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ANALYSIS & DESIGN OF COMMERCIAL BUILDING WITH DIFFERENT SLAB ARRANGEMENTS USING SAP2000

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ABSTRACT

The analysis and design of structures are influenced by earthquakes. A structure's behaviour under particular load combinations is determined through an analysis process. The process of determining suitable requirements for the construction is called design. Manually, the design of the structure and the analysis would take a long time. Any structure's study and design can be completed quickly using the software. The main goal of this study is to analyse and construct a commercial building using various slab configurations, including flat slabs, grid slabs with drop panels, and conventional slabs. A structure is considered commercial if at least half of its floor area is devoted to business purposes. Buildings with various slab layouts and the impact of seismic and wind forces has been analysed by utilising SAP2000 software. The engineering software programme SAP2000 is used for structural analysis and design. The IS 456-2000 code book is used for analysis and design, and M30 grade concrete and Fe500 steel are used. According to Design Code IS-875, dead load is taken (Part 1). Live loads are calculated in accordance with Design Code IS- 875 (Parts 2) and (Parts 3), while earthquake zones 3 and 4 are used for analysis. Both 1.2 (DL + LL + EQ) and 1.5 (DL + LL + WL) combination are taken into consideration. A number of issues have an impact on how well building's function, including story drift, base shear, and story displacement are key factors in determining how well structures respond to wind and seismic loads. The results are presented using tables and bar charts. Story displacement increased along with story height. In comparison to all other slab arrangements used in the wind and seismic load analyses, the results demonstrate that buildings with grid slabs are more stable.

Keywords: Earthquake loads, Wind loads, Story displacement, Base shear, SAP2000.

I. INTRODUCTION

Essentially, an RCC-framed structure is a collection of interconnected slabs, beams, columns, and foundations. In such a construction, the weight is transferred from the slabs to the beams, from the beams to the columns, from the lower columns to the foundation, and finally to the soil. A building with a R.C.C. frame has a floor area that is 10 to 12 percent larger than one with load-bearing walls. R.C.C. framed buildings can be built monolithically and are more resilient to shocks, vibrations, and earthquakes than load-bearing walled structures. In

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reinforced concrete, reinforcement with higher tensile strength and ductility is added to compensate for the relatively low tensile strength and ductility of concrete. Before the concrete cures, the reinforcement is typically passively inserted into the concrete.

Testing the fundamental presumptions that other researchers in the field have employed is the core strategy of this study. Even though an assumption has never been rigorously tested or proven, it is entirely conceivable for it to be taken as reality merely because it has been expressed or mentioned by numerous authors. If I can think of a means to test this unproven premise that I had the chance to uncover, my work will be of immeasurable worth to the discipline (provided it is well executed)
These days, technology is developing at an alarming rate. Every person needs to be knowledgeable about the most recent technologies because they occasionally make life easier. The process of changing technology and making complex things as simple as feasible involves great scientists and a creative work force. With the use of this study, I will learn about the newest technologies, compare some results, and determine how accurate the outcomes produced by technology utilised in our area are. The following is a summary of the considerations that will be made while conducting the research: Nowadays, various software is used as a result of my research, which I can now contribute to my technological expertise. From now on, I will be able to complete a variety of jobs, whether they include constructing or another type of structure. Since I had to address many different difficulties in college, things had been really difficult for me up until this point. However, using software for designing or analysing a framework doesn't require a lot of work. When altering and building complex models, models may be simply constructed utilising objects and by understanding the ideas.

II. LITERATURE REVIEW

[1] S.V. Mahamuni et al. (2018) have examined the various approaches to grid floor system analysis. He used the Stiffness method, Rankine-Grashoff method, and Plate theory to manually analyse the grid slab. used a number of methods to analyse the grid slab system. The ratio of the hall dimensions (L/B) between 1 and 1.5, with halls having a constant width of 10.00m, is taken into consideration for the study. After employing the theoretical calculations, he discovered that increasing the L/B ratio causes the bending moment in the x direction to increase linearly. The analysis's lowest bending moment in the x direction will be determined by utilising the Rankine-Grashoff method, which is the lowest value of all the methods utilised.
[2] R.S.More et.al (2015) has carried out analytical research on various flat slab types that have been subjected to dynamic loads. The maximum drift is between a flat plate and a grid floor slab. Drift is less than with other slabs of grid. He concludes that all slabs deflect to a certain extent when the strata are of type 1, or rock or hard soil. For a specific type of slab, there is a clear association between a rise in shear force and storey drift and a change in soil condition.
[3] Sudhir Singh Bhaduria et.al (2017) have examined the designs of the flat slab, grid slab, and traditional slab systems in comparison studies. Investigations revealed that flat slab constructions are more economically sound than other slab systems. The grid slab system uses

