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A COST ANALYSIS AND COMPARISON BETWEEN VOIDED SLAB & SOLID SLAB.

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Abstract :- ***In the following study the G + 3 Building has a Solid Slab compared to the economic Voided Slab. Plastic voided slabs provide comparable load carrying capacity to traditional flat plate concrete slabs but weigh extensively much less. traditional flat plate reinforced concrete slabs by describing how the slabs are constructed and resulting advantages and disadvantages of this construction. Before plastic voided slabs can be fully understood, a thorough knowledge of Solid reinforced concrete slabs- behavior, failure mechanisms, design, and limitations- is critical. When designing a reinforced concrete structure, the main design limit is the length of the slab between the columns. Then according to the specified criteria assigned it analysis the structure and design the members with reinforcement details for reinforced concrete frames .Building construction is the engineering deals with the construction of building such as residential houses. The design procedure and failure mechanisms for solid slabs are also described, whereas discusses the principles of voided slabs that led to the eventual invention of plastic voided slabs including previous applications of voided slab principles. Plastic voided slabs dispose of concrete from non-essential regions and update the eliminated concrete with hollow plastic void formers at the same time as reaching similar load capacity as solid slabs. A brand new method to reduce the burden of concrete structures and growth the spans of way strengthened concrete slab systems turned into evolved in the Nineteen Nineties in Europe and is gaining reputation and attractiveness worldwide. Everyone wants to have a comfortable home on average, usually spending two thirds of their life in the house***

I. INTRODUCTION

Sharan Kumar et al ; 2021 Building construction is the engineering deals with the construction of building such as residential houses. The buildings are an important indicator of the progress of the regional community. Everyone wants to have a comfortable home on average, usually spending two thirds of their life in the house.

Uday Kumar et al :2017 Buildings come with a wide range of shapes and functions, and have changed throughout history due to many different factors, from available building materials, weather conditions, to global prices, landscapes, special uses and aesthetic reasons. The design process of a multi- storey building requires not only thought and conceptual thought but also a thorough knowledge of architectural engineering without knowledge of practical aspects, such as recent design codes, bye rules, based on sufficient experience, intuition and judgment. The purpose of the standards is to ensure and improve security, to maintain the balance between economy and security.

Kivanc Taskin et al ; 2014 In this context, many new construction methods have been developed. Thus, that buildings are constructed economically and quickly to meet the needs of the people. The structure of a building is a three-dimensional structure consisting of a column,

beams and slabs due to population growth, higher structures are required. In the following study the G + 3 Building has a Solid Slab compared to the economic Voided Slab When designing a reinforced concrete structure, the main design limit is the length of the slab between the columns. Designing large spaces between columns usually requires the use of supporting beams and / or very dense slabs, thus increasing the weight of the structure by requiring the use of a large amount of concrete. Heavy buildings are less desirable than light structures in earthquake-prone areas because the heavy dead load of the building increases the size of the stressors that have to withstand the structure Finishing and closing materials.

Dr. K. B.Parikh (2020) A brand new method to reduce the burden of concrete structures and growth the spans of way strengthened concrete slab systems turned into evolved in the Nineteen Nineties in Europe and is gaining reputation and attractiveness worldwide. Plastic voided slabs provide comparable load carrying capacity to traditional flat plate concrete slabs but weigh extensively much less. This weight loss creates many advantages that ought to be taken into consideration by engineers figuring out the structural gadget of the building. Plastic voided slabs dispose of concrete from non-essential regions and update the eliminated concrete with hollow plastic void formers at the same time as reaching similar load capacity as solid slabs.

