, with topping for floor finish.
– All beams, columns and bracings are made of steel.
– The effective width of beam is taken as span/4 for T beams and span/8 for L-beams as per codal provisions.
– The model is analyzed & design with rigid condition prevailing in steel structure and for concrete complete fixidity is assumed to act.
– The model is assumed to have fixed support at base constructed on medium type of soil, located in zone III with depth of foundation of 1.8 meters.

## IV. RESULT

TABLE 1.1 FOUNDATION MOMENT Mz DUE TO EQX (kN*m)

| | | BF | MF | BF(ASY) | MF(ASY) |
|---|---|---|---|---|---|
| G+3 | B1 | 263.269 | 309.54 | 232.39 | 266.48 |
| | B2 | 1393.54 | 571.11 | 1141.269 | 473.83 |
| | B3 | 278.65 | 317.65 | 229.858 | 265.55 |
| G+6 | B1 | 274.108 | 409.63 | 243.78 | 355.84 |
| | B2 | 1202.559 | 678.85 | 1042.516 | 571.68 |
| | B3 | 291.093 | 420.64 | 243.243 | 355.5 |

TABLE 1.2 FOUNDATION MOMENT Mz DUE TO EQZ (kN*m)

| | | BF | MF | BF(ASY) | MF(ASY) |
|---|---|---|---|---|---|
| G+3 | B1 | 25.82 | 105.63 | 223.76 | 129.92 |
| | B2 | 825.276 | 250.09 | 733.344 | 225.32 |
| | B3 | 219.875 | 124.55 | 148.84 | 87.55 |
| G+6 | B1 | 39.58 | 150.98 | 264.225 | 172.94 |
| | B2 | 574.3 | 228.514 | 492.194 | 200.48 |
| | B3 | 272.12 | 168.798 | 192.9 | 124.89 |

TABLE 1.3 BASE SHEAR

| | BF | MF | BF(asymmetric) | MF(asymmetric) |
|---|---|---|---|---|
| G+3 | 2118.16 | 2216.1 | 1775.73 | 1873.67 |
| G+6 | 2525.037 | 2663.38 | 2129.76 | 2268.11 |

TABLE 1.4 DISPLACEMENT IN X DIRECTION

| | | BF | MF | BF(ASY) | MF(ASY) |
|---|---|---|---|---|---|
| G+3 | Base | 0 | 0 | 0 | 0 |
| | G | 1.06 | 1.98 | 0.89 | 1.67 |
| | 1 | 3.3 | 5.71 | 2.77 | 4.85 |
| | 2 | 5.99 | 9.95 | 5.03 | 8.37 |
| | 3 | 8.69 | 13.72 | 7.32 | 11.55 |
| | Roof | 11.28 | 16.74 | 9.52 | 14.1 |
| G+6 | Base | 0 | 0 | 0 | 0 |
| | G | 1.57 | 2.41 | 1.32 | 2.04 |
| | 1 | 4.9 | 7.22 | 4.11 | 6.11 |
| | 2 | 8.91 | 12.91 | 7.48 | 10.94 |
| | 3 | 13.02 | 18.63 | 10.93 | 15.79 |

| | | | | | |
|---|---|---|---|---|---|
| | 4 | 16.89 | 23.76 | 14.19 | 20.14 |
| | 5 | 20.29 | 27.69 | 17.04 | 23.46 |
| | 6 | 23.19 | 30.31 | 19.48 | 25.69 |
| | Roof | 25.8 | 32.16 | 21.71 | 27.27 |

TABLE 1.5 DISPLACEMENT IN Z DIRECTION

| | | BF | MF | BF(ASY) | MF(ASY) |
|---|---|---|---|---|---|
| G+3 | Base | 0 | 0 | 0 | 0 |
| | G | 2.09 | 6.03 | 0.98 | 6.05 |
| | 1 | 2.97 | 14.46 | 2.11 | 14.5 |
| | 2 | 3.11 | 22.41 | 3.12 | 22.48 |
| | 3 | 3.92 | 28.79 | 3.94 | 28.88 |
| | Roof | 4.41 | 32.71 | 4.44 | 32.811 |
| G+6 | Base | 0 | 0 | 0 | 0 |
| | G | 1.45 | 8.01 | 1.43 | 8.5 |
| | 1 | 3.2 | 21.02 | 3.14 | 20.67 |
| | 2 | 4.9 | 33.6 | 4.85 | 33.05 |
| | 3 | 6.54 | 45.62 | 6.5 | 44.88 |
| | 4 | 8.04 | 56.48 | 8.02 | 55.57 |
| | 5 | 9.22 | 64.68 | 9.2 | 63.64 |
| | 6 | 10.06 | 69.65 | 10.05 | 68.53 |
| | Roof | 10.57 | 72.34 | 10.56 | 71.19 |

TABLE 1.6 WEIGHT COMPARISION

| Sr. No. | Descriptions | MRF Weight in kg | BF Weight in kg |
|---|---|---|---|
| 1 | Total weight | 428131 | 412156 |
| 2 | Weight Difference | 15975 | |
| 3 | % Difference | 3.73% | |

## V. CONCULSION

- In Braced Frame, considerable reduction in storey displacement is observed compare to Moment Resisting Frame.
- The overall bending moment is reduced in structural component (*i.e column, beam & foundation*) when bracings are provided. It leads to decrease the size of component.
- Also the profile deck floor system is lighter than the solid concrete slab system and this reduction in weight will affect the total cost.
- Mass asymmetric structure should be design considering design eccentricity. For structure like car parking where distribution of live load is unfavorable; though the structure is symmetric in geometry, it is necessary to consider accidental eccentricity in design.
- Displacement is also reduced in braced frame than moment resisting frame.
- Base shear is also reduced in braced frame structure compare to moment resisting frame.
- The 3.73% weight reduces while considering braced frame over the moment resisting frame.

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