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Comparative Analysis and Design of Flat and Grid Slab System with Conventional Slab System

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ABSTRACT: Timoshenko's theory of plates is used to evaluate design moments and shears occurring in ribs of a Grid floor accurately. However, it involves assuming magnitudes of parameters like spacing of ribs, thickness of slab and width of rib which have considerable influence on the overall economy of the Grid floor slab. The aim of this study is to analytically find the effect of these assumed parameters on the overall economy of the structure. Grid floors of sizes 12 m X 16 m, 14 m X 16 m and 16 m X 16 m were designed for various dimensions of slab, rib and different spacing. The cost of each slab is estimated and interaction curves are developed. From this study, it can be concluded that the cost of the grid floor would be minimum if minimum thickness of slab, minimum width of ribs and maximum spacing of ribs is adopted. Further, for the typical case considered, the approximate method of Ranking - Grashoff theory underestimates the moments by around 20 %.

KEYWORDS: grid floor, economic design, width of ribs, spacing of ribs, thickness of slab, computer aided analysis and design.

I. INTRODUCTION

1. OVERVIEW

Slabs may be viewed as moderately thick plates that transmit loads to the supporting walls or beams and sometimes directly to the columns by flexure, shear and torsion. It is because of this complex behavior that it is difficult to decide whether the slab is a structural element, component or a system in itself. Purushothaman (1984) visualises Slabs as intersecting, closely spaced grid-beams and hence they are highly indeterminate. This is indirectly helpful to designers, since multiple load-flow paths are available. However, rigorous elastic solutions are not available for many practically important boundary conditions. Iyengar (2004) opines that Finite difference and finite element methods and more methods have been developed to find the collapse loads of various types of slabs through the yield-line theory and strip-methods. The study and detailing of slabs is a challenge as precise technical information is not readily available. An intuitive feel is still the basis for the design of slab as many parameters that affect its performance are assumed. As the greatest volume of concrete that goes into a structure is in the form of slabs, even a slightest change in these parameters will affect the economy. The basic idea behind intuitive or indirect design in engineering is the memory of past experiences, subconscious motives, incomplete logical processes, random selections or sometimes mere superstition. This will not lead to the best design. The shortcomings of the indirect design can be overcome by adopting a direct or optimal design procedure. The feature of the optimal design is that it consists of only logical decisions by setting out the constraints and then minimizing or maximizing the objective function (which could be either cost, weight or merit function).

Most civil engineering structures are even to-day designed on the basis of permissible stress criterion. However, some of the recent methods use a specified factor of safety against ultimate failure of the structure. Presently, the approach is based on the design constraints expressing the maximum probability of various types of events such as local or ultimate failure.

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During the early fifties there have been considerable advances in `art` and economy of the structural design through the use of better structural materials and refined knowledge of structural design processes. Thus, the aim was to put structural design on a scientific basis. The need for innovation and optimization arose in the challenging problems faced by the aerospace industry, which gave a Philip to research activities in this area.

II. GRID FLOORS

2.1 General

The cast-in-situ reinforced concrete roof and floor slab is the simplest form of slab construction, but it is rather wasteful in materials, particularly cement. Substantial savings can be affected by modifying the composition of the slab so that its weight is reduced without impairing its strength or behavior. Ribbed and waffle slabs are examples. Amit A. Sathawane and R.S. Deotale (2011) compared Flat Slab and Ribbed floor and found that the former is more economical. The formwork for such a system is complex and the extra initial cast may not be justified where a small-sized domestic construction is involved. Some weight reduction can be effected by the use of hollow clay blocks which eliminates the need for special form-work by acting as a part of the formwork in the construction of the in-situ ribbed slabs. Ribbed, hollow block or voided slab construction has been covered in the IS:456 (1978) code for the first time. Ibrahim. S. Vepari and H.S.Patel (2011), observed that Grid or coffered floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with a slab are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square voids formed in the ceiling are advantageously utilized for concealed architectural lighting. The size of the beams running in perpendicular directions is generally kept the same. Instead of rectangular beam grid, a diagonal grid can also be used with the beams inclined at 45° to the sides.

2.2 Methods of analysis

According to the Indian Standard Code of practice for Plain and Reinforced Concrete i.e. IS: 456 (2000), the ribbed slab system can be analyzed as a solid slab if the spacing of the ribs is not be greater than 1.5 m and 12 times the flange thickness. In situ ribs should not be less than 65 mm wide. The ribs should be formed along each edge parallel to the span, having a width equal to that of the bearing. The moments and shears per unit width of grid are determined from Table 22 of IS: 456 (2000) code and the reinforcements are designed in the ribs. In slabs, reinforcement generally consists of a mesh or fabric.

A second approximate method which is applicable to the grid floor system is the Ranking Grashoff (1857) Theory of equating deflections at the junctions of ribs. However this method does not yield the twisting moments in the beams. For small span grids with spacing of ribs not exceeding 1.5 m, it can be used. But for grids of larger spans with spacing of ribs exceeding 1.5 m, a rigorous analysis based on orthotropic plate theory is generally used. A reinforced concrete grid floor with ribs at close intervals in two mutually perpendicular directions connected by slab in between in the ribs can be considered as an orthotropic plate freely supported on four sides. Timoshenko and S. Woinowsky-Krieger (1963) evaluated the moments and shears in the grid which depend upon the deflection surface. Maximum Bending moments develop at center of span while maximum torsional moments are generated at the corners of the grid and maximum shear forces develop at mid points of longer side supports. Al-Ansari (2006) adopted MATHCAD for two way ribbed slab analysis and design.

2.3 Minimum cost design of grid floor

The most common form of reinforced concrete construction of private and public buildings is T-beam and grid floor. The design of these structures is generally based on either stress design or strength design. It has been well established that the strength design is more logical and also economical. For the design slabs of various shapes and edge conditions limit design procedures have also been well established. These methods result in considerable economy in the design of reinforced concrete structures. However, one can further improve the design if one chooses the dimensions optimally.

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The cost of the structure is often a nonlinear function of the dimensions of the structure. It is necessary that the structure in addition to being low cost must meet the safety and functional requirements. These are also generally nonlinear. Adidam (1978) investigated the optimal design of T-beam and grid floors using Nonlinear Mathematical Programming Technique in which the objective function represents the cost of one beam and slab assembly per unit length along the beam span per unit spacing. This is also expressed as a ratio of cost per unit area of floor to the cost of one unit of concrete. An existing square grid of 18.83 meter span was optimized. He found that the optimal design turns out to be 1.2 meter square grid instead of existing one meter square. This indirectly results in saving of form work and material.

From study of literature, it can be understood that the economy of a Grid slab is not only affected by the Geometry, but also the Design parameters. The following are some of the parameters that affect the overall cost of a grid floor.