the least steel and concrete compared to the flat slab system. We find that the grid slab system has maximum bending moment, maximum displacement, and maximum force. In the flat slab system, the maximum bending moment, maximum displacement, and maximum force are all discovered to be minimum in every direction.

III. METHODOLOGY

The research consists of numerous factors that are thought to help me get the information I was looking for. The methodology ought to be well-established and useful in real life. Due to their widespread use today, I determined that SAPP2000 would be an appropriate choice for my fact-finding procedure in this research. If there is ever a need for assistance with a technical problem, experts are available.
Below is a brief history of these follow software programmes:
In structural design and analysis various types of software uses like: -

- ✓ One of the most well-known programmes for analysing and designing structures, including as buildings, towers, bridges, industrial, transportation, and utility structures, is STAADPRO.
- ✓ The programme SAP2000 is used to build and analyse structural models. It enables engineers working on transportation, industrial, public works, or other facilities to produce complicated models and conduct extensive testing thanks to its various capabilities offered via a single, customised user interface.
- ✓ ETABS is a piece of engineering software that handles the study and design of multi-story buildings. The grid-like geometry specific to this class of structure is taken into account by modelling tools and templates, code-based load prescriptions, analysis techniques, and solution approaches.
- ✓ The best tool for planning concrete floor and foundation systems is SAFE: it. SAFE unifies every step of the engineering design process, from frame planning to the creation of detail drawings, in a simple and user-friendly setting.

With STAAD PRO's cloud services, many design alternatives may be performed simultaneously and the results can be compared graphically side by side. Using Finite Element analysis, design for seismically active areas or normal conditions. Improve BIM processes for concrete and steel by fully integrating surfaces. SAP2000 will generate and apply seismic, and wind loads automatically based on various domestic and international codes. Users can apply moving loads to lanes on frame and shell parts using SAP2000's powerful moving load generator.

DESCRIPTION OF MODEL TYPE

The model has a base made of concrete and an RCC frame. At each level of the building, this proposal primarily consists of conventional slabs, grid slabs, and flat slabs. The front of the building uses a flat slab to create a beamless space for aesthetic reasons, whereas the interior Buildings have grid slabs to more readily withstand loads and strengthen the structure. By taking into account both flat slabs and grid slabs, we are able to use less closely spaced columns. The following list includes the numerous criteria used in the analysis and design process.

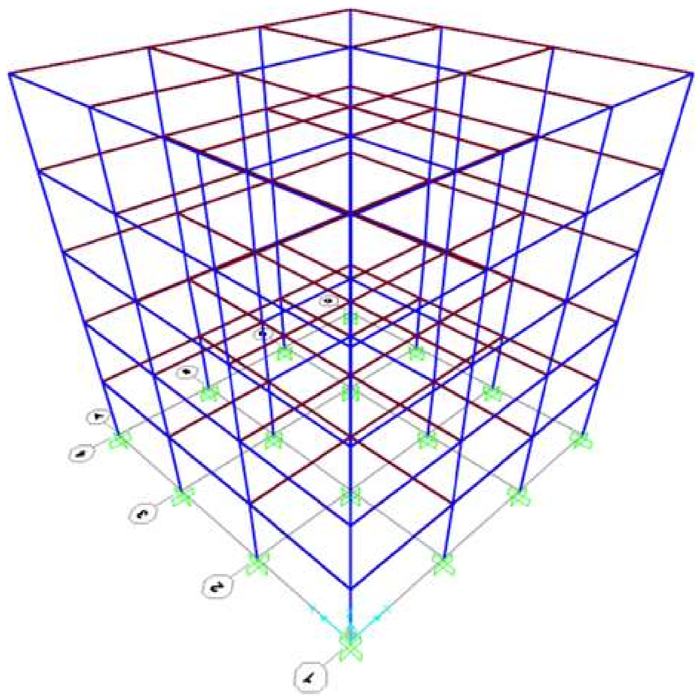

Figure 1: Isometric view of structure

- ➢ Height of each Floor =3m
- ➢ Spacing between two Grids = 4m
- ➢ Five Storey Building
- ➢ Beam Size = 225 mm X 300 mm
- ➢ Column Size's taken = 500mm X 500mm.
- ➢ Conventional Slab Thickness = 150 mm
- ➢ Flat slab thickness = 150mm
- ➢

