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Structural Building and Cost Optimization with Different Floor System

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ABSTRACT

The analysis is a technique for determining the ways of a structure under various load combination. Design is the procedure of achieving convenient description for a structure. It takes a long time to manually plan and analyse a structure. The goal of any structural design process is to produce a safe design that meets all the design codes requirements, while trying to minimize the cost of the design. Until recently, this process was based on the judgment of the designer. Optimization in structural design is a recent concept that has been introduced and used in the last couple of decades to find the optimum designs based is more accurate compared to human judgment. Then it is applied to the design of the whole structure, considering seismic load. The model resulted in savings of 6.7-9% for the slab optimization compared to the original design, and 8.5% for the high-rise structure optimization, compared to the original design. For high-rise structures, these savings mean hundreds of thousands of dollars. This is the start of a new structural design software era, where the whole structural design is performed using inclusive software that guarantees minimum time and cost for a structurally sound design. This paper discusses various optimization techniques and applies them to real world cases like reinforced concrete structures in virtual environment. The study includes survey of structural optimization principles, procedures, software tools available for structural design & analysis. Further, it discusses about the optimization of multi-storey reinforced concrete structures (RCC) building structure using structural analysis software like STAAD-PRO.

KEYWORDS: *Floors system, storey displacement, storey drift, storey shear, base shear, Economics of slab construction Optimization, Structural analysis, STAAD-Pro*

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INTRODUCTION

While designing the structures, the optimization plays a crucial role in order todevelop cost effective, more robust and safe designs. In general, the structural optimization is performed by “trial and error” or “one factor at a time” methods, although fact is that they are very less effective as well as less efficient. Present optimization techniques are improved significantly over years. The exponential advancement in the computational capabilities in last few decades helped the seamless integration of optimization procedures in structural designs. The primary requirements for optimization are detailed mathematical models based on thephysics. Once these models or transfer functions are developed – they can be coupled with suitable optimization algorithm. Specifically for structural design problems, the structural analysis and optimization algorithms are combined through optimization procedure, in order toachieve the desired objectives and solutions. From the perspective of a structural engineer, a tall structure or multi-story building may becharacterized as one that, by virtue of its height, Height is modified to some extent by lateral forces caused bywind, earthquakes, or both. They play a crucial part in the design of the structure.

Tall structures have always captivatedme. Humans since the dawn of civilization The Egyptian Pyramids are one of the world's most famous structures. Because of its apparent practical value, it has been the topic ofintensive research since the late 1950s, resulting in a large body of literature. Various marketed project management software packages have been created and used in actual project management situations over the years. Despite all of these efforts, a large number of publications have failed. The purpose ofthis work is to compare and contrast current project scheduling theory with current project scheduling practice, namely the usage of commercial project scheduling software. While project management and cost engineering have come such a long way, we still see far too many major budget overruns and delays. There is a solution to the massive problem of budget overruns. During the later TYPE OF SUSPENDED FLOOR:-

Ribbed slab
Flat slab
Flat plates slab

decennials, the Successive Principle wasused to show this. It has proven in practice that correct, unbiased decisions can be made. Statistical projections of the project's real cost or other critical metrics. Given the circumstances, the findings presented here may be surprising. Cost overruns have a well-documented history. These principles have been generally recognized by top management in Scandinavia. Professional project management has improved as a result of it.

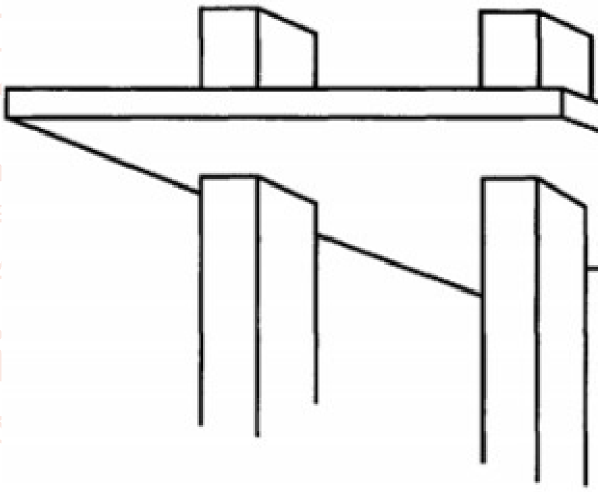
Fig:- Tall Building with MultistoriedBuilding

