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# Analysis and Design of Pre-Engineered Parking Plaza

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***Abstract*— The population of India is continuously increasing day by day and towns and cities have grown up around their public transport system. The parking scenario is woefully falling short of the current requirement in the country. The resultant scarcity of parking space has begun to spill over to other aspects of urban life in form of congestion, fuel loss, dispersed land use and low air quality.**

**Multi-level car parking has come with no. of reliefs since they come with no. of advantages such as optimal utilization of spaces, flexibility for realization of optimum parking solution. Providing Pre-engineered structure for such parking is relatively new concept in India.**

**This paper presents the analysis and design of pre-engineered multi-level car park for the mitigation of traffic challenges in public areas using STAAD.Pro & ETABS software. Design of pre-engineered multi-level car park was carried out by using static analysis and suitability of it was checked accordingly.**

***Keywords*— *Parking plaza; pre-engineered building (PEB); STAAD.Pro; ETABS***

## I. INTRODUCTION

The vibrant nation India, home to over thousands of million people, is currently facing one of the biggest problems now days. The situation is such that on any given working day approximately 40 % of the roads in urban India are taken up for just parking the cars. It is also noteworthy that a personal vehicle is on the move hardly for 2 to 3 hours in a day, while for the remaining period it is parked at the residence or destination and sometimes on-route. Even commercial vehicles will be found to be parked for about 60% of time on an average. So, this problem of parking is rising day by day.

There are some other ways to solve car parking issues, such as multi-level car parking. Multi-level car park is unique structure in which all elements of the structure are normally exposed to the public. Multi-level car parking is of two types:

1. Conventional
2. Automated

Conventional car parking can be done anywhere on ground or under it. The open parking areas are more preferred as opposed to closed areas in case of parking above the ground as specified fire protection system and mechanical ventilation are not needed in this case. Automated multi-level car parking is more difficult to achieve in India considering that it is entirely technology driven and does not involve much human element. The more conventional option seems to be the better best. But conventional multi-level car parking is needed to be modified in structural means. Hence another option which came into existence is providing pre-engineered structure for car parking.

## II. PRE-ENGNEERED BUILDING

Pre-Engineered Steel Buildings use a combination of built-up sections, hot rolled sections and cold formed elements which provide the basic steel frame work with a choice of single skin sheeting with added insulation or insulated sandwich panels for roofing and wall cladding. The concept is designed to provide a complete building envelope system which is air tight, energy efficient, optimum in weight and cost and, above all, designed to fit user requirement like a well fitted glove.

These Pre-Engineered Steel Buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascia's, interior partitions, crane systems etc. The building is made water-tight by use of special mastic beads, filler strips and trims. This is a very versatile building system and can be finished internally to serve any required function and accessorized externally to achieve attractive and distinctive architectural styles. It is most suitable for any low-rise building and offers numerous benefits over conventional buildings.

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Pre-engineered buildings are generally low-rise buildings; however, the maximum eave heights can go up to 25 to 30 meters. Low rise buildings are ideal for offices, houses, showrooms, shop fronts etc. The application of pre-engineered concept to low rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time especially when complimented with other engineered sub-systems.

## III. PRE-ENGINEERED BUILDING AS PARKING PLAZA

PEB as a Multi-level car parking have provided relief to all the problems which are likely to be faced by R.C.C. multi-level car parking, since they come with a no. of advantages like:

1. Optimal utilization of space
2. Lower maintenance and operational cost
3. Lower construction cost (owing to the prefabrication)
4. Withstands high wind speeds, dynamic loads and seismic loads

Hence now days PEB multi-level car park is a new trend in a construction industry to design the structure around car parking and not the car parking car parking designed around the building.

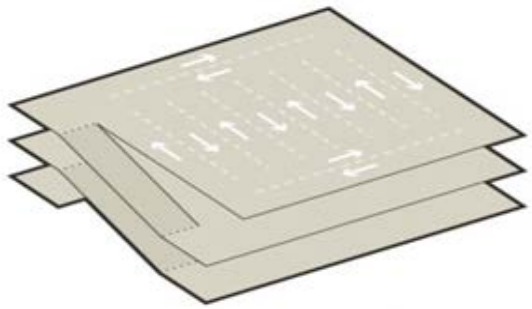

Fig. 1. Flat deck type parking plaza

## IV. MAIN FRAME

### A. *PROBLEM STATEMENT*

It is seen that, the daily traffic volume in the areas of Railway Station, Khandesh Central Mall and Phule Market in Jalgaon is heavy i.e. near about 100-150 vehicles/hour. And there are no appropriate parking facilities available near that areas. To eliminate this problem, pre-engineered parking plaza will be the best solution.