G

rid Slab Thickness (Waffle Slab) = 650 (Overall) Live load on each floor 3 KN/M^2

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COMPARISON OF RESULTS

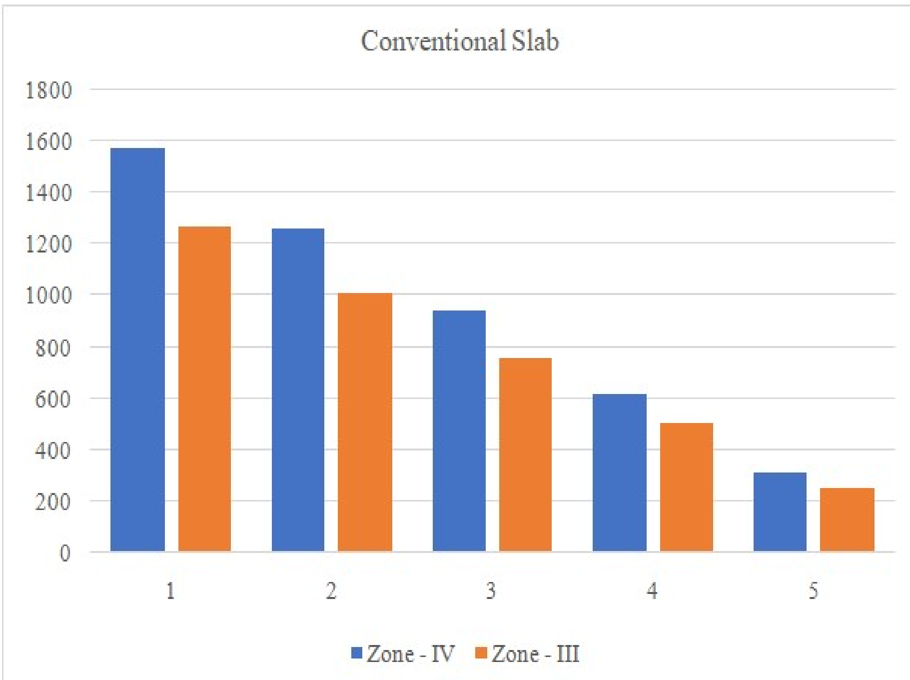