(Qasim ; 2016). Before plastic voided slabs can be fully understood, a thorough knowledge of Solid reinforced concrete slabs- behavior, failure mechanisms, design, and limitations- is critical. Chapter 2 discusses traditional flat plate reinforced concrete slabs by describing how the slabs are constructed and resulting advantages and disadvantages of this construction

voided slabs including previous applications of voided slab principles.The main objective of this study is to analyze and design a multi-story building (3D- dimensional reinforce concrete frame), the design of reinforced concrete slabs, beams, columns were calculated by hand calculations according to IS code and Modeled in Etab's to compare the results by using Etab's

Etab's has a very interactive user interface which allows the user to draw the frame and input the load values dimensions and materials properties. Then according to the specified criteria assigned it analysis the structure and design the members with reinforcement details for reinforced concrete frames

A. SOLID SLAB

(Pande et al 2018) Concrete frame structures are a very common - or perhaps the most common- type of modern building. As the name suggests, this type of building consists of a frame or skeleton of concrete. Horizontal members of this frame are called beams, and vertical members are called columns. Humans walk on flat planes of concrete called slabs.

(Pande et al 2018). Concrete floor slabs may be in situ or prefabricated. The in situ concrete slab floor are built using form-work, which is commonly made of wooden planks & boards, plastic or steel & contains steel bars, called reinforcement. Reinforcing steel for slabs is primarily parallel to slab surface. Straight bar reinforcement is generally used, although sometimes alternative cranked bar is used. On the basis of reinforcement provided, beam support, and the ratio of the spans, slabs are generally classified into one-way slab and two-way slab. The former is supported on two sides and the ratio of long to short span is greater than two. However, the latter is supported on four sides and the ratio of long to short span is smaller than two.

Lamba & Chakrortty 2020. Varying conditions and stipulations ask for the selection of appropriate and cost-effective concrete slab, keeping in view, the type of building, architectural layout, aesthetic features, and the span length. Concrete slabs, therefore, are further classified into one-way joist slab, flat slab, waffle slab, hollow core slab, precast slab, Bubble deck Slab (voided Slab), hardy slab, and composite slab.

In this type of design, no support beams or girders would be needed as the slab wouldbe capable of spanning between columns with proper reinforcement detailing.

One of the biggest advantages for a two-way flat slab compared to one-way slabs or two way slabs that transfer load to beams and girders is that floor-to-floor heights are generally smaller for flat slabs. When no beams and girders are present, the structure occupies far less space, as much as a foot less at each floor. In a multi-story building, this can lead to several feet being reduced from the height of the overall building. Reduced building height allows for many different types of savings including less finish material such as building cladding and paint as well as reducing HVAC load requirements.

Concrete slabs are typically classified as one-way or -manner systems primarily based at the span lengths ratio inside the fundamental horizontal guidelines. Depending on the span duration ratio, the flexural stiffness of the slab, solid strengthened concrete slabs are commonly designed as either one-four way or two-manner slabs. A one-manner slab usually has a span ratio greater than 2. One-way slabs are designed as though they span in simplest one route. The slab spans to beams and relying on reinforcement placement spans continuously over multiple bays. Those slabs are designed as one-foot huge sections that transfer loading in only one course. Reinforcement is designed to face up to flexure in the short course, perpendicular to the beams. Usually, the long direction, parallel to the beams, is gently bolstered, assembly temperature and shrinkage resistance requirements. One-way slabs are the most effective type of bolstered concrete slab to layout as it calls for much less calculation and details than two-way slabs. for the reason that load carried out to the slab is transferred in one direction to the beams after which to helping girders And columns, one-manner slab construction can result in deeper structural contributors

B. VOIDED SLAB

(Dwivedi et al 2020).The voided slabs are reinforced concrete slabs in which voids allow to reduce the amount (volume) of concrete. In building construction, slab is very important structural member to make a space. And the slab is one of the largest member consuming concrete. The main obstacle with concrete constructions, in case of horizontal slabs, is the high weight, which limits the span. For this reason major developments of reinforced concrete have focused on enhancing the span reducing the weight or overcoming concrete's natural weakness in tension.

However recently due to more use at domestic level slabs are subjected to more noise and vibration, so to minimize it there is need to increase the thickness which ultimately result in increased weight of slab. Increasing the slab thickness makes the slabs heavier, and will increase column and foundation size. Thus, it makes buildings consuming more materials such as concrete and steel reinforcement. To avoid these disadvantages which were caused by increasing of self-weight of slabs, the voided slab system is used. The Bubble Deck method for the two direction reinforced composite concrete slab with gaps was inverted in Denmark, it was conceived to achieve saving of concrete in building construction. These slabs are made of Bubble Deck type slab elements with spherical gaps, poured in place on traversal and longitudinal direction.