Slab with beam

Ribbed slab:- Monolithic joists are sometimes known as pan-joist floors, because they are cast on steel forms called pans. The strength of a joist system is determined mainly by the depth and spacing of the joists. Joists are typically 150–500 mm (6–20 in) deep and about 600mm (2 ft.) apart.

Flat slab:- The difference between the flat slab and the flat plate is that the flat slab has thickened parts above the columns or piles. The thicker parts aid in punching shear resistance. The flat slab is more difficult to construct than the flat plate, butit uses materials more economically.

Flat plates slab:- The flat plate is the most basic two-way floor since its thickness remains constant throughout. Its biggest benefit is how simple it is to put together. Because the soffit (underside of the floor) is flat, erecting formwork is simple. Because formwork may account for more than half of a floor's cost, a design that allows for basic forms is appealing to many people. Flat plates also help to reduce the height of the story.



LITERATURE REVIEW:-

Ullmann , Skolicki and Freischlad (2020) design both steel and concrete structural systems through the introduction of evolutionary design processes and tools. In their paper, they provided a general overview of structural design of reinforced concrete structures in tall buildings. They included the comparison of various selection strategies and the comparison of evolutionary design processes when crisp and fuzzy evaluation of designs was used.

Stark (2012) used the traditionally "steel structures" and "concrete structures" formed more or less two different worlds in structural engineering. He showed that each of the two materials has advantages and disadvantages and that often an optimal solution was found bycombining both materials. This might be a combination of steel and concrete in an element as is the case in "Composite steel-concrete construction" or the combined used of concrete elements and steel elements in "Mixed construction".

Guerra and Kiousis (2019) showed the optimal sizing and reinforcing for beam and column members in multi-bay and multistory RC structures incorporates optimal stiffness correlation among all structural members and results in cost savings over typical-practice design solutions. A Nonlinear Programming algorithm searches for a minimum cost solution that satisfies ACI 318-05 code requirements for axial and flexural loads. Material and labour costs for forming and placing concrete and steel were incorporated as a function of member size using RS Means 2005 cost data. Successful implementation demonstrated the abilities and performance of MATLAB's (The Math works, Inc.) Sequential Quadratic Programming algorithm for the design optimization of RC structures. A number of presented examples demonstrated the ability of this formulation to achieve optimal designs.

Anderson (2020) used continued and further development. It was appropriate to do this at the present time when documentation and software were needed to introduce the Eurocodes. Approximated methods still had a role, in initial design. For unbraced frames early consideration needs to be given to limiting sway in service conditions. A very simple formulation was presented, to enable section sizes to satisfy this criterion.

Kose and Sirikci (2019) showed the use of concrete and steel structures with the same floor planes. The design and cost of the structures were compared with each other. Concrete structure was designed by using STA4CAD software. Design of steel structure was performed using elastic and plastic design method. Elastic design of steel structure was performed by using SAP2000 software. In plastic design process, rigid plastic hinge method was used. A separate computer program was written for plastic design of steel structure to run with SAP2000. Member-end forces determined by SAP2000 and then to the computer entered code to find the location of plastic hinges. Model in SAP2000 was then modified by entering the plastic hinges and then rerun. Cost comparison of these three structures was performed. It was found that plastic design procedure reduced total cost of the structure up to 16% for the selected floor plan. Although cost of steel structure is higher than concrete structure, completion time of steel construction is about one third of completion time of concrete structures.

