

Design on Effectiveness of Multi – Level Parking Configuration in High Density Areas

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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, geometry and the structural aspect of the multilevel car parks in India. Accordance with various structural system, type of decking system also has been studied. From literature survey, it is observed that, for the construction of high rise multilevel car park system, the steel-concrete composite option is cost effective solution over the RCC. For deciding the geometry of car park system, the split level type car parks have been considered. It also provides effective and economical solution over the other functional system. Design component of steel-concrete composite construction like: deck slab, and girder has been carried out using the excel worksheet. Design of deck slab and beams has been done using BS- 5950 (Part-4) and Eurocode-4. Analysis has the analysis and design of columns been done using STAAD. Pro 2006. The comparison of moment frame and braced frame has been done. The comparison of Deflections, weights and moments are compared for the above two system.

Keywords: Multilevel, metropolitan, congested, Deflections.

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. As early as 1918, pioneering Chicago began to innovate new architectural designs to keep cars. Holabird and Roche designed a vertically stacked 5-story structure with a spiraling ramp for the Hotel "La Salle".

1.1 Types

1.1.1 Operational Type

Automated park facilities: This form of car parks requires half the volume of a conventional car park to store the same number of cars. This is because these steel- framed car parks do not require access ramps or roadways within the car storage area. The driver parks the cars on a robot trolley within an entrance module. From this point the trolley takes the car to an empty parking space.

Self-park: In the self-park facility, driver drives the car from street to the stalls without any obstruction. For exit and entrance the different stair or lift arrangement provided for the driver.

1.1.2 Material Type Construction of multilevel car park with different material like.

- Reinforced concrete construction
- Steel Concrete Composite Construction
- Steel Construction

1.1.3 Functional Type

Twin-spiral type: The ramps, situated in opposite corners, are angled to facilitate the movement from the floors to the ramps. Entrances and exits have been provided on separate levels to take advantage of the different elevations.

Split-level type or staggered floor type: The ramp systems feature separated one- way operation, and access is on only one street. Ninety- degree parking is utilized throughout the four floors.

Straight ramp type: Straight ramp is provided. A portion of the aisles is used in the floor-to-floor circulation. The widths of the ramps should not be less than 3.65m for a single ramp and 7.0m for a double ramp.

Spiral ramp type: The preparation of a design for an irregular shape site presents many problems, especially when self-parking is to be provided. At that time this type of system can be used.

1.2 Objective of Study

The main objective of present work is optimum solution using composite construction. Comparison of RCC and steel-composite construction studied in INSDAG publication, as per that the steel-composite construction gives optimum solution over the RCC construction above the three storey parking and also it gives large column free area. So here, attempt has been made to achieve optimum solution for multi level car park, while adopting composite construction and making comparison of different types of structural system.

II. LITERATURE REVIEW

- **Pydi Lakshmana Rao et al. [1]** discussed the requirement of multilevel car parking for the high density area of car. Also they discussed the analysis, design & cost comparisons of 3, 5, and 7 levels car parking with the RCC & steel- concrete composite option. After above study they concluded that the composite construction is economical over the RCC in case of 5 and 7 levels of parking. Composite option can provide large span so that it provides no columns interrupt movement and large

column free area. Also in composite option of columns can be reduced by 50% allowing easy maneuvering of vehicles.

- **PCI [2]** This precast prestressed concrete manual's is to show the uniqueness of precast prestressed concrete parking structure and to emphasize areas of special considerations required in the design of this structures. Chapter 1 and 2 explains some of the key considerations an owner/developer must entertain when creating a parking structure. The remaining six chapters are describing the basic knowledge of structural and prestressed concrete design. As well as it also gives the parking structure durability, functionality cost considerations, structural design consideration, and connection detail etc. They offer a basic explanation of precast's advantages, design options, and technique to improve functionality.
- **Steel Tips [3]** presents information and tips on the design and construction of steel parking structures including information related to seismic behaviour and design of such parking structures. Also it explained the various considerations for steel parking system like: painting guide, fire code requirement, and slab design consideration. Also the different type of frame system and seismic design has been discussed.
- This is the third edition of the **Steel framed Car Parks [4]** brochure, prepared by Corus Construction. In this brochure, the various aspects of parking structure are given like: outline, circulation design, structural form, fire resistance, durability, aesthetic design, commercial viability, latest development. Also the some case study of various parking structure is given
- Open deck parking structure by **Emile Troup and John Cross [5]** content information like: advantages of steel framed parking structure; general planning parameters, the guideline for the inspection and its maintenance, the structural and non-structural system design parameters. Also the various aspects of costs, seismic resistance, aesthetics, durability, early occupancy and the efficiency has considered.
- **Cast in place concrete parking structure [6]** this brochure contains case studies of 20 parking structures located throughout the United States. In most of these cases, a post-tensioned structural system was selected after careful economic studies and comparisons indicated initial or life cycle cost savings.
- Guideline for the **Design of off-street car parking [7]** explains various aspects of parking structure. The different sizes required for the different ramp system, design guideline, various term define which uses in off-street parking, classification of off-street parking, different types of angled parking, various marking and signage guide to easy access, it also includes the sizes of cars and its wheel where it fits in stall.
- **INSDAG (Institute for Steel Development & Growth) [9]** Publish "Hand Book on Composite construction (Multilevel car parking), Literature explain term composite construction, Fundamentals of Composite action, Various Construction Methods, Fundamentals of shear connection, Beam and Column behaviour, Flooring system. Also deals with practical problems and provide solutions. Also result carried out from comparisons of RCC and composite construction.
- **INSDAG (Institute for Steel Development & Growth) [10]** Publish "[B+G+20] Storeyed Residential Building with Steel-Concrete Composite Option" in this the study has covered design principle and guidelines, analysis and design of building and cost estimation. Also this study will