Figure 2: Shear for conventional Slab

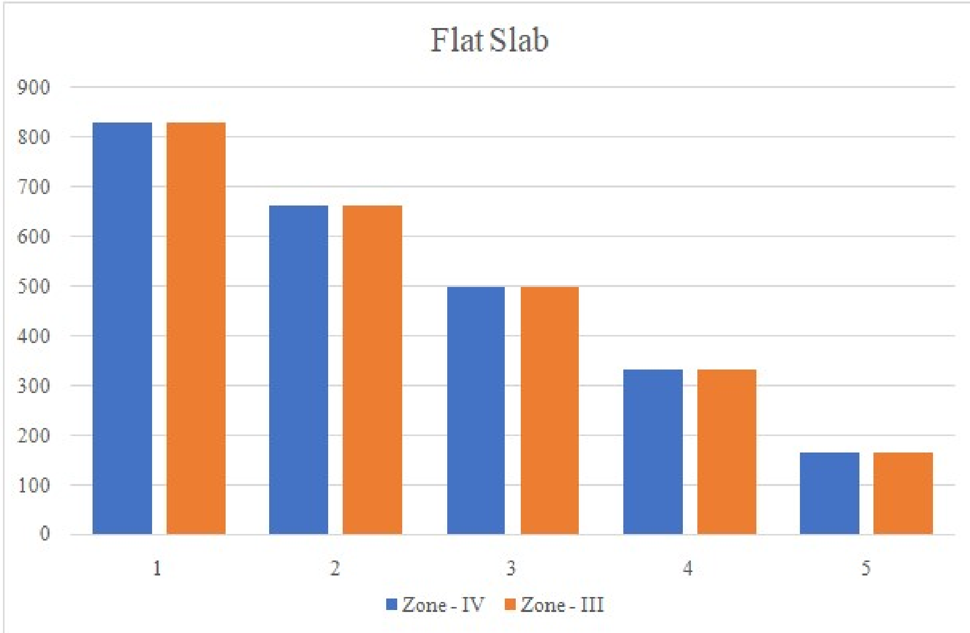


Figure 3: Shear for Flat Slab

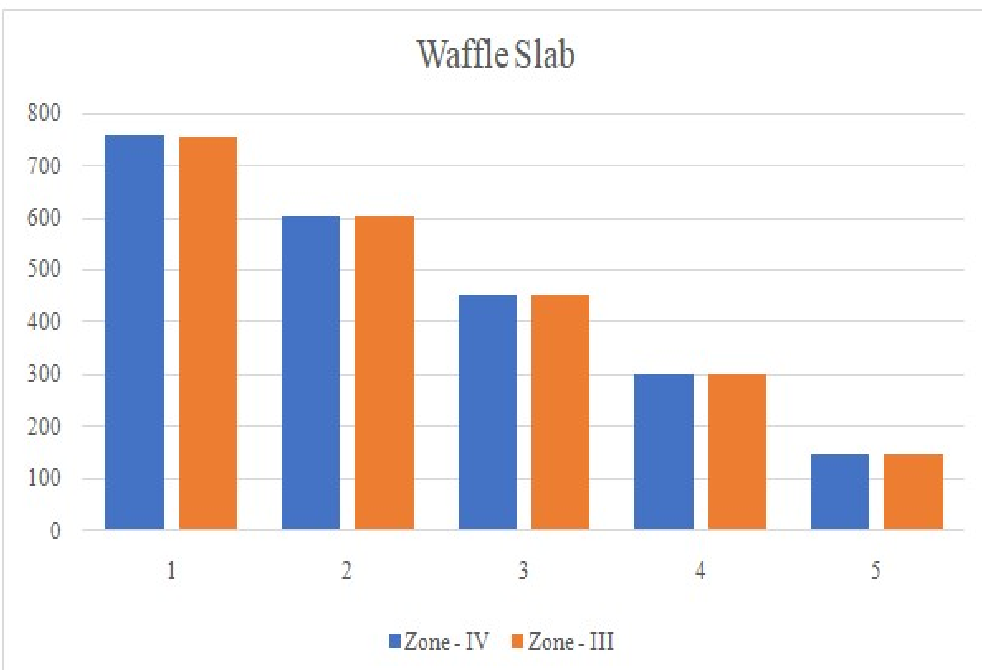
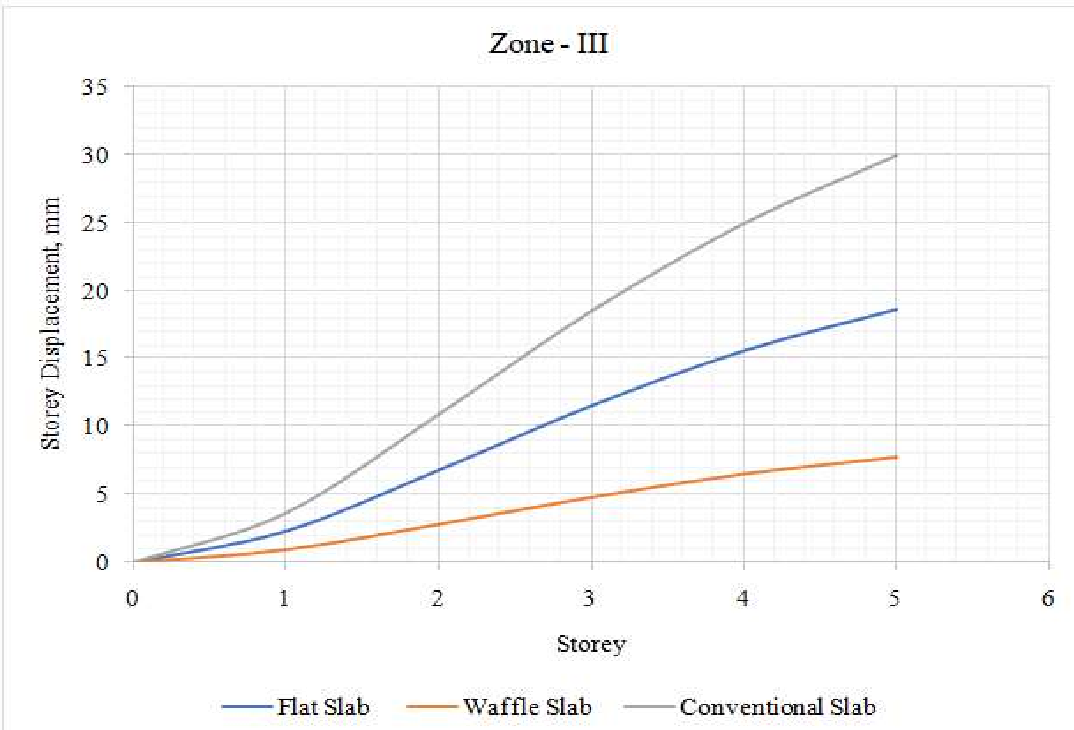


