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Analysis and Design of Mono-Column Structure

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ABSTRACT: *A building is the first structure, which enter one's mind as soon as one thinks of civil engineering. The building not only provides housing for the occupants but also protects them from many natural disasters. Preventing all the forces that cause such incidents is a requirement for the design of the building. But designing a building requires a lot of processes. In a typical building, there are many columns at ground level to support the structure. Thanks to this mono column, the system is safe, but there is some problem with space due to any column number. It takes up more space and issue in the parking lot and another service area. Due to the need for large service spaces, the mono-column structure of the building may help to solve the problem. With the use of a mono column building system, a lot of space will be available on the surface of the earth, and it will contribute to better construction.*

KEYWORDS - *Composite material, E-tabs, Floating column, Mono-column structure, multi-storey building*

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I. INTRODUCTION

Many buildings are being developed at present. The maximum structure built at present tends to be wind sensitive because of their shapes, slenderness, flexibility, size, and lightness and with multi-column at ground floor. Extensive work is carried out on the mono- column supported structure. A review is done on the comparison of mono-column structure with multi-column structure with several configurations. Structure supported on a multi-column has less usable floor space compared to structure supported on single Column. Multi-column uses more ground space as requires an area for providing a foundation and offers less room for parking. Extensive work is carried out on the single column supported floor in a multi-storey building by using composite material. Majority of previous works over steel-concrete composite material in the structure. A very few works are available over the analysis & design a structure supported on single Column. Basically, in all research works different types of a structure supported on the mono column by using the material, i.e., RCC OR steel is taken for supporting whole structural block. Still, each floor in multi-storey structure independently supported on single Column using composite material is not carried out in any research work.

1.1 PROBLEM DEFINITION

The rapid increase in population and scarcity of land tends to the development of construction technology and high-rise commercial structures are becoming major crucial task nowadays. On the other side, the single column high rise structure may be considered as the option for the large floor space which is major challenge for construction industry.

1.2 RESEARCH OBJECTIVE

The planning and analysis of mono-column high-rise structure should be developed through design software. The comparison of analytical result of seismic load applied on mono-column high-rise structure and multi-column high-rise structure. Also, to study the performance of lateral displacement on mono-column building and multi-column building. The bracing in the mono-column building should be provided.

II. LITERATURE REVIEW

In this literature review study, there are three categories, namely mono-column design, member of structure, comparison of single RCC column with a multi-column RCC structure and the use of a composite object.

2.1 MONO-COLUMN DESIGN

Prathamesh Ghare [1] shows his great inspiration for this paper by describing the composition of the tree. The mass of the leaves and branches is transmitted to the trunk and is disturbed in the ground by the root. Analyzes planning, structural analysis and the construction of a single building are considered for a survey. The

structure consists of a central core that carries a load of surface metal. All members will act as cantilevers. E-TABS software is used for structural Analysis and Design based on a limited feature process. It is analyzed and designed for a critical situation. It is created only within the state boundary of the road. Load numbers assigned the IS 875 (part 1) dead cargo structure, 2-partlive cargo, three air cargo 3, IS 1893 (1 part) 1 seismic load. We have concluded that the building is safe from all types of loading and is safe from earthquakes and winds, and according to IS 456, the building is safe from permissible deviation.

Palaram Nikhil and Sanaka Vineela [2] demonstrate that the structure and analysis of the RCC framework based on a single column. Structured modeling, compression, bending, shaving power, and structural design considerations using E- TABS V9.7.2, and comparing one Column of RCC with RCC multi-column. We conclude that the cost of towing a building is increasing with the increase in space. It also concludes that the shear value, the shear strength, the shear strength also increases with the growing area. It is supposed that a mono column building should only be built on the ground floor, and a building with a mono column structure is high-priced.

S. Ramramani, S. Priyanka, E. Sahul Hameeth [3] analyzes and designs the proposed site-building in Salem. The total area of the program is 190 Sq.m. Both analytical and manual calculations are described in the proposed format. It is concluded that the cost of a mono column is much higher than the structure of most columns. The single-column formula has been successfully designed to withstand all hundreds of earthquakes and hurricanes.