Jayachandran (2018) design a tall buildings essentially involved a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria were strength, serviceability, stability and human comfort. The strength was satisfied by limit stresses, while serviceability was satisfied by drift limits in the range of H/500 to H/1000. Stability was satisfied by sufficient factor of safety against buckling and P-Delta effects. The factor of safety was around 1.67 to 1.92. The human comfort aspects were satisfied by accelerations in the range of 10 to 25 milli-g, where g=acceleration due to gravity, about 981cms/sec^2. The aim of the structural engineer was to arrive at suitable structural schemes, to satisfy these criteria, and assess their structural weights in weight/unit area in square feet or square meters. This initiates structural drawings and specifications to enable construction engineers to proceed with fabrication and erection operations. The weight of steel in lbs/f2 or in kg/m2 was often a parameter of the architects and construction managers whom looking for the structural engineer. This includes the weights of floor system, girders, braces and columns.

Sara A. Babiker, Fathelrahman. M. Adam, Abdelrahman E. Mohamed (2019) titled "Design Optimization of Reinforced Concrete Beams Using Artificial Neural Network" discusses an Artificial Neural Networks (ANN) model for the cost optimization of simply supported beams designed according to the requirements of the ACI 318-08 code. The model formulation includes the cost of concrete, the cost of reinforcement and the cost of formwork. A simply supported beam was designed adopting variable cross sections, in order to demonstrate the model capabilities in optimizing the beam design. Computer models have been developed for the structural design optimization of reinforced concrete simple beams using NEURO SHELL-2 software. The results obtained were compared with the results obtained by using the classical optimization model, developed in the well-known Excel software spread sheet which uses the generalized reduced gradient (GRG). The results obtained using the two modes are in good agreement.

Objectives:

Structural optimization of Design of Building and Cost Optimization with Different Floor System

- Survey of historical & recent development in this field
- Survey of Optimization Techniques, types, methodologies
- Design Analysis and optimization of multi-storey building with the help of STAAD-PRO, MINITAB software and Evolutionary Algorithm.

METHODOLOGY:-

Moreover, it will describe the procedures, plan, size and dimension of members, this study focuses on comparing floor system with slab with beam and flat plate system. To design those models the ″Etabs 2016″.

MATERIALS

Concrete compressive strength is 25MPa.

Steel yield tensile strength is 420MPa. Reinforce Concrete Frame

In this research Estimated for three modelsthat only their span length are differentbetween models for two different type of slab that are flat plate system and slab withbeam system The plan shown is a School .

Column size is 400 × 400 mm .Live Load : is equal to 3.83

For design those models the ″ Etabs 2016″program are used by this procedure:

1. Selecting the design systems.
2. Selecting the grid and stories.
3. Defining the material used :

➢ Concrete compressive strength 25MPa

➢ Steel yield tensile strength is 420MPa

4. Defining the frame properties :

➢ Slab with the selected depth concretecompressive strength.

➢ Beam with required depth and width and concrete compressive strength and steel yield tensile strength.

5. Drawing the frame for all six models.
6. Choosing the load pattern for dead loadand live

Table Minimum thickness of slab and minimum depth and width of beams

Type of slab	Span length (m)	Minimum Slab thickness (mm)	Beam	
			Minimum Width (mm)	Minimum Depth (mm)
flat plate slab	6	190		
	7	220		
	8	260		
slab with beam	6	150	220	330
	7	220	270	380
	8	230	300	440

load and super dead load.

7. Choosing the load combinations for concrete frame and concrete slab design.
8. Appling the live load and super dead load on the floor and beam in the slab withbeam models and on the floor in a flatplate models, don't applying the dead load of the frames because the program automatically applying it .
9. Run the model and in display determined the moment and shear and deflection of all frame required.
10. Designing the frame and concrete reinforced slab that displayed the steel required.
11. In detailing can take all detail required

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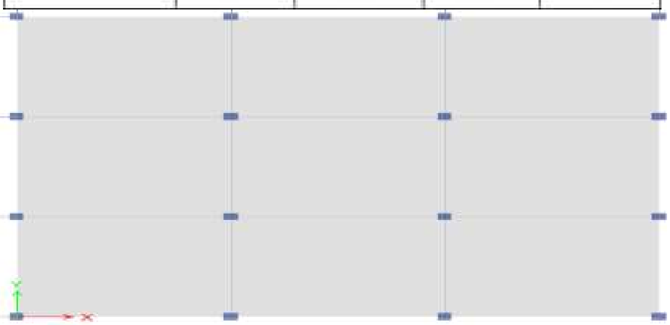