Dwivedi et al 2020 The major function of voided slabs is to reduce the concrete volume and thereby decrease the self-weight of slab. If designed properly, it can reduce the self-weight of slab up to 35% as compared to solid slab for same section and span. Voided slabs are characterized by presence of voids within the slab.

Voided slab construction removes concrete in locations of the slab that are less critical to resist the applied loads. Removing concrete from the slab interior while maintaining overall depth of the section allows for comparable utility in most applications as the section modulus and stiffness are roughly equivalent to a solid slab, but the self-weight of the section is greatly reduced. This reduction has many benefits. Sangeetha & Kartika 2018 Voided slab systems are constructed primarily by two methods: a filigree method in which some part is precast in workshop or concrete yard, and method in which the whole system is constructed on cast on site. In both methods, plastic void is main component. These voids are often spherical, hollow, and made of recycled plastic. The voids allow the slabs to be lighter than traditional concrete slabs since the voids are nearly weightless and replace concrete in the center of the slab.The next main component is the steel cage. Steel reinforcement is added to resist flexure for the slab, but a cage of thin steel is also used to hold the voids in place, keeping them in the center of the slab.

The third main component is the concrete, which surrounds the voids and forms the slab. The concrete ultimately determines slab strength.

Advantages of Voided Slab:

They weigh less, making the whole building structure more seismically resilient, The foundations are less stressed because of the decreased construction load,

Are suitable for medium to large spans (7 – 12 m),

Even voided, these slabs have the same strength as solid slabs.

Voided slabs are suitable for spaces with irregularly positioned columns, Larger spans offer higher flexibility of interior space organization, Flat lower surface provides uninterrupted passage to conducts and pipes,

Improved aesthetics for flat and smooth ceiling surface,

Easier further processing, plastering, or mounting of suspended ceiling Use of plastic formwork embedded in concrete slabs decreases the concrete volume used (up to 20%),They save costs and time speeding the construction process Plastic voided slabs are lightweight when compared to traditional slab construction. Plastic voided slab systems can reduce the dead load of slabs by as much as 35% when compared to solid slab construction with the same capacity (Mota, 2009). Lighter slabs affect many aspects of structural design, such as floor span, floor-to-floor height, column reinforcement and size, seismic effects, and sustainability

By eliminating unnecessary concrete and reducing floor weight, voided slabs are able to achieve longer spans than traditional slabs. The ability to achieve longer spans allows for more design flexibility as fewer columns are required, leading to more beneficial open space. For example, more open space in retail construction means more display space. Plastic voided slabs have been used in Europe to achieve floor spans of over 50 feet (15.2m) in office buildings. Nasvik, 2011.Typically, voided slab systems are thicker than solid slabs with the same capacity, but voided slab systems usually do not require beam supports. The cumulative height of beams and solid slabs is generally more than the height of voided slabs, meaning that the utilization of a voided slab can allow for reduced floor-to-floor heights. Smaller floor-to-floor heights impact many parts of a building, including exterior cladding and HVAC equipment Nasvik, 2011. As a result, reduced floor-to-floor heights can lead to significant savings in some applications.Lighter floor slabs also have a large effect on column size and reinforcement. Lighter floors mean smaller columns are able to be used as well as less reinforcing steel. Smaller columns can also lead to a large reduction in the overall amount of concrete and steel used in the entire building, consequently allowing for large savings in structural costs. In some cases, column dimensions have been reduced as much as 40% through the use of plastic voided slabs.

One of the biggest advantages of voided slabs is seismic performance. Weight is a leading factor in determining how much seismic force acts on a building during an earthquake. Reducing the weight of the slabs can lead to a large reduction in the overall seismic force induced in the building.

Mota, 2009Less seismic force leads to smaller components in the lateral force resisting system, allowing for greater savings in structural costs

METHODOLOGY

Step 1. Review previous research related to the subject of voided slab designing and modelling.