Ambati Venu Babu, Dr Dumpa Venkateswarlu [4] described the planning, structural analysis, composition and drawings of various elements and the estimated cost of the entire structure. A single-column structure is supported by a single rectangular column in the center. There is an addition of five storey on the ground floor. The concrete range of M20 and M30 is used in one Column. The composition of every member of the building is guaranteed in IS 456-2000. They study the effects of lateral migration in various areas, the effectiveness of wind energy in an unusual structure in less than six places.

2.2 MEMBER OF THE STRUCTURE

U-E K Mohan raj [5] analyzed one Column supporting the structure, in which all other members act as cantilevers—reducing the cantilever time for columns that convert two-thirds of the length if they are supported by providing two ring beams and inclined beams. The structure is analyzed and constructed using the STRAP (Structural Analysis Package), which is based on the Stiffness Matrix process. Conclude that if the use of high space is considered during planning and design, it will significantly enhance its high-performance.

Ambati Venu Babu [6] has done analysis of the structure of a triangular structure in which a mono column is located at the edges of the triangle and not its center and found that a single-column structure is sensitive when it is in an equal and vertical loading position. As one Column supports the entire structure, all the other members will act as cantilevers. It is reducing the cantilever time for columns that convert two-thirds of the length if they are supported by providing two steel beams and inclined beams. The structure is analyzed and constructed using the Staad pro (structural analysis package), which is based on the matrix strength method. The above structure has been studied for many loading conditions, and criticism has been selected for construction.

BB Babicki [7] provide details on the layout of the building and facilities in the West coast Office Building located in Vancouver Canada in an excellent location and one of the city's significant ducts connecting the city center and residences. The building has 152,000 square feet of office space and has a parking space for 200 cars. The idea of the building was a slight disruption to the ecosystem and earthquake resistance since Vancouver is in one of the most critical earthquake areas from California to Alaska. The state-of-the-art building has 277 square feet of concrete space with 36x 36 meters in the planning area and occupies 21 levels from the base to the top. Three levels of underground parking, equivalent to three levels of the open plaza, 12 floors of common office space, 110 x 110 meters in a fixed location from the center of above the plaza space and, three levels within the upper deck of the cable elevator are considered for a survey.

Badikala Sravanthi [8] done Design and Analysis of a single-column RCC structure is performed on this project (Figure 1). Cost Comparisons are made between one RCC column and an RCC column structure. This paper presents structured modeling, pressure, bending time, shear strength and structural design considerations and is analyzed using STAAD Pro.

The various steps involved in building an RCC structure are based on a single column using STAAD pro and comparing a single RCC column with a multi-column RCC framework. They conclude as follows: -

a) A single-column structure is successfully designed to withstand all loads, including earthquakes and the burden of the spirit.

b) The formation of a single column is 20% more expensive compared to the shape of a multi-column.

c) A single-column structure provides a better view of the construction and open space of the world despite the cost slightly beyond the formation of multiple columns.

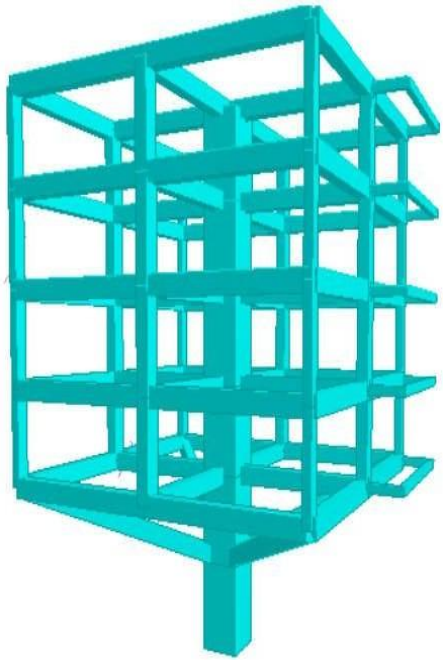

Figure 1: RCC structure based on one column.