Region – Maharashtra

Location – Jalgaon

Type of support – Fixed support

Type of Structure – G+2

Type of building – parking plaza for car and motorcycle

Type of parking arrangement – $60^0$

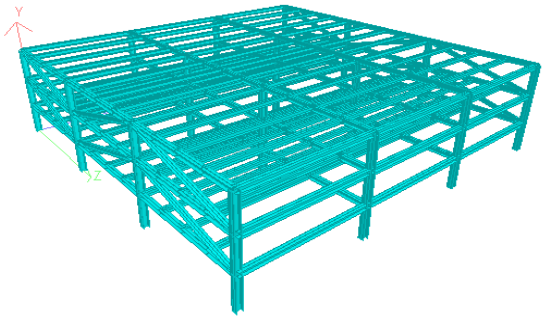

Fig. 2. 3D model of main frame.

Width – 42 m

Length – 42 m

Building height – 12 m

Floor height – 4m

Column spacing – 14 m

Wind speed – 39 m/s

Type of floor – flat deck type

Type of slab-- RCC

Area of opening – 80%

Vehicles – i) motorcycle – 300 On ground floor

ii) Light van – 108 No's

### B. STRUCTURAL DETAILS

Pre-engineered structures are generally used for the longer span. In this parking plaza building primary beams are provided having span about 14m and over it secondary beams are placed. A RCC `slab was provide over these beams.

For slab- Method of design-IS

Span in x direction- 14m

Span in y direction- 3.5m

Depth of slab- 150mm

For main frame-Main beam- 72 no.

Main column – 16 no.

Secondary beam-81 no.

Bracing-12no.

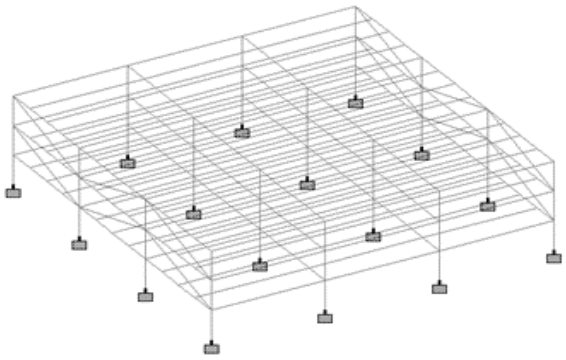

Fig. 3. Skeleton of structure of main frame.

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*C. LOAD CALCULATION:*

*1) Dead load:*

Self-weight

Weight of RCC slab – 3.75 KN/m2

Floor finish – 1 KN/m2

Collateral load – 0.383 KN/m2

Total – 5.133 KN/m2

*2) Live load:*

Weight of the vehicle

1) Weight of car – 4.2 tons = 4.2x103 kg

Weight of 108 car – 108x4.2x103 kg x 9.81

- 4449816 N

Weight of car per floor – 4449816/2 = 2224908 N

Intensity of load per square meter – 2224908/42x42 N/m2

--1.261 KN/ m2

2) Minimum live load according to IS 875 part II –

3 KN/ m2

Total – 4.261 KN/ m2

*3) Wind load:*

Wind load is analyzed by STAAD.Pro

According to IS code 875 part III

For 10 m height wind intensity – 0.8

For 15 m height wind intensity – 0.9

*D. ANALYSIS & DESIGN IN STAAD Pro*

1) *Modelling:* In STADD.Pro the co-ordinate system was used for establishing nodes of junction. And that nodes were connected by add beam command.
2) *Properties:* Properties were assigned to the beam and column such as material sections.
3) *Supports:* Fixed supports are provided to the base of the column. At which all degree of freedom is zero.
4) *Loading:* loading was applied on the frame for the calculated load and combinations were generated by STAAD.Pro according to IS.
5) *Analysis:* In this process software analyze the structure and calculate different parameter which is used for design.
6) *Output:* After applying the load frame analysis was carried out from that following result were obtained:
   - Reaction in frame.
   - Moments in frame.
   - Shear in all member.
   - Bending moment in all member.
   - Deflection in members.
7) *Design*: In design check code command was used which gives the check according to IS 800-2007 LSD for all the sections.

Slab, base plate and footing for the main frame design manually by IS method.

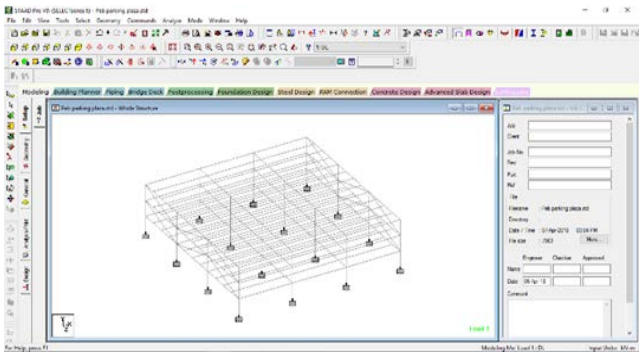

Fig. 4. Structural element of main frame in STAAD.Pro

## V. RAMP

*A. STRUCTURAL DETAIL*

In this the ramp was provided adjacent to the main frame of structure having following data:

Ramp for G+2 parking plaza

Ramp type – Flat deck

No. of flight - 2

Width of ramp– 4m

Length – 35m

Height between landing – 4 m

Landing size – 3.5x4m

Pitch – 1/9.1

Wind speed – 39 m/s

Area of opening – 80%

For slab- Method of design-IS

Span in x direction- 4m

Span in y direction- 3.5m

Depth of slab- 150mm

Type of slab– RCC

Type of floor- flat deck

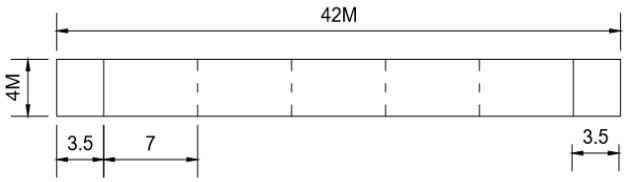


Fig. 5. Plan of ramp

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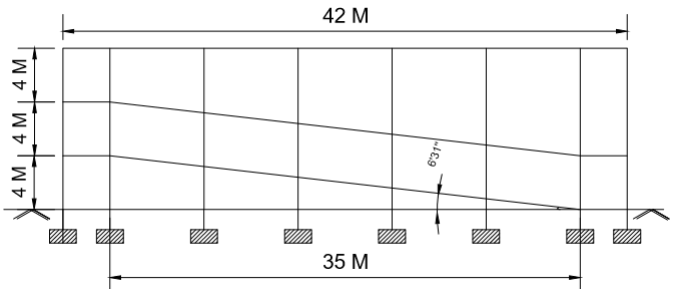


Fig. 6. Plan and elevation of ramp

### B. *LOAD CALCULATION*

*1) Dead load:*

Weight of RCC slab – 5.133KN/m2

2) *Live load:*

Total live load – 3 KN/m2Xx1 = 3 KN/m2

*3) Wind load*

Wind load is analyzed by ETABS

*4) Dynamic load*

Vehicle load - 3 KN/m

### C. *ANALYSIS PROCESS IN ETABS*

Ramp is having inclined members and its difficult to analyze it in STAAD.Pro software therefore it was analyzed in ETABS software by following steps:

1) *Modeling of ramp*: In ETABS Software modeling of ramp was carried out as follows:
   - Plan grid system
   - Specification of material
   - Define section of material
   - Define shell slab for ramp
   - Apply section to models
   - Define static load and load combination
2) *Analysis process*: In this process software analyze the structure and calculate different parameter which is used for design.

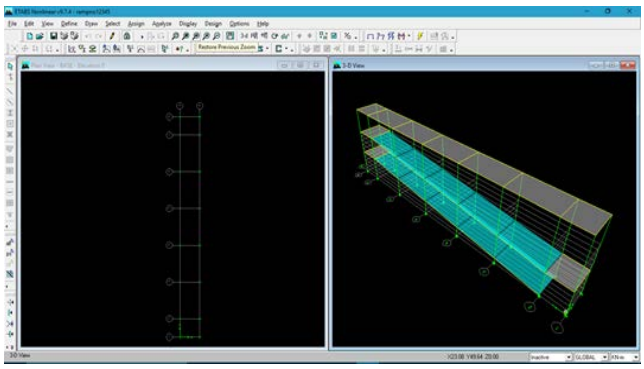

Fig. 6. Structure of ramp in ETABS software

## VI. ADVANTAGES OF PRE-ENGINEERED PARKING PLAZA

Steel construction is well placed to satisfy all the requirement of good vehicle park design. Steel is:

- Ideal for long span – providing column-free parking space
- Lightweight- reducing foundation requirements
- Robust and fire resistant
- Fast in construction
- Easily maintained
- Vandal resistant
- Economic.

## VII. RESULT AND DISCUSSION

From the outputs of STAAD.pro & ETABS it has been seen that:

- Every structural member satisfies all the checks such as deflection, area and section modulus check.
- The ramp structure can sustain the moving loads.

## VIII. CONCLUSION

The goal of this project was to provide a better parking solution for the traffic problem in Jalgaon and to design the pre-engineered parking plaza for the same. Hence it can be concluded that:

- A Pre-Engineered parking plaza is an application of PEB which can be used as a solution for parking problem in various urban cities. This parking plaza offers strength, durability, flexibility, adaptability and recyclability and helps for the sustainable development.
- Sections designed by using STAAD.Pro software are efficient and are found economical than the conventional steel sections. After analyzing the ramp structure in ETABS it has been seen that the ramp structure is efficient to sustain the moving loads
- To conclude, the pre-engineered parking plaza is best suited for providing end users a much more economical and better solution for larger column free parking space.

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