A study on analysis of warehouse design with Pre Engineered Building system resting on different soil strata

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Abstract - *Nowadays Pre Engineered Building concept is majorly used in industrial and commercial sectors due to its benefits of time optimization and economy. Pre Engineered building means a steel building system that is predesigned and prefabricated. Various research on the comparison of displacement and weight parameters for conventional and PEB has been already done. This paper represents an investigation of PEB resting on different types of soil strata with pinned base and fixed base support. In this study a PEB structure of span 15m, 20m, and 40m resting on hard, medium, and soft soil strata with pinned and fixed base support is to be analyzed and designed according to Indian standard code IS 800, 2007, The design and analysis can be done using the software STAAD Pro.*

Key Words: Pre Engineered Building, STAAD Pro, pinned base support, fixed base support, tapered section.

1. INTRODUCTION

The study is mainly focused on the Pre-engineered building structure with varying support conditions with different soil strata. Pre Engineered Building concept involves steel building systems that are predesigned and prefabricated. PEB concept lies in providing the section at a location only according to the bending moment deflection requirement at that actual condition. The concept of PEB is the frame geometry that matches the shape of the internal stress such as the bending moment diagram thus optimizing material usage and reducing the total weight of the structure. Pre Engineered Building material section involves the steel building systems which are predesigned and prefabricated

A typical cross-section can be molded based on the bending moment diagram achieved at that particular section. The sections can be varying throughout the length according to the bending moment diagram. Tapered I section made with built-up thin plates of highly stressed and tested are used to achieve this configuration. The use of the optimal least section leads to beneficiary savings of steel and cost reduction.

Presently, a large column-free area is an utmost requirement for any type of industry, and with the advent of computer software, it is now easily possible. With the improvement in technology, computer software has contributed immensely to the enhancement of quality of life through new research. Pre-engineered building is one such revolution that is fully fabricated in the factory after design, then transported to the site and all components are assembled and erected with nut bolts, thereby reducing the time of completion. Pre-Engineered Buildings have bolted connections and hence can also be reused after dismantling. This flexibility would seem to readily lend itself to the optimization of member cross-section shapes. India has the second fastest-growing economy in the world and a lot of it is attributed to its construction industry which figures just next to agriculture in its economic contribution to the nation. In its steadfast development, the construction industry has discovered, invented, and developed several technologies, systems, and products, one of them being the concept of Pre-engineered Buildings. Steel is a material that has high strength per unit mass. Hence it is used in the construction of structures with large column-free space. The scientific-sounding term pre-engineered buildings came into being in the 1960s. The buildings were pre-engineered because they rely upon standard engineering designs for a limited number of configurations. These buildings are mostly custom-designed metal buildings to fill the particular needs of the customer.

2. LITERATURE REVIEW

Watwood V. B. [1985]
In this article, the author found that the approximation used for the boundary strata at the column bases should adequately account for the behavior of the foundation and more than one approximation may be necessary. They defined uneven loading is shown to be very significant, and it is recommended that gable frames always be designed for some uneven distribution of load. It is suggested that if there is significant axial stress in the rafter, caution should be exercised in the use of specification limitations, which are based on girder behavior where there may have been no axial stress considered in the derivation and testing of the specification limitations.

Hwang J. S., Chang K. C., Ketter R.L. [1989]
In this paper, the researcher constructed a pinned-base steel gable frame structure composed of prismatic members, and the dynamic characteristics of that structure are investigated using the shaking table. The tests are carried well into the inelastic range so that ultimate lateral strength under seismic excitation can be quantified. In addition, the excessive elastic and inelastic story drifts, which are attributed to the pinned-base condition, require careful evaluation to ensure structural safety against large side sways.

Hwang J. S., and Chang K. C., etl Ketter R.L. [1991]
In this study author evaluated the dynamic responses of a one-fifth-scale gable frame structure composed of tapered members subjected to El Centro earthquake ground motions, using a shaking table. The width-thickness ratio of the flange

and the depth-thickness ratio of the web of the members satisfy the requirements of a compact section. The experimentally determined ultimate strength of the test structure is compared with those predicted by the codes AISC load and resistance factor design. The unbraced length also meets the criteria for a compact section based on the dimensions of the shallow-end cross-section. Failure of the test structure is due to lateral buckling of rafters. No local buckling before the lateral buckling is observed.

