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Civil Engineering

STATISTICAL ANALYSIS FOR THE STRUCTURAL BEHAVIOUR OF TWO-WAY REINFORCED CONCRETE SLAB

Samer ALATTABI

Master's Thesis

Supervisor

Prof. Dr. Tuncer ÇELİK

Istanbul, 2023

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The thesis titled STATISTICAL ANALYSIS FOR THE STRUCTURAL BEHAVIOUR OF TWO-WAY REINFORCED CONCRETE SLAB prepared SAMER ALATTABI and submitted on 14/04/2023 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering

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I hereby declare that this thesis meets all format and submission requirements of a Master's thesis.

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I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Samer ALATTABI

Signature

DEDICATION

I dedicate this thesis to my god, who gave me the ability to complete it to the advisor (Prof. Dr. Tuncer Celik), the university, my family, my father and mother, who guided me to study and taught me its alphabet since childhood. We hope that God will grant them and everyone health and long life, and makes them proud and also makes us a support for our children to guide them to the route of knowledge, and from God grant success.

ABSTRACT

STATISTICAL ANALYSIS FOR THE STRUCTURAL BEHAVIOUR OF TWO-WAY REINFORCED CONCRETE SLAB

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The coefficients distribution method for the slab distribution of moments was analysis by the study. The analysis was built by taking the case of slab with beam between all supports. The study took two lines in the study: the first was the explanation of the ACI code tables related to the method of distribution coefficients. The second line was bonding the effective parameters into simpler equations to find out the destination factors for the moments in the interior panels in which negative and positive case. The study showed the simplifying output by examining the effect of the beams height and widths, and also the slab lengths of the panels in each direction. The study derived the magnitude of αm as it the average of the impact of the moment of inertias for beam and slab at each side of the panel strip. The study then mixed the statistical processes in the analysis techniques by evaluation the effect of the beam width and height on the distribution coefficient and the variation happened by identifying the standard deviation for each value when beam width and height been equal.
The study explained this state by drawings that showed two stages of variation for the case of interior negative moment coefficients while one stage of variation for the interior positive moment coefficients. The study showed the way to enhance the identifying of the interior moment coefficients by linking the equation that derived for the ACI table for negative and for positive interior moment and the equation that derived for αm. The study supported the behavior theory of the moments action on the slab panels by simulating the cases by ANSYS

program. the normal stresses at each direction showed the considerable attacking of the moments portion on the interior panels.

Keywords: Two-Way Slab, Reinforcement, Long Direction, Direct Design Method, Carbon Fiber Reinforced Polymers.

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ABBREVIATIONS

DDM : Direct Design Method

CFRP : Carbon Fiber Reinforced Polymers

LIST OF SYMBOLS

S	:	Standard Deviation
I	:	Moment of Inertia
M	:	Moment on Beam
D	:	Dead Load
L	:	Live Load
qu	:	Weight of Slab
h	:	Height of Beam
b	:	Width of Beam

1. INTRODUCTION

1.1 INTRODUCTION

Whenever the slab is supported on all four sides and the length, L, is less than twice the width, S, the slab deflects in two directions and the loads above the slab are transferred to the supports on all four sides. The slab is designated as a two-way slab. Because the bending moments and deflections in like slabs are less than those in one-way slabs, the same slab may carry more loads when assessed on four sides [1].

A loading in this situation is carried in two directions, and the joining moment in any of them is greater than the bending moment in the slab if the load were carried in only one direction. Typical slab–beam–girder configurations with one-way and two-way slabs. A Two-Way Slab is simply a slab that transfers forces in both directions (length and width) to its supports (Beams or Columns). This is because its length to breadth ratio (Long/Short) is insufficient for forces to travel only in the short direction (width) [2].

Slabs have four supports to which they can transfer their weight (two in each direction). Slab is structural member with a relatively high breadth and length in comparison to its thickness. Designed to carry whatever loads the structure is intended to take and transfer them to its supporting elements. Loads include the slab's own weight, the slab's covering and finish, and live loads (people, furniture, machines...and so on). Beams or Columns on which the Slab rests at its four corners (may be on. The slab transfers its loads to the supports, which then transfer those loads to the ground foundations, which then transport all of these loads to the ground beneath the building [3].

1.2 TWO WAY SLABS GENERAL PROPERTIES

a. The Length not exceeds twice the Width (Long/Short < or equal 2) [4]

b. The majority of the loads travel in two direction.

c. Four supports on the direction will support the slab and all of its loads.

d. Reinforcement (steel bars or other) to resist the straining actions generated by loads in two directions going through this route to the supports. in one way.

e. Slab thickness is calculated according to the two directions.

The two-way slab will divert attention in the future inside a dish or spaceship shape due to weight action. The angles of the two-way concrete surface lift up if the surface is not cast integrally with the endorses (facades). The two-way slab is started building both for directions because it bends in both directions.

A two-way slab can be defined as one that is assessed on 3 sides or 2 adjacent edges. Loads are split in more than one way depending here on side ratio. In two-way slabs, the primary bars are parallel to one another with access available in all directions.

When the edge of a 2 slab that is easily backed is not kept down, it will strive to lift off the aide in the future, leading to the development of deleterious instants. As a consequence, corner reassurance (torsional reassurance) for the 2 slab's non - continuous edge may be supplied[5].

1.2.1 Two-Way Slab Minimum Depth

Minimum depth of a two-way slab, which is usually regulated by deflection criteria. Sometimes the minimal depth is sufficient for per flexure making, but if the deflection criteria is not reached, such slabs will vibrate even under little loads such as walking, leaping, and so on. As a result, even if there is derive checks, they may offer less depth; always check for deflection. Here, it can provide a significantly greater depth while reducing steel to save money [6].

1.2.2 Design Styles for Two-Way Slab

The architectural, structural (quantity of resultant loads, period lengths, as well as specified lateral load-resisting structures), as well as construction considerations influence the selection of numerous two-way slab system applications[7]. There are primarily types of designs for two-way slabs:

a. Solid two-way slab: The slab is assessed on beams in a two-way rigid slab system. It can be constructed for a wide range of loading circumstances depending on the arrangement of the beams and columns [8].

b. Waffle Slab in Two Directions: The two-way waffle slab regime is used for low-rise office structures, and warehouses. In comparison to the rigid slab, the two-way waffle slab has a larger span[9].

Waffle flat slabs are constructed with a grid square of narrowly spaced beams and infill panels above the pillars. Lightweight concrete blocks may be utilized in their construction, similar to standard two-way waffle slabs, atop temporary or permanent shuttering, and vaulted forms are mislaid about the columns to make inflexible panels. The body of concrete in the beams and the slabs is poured characteristically [10].

1.2.3 Two-way Slab in Conjunction with The Hollow Block

A ribbed floor formed of the precast double-tee section, a ribbed flooring with integral beams, and hollow-block [11].

1.2.4 Two-Way Flat Plates Slab

That really is merely a slab of constant thickness that has huge benefits on columns and therefore is usually suitable for light weight training. Two-way flat panels can span up between 8m in concrete and up to 11m in a comment system. Flat plate is by far the most expense floor regime due to the ease with which formwork as well as strengthening work can indeed be completed. Two-way flat plate slabs shorten construction time as well as provide exposure flat roofs with greatest possible story height[12], that have poor deflection rigidity and poor post - punching ability. Beams are frequently used around the periphery of the slab to strengthen the free edges as well as provide support again for brick walls. Those who are not recommended in seismic zones. Shear barriers may be used to withstand entire lateral quake loads, leaving the flat surface with section to endure only structural load[13].

In comparison to flat plates, two-way flat slabs are more suited for bigger loads and spans. The situation is since of the drop boards and/or column capitals that the shear too flexural strength is increased. Thus, flat slabs are employed for greater loads and longer spans. In comparison to flat plates, it requires less concrete and reinforcement[14]. The selection of some slabs for a specific construction determination be determined by the reduced, build capability, loading states, and span. The total of the slab may be very great in comparison to the total cost of the construction slightly than the cost of t beam. If a two-way slab is made for moment only, the slab's thickness is reduced. As a result, we see tremors on the ground, but it does not collapse. However, when the slab is constructed for moments, shear, and deflection, the thickness of the slab increases and it have a vibration-free slab [15].