1. Size of Grid Floor and Spacing of Ribs (in X and Y directions)
2. Grade of Concrete and Grade of Steel
3. Live load on the slab
4. Thickness of slab, Width of Rib and Depth of Rib
5. However, the structural design engineer has control over Thickness of slab, Width of Rib and Depth of Rib only and hence the study of their effect on the cost of the Grid floor is important.

III. COMPUTERISED ANALYSIS AND DESIGN OF GRID FLOOR – NECESSITY

Grid Slabs, being highly indeterminate, are difficult to analyse by elastic theories. Since slabs are sensitive to support restraints and fixities, rigorous elastic solutions are not available for many practically important boundary conditions. Since large volumes of reinforced concrete go into slabs, the slightest change in different parameters will lead to considerable economy in the final analysis. Economy is the basis of all good designs, the slab being no exception to this golden rule. Repeated analysis and design leads to economical design but is tedious. Hence it is necessary that the analysis and design of Grid Floors be computerized to arrive at a more rational design.

The approximate method underestimates the bending moments developed in X and Y directions, to the extent of 17 % and 21 % respectively. The moments are very much under estimated in the long span direction.

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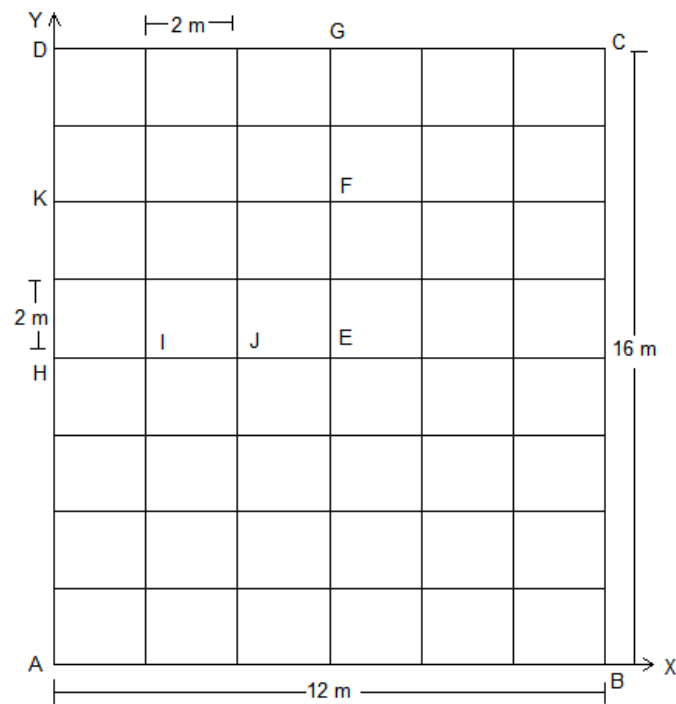


Fig. 1 Reinforced Concrete Grid Floor – Dimensions in Plan

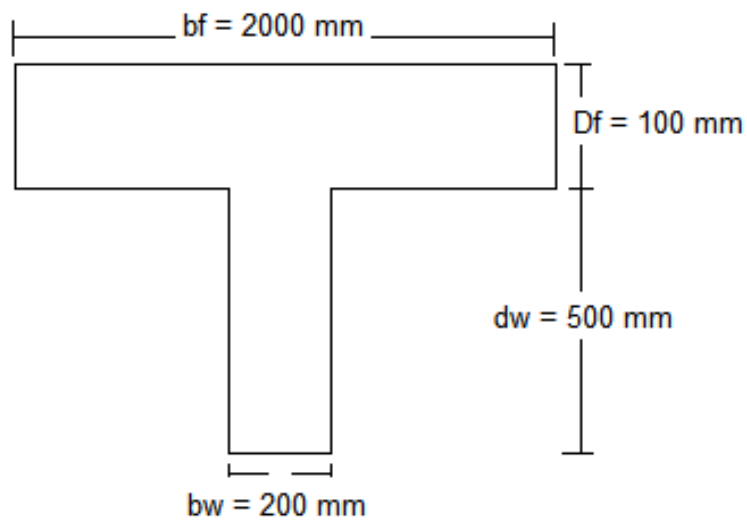


Fig. 2 Reinforced Concrete Grid Floor – Section of Ribs in X and Y Directions

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Table 1 Comparison of maximum moments in Grid floor

Method	Moment Mx kN_m / m width	Moment My kN_m / m width
RankineGrashoff Theory (Approx.)	90	48
Timoshenko's Plate Theory (Rigorous)	108	61
From Excel work sheet developed	112.95	63.53

IV. OBJECTIVE

The following are the objective of the present study:

1. To design various form of slab system for example conventional slab, flat slab and grid floor slab for the given plan area and their comparative study.
2. To study various parameters related to Grid Floor slab.
3. Grid floor slab will be tried to analyzing using Timoshenko's Plate Theory
4. Grid floor slab will be tried to analyzing using RankineGrashoff Theory
5. To study comparative costing of various types of slab system.

V. BACKGROUND AND MOTIVATION

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

Grid slab:

Interconnected grid systems are being commonly used or supporting building floors bridge decks and overhead water tanks slabs. A grid is a planar structural system composed of continuous members that either intersect or cross each other. Grids are used to cover large column free areas and have been constructed in number of areas in India and abroad. Is subjected to loads applied normally to its plane, the structure is referred as Grid. It is composed of continuous member that either intersect or cross each other. Grids in addition to their aesthetically pleasing appearance provide a number of advantages over the other types of roofing systems.

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Figure 3: Grid slab

Structure grids:

The plank and beam system described above is the simplest system for creating flat, horizontal surfaces. However, greater efficiency can be achieved by designing the flooring as one integral slab and spanning the flooring in two directions supported by a rectilinear grid of beams known as structural grid.

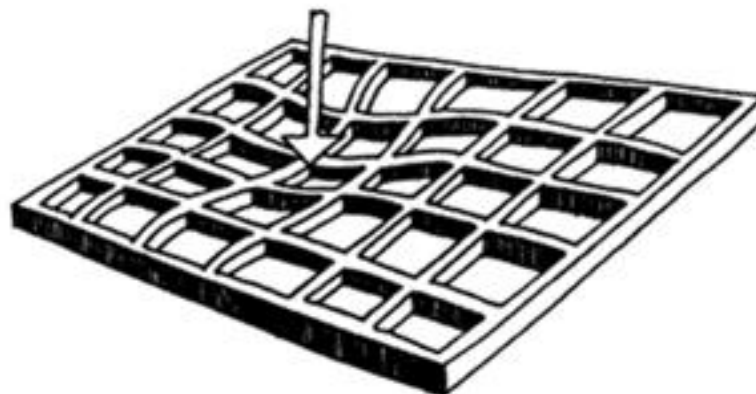


Figure 4: Rectangular structural grid

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Skewed Grids:

When the overall shape of a structural grid does not approximate a square, structural and economic efficiency can sometimes be gained by employing a skewed grid.