Saka M. P. [1997]
In this study, Author has developed an algorithm for the optimum design of steel frames composed of prismatic tapered members. The width of an I-section is taken as constant, together with the thickness of the web and flange, while the depth is considered to be varying linearly between joints. The depth at each joint in the frame where the lateral restraints are assumed to be provided is treated as a design variable. The objective function which is taken as the volume of the frame is expressed in terms of the depth at each joint. The displacement and combined axial and flexural strength constraints are considered in the formulation of the design problem. The strength constraints, which take into account The lateral-torsional buckling resistance of the members between the adjacent lateral restraints, are expressed as a nonlinear function of the depth variables

Saffari H., Rahgozar R., and Jahanshahi R. [2007]
In this article, the researcher proposed a method for quick calculation of the effective length factor of columns in steel gabled frames with tapered members. The method is based on two-dimensionless design-oriented charts relating the critical load of columns to frame characteristics and boundary strata. Since I-sections are usually used for gabled frame members, the variation of a moment of inertia along the length of members (beams or columns) is approximated as a parabolic function. As is demonstrated in the Numerical Studies, these calculations can yield, in a very efficient way, accurate results for gabled frames consisting of tapered elements.

Syed Firoz, Sarath Chandra Kumar, S.Kanakambara Rao.[2012]
This paper represents an introduction to Pre Engineered Building which is the most efficient and simplified building type in the steel construction industry. The pre-engineered steel building system construction has great advantages to single-story buildings, practical and efficient alternative to conventional buildings, the System represents one central model within multiple disciplines. The pre-engineered building creates and maintains in real-time multidimensional, data-rich views through project support and is currently being implemented by Staad pro software packages for design and engineering. In this study, the STAAD Pro procedure for PEB overview, structural design, and analysis is discussed. It is concluded as choosing steel to design a Pre-engineered steel structure building is to choose a material that offers low cost, strength, durability, design flexibility, adaptability, and recyclability. Steel is the basic material that is used in the Materials that are used for Pre-engineered steel buildings. It negates regional sources. It also means choosing reliable industrial products which come in a huge range of shapes and colors; it means rapid site installation and less energy consumption. It means choosing to commit to the principles of sustainability. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development.

C. M. Meera [2013]
This paper is a study on the design of an industrial warehouse structure located at Ernakulam. The actual structure is proposed as a Pre-Engineered Building with four spans each of 30 meters in width, 16 bays each of 12 meters in length, and an eave height of 12 meters. In this study, a typical PEB frame of a 30-meter span is taken into account and the design is carried out by considering wind load as the critical load for the structure. The designs are carried out under Indian Standards and with the help of the structural analysis and design software Staad.Pro.

Zende A., Kulkarni A., Hutagia A [2013]
This paper presents the mechanical behavior and capacity of innovative fabricated structures. The structure consists of corrugated steel plates. It mainly focuses on numerical and experimental models. The column is fabricated by welding four corrugated plates 3 mm thick. For load-displacement curves, the axial load is applied to column sections. Gable frame models are also done by using STAAD PRO software. The effect of material and geometric nonlinearity is taken into account. The software results are validated with experimental results. The cost comparison of innovative and conventional structures is also carried out in this paper.

Deshpande N.N, Kulkarni D.B & Lale Nitin[2017]
In the present study, attempts have been made to study the influence of soil structure interaction on Pre Engineered Buildings (P.E.B). Usually, the structural behavior is analyzed assuming the fixed support conditions at the base of the structure. In the conventional method, the foundation flexibility of soil mass is ignored which is likely to affect the structural response of the building. The soil flexibility is integrated into the analysis of the structure using Winkler's spring model approach. For analysis, P.E.B with a 15m span is considered with equal bay spacing. Three different soil strata i.e. hard, medium, and soft are used for the SSI study. The analysis is carried out in STAAD Pro.V8i software using response spectra of IS 1893-2002. The effect of SSI on various parameters like base shear, lateral displacement, etc is studied and discussed. The study reveals that SSI significantly affects the performance of the structure. It concludes that base shear and lateral deflection for soft soil is 39.15% and 32.28% less as compared to fixed support conditions. The column moment of the structure increases due to the SSI effect. It increases with the flexibility of soil, column moment is the main parameter while designing the P.E.B structure. Considering the SSI effect is prominent for steel structure building since support
conditions on site are not rigid, it possess some flexibility due to different soil conditions.