Figure the top view plan of school

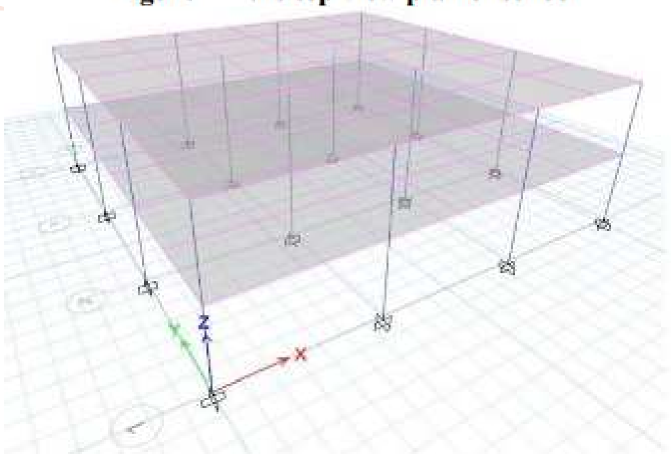

Figure 3D plan of the school

Result and Discussions:-

The constraints are drawn and seen in the following figures after studying all five cases structures in the ETABS. The two load combinations preferred from all of theload combinations considered are EQX and EQY. Displacement, Drift, Shear Force, Base Shear have been calculated to find out the effect in the building.

This part includes quantity surveying workwhich is required to estimate the quantitiesof various required materials and the labor involved for satisfactory completion of the construction project. Tables 3 to 6 present the quantities for each element of theb uilding with different floor system.

Table 3. Quantities estimation of FPS

Type of member	Concrete Volume (m^3)	Steel Bar (ton)	Formwork (m^3)	No. of Blocks
Footing	29.17	0.83	1.73	-
Column neck	2.28	0.58	1.01	-
Columns	14.42	2.48	6.55	-
Floor Slab	81.40	6.97	20.69	-
Drop beams	0	2.44	0	-
Total	**127.27**	**13.3**	**29.98**	

Table 4. Quantities estimation of SSS

Type of member	Concrete Volume (m^3)	Steel Bar (ton)	Formwork (m^3)	No. of Blocks
Footing	28.56	0.83	1.72	-
Column neck	2.07	0.51	0.95	-
Columns	13.11	2.18	6.15	-
Floor Slab	61.05	6.21	20.69	-
Drop beams	14.06	3.63	3.64	-
Total	**118.85**	**13.36**	**33.15**	**-**

Cost Estimation:-

ost estimation in construction projects is an important factor for decision making in all the project phases. The cost estimating for construction project starts in the planning phase or in feasibility study to determine the required financial requirements. Then in the construction phase, the actual cost is estimated and compared with the planned cost to assess the variation cost. The successful estimating process essentially depends upon estimator's experience, and acquaintance with achieving an accurate cost assessment; which shouldn't be different a lot from the actual cost. The results of cost estimation are summarized in table 7 to 10. For each floor system and regarding the cost of materials and labor of the floor slab system, the results show that the use of flat plate system saves 31.40 % in comparison with solid slab system, 18.27% in comparison with two way ribbed slab system, and 17.99%in comparison with one way ribbed slab system. In addition, the results show that the use of flat plate system compared to other types of slab systems reduces the total cost of construction.

DISCUSSION & CONCLUSION:-

1. For all system floors, the cost constitutes the major part of the totalstructural cost of reinforced concrete residential building.
2. The cost of floor slab may range from13 to 16 % of the structure cost in building work. The percentages are
3. Using flat plate system is more economical than any other systems.
4. The flat plate system is economicalsince it has no beams. So it can reduce the floor height by (10-15) %.
5. The Results figure out that using flat plate system reduces the total cost of construction by 7% compared to the solid slab system, 4 % compared to the one way ribbed slab system, and 3.33% compared to the two way ribbed slab system.

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