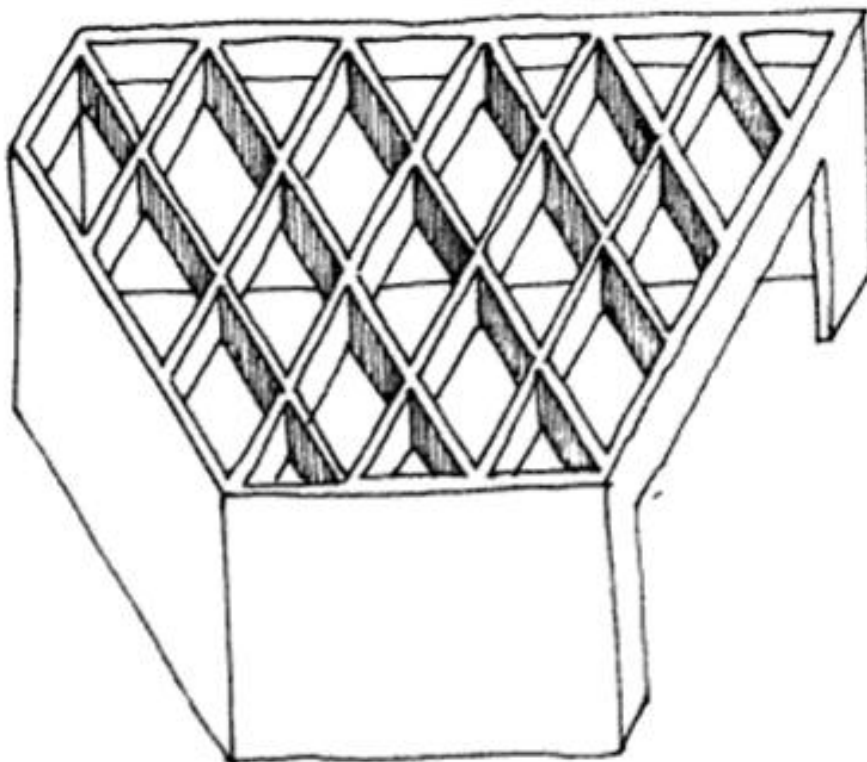


Figure 5: Skewed Grids:

Curved surface Grids:

The skewed grid can be warped to form a curved surface grid and spans large distances in an efficient manner. The structural concept of the arch is combined with the characteristics of skewed grids to increase efficiency.

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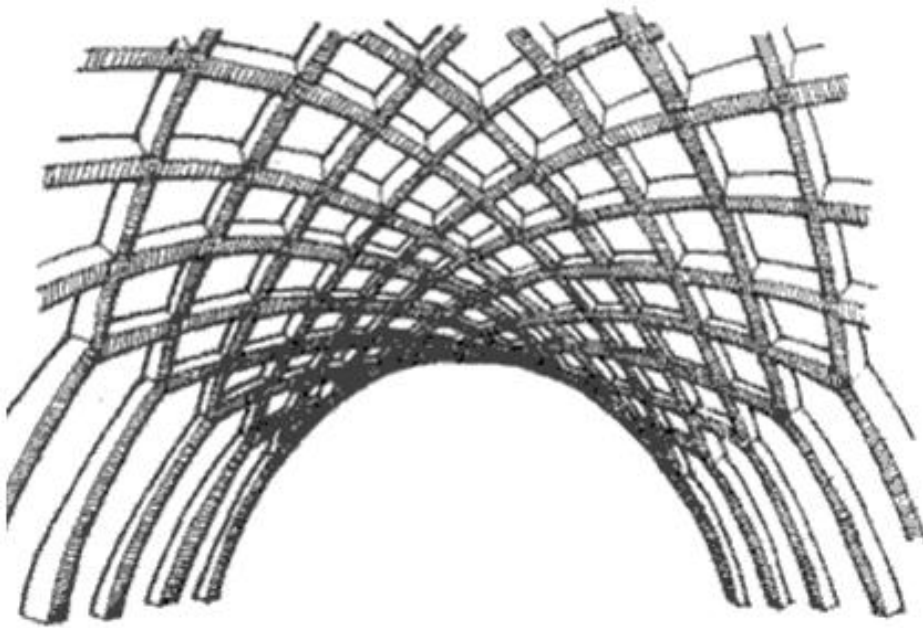


Figure 6: Curved surface grid

Advantages of Grid slabs:

1. Grids are very efficient in transferring concentrated loads and in having the entire structure participate in the load carrying action.
2. Reduce the depth to span ratio of rectangular grids.
3. Reduction in depth, towers, structural and other cost by reducing the height of the building

Grid floor system is a conventional method of construction in which beams are spaced at regular intervals in perpendicular directions and monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums ,theatre halls e.c.t; where column and free space is often the main requirement A waffle slab is a type of building material that has two directional reinforcement on the outside of the material, giving it is the shape of the pockets on a waffle. This type of reinforcement is a common on concrete, wood and metal construction .a waffle slab gives a substance significantly more structural stability without using a lot of additional material .it makes a waffle slab for large flat areas like foundations or floors. And the floor construction of a dwelling must fulfill several criteria and the following design function must be taken into consideration

- The provision of a uniform, level surface
- Sufficient strength and stability
- Exclusion of dampness from inside of building
- Thermal insulation
- Resistance to fire

A reinforced concrete flat slab also called as beamless slab is a slab supported directly by columns without beams. A part of the slab bounded on each of the four sides by central line of column is called panel. The flat slab is often thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in the support regions. The thickened portion i.e; the projection below the slab is called drop to drop

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panel ,in some cases the sections of column at top , as it meets the floor slab or a drop panel is enlarged so as to increase primarily the parameter of the critical section for shear and hence, increasing the grid floor technology.

5.1. Details of Grid Floor System for the Analysis

A typical grid floor system of standard dimensions adopted in practice has been considered. A rectangular grid floor of size 9m x 12m with center to center spacing of ribs at 1.5m in both ways having simply supported ends on two adjacent sides and fixed ends on the other two sides have been assumed. The thickness of the slab is assumed as 0.1m and the overall depth of the grid beam is assumed as 0.55m. The width of the grid beam is assumed as 0.15m. The live load on the floor is assumed as 1.5 kN/m² as given in IS 875-part 2 (1987). The grade of concrete M20 and steel of grade Fe 415 are assumed. The maximum bending moments M_x and M_y developed at the center of span, the maximum torsional moments M_{xy} and M_{yx} developed at the ends of the grid and the shearing forces Q_x and Q_y developed at the supports are predicted using the models proposed by Rankine's Grashoff method, Timoshenko's plate theory and ANSYS software. The analysis using ANSYS is involved with meshing (repeating sentence). The loaded structure and the predicted results obtained by the classical methods are compared with the corresponding analytical results obtained by the numerical method. The analytical results are given in Table 1. The results obtained by RankineGrashoff theory is not in good agreement with the results obtained by numerical method. However the analytical results predicted by the numerical model are in good agreement with the analytical result.