Shivani Meher, Ruchita Nar, Sadichha Jagadale &Gautami Kalal [2018]
This study gives an idea to carry out the design of an industrial warehouse. This topic of work is decided to know

the different types of force/load effects to be considered while designing an industrial warehouse with the help of a literature review. This structure is proposed to design according to IS 800:2007 and the dead, live, the wind load analysis is done according to IS 875:1987 (Part-I, Part-II, Part-III). The area for the proposed warehouse design was decided and a proper architectural plan was prepared according to the requirements. The forces acting on the adjacent members when one of the members is under loading and calculating the excess stresses and ratios induced in these connected members and also, the moments and forces produced are obtained and mentioned. Then different members of a warehouse e.g. Truss members, columns and connections, etc. were designed and the final result are obtained. Finally, the conclusion is made that warehouse can be designed easily by adopting simple design procedures and IS specifications.

3. METHODOLOGY

1. Collection of relevant research data from national and international journals, research papers web sources, textbooks, reference books, etc. to know past studies related to a research topic.
2. Find out the scope of further research in the Optimization of warehouse design with Pre-engineered building structures resting on different soil strata.
3. The PEB structure of various spans of 15m, 20m, and 40m sizes are taken to study the effects of weight parameters and deflection criteria on the different soil strata.
4. The preparation of models of constant bay spacing 6m, and eave height 8m by using FEM-based software.
5. As per the bending moment tapered sections are molded and optimized with relevant utility check of ratio below 1.
6. Design of Pre-engineered building section with secondary material consideration as per the Indian standard.
7. The results of the analysis and design of PEB structures are evaluated and compared to various span sizes and soil strata.
8. Result discussion will be prepared from a comparison of results of analysis and design.
9. Conclusion will be drawn based on the results discussions

4. OBJECTIVES

1. Design of Warehouse with PEB System having fixed support and pinned support with a moment and shear connection which is resting on different soil strata such as Hard, Medium, and Soft soil.
2. Investigate the behavior of PEB structure for various spans such as 15m, 20m, and 40m and soil strata such as Hard, Medium, and Soft soil.
3. Establish the optimized design of the Warehouse with PEB System.
4. To develop nomograph/design guidelines for the PEB system.

5. RESEARCH GAP

In previous studies, research is carried out only on conventional and PEB steel structures. Also, all studies are carried out on the comparison of both types. But there is a lack of research on different types of support and soil strata's effect on the tapered sections. Also in general for the construction and design of pre-engineered building a maximum cost is required, but there was no optimum design or types available to reduce the cost. Hence there will be optimization of warehouse structure as per different soil strata. The future scope of studying this type of research work is an essential part of this review paper. A study of the effect of fixed-end support and Pinned end support with varying soil strata such as hard, medium, and soft can be studied. Comparison can be made with Fixed and Pinned support conditions. Moreover, changing the bay spacing, and changing the slope angle is an essential aspect to be thought of for further study.

6. FUTURE SCOPE

1. Design criteria for various Bay spacing of PEB Structure.
2. Developing the design of the PEB Structure with and without bracing.
3. Developing the Comparison of Tapered and cold form sections for PEB Structure

7. CONCLUSION

Depending upon the research and reviews discussed, this study concludes that choosing steel to design a Pre-engineered steel structures building is to choose a material that offers low cost, strength, durability, design flexibility, adaptability, and recyclability. Thus, conveys that PEB structures can be easily designed by simple design procedures following country standards. In light of the study, it can be concluded that PEB structures are more advantageous than CSB structures in terms of cost-effectiveness, quality control speed in construction, and simplicity in erection. Considering the SSI effect is prominent for steel structure building since support conditions on site are not rigid, it possesses some flexibility due to different soil conditions.

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