Figure 4: Shear for Waffle Slab

Figures 2,3, and 4 show the base shear for different zones, zone 4 and zone 3, respectively, and the base shear is then represented in the bar diagram. The x axis in the figures above represents story height, and the y axis represents base shear values. The colours blue and orange represent zone 4 and zone 3 base shear, respectively. In a conventional slab, we are comparing the base shear in zones 4 and 3, respectively. Zone 4 has the highest base shear, and zone 3 has the lowest base shear. So, the shear is maximum at the base floor and minimum at the top floor. In this slab, the base shear varies in zones 4 and 3 at each floor. In a flat slab, we are comparing the base shear in zones 4 and 3, respectively. Here we have neutral base shear in zones 4 and 3. So the shear is maximum at the base floor and minimum at the top floor. In waffle slab, we are comparing the base shear in zones 4 and 3, respectively. Here we have neutral base shear in zones 4 and 3. So the shear is maximum at the base floor and minimum at the top floor.

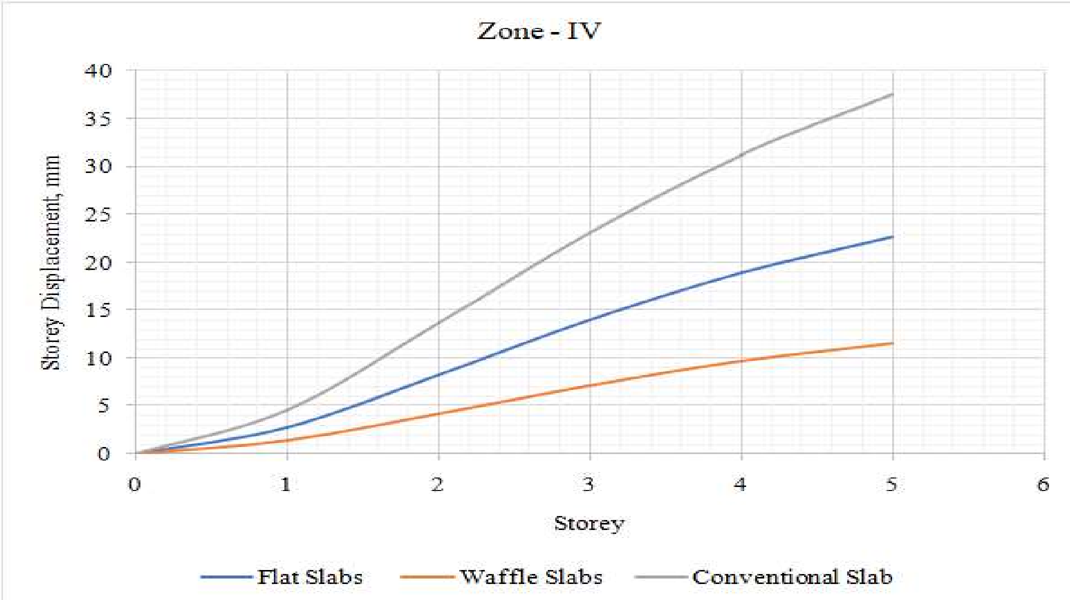
Comparison of Story Displacement for different Zones