Madireddy Satyanarayana [9] analyzes and designs a multi-storey building that occupies in a single column using a different code provision. A detailed plan for this proposed building is drawn up using AutoCAD 2010. The building has a ground floor and five storeys'; He planned the construction as instructed by the standard Indian code. Construction frames are manually analyzed by the Limit state method and provide a detailed structure for RC.C members.

Donald MacLeod [10] has done a research study in which a mono column is directly supported by a pile of existing jackets on the seabed and utilizes the disused platform capacity of the platform to increase the economic space available for new areas of pressure. The simple spigot interface between the mono column and the existing bulk also counteracts the need for grouting, temporary adjustment, and any subsea intervention. Traditional methods of expanding housing and land on overseas foundations include the installation of cantilevers or shoe shakers in inefficient spaces leading to overseas hours and extended closures. An important consideration for this building is its ability to survive in the event of a ship's impact.

2.3 COMPARISON OF ONE RCC COLUMN WITH A MULTI-COLUMN RCC STRUCTURE

Mr. Jayant S. Ramteke, Mr.M.R. Nikhar [11] describes comparisons of a one- column RCC structure and a multi-column RCC structure. They edit and analyze multiple columns and single-column structure G + 4 in software. The design is based on the requirements and standards recommended by IS codes and national building codes. Editing is done using 3D modeling software with the help of AutoCAD 2014. The purpose is to develop, edit and analyze a high-level model in STAAD-Pro and study the seismic load used in the building by IS 1893-2002. Also, confirm the reduction of one Column and multi-column structures and learn the lateral function of lateral migration in area II. It has been concluded that a single-column structure is 20% more expensive and a multi-column structure. It also concluded that the RCC column provides satisfactory results under normal loading conditions. The rise of the news in the form of a high ascent refers to the extreme deviation.

Ankur Pandey, Vaibhav Singh, and Gaurav Awasthi [12] analyzed single- column storey structure using the software. Various steps are geometric modeling, provision of visual aids and phase structures, adjustment of foundations and boundary conditions, requirement of loads and loading integration, analysis specification and design instruction— comparison of composite materials and reinforced cement. From the survey, it was finalized that the RCC column provided satisfactory results under the constant loading conditions. The composite structure with less dead weight compared to the RCC structure and with increasing migration of co-deliver floor node displacement is also growing.

III. METHODOLOGY

A model of G+11 storey for multicolumn building and mono-column building is created, investigated, and configured using ETABS V17 design software. AUTOCAD 2020 is used for the planning of building drawing. Building measure is 15m x 17m is located on site at multicolumn building. The building is arranged in

zone III. Seismic zone coefficient is taken as 0.16 according to IS code. Grade of concrete used for multicolumn building is M25 and for mono-column building is M30. Steel used in multi-column and mono column is Fe415. Following particulars are given to the structure.

Below Table 1 shows the specification for multicolumn structure and mono-column structure. In mono-column structure inclined RCC struts is provided to reduce deflection. Total 8 number of struts are provided in structure at first slab. Mono column is taken as shear wall at all four side at the center of building. The two types of braces are used in structure as X-type and V-type for comparison and for better result of structure.

Table 1: Specification for Multi-column and Mono column building structure.

Sr. No.	Structural component	Multi-column building	Mono-column building
1	Column specification	300 mm x 450 mm 300 mm x 525 mm 300mm x 600 mm 300 mm x 700 mm	300 mm x 600 mm 450mm x 600 mm
2	Beam specification	300 mm x 450 mm	450 mm x 600 mm 900 mm x 600 mm
3	Slab specification	150 mm	150 mm
4	Struts	No	8 struts at base
5	Specification of struts	No	370 mm x 450mm
6	Braces	No	X type, V type
7	RCC wall	No	610 mm