definitely encourage the builders to go in for steel intensive building for residential usage because using steel-concrete composite technology.

- **Kober and Dima [11]** carried out study on behaviour of eccentrically braced frames with short links. The paper is intended to illustrate some features of different bracing systems used for eccentrically braced frames located in seismic areas.
- Composite floor system- A cost effective study by **Hedaoo and Athare [16]** present the study of comparison is between RCC and composite floor construction for a G+5 commercial Building. From study, it is found that direct construction cost required for composite floor is higher than RCC floor. But over all the net cost required for composite floor is only 0.45% more than RCC floor considering time related savings. Also the study says that the time required for composite floor construction is half than RCC floor.

III. METHODOLOGY

3.1 General

3.1.1 Design of Parking Structure with MRF System

A moment frame structure consists of columns and girders jointed by moment- resistant connections. The lateral stiffness of a moment frame bent depends on the bending stiffness of the columns, girders and connections in the plane of the bent. The principal advantage of moment frame is its open rectangular arrangement, which allows freedom of planning and easy fitting of doors and windows.

Gravity loading also is resisted by the moment frame action. Negative moments are induced in the girders adjacent to the columns causing the mid-span positive moments to be significantly less than in a simply supported span.

There are many functional layouts used for multilevel car parks, each having specific advantage. Here, the split level type car park is used considering more economical option for composite construction. The moment frame building consists of composite floor considering profile decking and composite beam of steel section while steel column has been used for fast erection consideration.

3.2.2 Design of Parking Structure with BF System

The braced frame is a common system employed to resist the significant lateral loads that exceptionally tall structures are subjected to. The advantages of braced frames from a structural engineering standpoint are enormous. Braced frames carry the lateral forces in an axial manner than through the bending of elements which is highly inefficient. The largest drawback for braced frames is that the scheme is obstructive and significantly reduces openings within bays. But in the case of multilevel car parks, the requirement of opening is not much. However, it should be noted that while the bracing element covers a significant portion in criteria bays, the separation of the lateral system from vertical system leads to much large column spacing which allows more flexibility in programming of the interior space within those bays. Here, also the same general consideration has been taken which are describes in chapter 5. Like design methodology, split level type system, profile steel decking, beam and column. In this chapter, the braced frame analysis and design will be studied.

IV. RESULTS AND DISCUSSIONS

4.1 General

In multi-storey buildings, structural steelwork is typically used together with concrete; for example, steel beams with concrete floor slabs. It is a fact, however, that engineers are increasingly designing composite and mixed building systems of structural steel and reinforced concrete to produce more efficient structures when compared to designs using either material alone. Study says that above three storeys, the composite construction is economical for multilevel car parks. Literature survey shows that in most multilevel car parks the steel framing is used. Purpose behind the use of steel framing is saving the time and achieving the fast construction. So here, the comparison has been carried out considering the two framing system. One is moment resisting frame system and other is braced frame system. For the braced frame, it is find that the x-bracing is economical over the other types of bracing system. And it is better solution for resisting a lateral loads which coming from the either direction.

4.2 Weight comparison

Weight comparison of two systems has been carried out. Detailed weight comparison has given in Table 7.5. The braced frame system is more economical than the moment frame system in case of weight comparison.