5.2 Grid Floor Slab

The structure which is formed vertically to support its load and other similar type of load. The slab must be considerable and stable to bear the dead and its load. To ensure stability, the floor needs sufficient vertical supports to address the possible of limbering when it is loaded by big loads.

5.3 Functions of Slabs

- To prepare a plain surface
- To support loads
- Operate as a sound, fire and heat insulator or resistance
- The space between the floor and ceiling can be used and to placed building equipment and materials

5.4 Characteristics of Slabs

- Much have long lasting endurance without any improvement or repairing
- Capable to with stand and resist on great fire for certain period
- Resistance to heat transmitting
- Sound proof

5.5 Failures of Slabs

- It caused by the soil moisture below the floor
- The moisture penetration from the underground to the floor surface depends up on the soil features.
- The buildings basements condition, weather it is plain or step

Example: - typical one way beam grid and slab system. The parking structure has columns on a rectangular grid pattern the essential one way design of a system can be seen by the relative lengths and sections of the main beam, and the primary and secondary beams under the slab. The rectangular shape of UN supported slab indicates one way slab action.

Typical waffle slab for parking structure, with columns on a 33.ffx27ff pattern the design uses 3ft square waffle, note the in filling of the square of the head of the column resist both shear and negative moments .waffle –slab roof, can see

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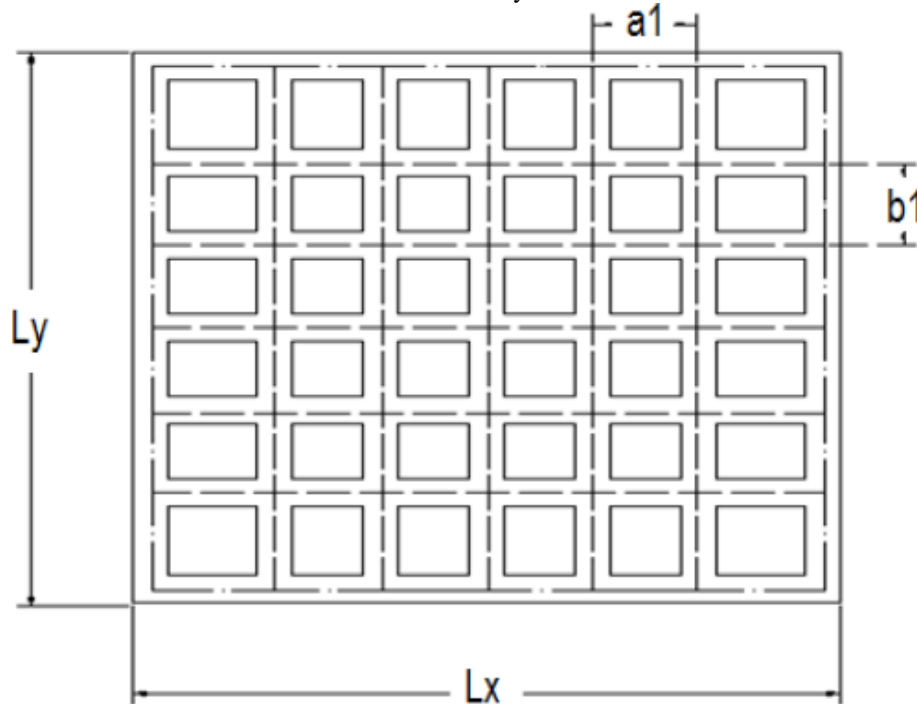
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Diego airport, not heavily loaded or a roof structure, the slab system be extended into the overhang where the moments are negative .note also the supporting columns with a baiting point of zero moment at two third high.

5.6 Grid Floor Plan

The rectangular or square void formed in the ceiling is advantageously utilized for conceded architecture lighting, the size of the beams running in perpendicular directions and generally kept the same the grid plan dates from antiquity and originated in multiple cultures some of the earilistpl and city build using grid plans by 2600BC MOHENJO-DARO and HARAPPO major or cities of the Indus valley civilization ,were built with blocks divided by a grid of straight streets, running north-south and east-west .each block was sub divided by small lanes.



The cities and monasteries of grandmas, dating from the first millennium BC to the 11th century AD, also had grid base designs. Islamabad, the capital of Pakistan since 1959, was also founded on the grid plan of the nearby ruined city of scarp. The tradition of grid plans is continuous in china from 15th century BC onward in the traditional urban planning of various chinese states. Guideline put into written form in the kaagongji during the spring and autumn period. Three gates on each side of the parameter lead into the nine main streets that crisscross the city and define its grid pattern. And for its layout the city should have the royal court situated in the south.

The grid planning tradition in area continuous through the beginning of the 20th century with Sapporo, jappen (est 1868), following a grid plan under American influence.

The grid plan became popular with the start of the renaissance in northern Europe.in 1606 the newly founded city of Mannheim in Germany was the first renaissance city laid out on the grid plan. Latter came the new town ealnburgh and almost the entire city of Glasgow, and many plan communities and cities in Australia,Canada and the united states such as new York and adelaide

The borogue capital city of malta,Valletta,dating back to the 16th century was built following a rigid grid plan of uniformly designed houses, dotted with places churches and squares.

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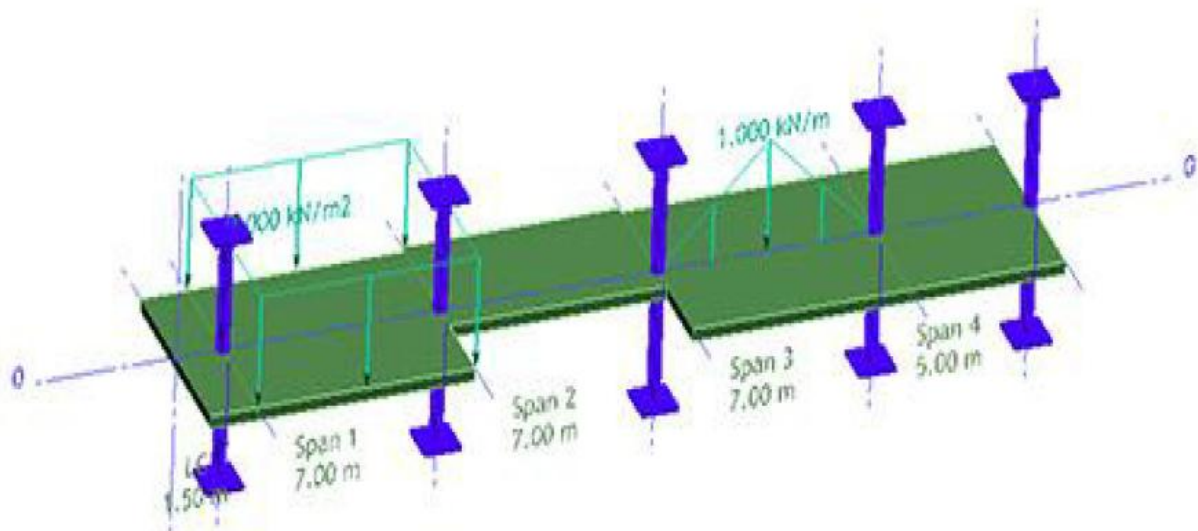
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5.7. Grid Foundation