1.3 PROBLEM STATEMENT

The two way slab is important structure that can cover large space in the construction project. The positive and negative moments formed in variety in the sides of long and short directions of the slab. The variety lead to the stresses to attack the slab body from the middle area to the constrained part. The problem of the unsupported area in the middle of the slab must be taken in concern in the design. As the member included large amount of reinforcement along the two direction, it reflect more burden of cost to the project.

1.4 CONTRIBUTION

The statistically detection of the structure performance of two way slabs can support the design of these elements types and give more precise figure of the ways to improve that design under the case of various dead and live loads. The structural analysis that taken by the study tried to use mathematical and statistical analyzing procedure to build significance strategy in figuring the structural and flexural behavior of the reinforced concrete two way slabs.

1.5 OBJECTIVE

a. Assigning of the properties as input variables for the two way slab like the geometrical properties, the reinforcement in long and short direction, the properties of concrete and steel, and load cases.

b. Analysis the slab under suitable structural design method for assigning the available strengths.

c. Statistical analysis for the case of slab by using SPSS program as the input data use the required parameters in the structural analysis procedure.

d. Simulation the cases as three-dimensional figure using ANSYS program under the finite element method.

e. Modeling the results for improving the achievement of the better design of slab.

2. LITERATURE REVIEW

2.1 INTRODUCTION

In overall, there are two types of slabs: one-way slabs and two-way slabs. That one way slab is one direction and deflected and the primary reinforcement is located in one path, whereas the two way slab deflects in multiple directions and the primary reinforcement is placed in two directions. The straightforward derive method, also recognized as the straightforward analyzing technique, is described in the sections that follow since it determines as well as prescribes memories for various parts of something like the slab board without needing structural actually solving[16].

2.2 PROCEDURES FOR TWO-WAY SLAB DESIGN

a. Determine the type and layout of the slab.

b. Choose a slab thickness that will allow for bypassed excessive deflections while also satisfying shear for the interior and exterior columns.

c. Select the derivation method (direct derive method in this case)

d. Determine the slab's positively and negatively moments.

e. Divide up moments to across slab's size.

f. Compute reinforcements for moments discovered in two previous points.

g. Examine shear strength[17] [18].

2.3 FUNDAMENTAL ANALYSIS

The crucial aspects of the emerged as a form can be used to create a two-way slab analysis. The slab design must satisfy coercing balance and strain interoperability using the viscoelastic method. Quintessential model . this approach on above elastic universe theories; mathematical solutions discrete - time elements; output analyzing; or tape ways analyses can all be used to determine the coercing conditions all around supports throughout relation to shear, bending moments, and flexure [19].

Nevertheless of analysis technique, Deviations in slab ’s condition dimensions from commonly used techniques must be justified using information regarding predictable lots and lots, the serviceability of calculated stress and pressure, and the structure's deflections. A two-way slab system analysis could take into account the aspect ratio of any slab panel as well as the relative stiffness of the slab panels, , as well as enables the formation or walls. Construction loads, normal tenancy loads, anticipated overheating, and volume variants can all cause slab cracking during in the life of a structure[20]. Excessive going to crack exposes the concrete body to moisture infiltration, which can lead to reinforcement corrosion and deterioration of structural elements. Cracking can cause large vertical deflection under sustained gravity loads, causing damage to nonstructural elements [21]. When horizontal forces act on a structure, cracking lessens slab stiffness and tends to increase lateral deformation. Slab fracturing must be taken into account in stiffness estimations so that wind or quake drift is not vastly underestimated. Floor connections could be cautiously analyzed using a structural rigidity lowering factor that offers a bigger reduction in rigidity to ensure lateral deformation and also that derive troops are not undervalued [22].

2.4 CONSIDERATIONS BASED ON ANALYSIS OF CONSTRUCTION

a. The structure is thought to be built on top of equivalent frames that run longitudinally and transversely through the building.

b. Each frame is made up of a row of columns or supports and slab-beam strips that are bounded laterally by the centerline of a panel on any of the sides of the centerline of columns or supports.

c. Torsion representatives are presumed to be used to connect directly columns or aids to slab girder strips. translocate to the direction of the span for determining memories, and trying to extend to leaping lateral committee woman - centered over each side of a section [23].

d. iv. The lines of isotropic plates define frames parallel to and adjoining to an edge.

e. v. Assessment where all equivalent shapes are permitted. For static load, an output is called of each floor or roof, as well as the far ends of articles considered fixed, is allowed.

f. vi. Once trying to analyses slab-beams individually, deciding the point in time at a provided support while supposing that the floor is fixed for every support and over each panel away is allowed, provided this same slab persists beyond the locations of fixity.

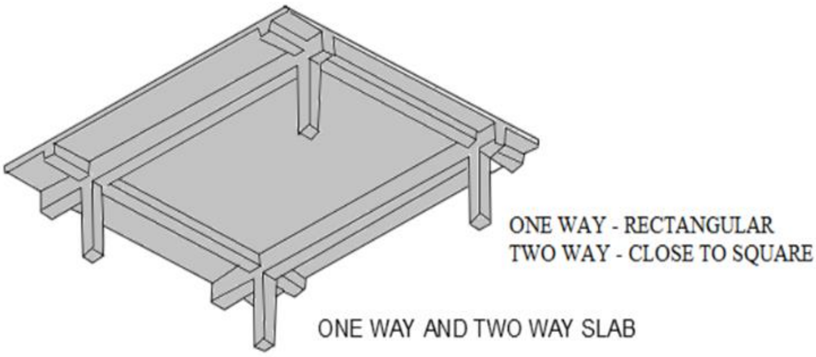

Figure 2.1: Two Way Slab-Typical Appearance [43]

2.5 STRIP WAYS ANALYSIS

Additionally, there are additional analysis techniques available, like the strip technique, that adheres to the core rules of the in individual actions of two-way action stone blocks and plates. The strip technique, in comparison to a yield line method, provides a lower-bound solution to a failure load by ignoring trying to twist memories so because plate is fragmented into girder strips[2]. As a result, the solution is based solely on element action within the boundaries of satisfying equilibrium for all points in the slab. As a result, unlike the yield-line technique, which can be applied to any imaginable shape, it is only applicable for adjusting rectangle two-way slabs and sheets. The strip technique allows the designer some flexibility in deciding how the surface should fight back load in addition to evaluating as well as developing the slab to fulfill the loading [24].

2.6 YIELD-LINE THEORY

The yield-line hypothesis is an analytical technique that selects the appropriate top model to determine this same maximum stress ability of a systemic slab or plate inside a ductility failure mode with perfect plasticity. This sort of charge stage is also known as a "top" solution. The name comes from a series of hinge pop acts that form an appropriate loading level and are glamorized by lines. According to the hypothesis, each skin of a tangible plate or slab section continues to remain flat until it crumbles, resulting throughout rigid planar sections [25].

As a result, misdirection and tensile or compressive cell wall forces acting in the plane of a slab or tray are not considered in hypothesis. The plates or slabs in this procedure are significantly inadequately and therefore require ductility. This is done by lowering the validation ratio to 1.0 % of the section required to maintain the ductility 366 and steel strain within such a 0.010 range. The continuous improvement portion is required because of the dominant role of horizontal shear method at the column limits in flat plates [26].

If the residual stress is known or easy to predict, the model allows an engineer to create the maximum load of a triangle shaped, trapezoidal, rectangle, circular, or other shape exposed to dispersed or centered loads. Even though main failure shapes are currently identified, remedies are no longer difficult to obtain [27].

2.7 GRAVITY LOADING

For dynamic loading, the element size of each slab board, in addition to the relative rigidity of the concrete slabs, assisting light, and continuing to support sections or walls, must be taken into account during the evaluation of a floor regime. Gravity dead weight includes one's weight as well as long-term superimposed loads like wood floors, ceiling, stopped nonstructural components, or feet equipment. The conscientious load created on the building occupancy is specified by the governing framework code. Permanent partitions that may include dead loading or extra existing pack above the occupancy microservices in the governmental building code [28].