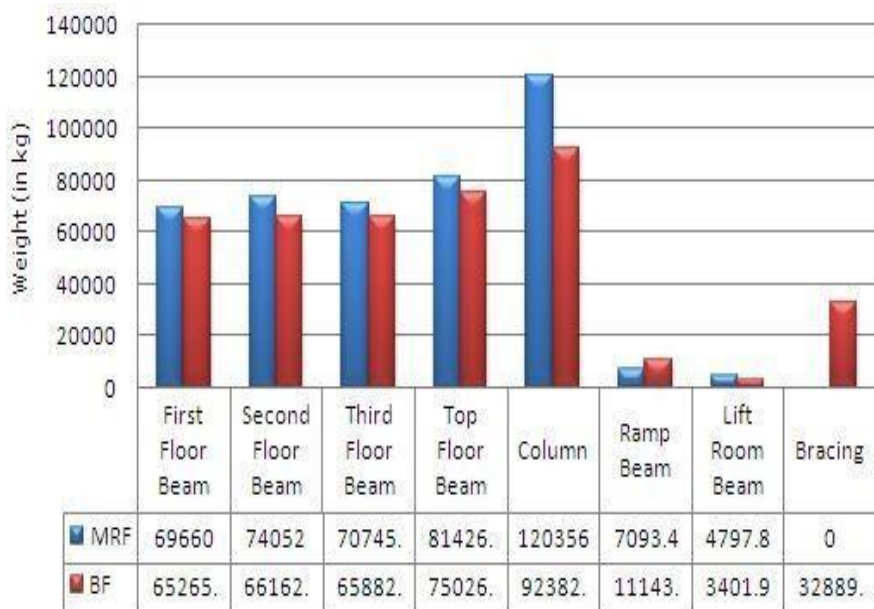


Figure No. 4.1: Weight Comparison

4.3 Foundation Moment Comparison

When the bracing is provided in the structure, very less difference is observed in case of dead and live load. But the moment is reduced in case of earthquake loading at the foundation.

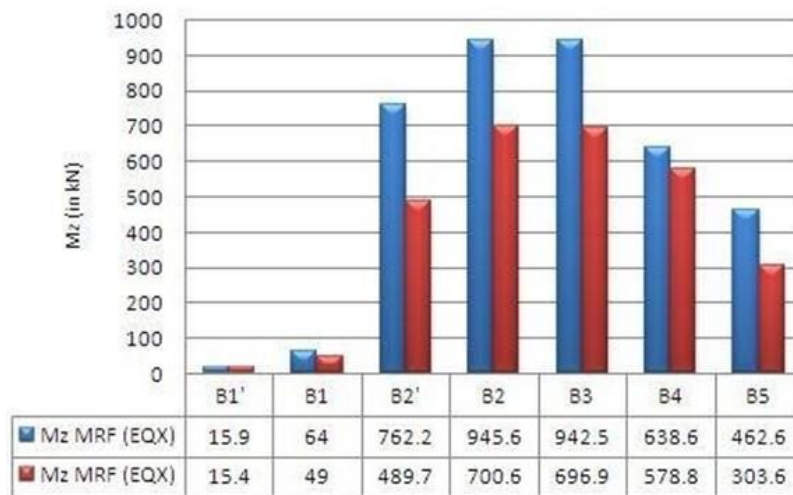


Figure No. 4.2: Foundation Moment Comparison

V. CONCLUSION

5.1 Conclusion:

The study shows that the multilevel car park construction is cost effective while considering composite construction. The result of analysis shows that the saving in weight while the braced frame is used rather than the moment resisting frame. Also, the profile decking floor slab is time effective solution. Hence, the composite construction can be adopted for saving in time and in cost also. There are some other conclusion is:

- The 3.7% weight reduces while considering braced frame over the moment resisting frame.
- The reduction in the deflection is also observed.
- The load carrying behaviour (Through element bending) of moment frame results in significant column and girder end moment.
- This larger moment leads to design the larger section.
- Due to higher design end moment the connection cost will be affected.
- The bending moment is reduced in column and beam when bracings are provided.
- Due to reduction in bending moment, the smaller section can be provided. Also it reduces connection cost.
- The bending moment gets reduced in foundation also. So it gives lighter foundation while bracing is used.
- The construction of profile deck floor system is saving a half the time over the solid concrete slab.
- Also the profile deck floor system is lighter than the solid concrete slab system and this reduction in weight will affect the foundation cost.

5.2 Future Scope of Work

Based on the present study of multilevel car parks work can be extended further in:

- The same type of study considering different functional system of multilevel car parks.
- One can do the comparative study between automatic parking with different self park system.
- Also study can be done considering precast prestressed concrete system.

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