Grid foundations constitute a type of shallow foundation intermediate between combined footings and rafts, depicts the progression of possible forms of shallow foundations, all for same configuration and loading, but on different soil. In other words, they represent different soil designs and for the same column data. Among the forms on the one end we have a system of independent footing possible under the best soil conditions (highest allowable soil pressure) while on the other we have the worst soil condition (in the terms of the allowable soil pressure) requiring raft to cover the entire building area. A soil condition where a system of combined footings for all the columns in the rows.

An Easy-to-use and learn software for the Design, Analysis, and Investigation of Reinforced (Non prestressed) Concrete Beams, Beam Frames, Slabs and Floor Systems - a must have production tool in every structural engineering office.

ADAPT-RC is for the analysis and/or design of reinforced concrete beams, slabs and floor systems. It is based on a single story frame, featuring the Equivalent Frame modeling of the ACI code as an option. In its design mode, the program determines the deflection and reinforcement for user defined geometry, material and loading. In its analysis mode, for a given floor geometry, loading and reinforcement, the software determines the capacity of the floor and compares it with the code stipulated demand. In both the design and the analysis modes, the deflections are calculated using cracked sections, with each span subdivided into 20 segments. ADAPT-RC is easy to use, yet thorough and rigorous in its formulation. Its graphical display gives a vivid account of moments, reinforcement and other parameters. ADAPT-RC handles both prismatic and non-prismatic spans, as well as supports with different boundary conditions. A solid model viewer allows the user to examine the input structure for a visual check on the accuracy of data entry. The primary application of the software is in building construction and parking structures.



5.7.1 Applications

- Simple and continuous beams and beam frames
- Multiple beam cross-section: T, L and I-section
- One-way slabs
- Two-way flat plates
- Two-way flat slabs
- Drop caps, drop panels, transverse beams, steps above and below the slab
- One-way pan joist (pan-formed beam) systems

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- One-way skip joist (pan-formed beam) systems
- Two-way joist (pan-formed beam) systems
- Waffle slab

5.7.2 Features

This software is based on the time proven Equivalent Frame Method (EFM) of analysis and features the following:

- Complete modeling and design of reinforced concrete beam and floor systems
- Fast, intuitive tabular input for project models
- Investigation mode - analysis and capacity calculation of an existing floor
- Performs capacity/demand analysis for existing floor systems
- Calculates deflection based on user specified loading and reinforcement Advanced analysis options
- Moment redistribution
- Inclusion of lateral loads
- Deflection calculation, including cracked section analysis Comprehensive design capabilities
- Reinforcement check for strength and minimum code requirements
- Beam shear and punching shear checks
- Integrated punching shear reinforcement design (studs or stirrups) Concise reporting
- Graphical display of moments, shears and deflections for each load combination
- Graphical and tabular display of location, length and amount of reinforcement required Two version options to meet your project and budget size
- Both versions contain same functionality, but vary in max number of spans allowed
- ADAPT-RC Standard: up to 5 interior spans and 2 cantilevers
- ADAPT-RC Plus: up to 20 interior spans and 2 cantilevers

5.7.3 Design Procedure

The basic design procedure of a two-way slab system has five steps.

1. Determine moments at critical sections in each direction, normally the negative moments at supports and positive moment near mid-span.
2. Distribute moment's transverse at critical sections to column and middle-strip and if beams are used in the column strip, distribute column strip moments between slab and beam.
3. Determine the area of steel required in the slab at critical sections for column and middle strips.
4. Select reinforcing bars for the slab and concentrate bars near the column, if necessary.
5. Design beams if any, using procedures you learned in CIVL 4135. Positive and Negative Distribution of Moments
For interior spans, the total static moment is apportioned between critical positive and negative bending sections as (See ACI 318-02 Sect. 1)

As was shown, the critical section for negative bending moment is taken at the face of rectangular supports, or at the face of an equivalent square support

5.7.4 For the Case of End Span

- The apportionment of M_o among three critical sections (interior negative, positive, and exterior negative) depends on 1. Flexural restraint provided for slab by the exterior column or the exterior wall. 2. Presence or absence of beams on the column lines. ACI Two-Slab Depth Limitation
- Serviceability of a floor system can be maintained through deflection control and crack control
- Deflection is a function of the stiffness of the slab as a measure of its thickness; a minimum thickness has to be provided irrespective of the flexural thickness requirement.
- Table 9.5(c) of ACI gives the minimum thickness of slabs without interior beams.
- Table 9.5(b) of ACI gives the maximum permissible computed deflections to safeguard against plaster cracking and to maintain aesthetic appearance.

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- Could determine deflection analytically and check against limits.
- Or alternatively, deflection control can be achieved indirectly to more or less arbitrary limitations on minimum slab thickness developed from review of test data and study of the observed deflections of actual structures.

5.8 Design and Analysis Procedure Method

5.8.1 Operational Steps

1. Determine whether the slab geometry and loading allow the use of the direct method.
2. Select slab thickness to satisfy deflection and shear requirements. Such calculations require a knowledge of the supporting beam or column dimensions. A reasonable value of such a dimension of columns or beams would be 8 to 15% of the average of the long and short span dimensions, namely $(l_1 + l_2)/2$. For shear check, the critical section is at a distance $d/2$ from the face of the support. If the thickness shown for deflection is not adequate to carry the shear, use one or more of the following:
 - a) Increase the column dimension.
 - b) Increase concrete strength.
 - c) Increase slab thickness.
 - d) Use special shear reinforcement.
 - e) Use drop panels or column capitals to improve shear strength.
3. Divide the structure into equivalent design frames bound by centerlines of panels on each side of line columns.
4. Compute the total statically factored moment M_{total} .
5. Select the distribution factors of the negative and positive moments to the exterior and interior columns and spans and calculate the moments.
6. Distribute the factored equivalent frame moments from step 4 to the column and midspan.
7. Determine whether the trial slab thickness chosen is adequate for moment-shear transfer in the case of flat plates at the interior column junction computing that portion of the moment transferred by shear and the properties of the critical shear section at distance $d/2$ from column face.
8. Design the flexural reinforcement to resist factored moments in step 6.
9. Select the size and spacing of the reinforcement to fulfill the requirements for crack control, bar development length.