Overlaid gravity killed and extant loads arising from carrying facade for light-frame building structures supported on a grand prix single plate or flat slab could be specified. Line pile direction parallel to span direction ought to be part of the design as a load applied. Above an effective tile width no greater than four times this same width of the slab, line loading perpendicularly to the involves altering ought to be considered a distributed load [29].

2.8 FLEXURAL DESIGN

The slab design is possible by trying to combine the use of iconic solutions as the base of an elastic spectrum and evaluating the stressors over the supports in connection to shear and bending moment of the well of flexure. The designer was aware of the limitations of the applicability of simplified derive presumptions. The choice from which size and shape of the slab might be especially in comparison to standard office practice was made on the basis of knowledge of probable powers and the reliability of the thought stresses and obfuscations of the construction [10].

This is particularly true for an inner section made of a single plate, in which the prevalent validation stresses already are high, likely to result throughout flexural, shear force, and torque stress values which have traditionally been overlooked. Ductility reassurance in column strips must be portioned on the grounds of the filled amplitude of the deleterious present time, with ACI 318-14 allowing no lowered distribution of wealth of negative instants [30].

Checking two-way slab shear for the one critical section is sufficient for slabs of uniform thickness. Provide stirrups or stud reinforcement when shear controls are present at the support. Check shear for several critical sections on slabs with varying thicknesses, For example, the edge of drop frames or shear caps. At points where its slab cantilever brakes beyond the section, the critical exclusion zone for edge sections will be three to four sides. In slabs exposed to multiple joining, the critical part for shear continues to follow the perimeter just outside of the important support region. At factored loads, the shear force acting on this section is a function of fc′ and the ratio of the column's side dimension to the effective slab depth. By assuming a pseudo-critical section located at a distance d/2 from the periphery of the effective assist area, a much simpler design equation is derived [31].

Ultimate stress is almost self - reliant of the columns to slab effective depth when these are done. For square columns, this critical section is described by straight dividing lines perpendicularly to and at a distance of factors that tend from the column corners [32].

2.9 MINIMUM SLAB THICKNESS

Serviceability issues could be taken into account in the design of two-way flat slabs. These include determining the minimum slab thickness as well as the immediate and long-term deflections. For two-way slabs, the long-to-short span ratio is limited to 2-to-1. The minimum slab thickness for slabs with non-prestressed reinforcement should adhere to the prescriptive. Slabs without interior beams spanning in manner between supports [33].

The minimum thickness for slabs without drop panels could be a few 5 in (125 mm). The minimum thickness for slabs with drop panels could be a few 4 in (100 mm). Engineering and observational experience have improved the minimum thicknesses described above. Consider the range of loads, material types and properties, boundary conditions, and surrounding environment effects when determining slab thickness using computational analysis process as prescribed in ACI 435R-95. Slab deflection due to prolonged force of gravity for heavily loaded slabs, which should be analyzed in accordance with 6.2 for light frame buildings supported on a podium flat plate or flat slab. Slabs through beams that span among supports on entirely sides [34].

2.10 CURRENT WORK

The study aimed to identify the effective way to improve the design and the analysis of two-way slabs. The study analyzed the related parameters that impact the output strength of the slab including the geometrical properties then building effective statistical analysis for these parameters using SPSS program. the study supporting the results by simulating the cases obtained under the built-in finite element technique of ANSYS workbench program.

2.11 LITERATURE SURVEY

Analysis of these two slabs has improved in recent years, and many methods and theories are available in structural derive codes. Most of these methods are imprecise, including Rankine-Grashoff, Marcus, ACI 318-63 code, EC 2 code, and ECP 203-2017 code, because they are widely used due to their simplicity. This same main idea behind this study is to compare the magnitudes of truck full giving out features based on the above bending stress outcomes with corresponding orders of magnitude from a finite element relative softawre using more precious analysis (SAFE 2016). This research used two solid slab models for resolving, the first is simply supported and the second is single short edge continuous with variable boundary beam stiffness, to understand the conditions under which these methods could be applied, as well as the effect of boundary beam stiffness above load distribution parameters in both directions. The results show that as the aspect ratio increases, the load distribution parameters in the short direction increase while the loading distribution factors in the long direction decrease, but the rate of increase or decrease is dependent on the stiffness of the perimeter beams.

. The results of load giving out factors in finite element for linear supported slab are broadly compatible with in not as approximate methods, leading to the conclusion that approximate methods are the foundation of the linear assessed slab case. Values for the close to adequate aspect ratio decrease as short beam stiffness increases, while orders of magnitude slightly increase, and as long element stiffness grows. Significantly lower values [35].

Reassurance of existing concrete structural elements' cobody is an effective way to improve their performance. There has been a lot of research done on the reinforcement of beams and columns. However, research on bidirectional plate strengthening is extremely rare. As a result, there is a need for both academic and industry research into this issue, both empirically and theoretically. This thesis is an attempt to meet the need for experimental and theoretical research on perforation shear and bidirectional slab system joining strengthening.

The first series of samples will be used to build and enhance a reinforcing technique that incorporates the fusion of steel plates and steel nails. The effectiveness of four different steel plate and steel rivet configurations is assessed. The steel plates are intended to act as horizontal flexural reinforcement, equivalent to a tangible drop plate. Steel bolts are also intended to provide vertical shear reinforcement, transfer horizontal forces between steel plates and concrete slabs, and restrict concrete between steel plates. In comparison to the non-reinforced sample, the average increase in forces action capacity is 50% [36].

This study also offerings the Finite Element Method for investigating the failure design of a quadrilateral slab with different edge settings. ANSYS 15 software is used for nonlinear static analysis. Using SOLID65 solid elements, the plasticity algorithm facilitates concrete compressive crushing, while the nonlinear material model accommodates concrete body cracking in tension zone. Spattered reinforcement is attempted, as well as introducing a proportion of steel in the concrete surface. The type of behavior of the evaluated concrete block in terms of crack template and dislocation was observed for various loads and boundary circumstances. The results of finite elements are also compared to experimental data. Another goal of the recent study is to show how similar the crack route did find by the ANSYS program to those noted again for yield line method. Smudged reassurance has proven to be more feasible, especially for layered members like concrete blocks. This has the benefit of not requiring clear and specific modeling of a rebar as well as allowing for a much relatively coarse mesh to just be distinguished [37].

Several methodologies for analyzing moments of reinforced body of cement two way slabs have been developed over the years. The goal of this instruction is to compare the moments of strengthened bodies of concrete two-way slabs under gravity forces determined by variant analysis methods specified in construction codes with finite element methods. There are significant differences between slab analysis methods. In overall, the yield line methods provide an economical design that is validated by variant experimentations. The system provision gives the second less action of moment at the assist and at the span It produces better results in both directions at the same time. The reasons are as follows: (1) it assigns negative moment redistribution; according to EBCS 2,1995, the maximum negative moment redistribution for slab is 25%, but in this study, the code provision gives approximately 44 percent in which of negative moment redistribution) as shown in fig (c). (2) It is an approximation and empirical method that produces conservative results. In all states, the plate theory, SAP2000, and ABAQUS methods produce nearly identical results [38].

This paper includes a numerical analysis of simply supported square slabs with square central openings strengthened with Carbon Fiber Reinforced Polymers (CFRP) linked to its four corners in a skew pattern. Other inside uniformly distributed stocking up to failure was applied to the slab. A purpose of this work is to gather information about the performance of an RC slab with a sawn up opening bound by CFRP. The effect of CFRP thickness on load carrying capacity and stress offering out for overall slab performance is also investigated. The program was used to perform analysis two-dimensional finite element. Material nonlinearity and complex support states are considered. The analysis results revealed that the load carrying capacity of the slab is sensitive to the thickness of the CFRP. This same optimum thickness value was obtained to be 0.125 mm; beyond this value, the influence of increasing CFRP thickness was insignificant. The analysis concludes that the use of CFRP strips combined with critical thickness magnitude in cut-offs is a sufficient and effective way of strengthening in terms of load capacity [39][9].