Graph 1.1: Story Displacement for Zone III



The graph above depicts storey displacement along the y axis and storey height along the x axis. So, we are comparing three types of slab displacements, as shown in the above graph. The displacement is shown in different colours for different slabs, with the conventional slab in black, the flat slab in blue, and the waffle slab in red. The conventional slab has more displacement compared to the flat and waffle slabs. The flat slab has less displacement compared to the conventional slab and more displacement compared to the waffle slab. Finally, waffle slabs have less displacement, as shown in Graph 1.1. Hence, we have less displacement in waffle slabs and more stiffness in waffle slabs because we used more waffle beams to overcome deformation in slabs.

Graph 1.2: Story Displacement for Zone IV



The graph above depicts storey displacement along the y axis and storey height along the x axis. So, we are comparing three types of slab displacements, as shown in the above graph. The displacement is shown in different colours for different slabs, with the conventional slab in black, the flat slab in blue, and the waffle slab in red.

The conventional slab has more displacement compared to the flat and waffle slabs. The flat slab has less displacement compared to the conventional slab and more displacement compared to the waffle slab. Finally, waffle slabs have less displacement, as shown in Graph 1.2.

Hence, we have less displacement in waffle slabs and more stiffness in waffle slabs because we used more waffle beams to overcome deformation in slabs.

CONCLUSIONS

The methods used to evaluate the performance of multiple slabs within a single building may differ, but the basic objective remains the same: evaluating the effectiveness from a structural standpoint. To understand how the slab and beams will respond collectively to external loading, static and dynamic analysis is being done. Numerous studies have examined economical sections under various load circumstances. Grid slabs are used to minimise storey drift. After reading through all of these articles, I discovered that a grid slab is not required from an economic standpoint.

However, grid slabs are extremely crucial for constructing significant structures that require enormous expanses. Some structural engineers advise installing floating columns in parking lots, open areas, etc., but this requires additional reinforcing for neighbouring beams and columns that don't receive the same loading that the floating column does.

To understand how grid slabs and flat slabs relate to one another, how they depend on surrounding beams, and how this affects section details and reinforcing. I reached to the conclusion from this research by looking over some of the earlier studies that :

1 If we look at it from an economic perspective, a flat slab is preferable to a grid slab for design purposes.
2 In comparison to grid slabs, flat slabs have less reinforcement.
3 Grid slabs' rigidity and ability to support longer spans reduce the number of columns that must be provided. However, because they are not supported by beams, flat slabs are unable to withstand so much weight.
4 In comparison to grid slabs, flat slabs are found to be under the most stress. Therefore, flat slabs will have a greater possibility of cracking.
5 As found in analysis result stress is minimum at column joints in both the cases but in case of flat slab drop panels are used to minimize stress on columns. Drop panels distribute loads evenly from all directions
6 Since flat slabs are not supported by beams, deflection occurs more frequently in their case, whereas grid slabs exhibit superior deflection resistance.
7 By conducting this research, I came to the conclusion that grid slabs must be used to create a frame that is as rigid as feasible for any major project, such as a public building. In contrast, it will cost more but be sturdier and safer than flat slabs. Flat slabs are typically employed when we wish to offer a different architectural look for the structure while also prioritising aesthetics.
8 In zones 3 and 4, comparing flat slab, conventional slab, and waffle slab, we get less displacement in the waffle slab, which is safer for public buildings.
9 Check the slab behavior in both zones to determine the appropriate type of slab, and here the waffle slab is good to resist loads, has more reinforcement, and has a drop panel.
10 When designing a long span building on SAP2000, it is evident that ETAB provides the best results for reinforcement data. This is the primary explanation I discovered when conducting this inquiry. Second, SAP2000 provides the reinforcement detailing with drawings as separate tables.
11 If using SAP2000, failing members can be checked immediately following the design phase. Design Engineer can modify the section of those members by placing them in "see chosen objects only" after selecting them under "Check failed members" in the design section. Then, in order for those members to pass the specified loading, the section is modified. Because SAP2000 requires several steps to finish a design by assigning each design parameter, results were obtained by using this programme.

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