5.8.2 Design of slabs

The design of slabs has to fulfill both Serviceability Limit States (SLS) and Ultimate Limit States (ULS) requirements (in this exact order!). In general the height “ h ” of slabs is controlled by the deflection limits (EC2 7.4). In the case of flat slabs, punching frequently also governs.

In EC2 the deemed-to-satisfy rule for verifying SLS deflection is based on the limitation of elements’ “slenderness” by setting maximum “slenderness ratios” (l_{ef}/d) of the “effective span” distance in the case of supporting beams, or center distance of columns in the case of flat.

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The direct design method gives rules for the determination of the total static design moment and its distribution between negative and positive moment sections. The EFM defines an equivalent frame for use in structural analysis to determine the negative and positive moments acting on the slab system. Both methods use the same procedure to divide the moments so found between the middle strip and column strips of the slab and the beams.

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The thickness of a floor slab must be determined early in design because the weight of the slab is an important part of the dead load of the structure. The minimum thickness can be determined by many factors:

- Shear strength of beamless slabs (usually a controlling factor); slab must be thick enough to provide adequate shear strength
- Flexural moment requirement (less often a governing factor)
- Fire resistance requirements
- Deflection control (most common thickness limitations)

Grid is highly redundant structural system and therefore statically indeterminate. Various approaches available for the analysis of grid floor frame are as listed below

1. Analysis of grid by Rankine – Grashoff method
2. Analysis by plate theory
3. Stiffness method.

5.8.3 Rankine – Grash off Method

This is an approximate method. It is based on equating deflections in either direction at the junction's of ribs. This method is suitable for small span grids with the spacing of ribs not exceeding 1.50 m. In this method the slab is considered as simply supported on edges. This method computes moments and shear force per unit width of slab strip.

5.8.4 Plate Analogy Method

This is a rigorous method of analysis. This is based on Timoshenko's analysis of orthotropic plate theory considering plane stress analysis. As in Rankine- Grashoff method, in this method also the analysis is done by considering the grid simply supported on edges. Bending & torsion moments and shears are obtained per unit width of slab strip.

5.8.5 Stiffness Method

This method is based on matrix formulation of the stiffness of the structure and gives closed form solution by using this method the analysis can be done by considering rigid supports as well. Various application software's are available to carry out analysis by this method. In the present work while analyzing grid floor frame by stiffness method, the simple supports are considered at closer distance so as to simulate the support conditions similar to Rankine- Grashoff method and Plate theory.

VI. LITERATURE REVIEW

CH.RAJKUMAR et al.(2017) In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square void formed into ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Instead of rectangular beam grid a diagonal. In the present problem G+ Building is consider and analysis and design is done for both Gravity and lateral (earth quake and wind) loads. And this is compared with the flat slab.

Anitha.K et al. (2017) They are generally employed for architectural reasons for large rooms such as auditoriums, theatre halls e.c.t; where column and free space is often the main requirement A waffle slab is a type of building material that has two directional reinforcement on the outside of the material, giving it the shape of the pockets on a waffle. The parameters considered in this study are span to depth ratio, spacing of transverse beams, thickness of web and thickness of flange. The magnitude of span to depth ratio considered is 16 to 60. The spacing of transverse beams

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is varied from 0.5m to 2.0 m. Thickness of slab and the rib is made constant and is equal to 0.1m and 0.15m respectively. The bending moment, the shear force and the mid span deflection developed in grid floor beams have been predicted by conventional and numerical methods and the results are compared. The parametric study is carried out using the model proposed by ANSYS 12.0 software. The results of the study give an insight to the range for the magnitude of the various parameters to be considered for the optimum performance of grid floors.

Syed Abdul Qavi et al.(2016) Floor systems consisting of flat slabs are very famous in countries where cast-in place building is prime form of construction because of numerous advantages in terms of architectural flexibility, use of space, easier formwork, and shorter creation time. Flat slabs are being used chiefly in office buildings due to reduced formwork cost, fast excavation, and easy establishment. That's why it's crucial to think what you're getting into (or under) so you can maximize the comeback on your investment. Grid floor systems comprising of beams move apart at regular intervals in perpendicular directions, monolithic with slab. GRID SLAB interconnected grid systems are being commonly used or supporting building floors bridge decks and overhead water tanks slabs. In this study, slab system design and analysis for Low rise, medium and High rise building for different seismic zones and having medium soil condition by using ETABS 9.7.4 The analysis and design of slab system is done as per IS456-2000 and IS 1983-2002. Design of the slab system is done for different spacing/ grid size of column to find out which grid size of the column or plan area which slab is economical.

BharathNishan et al. (2017) In this paper a parametric study is conducted on different methods of analysis of grid slabs. A general purpose program has been developed in Visual Basic environment by combining the methodologies. The program was validated with results of standard software available for the intended purpose. The results obtained from the program are plotted for comparison and the conclusions are drawn. These methods are elaborate and time consuming to obtain the solution .The task of solving the problem manually is often tedious, unrewarding and the brain often gets tired and distracted. The probability of making mistakes increases. There was a need for developing a general purpose program which reduces the time required for solving the problem and produce results with high degree of accuracy Grid floors are types of floors with a flat surface, resting on series of interconnected beams called grids. It can be of solid concrete, wood, steel or composite. A grid floor essentially gives a more structural stability and stiffness without utilizing a great deal of extra material. This makes a grid floor ideal for supporting vast areas like establishments or floors. The top surface of a grid section is a smooth surface, similar to a conventional building surface, yet the underside has a shape reminiscent of a grid.

AnithuDev et al. (2017) slabs are used to when a large column free area is the main requirement. There are various methods available for analyzing the grid slab system. In present study some of these methods are method, Timoshenko's plate theory and stiffness method and compared with each other. The comparison is done on the basis of flexural parameters such as bending moments, shear forces and deflection obtained from various methods. The parameters considered for study include span to depth ratio, spacing of transverse beams, thickness of web and thickness of flange. The magnitude of span to depth ratio considered is 16 to 60. The spacing of transverse beams is varied from 0.75m to 1.75 m. Thickness of slab and the ribs are made constant and are equal to 0.1m and 0.15m respectively. The bending moment, the shear force and the mid span deflection developed in grid floor beams have been predicted by conventional and numerical methods and the results are compared and software validated. The parametric study is carried out using the model proposed by ETABS.15 software. More over the cost analysis is carried out with the help of MS.EXCEL program for finding economical design. The spacing of transverse beams is varied from 0.5m to 2.0 m. The bending moment, the shear force and the mid span deflection developed in grid floor beams have been predicted by conventional and numerical methods and the results are compared. The parametric study is carried out using the model proposed by ANSYS software. They found out that Timoshenko's plate theory is in good agreement with ANSYS results.