The paper described above describes an inquiry into the viability of strengthening reinforced cement slabs in elastic deformation, even without open positions, using carbon fiber reinforced thermoplastic strips formed a bond far above post - tensioning edge of the slab. Two series of slabs have been investigated. The first series consists of four slabs with no openings, while the second series consists of four slabs with central openings. Each series includes a control slab that is not reinforced with CFRP strips. This same test setup and instrumentation of the RC slabs allow deciding the overall stiffness and flexural capacity of the bolstered specimens in comparison to the control specimens. The use of fiber reinforced polymer composites for the reinforcement of reinforced concrete slabs has significant advantages over the "traditional" solutions that have been tried in the past and even in the present.

Some of these benefits include: the permanent forces do not increase significantly when using FRP materials; these materials are not affected by corrosion; and the ability to design the orientation of the fibres from the FRP reinforcement in order to conduct their properties in the required direction of strengthening. A better preparatory work for the experiments conducted is required in order to obtain accurate results that reflect the effectiveness of the strengthening system under consideration. The acquisition of as much information as possible is critical in rank in order to analyze and observe the route the strengthened element takes under force action and prior to failure. The study of these strengthening techniques is critical for overcoming the disadvantages and stumbling blocks that arise during installation and serviceability [40].

This paper examines the experimental results of an official inquiry above thick concrete trays placed on generating supports together across their periphery under short-term lateral loads. The producing supports are decided to make of members with annular cross-sections. Their function enables operations to be performed in elastic and elastic - perfectly stages, tried to follow by a strengthening stage. This individualized care scheme was used to simulate the numerous boundary that slabs exposed to impacts might well face in useful civil design .

The experimental results revealed that the rigidity and deformation stage of the supports have an impact on their deformability above the structural response under impact . The mathematical state simulation results derived above to use a simple mechanical prototype qualitatively concurred only with experimental data. As a result, this same model can be employed to replicate and architecture solid concrete plates subjected to impact or rising packing [41].

Bolstered concrete slabs are among the most important and complicated components of any building. In the case of supported edges slabs, if the ratio of long span to short span is equal to or less than one, the slab is considered two-way; otherwise, it is considered one-way. Due to the geometrically arranged columns suggested by architectural engineers who prefer a symmetric distribution of columns in their plans, two-way reinforced concrete slabs are popular in use in reinforced concrete constructions. The elastic method is commonly used for analyzing concrete slabs. Regardless, design methods based on elastic principles are functionally limited for a variety of reasons.. Limit traditional analytical, on the other hand, provides a powerful technique for considering such matter. The Yield Lines Theory is a limit state analysis based on the expected failure principle of slabs. The assumed failure principle is denoted by a pattern of yield lines, over which the reinforcement has yielded, and the location in which forces as well as boundary conditions are counted. The above paper compares Method 3 for two-way slabs that was provided with help of the ACI Code and the exact derivation of this ways by the Yield Lines Theory. A total of nine slab instances identified by method three are studied and evaluated using plastic analysis assumptions which of the yield routes theory. The results are summarized in terms of summarized formulae developed according to the Yield Lines Theory, which could be used as an alternative method for designing two-way reinforced concrete slabs in the ACI Code [26].

The serviceability criteria play a significant role in determining deflection in a structure. To calculate deflections in RC members in general, codal provisions are available. The codal provisions for calculating short-term deflection in RC two-way slabs are based on the effective action of moment of inertia (Ieff), which is based on the cracking moment (Mr) and maximum moment for causing service loading (M). Short-term deflections determined in accordance with the preceding provision for two-way RC slabs are not comparable with experimental values. The procedure can sometimes produce non-positive deflection.

The current paper presents. The Similar Flow Method assumes that the comparable load acts on the slab and is determined by calculating using Consists of the right formulae. This same equivalent load technique calculated deformation is found to just be closer to the actual values. Previous studies addressed deflection by multiplying the cracking activity. The appropriate time deflection is significantly different from calculated observations.

A approach has been suggested with in state of paper in which, rather than applying the factor 0.7 to Mcr, the cracking action of center of gravity is suggested to be employed in place of real action of the moment of inertia. The calculated deflection was found to be comparable to experimental outputs. The procedure has been validated using experimental data obtained and data presented in the literature. Experiment work has been completed for two end conditions, namely fixed supported and quickly supported two-way RC slabs. Six veer specimens were cast for both the limit state of variant thickness, sizes, and lots and lots [42].

3. METHODOLOGY

3.1 DIRECT METHOD IN TWO-WAY SLAB

The direct design method (DDM) ACI Code 8.10 is an approximate procedure for the analysis and design of two-way slabs. It is limited to slab systems subjected to uniformly distribution loads and supported on equally or nearly spaced columns. The method uses a set of coefficients to determine the design moments at critical sections.

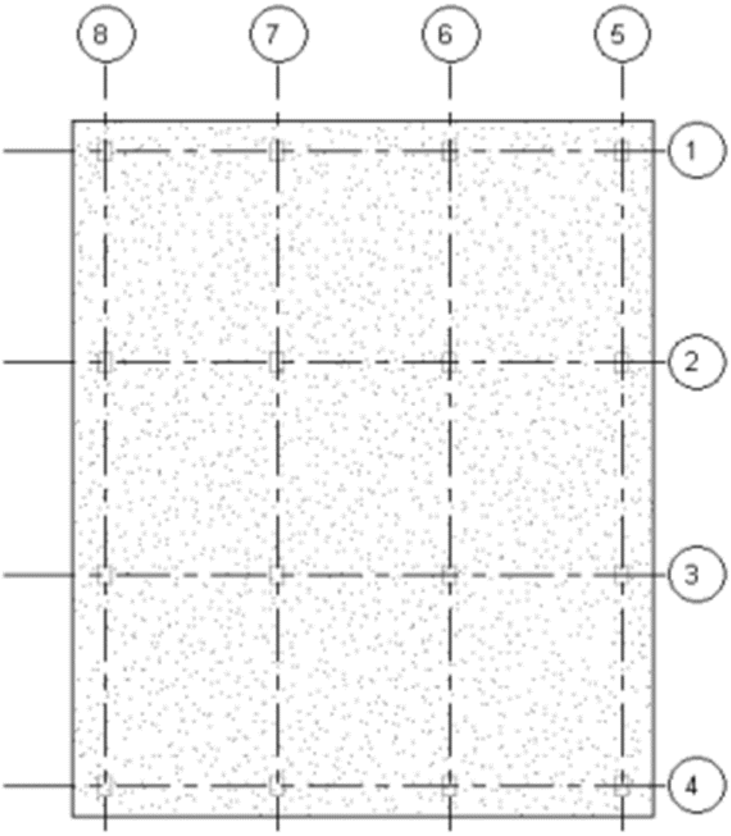

Figure 3.1: The Slab Spans Division (Exterior and Interior).