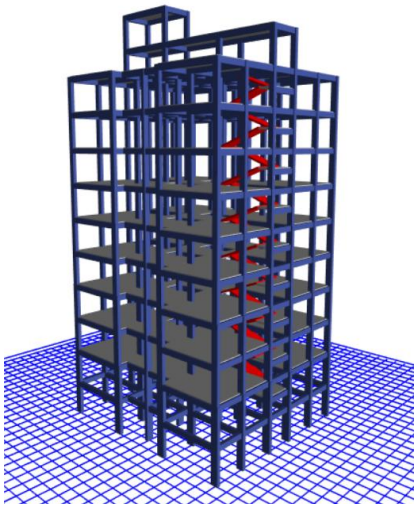

Figure 2: Multi-column building

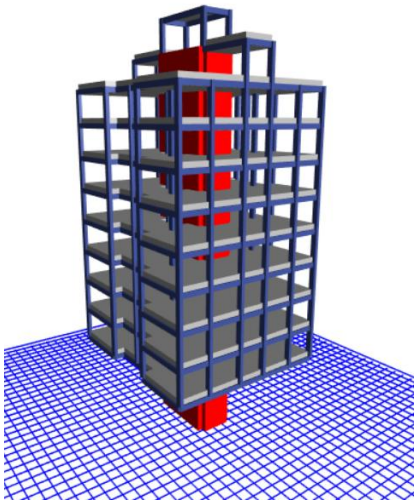

Figure 3: Mono-column building

3.1 STRUCTURE ANALYSIS IN E-TABS DESIGN SOFTWARE

3.1.1 MULTI-COLUMN BUILDING

Below mentioned Figure 4 and Figure 5 shows the bending moment and shear force diagram for multi-column building. which is required to design multi-column building with maximum bending moment and shear force.

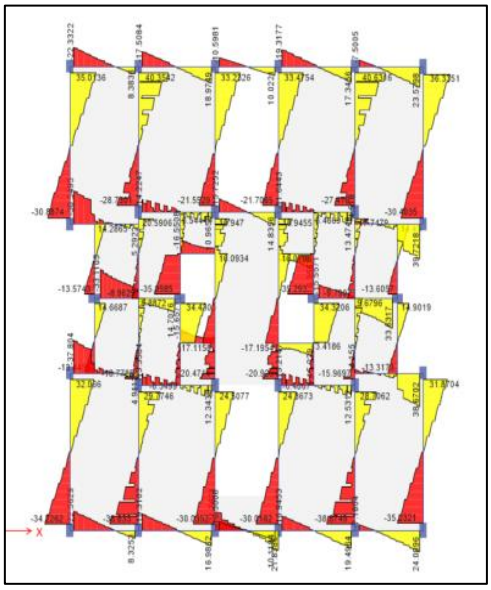

Figure 4: Bending Moment Diagram for multi-column building

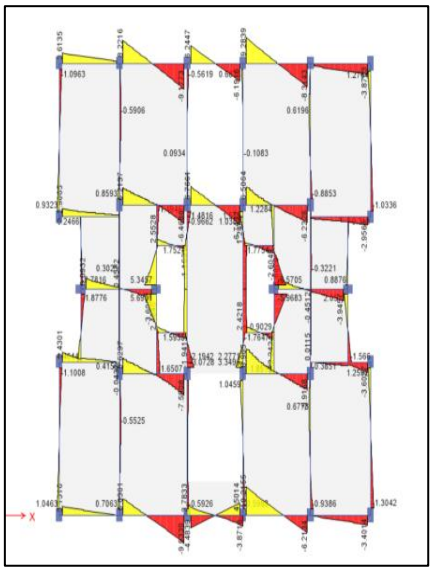

Figure 5: Shear Force Diagram for multi-column building

3.1.2 MONO-COLUMN BUILDING

Below mentioned Figure 6 and Figure 7 shows the bending moment and shear force diagram for mono-column building. which is required to design mono-column building with maximum bending moment and shear force.