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AVINASH PATEL et al. (2015) Flat Slabs are highly versatile elements widely used in construction, providing minimum depth, fast construction and allowing flexible column grids. In flat slabs, the beams used in conventional slabs are done away and the slab is made to rest directly over the columns. In case of higher loads, a drop panel or a column head is provided to reduce the intensity of loads. Flat slabs are particularly appropriate for areas where tops of partitions need to be sealed to the slab soffit for acoustic or fire reasons. Grid floor systems consist of beams spaced at regular intervals in perpendicular directions, monolithic with slab. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. Earthquake is the bane of such tall structures. As the earthquake forces are haphazard in nature & unpredictable, we need to acuminated engineering tools for analyzing structures under the action of these forces. This paper focuses on studying the behavior of conventional slab, flat slab and grid slab separately. A comparative study was done to identify the best slab system.

S. A. Halkude et al. (2014) The maintenance cost of these floors is less. However, construction of the grid slabs is cost prohibitive. By investigating various parameters the cost effective solution can be found for the grid slabs, for which proper method of analysis need to be used. There are various approaches available for analyzing the grid slab system. In present study some of these approaches are studied and compared with each other. The comparison is done on the basis of flexural parameters such as bending moments and shear forces obtained from various methods. For carrying out study, halls having constant width 10.00m and varying ratio of hall dimensions (L/B) from 1 to 1.5 are considered. In these types of slab, a mesh or grid of beams running in both the directions is the main structure, and the slab is of nominal thickness. It is used to cover a large area without obstruction of internal columns. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement.

J. Prasad et al. (2005) In this paper elaborates the results obtained from the analytical study carried out on waffle slab medium size floor system with a view to achieve the optimum dimensions of rib spacing, its depth and width. The waffle slab has been considered as monolithically connected to band beams. In addition to these strength requirements, they are required to satisfy the deformation criteria also, in terms of low deflection and crack width. This entails into the study of the role of various structural elements specially provided to meet one or more of the requirements in the domain of strength or deformation.

MuhammedYoosaf.K.T et al. (2016) This paper deals with the influence of various parameters on the economical spacing of the transverse beams in grid floor. The parameters considered in this study are span to depth ratio, spacing of transverse beams, thickness of web and thickness of flange. The magnitude of span to depth ratio considered is 16 to 60. The spacing of transverse beams is varied from 0.5m to 2.0 m. Thickness of slab and the rib is made constant and is equal to 0.1m and 0.15m respectively. The bending moment, the shear force and the mid span deflection developed in grid floor beams have been predicted by conventional and numerical methods and the results are compared. The parametric study is carried out using the model proposed by ANSYS 12.0 software. The results of the study give an insight to the range for the magnitude of the various parameters to be considered for the optimum performance of grid floors. Grid floor system consisting of beams spaced at regular intervals in perpendicular directions and monolithic with slab are used for large rooms such as auditoriums, vestibules, theatre hall, show room shops etc., Different patterns of grid are possible namely, rectangular, square, diagonal, continuous etc. Grids are found to be very efficient in load transferring. It is generally adopted when large column free space is required and reduces the span to depth ratio of rectangular grids.

S. A. Halkude et al. (2014) The Grid structure is monolithic in nature and is stiffer. It provides pleasing appearance and also has less maintenance cost. However, construction of the grid floor is cost prohibitive. By investigating various parameters involved, a cost effective solution can be found for the grid floor. The present work includes the parametric

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investigation in terms of flexural actions such as bending moments, torsion and shear force. Spacing of Grid beam is one of the parameters considered for investigation. The other parameter considered for investigation is the depth of Grid beams along with the design feasibility. Mesh or grid of beams running in both the directions is the main structure, and the slab is of nominal thickness. These floors are used to cover a large column free area and they are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement

UlfatSaboree et al. (2018) Grid slabs are those structures in which beams are provided at square or rectangular intervals, in perpendicular direction with slabs, in recent days grid slabs are more used by the construction companies and designers, they are using grid slab for making auditoriums, theater, vestibules, show rooms, where column free space are required. In this Paper analysis and design of Fat, Grid and their different combinations for several parameters have been carried out; such as for seismic behavior, summation of total moment, dead loads, base shear, storey drift, displacement Vs. height of the structure, design specification and their comparisons.

Hayder M.K. Al-Mutairee et al. (2019) in this paper concerns to use the isotropic perpendicular RC straight joists to resist the external load. The yield-line theory was adapted to analysis the circular waffle slabs. The steps of design were according to the ACI Code provisions. Fixed and simply supported circular slabs were presented. Closed form equations have been driven by author for the purposes of analysis and design this type of slabs by the present procedure. Uniformly distributed load was considered, that represent almost practical cases. Useful illustration example is presented in this study according to the available materials in Iraq to facilitate the job of designers. The good performance of RC circular slab which design by the present procedure proved clearly the efficiency of this technique. They may be floor and/or roof of building, halls, water tanks, silos, bunkers, etc., hence, many researchers devoted their studies for this field. The simply supported and fixed edge circular floors under uniformly distributed loads represent the most popular practical cases, thus, they are considered here.

VII. METHODOLOGY AND PROBLEM FORMULATION

7.1 METHODS OF ANALYSIS

Grid is highly redundant structural system and therefore statically indeterminate. Various approaches available for the analysis of grid floor frame are as listed below.

1. Analysis of grid by Rankine – Grashoff method.
2. Analysis by plate theory.
3. Stiffness method.

7.2 RANKINE - GRASHOFF METHOD

This is an approximate method. It is based on equating deflections in either direction at the junctions of ribs. This method is suitable for small span grids with the spacing of ribs not exceeding 1.50 m. In this method the slab is considered as simply supported on edges. (Refer Figure. No.2) This method computes moments and shear force per unit width of slab strip.

7.3 PLATE ANALOGY METHOD

This is a rigorous method of analysis. This is based on Timoshenko's analysis of orthotropic plate theory considering plane stress analysis. As in Rankine-Grashoff method, in this method also the analysis is done by considering the grid simply supported on edges (Refer Fig. No.2). Bending & torsion moments and shears are obtained per unit width of slab strip.