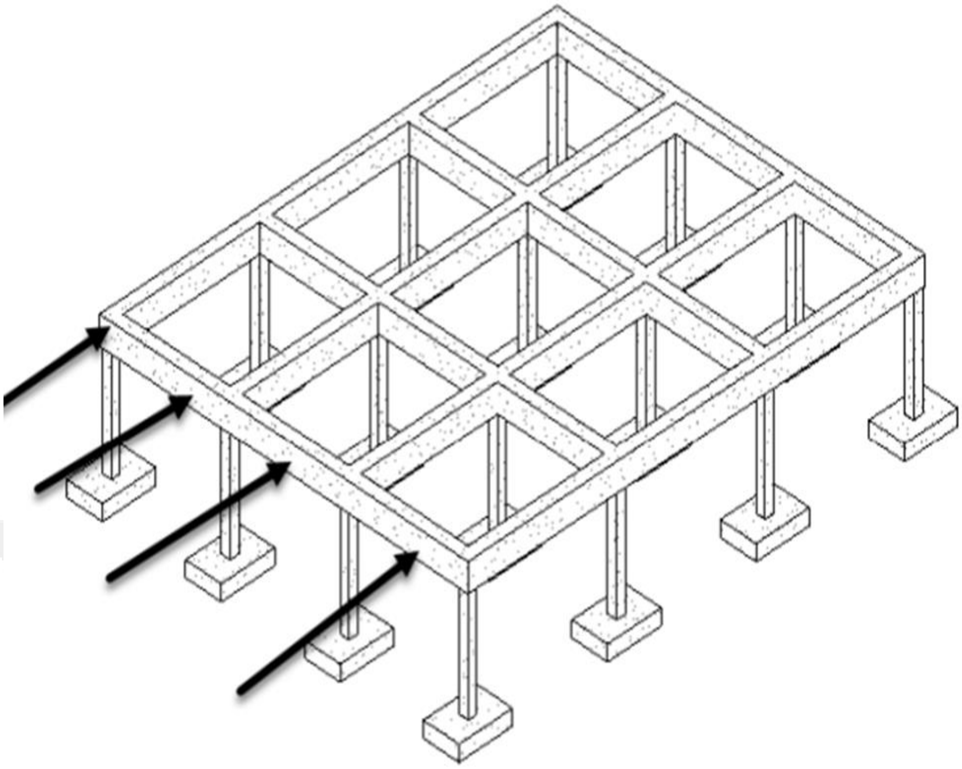

Figure 3.1: The Slab with Beam Between all Supports.

$$Mo = \frac{qu\,l \quad ln^2}{8} \tag{3.1}$$

$$qu = 1.2D + 1.6\,L \tag{3.2}$$

Table 3.1: Distribution Coefficient of End Span Total Factored Static Moment, MO.

	(1)	(2)	(3)	(4)	(5)
	Exterior edge unre-strained	Slab with beams between all supports	Slab without beams between interior supports		Exterior edge fully restrained
Interior negative factored moment	0.75	0.70	0.70	0.70	0.65
Positive factored moment	0.63	0.57	0.52	0.50	0.35
Exterior negative factored moment	0	0.16	0.26	0.30	0.65

Table 3.2: Distribution in Percent of Interior Negative Factored Moment to Column Strips.

ℓ_2/ℓ_1	0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	75	75	75
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	90	75	45

Table 3.3: Distribution in Percent of Exterior Negative Factored Moment to Column Strips.

ℓ_2/ℓ_1		0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	$\beta_t = 0$	100	100	100
	$\beta_t \geq 2.5$	75	75	75
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	$\beta_t = 0$	100	100	100
	$\beta_t \geq 2.5$	90	75	45

Table 3.4: Distribution in Percent of Positive Factored Moment to Column Strips.

ℓ_2/ℓ_1	0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	60	60	60
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	90	75	45

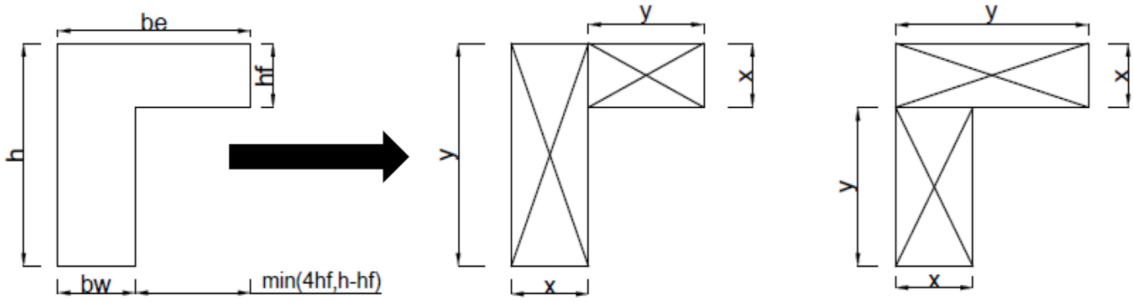

Figure 3.2: The External Slab-Beam Portion for Evaluation βt.

$$\alpha = \frac{Ib}{Is} \tag{3.3}$$

$$\beta = \frac{C}{2\,Is} \tag{3.4}$$

$$C = \sum \left(1 - 0.63\,\frac{x}{y}\right) x^3 \frac{y}{3} \tag{3.5}$$

3.2 STATISTICS APPLICATION ON TWO-WAY SLABS ANALYSIS

3.2.1 Standard Deviation

The theoretical basis of the standard deviation is complex and need not trouble the ordinary user. A practical point to note here is that, when the population from which the data arise have a distribution that is approximately "Normal" (or Gaussian), then the standard deviation provides a useful basis for interpreting the data in terms of probability. The Normal distribution is represented by a family of curves defined uniquely by two parameters, which are the mean and the standard deviation of the population. The curves are always symmetrically bell shaped, but the extent to which the bell is compressed or flattened out depends on the standard deviation of the population. However, the mere fact that a curve is bell shaped does not mean that it represents a Normal distribution, because other distributions may have a similar sort of shape.

$$S = \frac{\sum(xi - \bar{x})^2}{n-1} \quad (3.6)$$

By applying the standard deviation on the factors of interior and exterior moments:

Table 3.5: General Data of Factored Moment to Column Strips.

i	1	2	3
L2 /L1	V1	V2	V3
α L2 /L1 ≥ 1	F(v1)	F(v2)	F(v3)

If the ratio of the slab lengths L2 /L1 is greater or equal than V1 and less than V2:

Let Vi represents each value that satisfy the inequality:

$V1 \le Vi < V2$

$$x = \frac{\sum vi}{n} \quad (3.7)$$

$$f(\bar{x}_{in}) = F(v1) - \frac{F(v1) - F(v2)}{v1 - v2} \; (v1 - \bar{x}_{in}) \quad (3.8)$$

For slab with beam between all supports:

The magnitude of α is taken as the average of the effect of the moment of inertia for beam and slabs, the steps of calculating was explained as the following:

$$\alpha 1 = \frac{I_{beam}}{I_{slab}} \quad (3.9)$$

$$I_{beam} = \frac{b\,h^3}{12} \quad (3.10)$$

if $\mathrm{B_s}$ = width of slab for determining the moment of inertia:

For external beam edge:

$$B_s = \frac{L1}{2} + \frac{b}{2} \tag{3.11}$$

For interior edge:

$B_s = L1$

For other directions beams:

$B_s = L2$

$$I_{beam} = \frac{B_s\, hf^3}{12} \tag{3.12}$$

The magnitude of $\alpha m\ is\ the\ average\ of\ all\ the\ values\ of\ calculated\ \alpha$:

$$\alpha m = \frac{\alpha 1 + \alpha 2 + \alpha 3 + \alpha 4}{4} \tag{3.13}$$

3.3 SIMULATION

The simulation was made using ANSYS program, the span with beams between all joints was drawn as geometrical shape inside the elated panel in the program. The data used in the program were: L1=L2=400 cm, hf=20 cm, Wu=15kN/m^2, and b=h=30 cm. the boundary conditions were set according to the joints as fixed. The geometrical shape and the meshing data were explained in figures.

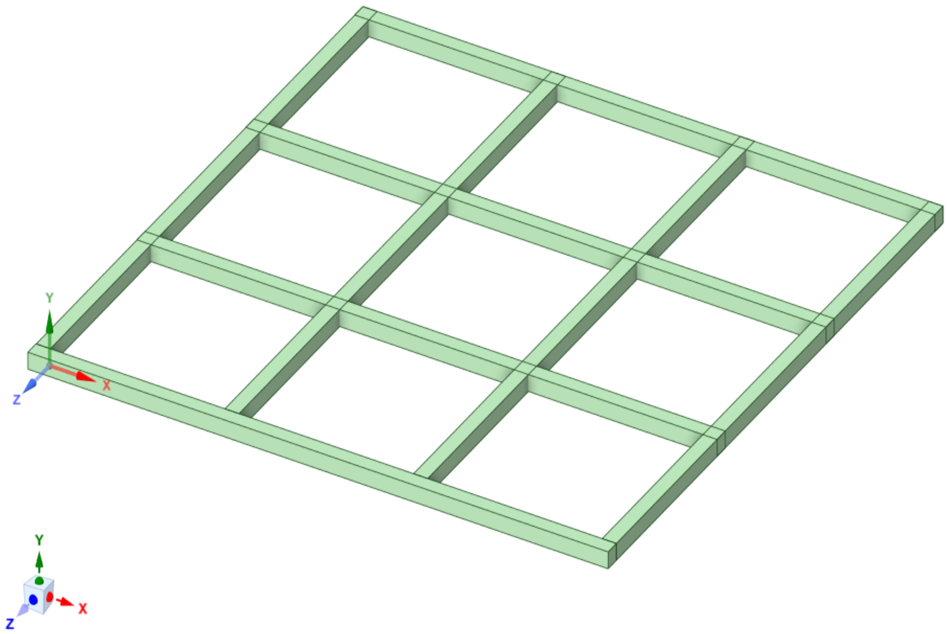

Figure 3.3: Geometrical Drawing of Beams Between Supports Under The Slab.