Step 2. Conducting an experimental analysis by casting conventional slab and voided slab using void creater materials listed above .

Step 3. Designing and modelling of conventional slab and voided slab by using E-Tabs Software.

Step 4. A comparative study of conventional slab with voided slab.

Step 5. To study ultimate load carrying capacity, bending strength and deflection behavior and Cost Analysis for concrete and steel by partially increasing the void ratio in the slab until failure

Design of Structure:

Name	Size	Material	Shape
Beam	230*350	M20	Rectangle
Secondary Beam	230*300	M20	Rectangle
Column	300*300	M20	Rectangle
Circular Column	⌀ 300	M20	Circle

Dead Load Calculation

Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials. The dead load includes loads that are relatively constant over time, including the weight of the structure itself, and immovable fixtures such as walls, plasterboard or carpet. The roof is also a dead load. Dead loads are also known as permanent or static loads.

1. Wall Load: -

a. **Exterior Wall:**
Unit Wt. Of Masonry * Wall Thickness* Ht. Of Wall
19 * 0.11 * (3-0.35)
5.5385 KN/ m
b. **Internal Wall:**
Considering 20% Openings =
4.4308 KN/m19 *0.23* (3-0.35)
11.58 KN /m
c.**Parapet Wall:**
Unit Wt. Of Masonry * Wall Thickness* Ht. Of Wall 19 * 0.11 * 1
2.09 KN /m

2. Staircase: - 11KN/ m
3. Water Tank:- 0.8868 KN /m2
4. Floor Finish:- 1KN/m^2
5. Roof Load :- 1.5KN/m^2

Live Load Calculation:

Live loads are either movable or moving loads without any acceleration or impact. There are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads whichever produce greater stresses in the part under consideration. Live loads include any temporary or transient forces that act on a building or structural element. Typically, they include people, furniture, vehicles, and almost everything else that can be moved throughout a building.

i. Live Load: - 2KN/m^2
ii. Live Load (Cantilever):- 3KN/m^2

Load Combinations:

A load combination results when more than one load type acts on the structure. Building codes usually specify a variety of load combinations together with load factors (weightings) for each load type in order to ensure the safety of the structure under different maximum expected loading scenarios. For example, in designing a staircase, a dead load factor may be 1.2 times the weight of the structure, and a live load factor may be 1.6 times the maximum expected live load. These two "factored loads" are combined (added) to determine the "required strength" of the staircase. The reason for the disparity between factors for dead load and live load, and thus the reason the loads are initially categorized as dead or live is because while it is not unreasonable to expect a large number of people ascending the staircase at once, it is less likely that the structure will experience much change in its permanent load.

Summary Cost Analysis:

Considering the above results, it is observed that 20% Voids in slab save upto 18.4% cost , whereas 30% Voids in slab save upto 23.2% cost.

Results show that with application of Voided Slab in structure, we can balance safety and economy.

Considering the advantages of voided slab discussed above and the results, Voided slab prove to be safe and economical.

Voided slab is economical when the slab construction is comparatively large and becomes uneconomical for very small construction. Weight and cost savings as well as architectural flexibility can be achieved with plastic voided slabs voided slab systems provide an excellent alternative to solid concrete slabs for many applications.

This innovative slab system with considerable reduction in self-weight and savings in materials combines all advantages of the other floor system, solving all problems caused by their disadvantages in the same time. Besides that the new floor system enhances the structural possibilities in combination with an improved cost-effective.