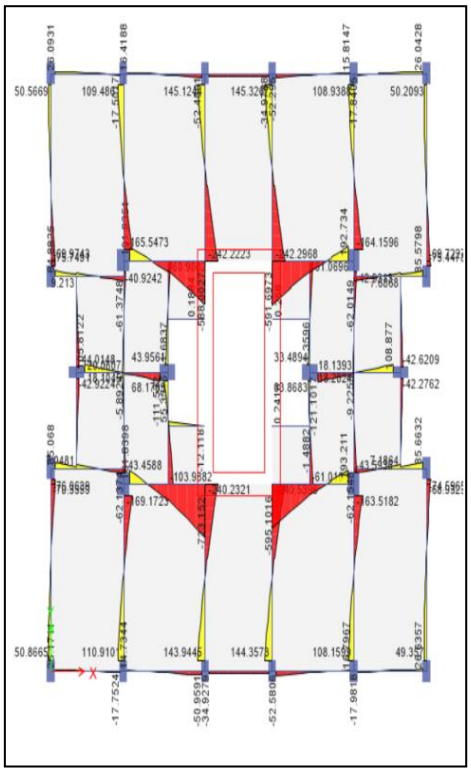

Figure 6: Bending Moment Diagram for mono-column building

The structural analysis of multi-column building, and mono-column building is derived using bending moment diagram and shear force diagram. The analysis is carried out according to the code IS 1893-2016(part 1). Here, the type of soil, seismic zone factor should be entered from IS 1893-2016. The type of soil and seismic zone factor is applied to building for analysis in ETABS 2017 software.

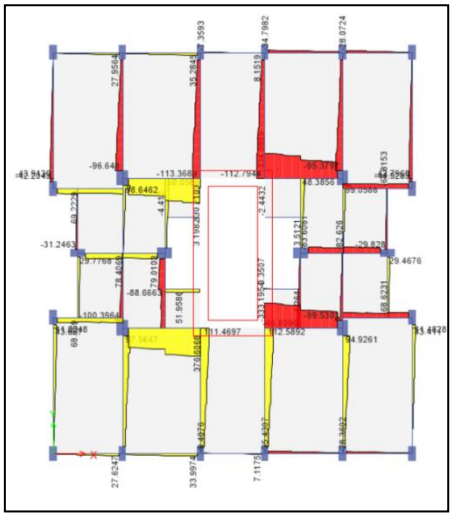

Figure 7: Shear Force Diagram for mono-column building

IV. RESULT AND ANALYSIS

Below mentioned Table 2 shows the result of storey drift for multi-column structure and Mono-column structure for X-type braces and V-type braces. The value of drift result for mono-column structure is higher than the Multicolumn structure but all value for drift is as per the IS code as is not more than 0.004.

Table 2: Result of Storey drift

STOREY	MONOCOLUMN STRUCTURE (X-BRACES)	MULTICOLUMN STRUCTURE	MONO-COLUMN STRUCTURE (V-BRACES)
Storey 1	0.459	1.273	0.451
storey2	1.276	2.876	1.257
Storey3	2.374	4.685	2.319
Storey4	3.6	6.499	3.536
Storey5	4.908	8.428	4.857
Storey6	6.265	10.27	6.248
Storey7	7.648	12.038	7.677
Storey8	9.039	13.588	9.123
Storey9	10.425	14.843	10.597
Storey10	11.799	15.731	11.996
Storey11	13.172	16.659	13.42
storey12	14.73	17.257	15.004

Table 3: Result of Displacement

STOREY	MONOCOLUMN STRUCTURE (X-BRACES)	MULTICOLUMN STRUCTURE	MONO-COLUMN STRUCTURE (V-BRACES)
Storey 1	0.00011	0.0002	0.00011
storey2	0.00023	0.0002	0.00027
Storey3	0.00036	0.0003	0.00035
Storey4	0.0004	0.0005	0.0004
Storey5	0.00043	0.0005	0.00044
Storey6	0.00045	0.0005	0.00046
Storey7	0.00046	0.0006	0.00048
Storey8	0.00046	0.0006	0.00049
Storey9	0.00046	0.0007	0.00049
Storey10	0.00045	0.0007	0.00049
Storey11	0.00045	0.0007	0.00047
storey12	0.00054	0.0007	0.00056

Above Table 3 shows the result of displacement for multi-column structure and Mono-column structure for X-type braces and V-type braces. The displacement result for mono-column structure is less than the Multicolumn structure.