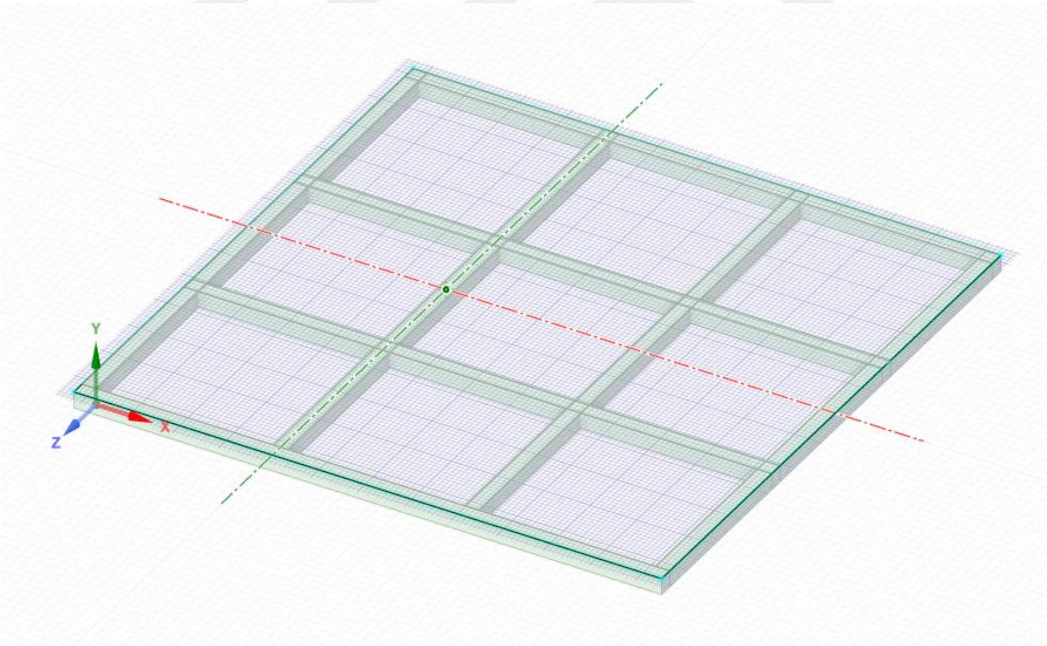

Figure 3.4: Explaining The Panels with The Beams For The Slab.

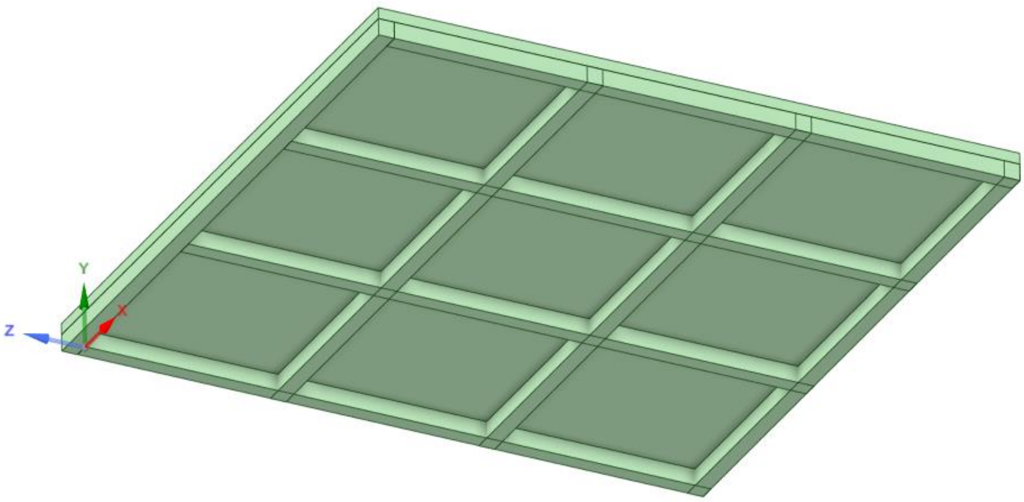

Figure 3.5: Geometrical Drawing of Panels with The Beams for The Slab.

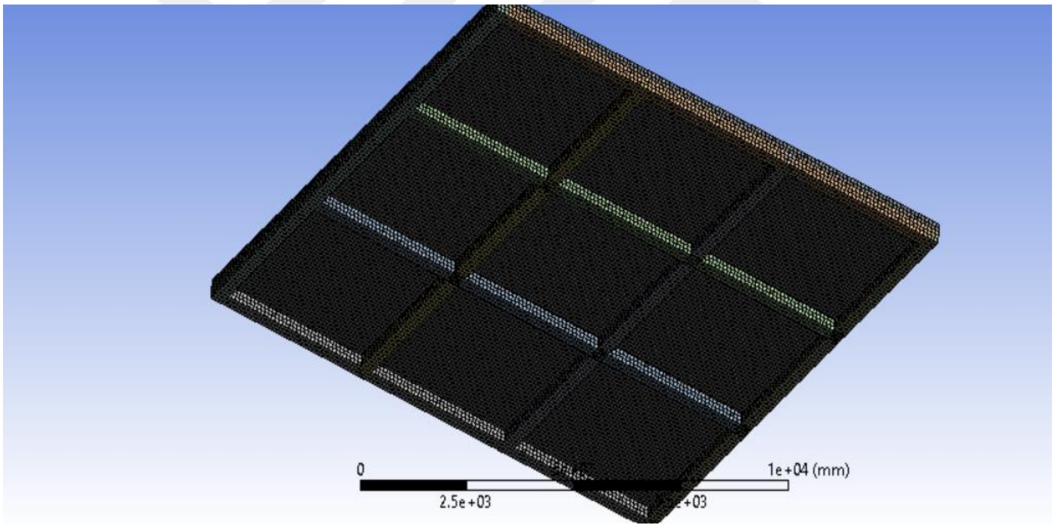

Figure 3.6: Mesh Processing for Slab System.

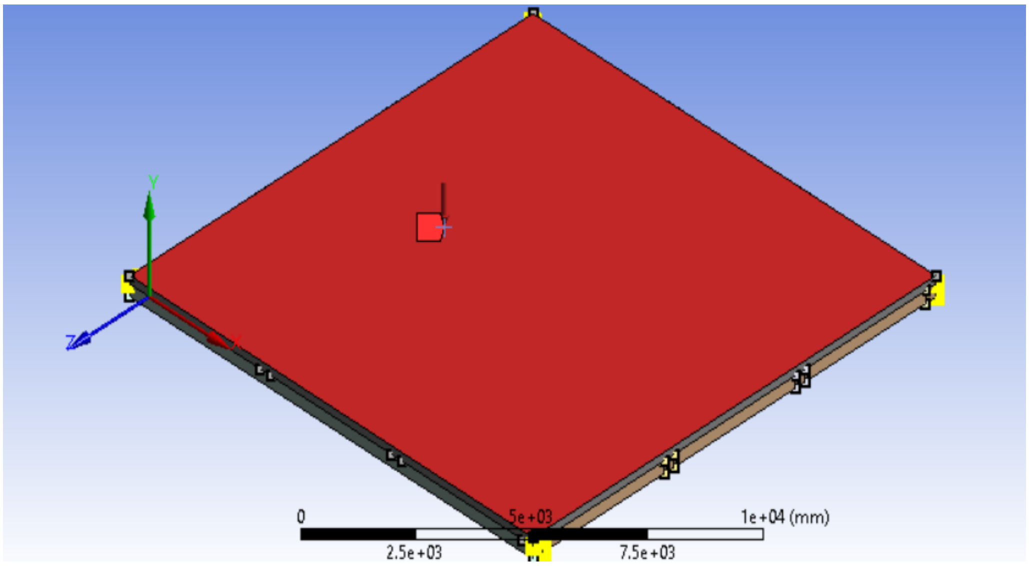

Figure 3.7: Applying The Uniform Loading on The Slab Panels.