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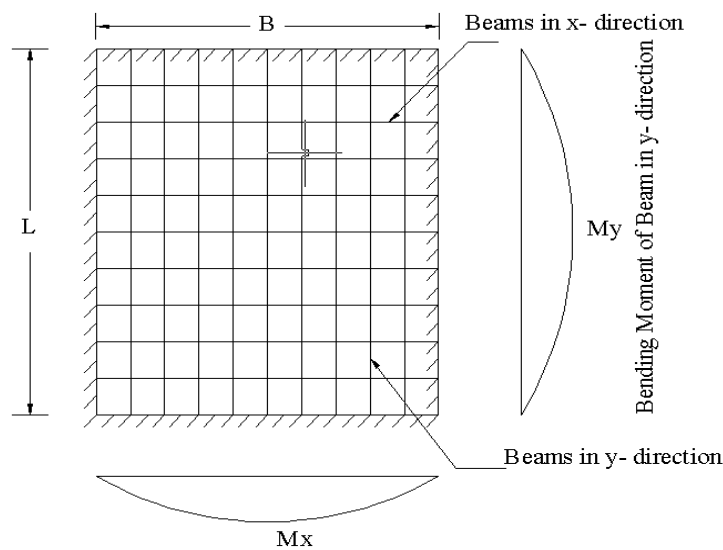


Figure No. 7 Typical grid considered in Rankine–Grashoff and Plate theory (Below grid)

7.4 STIFFNESS METHOD

This method is based on matrix formulation of the stiffness of the structure and gives closed form solution. By using this method the analysis can be done by considering rigid supports as well. Various application software's are available to carry out analysis by this method. In the present work while analyzing grid floor frame by stiffness method, the simple supports are considered at closer distance so as to simulate the support conditions similar to Rankine-Grashoff method and Plate theory. (Refer Fig. No.3).

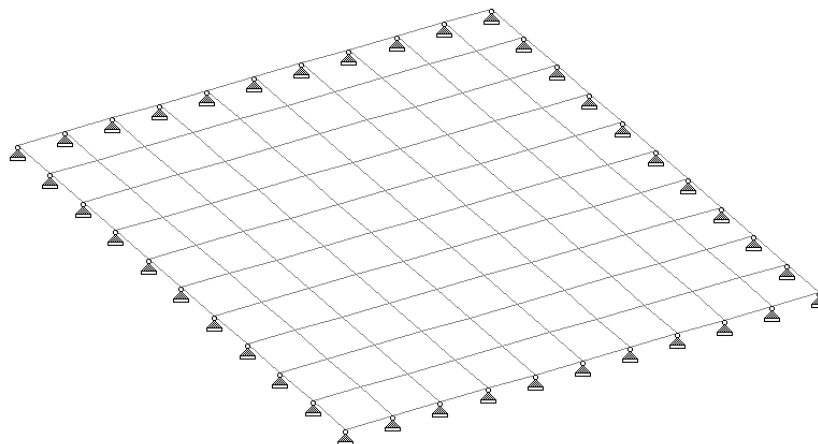


Figure No. 8 Typical Grid floor considered in stiffness method

CONCLUSION

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From this study, it can be concluded that the increase in cost with increase in thickness of slab decreases with increase in Grid size. Further, Cost of slab increases with increase in width of Rib and size of grid while increase in spacing of ribs decreases the cost of Grid floor. For the scope defined for this study, the cost of material is minimum for minimum width of Rib (200 mm), minimum thickness (90 mm) and maximum spacing (2.5 m) for all sizes of Grid floors. As most of grid floors adopted in practice are of the sizes discussed in this study, the guidelines are expected to be of use to the design engineers before actually designing it. Also, from the results of the typical grid floor analysis, it can be concluded that the approximate method underestimates the moments. However, further study and more results are required to give a quantitative dimension to this aspect.

Even though some of the resulting conclusions are easily foreseeable, (ie., cost increases with slab thickness and decreases with rib spacing), the study provides a quantitative insight into the effect of dimensions on economy of Grid Floor.

1. For an increase in thickness of slab by 10 mm, the increase in cost of steel and concrete requirement for a given grid size is in the range of 3 to 10 %.
2. For an increase in width of rib by 50 mm, the decrease in the cost of the steel and concrete for a given grid size is in the range of 9 to 15 %.
3. For an increase in spacing of 0.5 m, the decrease in the cost of the steel and concrete for a given grid size is in the range of 10 to 16 %.

REFERENCES

- [1]CH.RAJKUMAR "Analysis and Design of Multistory Building with Grid Slab Using ETABS" International Journal of Professional Engineering Studies Volume, VIII /Issue 5 / JUN 2017
- [2] Anitha.K "Design and Analysis of Grid Floor Slab" International Journal of Pure and Applied Mathematics, Volume 116 No. 13 2017, 109-115 ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version) URL: <http://www.ijpam.eu> Special Issue
- [3]Syed Abdul Qavi "Comparative Analysis and Design of Flat and Grid Slab System with Conventional Slab System" International Journal of Management, Technology and Engineering, Volume 8, Issue XI, NOVEMBER/2018ISSN NO: 2249-7455
- [4] BharathNishan "Automated Analysis and Parametric Study of Grid Floors" International Journal of Innovative Research in Science, Engineering and technology, (A High Impact Factor, Monthly, and Peer Reviewed Journal) Visit: www.ijirset.com Vol. 6, Issue 10, October 2017
- [5] AnithuDev "Analysis and Parametric Study of Waffle Slabs" International Journal of Innovative Research in Science, Engineering and Technology, (An ISO 3297: 2007 Certified Organization) Website: www.ijirset.com Vol. 6, Issue 4, April 2017
- [6]Avinash Patel "Studying the Response of Flat Slabs & Grid Slabs Systems in Conventional Rcc Buildings" Indian Journal .Science .Res, 14 (2): 516-521, 2017 ISSN: 2250-0138 (Online)
- [7] S. A. Halkude "Comparison of Various Methods of Analysis of Grid Floor Frame" International Journal of Engineering Science Invention, ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 3 Issue 21 February 2014 | PP.01-07 www.
- [8]J. Prasad "Optimum Dimensions of Waffle Slab For Medium Size Floors" Asian Journal of Civil Engineering (Building and Housing), VOL. 6, NO. 3 (2005)
- [9] MuhammadYoosaf.K.T "Finite element analysis and parametric study of grid floor slab" American Journal of Engineering Research (AJER), e-ISSN: 2320-0847 P-ISSN: 2320-0936 Volume-3 pp-20-27 www.ajer.org
- [10]S. V. Mahamuni "Effect of Spacing of Grid Beam and its Depth on Peripheral beams in Grid Floor Frame" International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181 Vol. 3 Issue 3, March - 2014
- [11]UlfatSaboree "Comparative Study Of Flat Slab And Grid Slab In Reinforced Concrete Structures" International Journal of Civil Engineering and Technology (IJCIET), Volume 9, Issue 5, May 2018, pp. 208–217, Article ID: IJCIET_09_05_024Available online at <http://www.iaeme.com/ijciyet/issues.asp?JType=IJCIET&VType=9&IType=5>ISSN Print: 0976-6308 and ISSN Online: 0976-6316
- [12]Hayder M.K. Al-Mutairee "Design Of Reinforced Concrete Circular Slabs By Two-Way Isotropic Straight Joists" International Journal of Civil Engineering and Technology (IJCIET), Volume 10, Issue 1, January 2019, pp.83-92, Article ID: IJCIET_10_01_009Available online at <http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=10&IType=1>ISSN Print: 0976-6308 and ISSN Online: 0976-6316