Below mentioned figure 8 shows the graphical representation of comparison for mono-column structure with X-type braces and V-type braces and multi-column structure for storey drift. and it clearly shows that the value for mono-column X-type braces structure is more than other type structure.

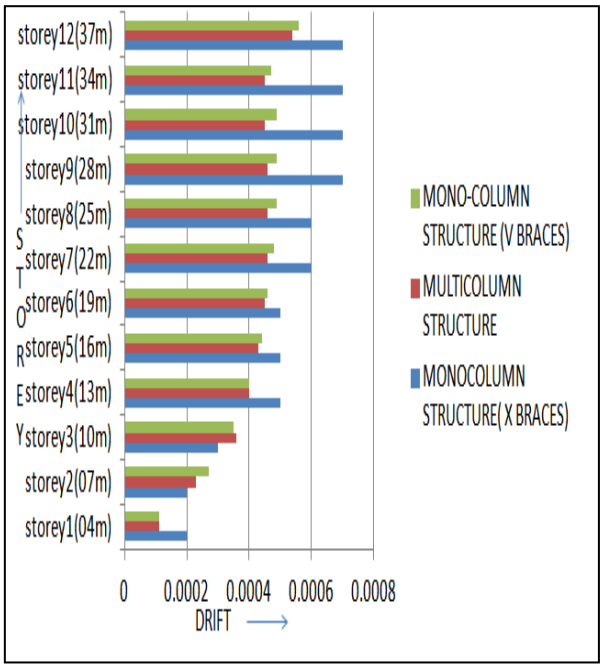

Figure 8: Value of storey drift for multi-column and mono-column structure

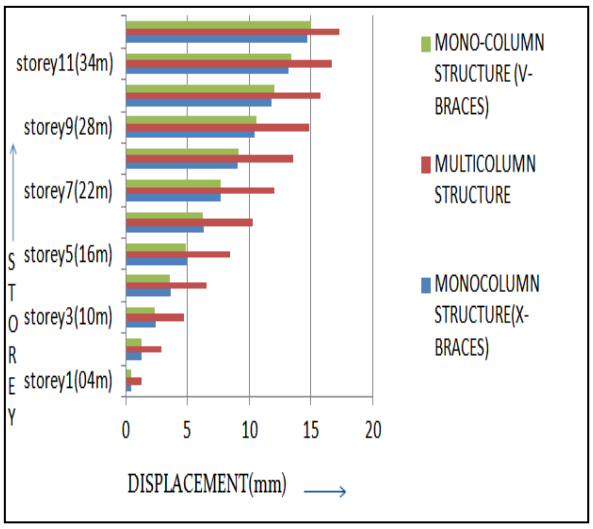

Figure 9: Value of displacement for multi-column and mono-column structure

Above Figure 9 shows the graphical representation of comparison for mono-column structure with X-type braces and V-type braces and multi-column structure for displacement. and clearly shows that the value for mono-column X-type braces structure is less than other type structure.

Table 4: Quality of Control and cost

Concrete quantity and cost		
Building type	Concrete quantity (cum)	Cost (Rs)
Monocolumn building	940	31,00,000
Multicolumn building	383	13,02,200

Above Table 4 shows the quantity of concrete in cum unit and it is cost for the mono-column building and multi-column building based on the concrete quantity for the comparison of multi-column and mono-column building.

V. CONCLUSION

The Mono-column structure and multi-storey conventional RCC structure are analysed for static and dynamic loading for different parameters. When the results of both structures are compared with specifications and its values, it is concluded that mono-column structure with X-type braces makes the building structure more serviceable compared to the multicolumn structure. It is concluded that the storey drift for mono-column building is more than the multi-column building and the result is verified under the permissible limit as per IS 1893-2016.In mono-column building, the displacement is increased with the increment of the height of the building. Mono-column structure is providing large column free space as compared to conventional RCC building comprising with safe design criteria. The cost of the mono-column building is more than the multicolumn building. However, it offers more facility, space compared to multi-column building.

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