4. RESULTS

4.1 CALCULATION OF THE MOMENTS FACTORS

The first step in the calculation route was the simplifying of the identification of αm as a way for dealing with the case slab with beams. The impact of the width of beam was set in table 4.1.

Table 4.1: The Variation of αm as B Increased.

b (cm)	**αm**
20	0.50
22	0.54
24	0.59
26	0.64
28	0.69
30	0.74
32	0.78
34	0.83
36	0.88
38	0.93
40	0.97
42	1.02
44	1.07
46	1.11

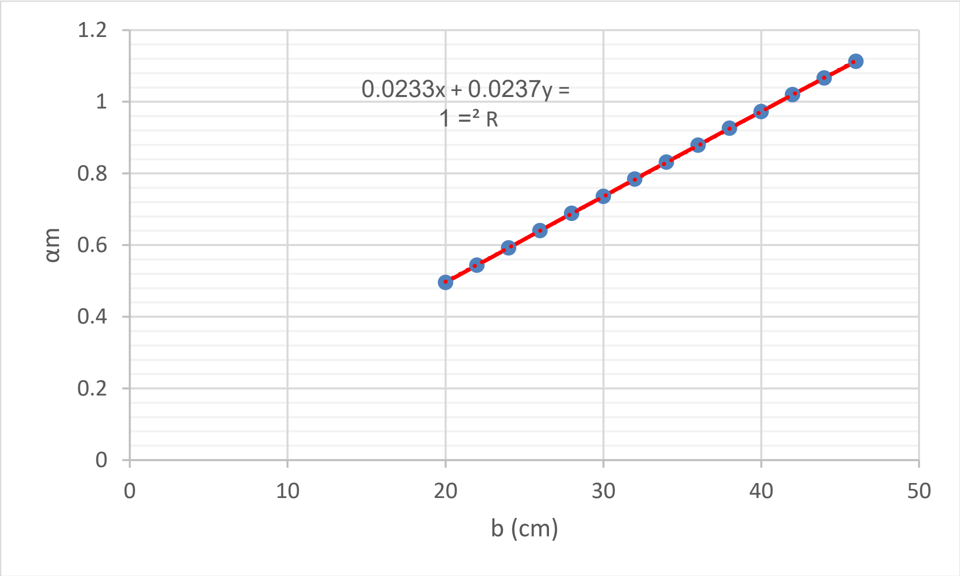

Figure 4.1: The Linearization of B and αm.

Same procedure was made for the height of the beams in which showed in table 4.2

Table 4.2: The Variation of αm as H Increased.

h (cm)	**αm**
20	0.1469
22	0.1955
24	0.2538
26	0.3227
28	0.403
30	0.4957
32	0.6016
34	0.7216
36	0.8566
38	1.0074

Table 4.2: The Variation of αm as h Increased "Table Continued"

h (cm)	αm
40	1.175
42	1.3602
44	1.5639
46	1.787

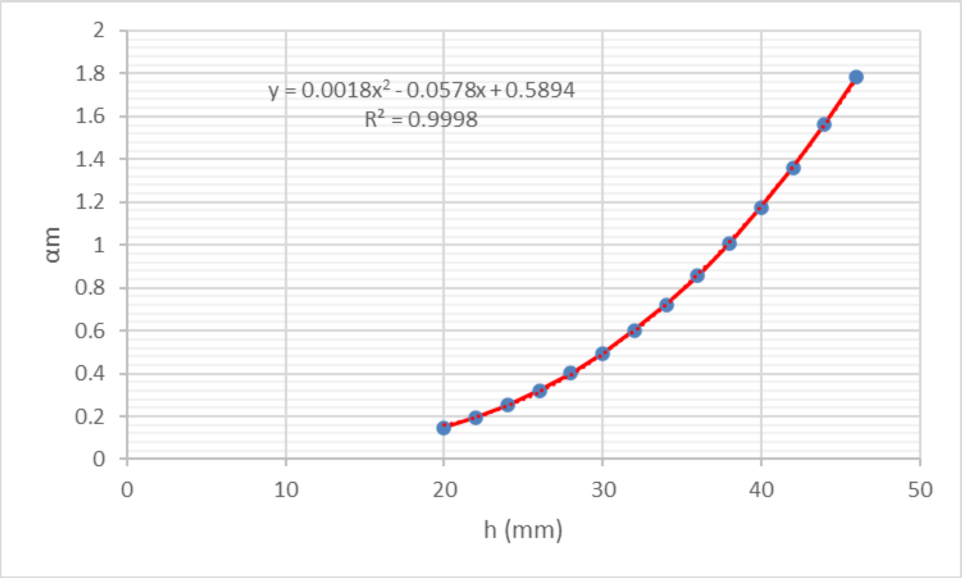

Figure 4.2: The Fitting of H And αm.

The impacts of the slab lengths L1 and L2 were explained in the tables known as 4.3 and 4.4.

Table 4.3: The Variation of αm as L1 Increased.

L1 (cm)	αm
300	0.4957
320	0.4794
340	0.4649
360	0.452

Table 4.3: The Variation of αm as L1 increased "Table Continued"

L1 (cm)	**αm**
380	0.4404
400	0.4299
420	0.4204
440	0.4118
460	0.4038
480	0.3966
500	0.3899
520	0.3837
540	0.3779
560	0.3726

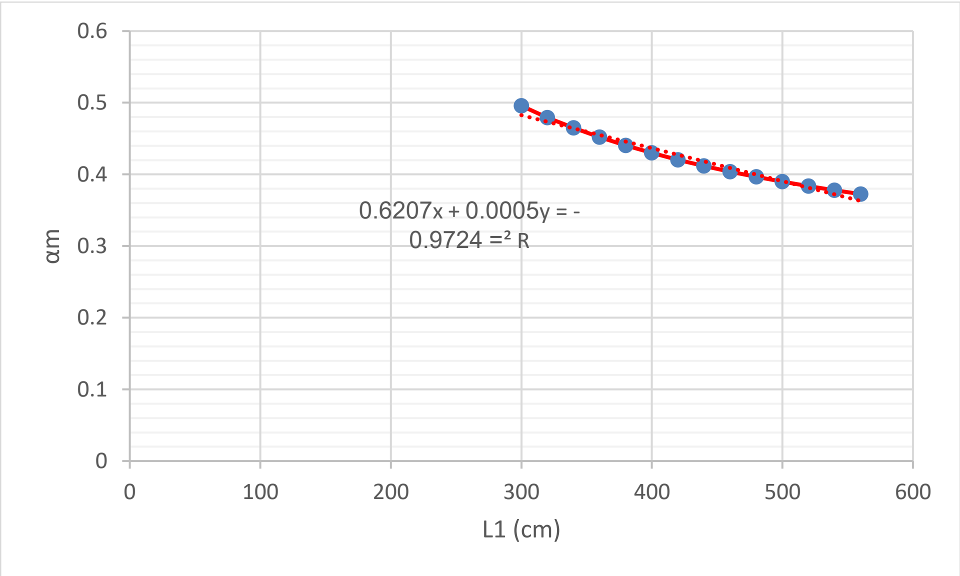

Figure 4.3 : The Fitting of L1 and αm.

Table 4.4 : The Variation Of αm as L2 Increased.