	Solid Slab		20% Voided Slab		30% Voided Slab	
	Steel	Concrete	Steel	Concrete	Steel	Concrete
Cost.	152422.05	550220	136870.80	505530	135648.15	483184
Cost Differed	-	-	15551.25	44690	16773.90	67036
% of cost saved.	-	-	10.3%	8.1%	11%	12.2%
Total % of Cost Saved.	-	-	18.4%		23.2%	

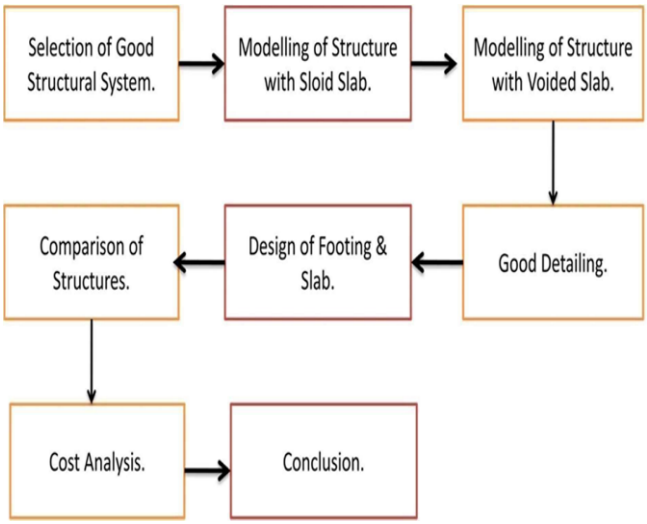

Fig 1:Methodology and Progression of Project (Pande et al 2018)

Fig .2 : Voided Slab.(Dwivedi et al (2020) P.P220)

Fig 3. Bubble Deck (Dwivedi et al PP.221)

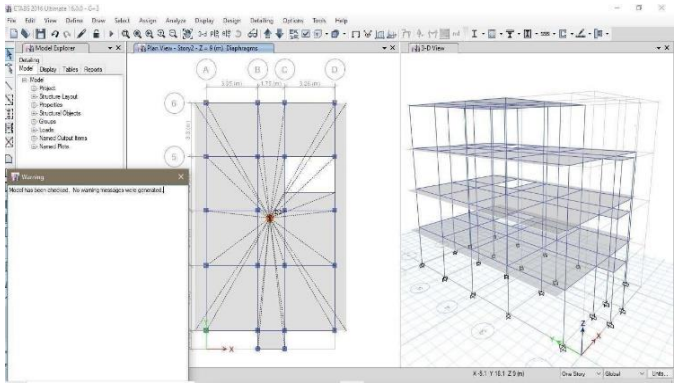

Fig.5: Application of Diaphragm.

CONCLUSION

This innovative slab system with considerable reduction in self-weight and savings in materials combines all

advantages of the other floor system, solving all problems caused by their disadvantages in the same time. Besides that the new floor system enhances the structural possibilities in combination with an improved cost-effectiveness.

From this study we observe that the quantity of material is saved leading to economical structure. Through this study we see that building with 20% voided slab saves upto 18.4 % cost whereas building with 30% voided slab saves upto 23.2% cost as compared to the solid slab.

Further on the floor system gives a tremendous contribution to sustainable development. The benefits of using plastic voided slabs, rather than solid slabs are greater for larger spans. Smaller spans do not require substantially thick slabs, therefore only small voids can be utilized and minimal savings are achieved. Larger spans are capable of using larger voids that greatly reduce the overall weight of the slab while meeting load capacity requirements.

Voided slab is economical when the slab construction is comparatively large and becomes uneconomical for very small construction. Weight and cost savings as well as architectural flexibility can be achieved with plastic voided slabs voided slab systems provide an excellent alternative to solid concrete slabs for many applications.

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Construction of plastic voided slabs requires more steps than solid slabs, but the construction process is not significantly more complicated. For bays of the same size, plastic voided slabs typically require less reinforcement. The only major change is placement of the plastic void formers. The void formers are placed above the bottom layer of reinforcement and are usually contained in a cage of very thin steel bars. The cage of void formers is typically constructed at the manufacturer's facility and shipped to the construction site, allowing for quick placement of the void formers and minimal changes to the construction schedule compared to solid slab systems.

Architectural freedom can also be achieved by utilizing plastic voided slabs. Plastic voided slabs make it possible to achieve longer spans with the same amount of concrete in the slab, allowing for less columns and a more open interior space.Overall, plastic voided slab systems provide an excellent alternative to solid concrete slabs for many applications. Weight and cost savings as well as architectural flexibility can be achieved with plastic voided slabs

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