L2 (cm)	**αm**
300	0.4957
320	0.4816
340	0.4692
360	0.4582
380	0.4483
400	0.4395
420	0.4314
440	0.4241
460	0.4174
480	0.4113
500	0.4057
520	0.4005
540	0.3957
560	0.3912

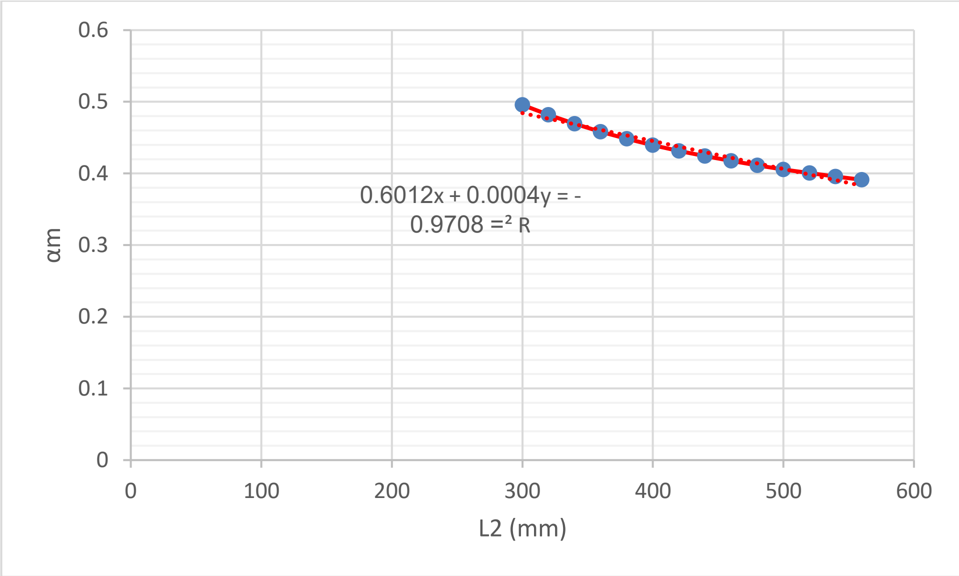

Figure 4.4: The Fitting of L2 and αm.

The contribution of the parameter b and h led to direct proportion with αm while the contribution of L1 and L2 led inverse proportion.

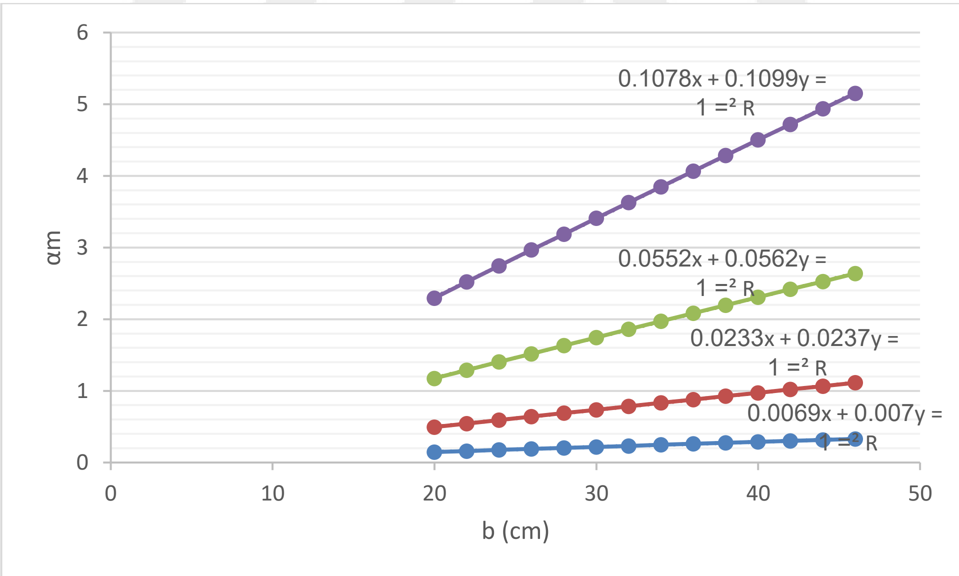

Figure 4.5: The Fitting of B and αm with Various H.

If the equations considered as y=k1 x+k2, the fitting of h with k1 and with k2 was showed in figures 4.6 and 4.7

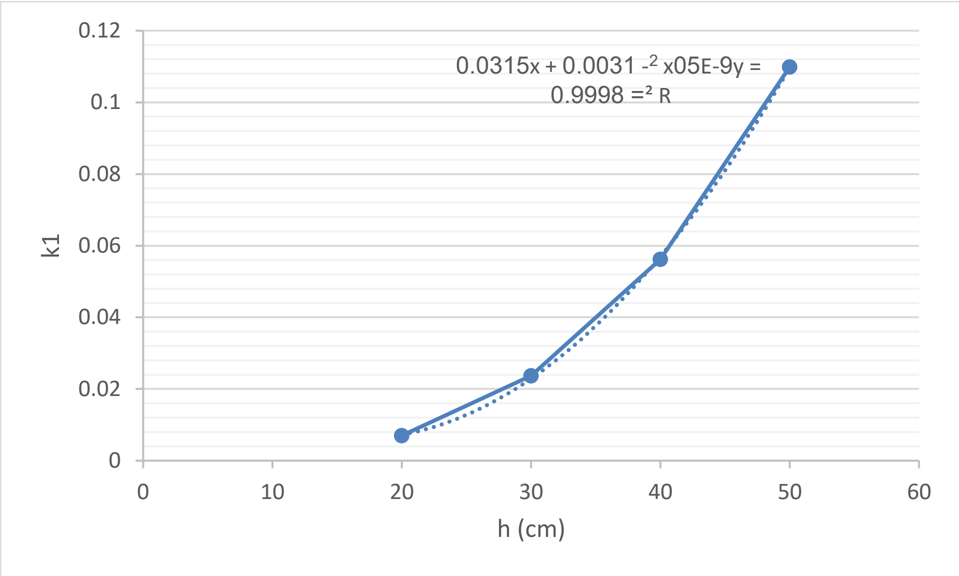

Figure 4.6: The Fitting of H and k1.

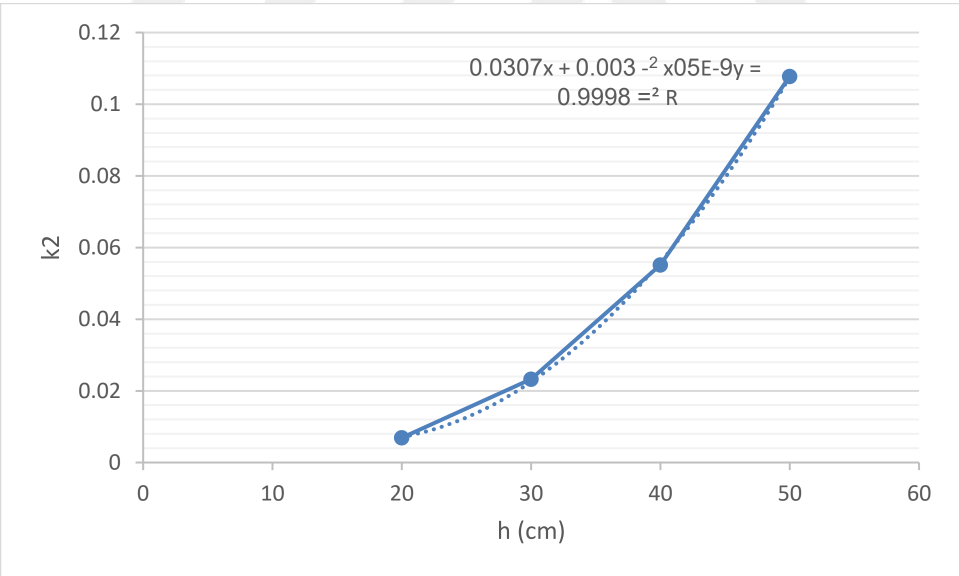

Figure 4.7: The Fitting of H and k2.

$$\alpha m' = 9\ 10^{-5}\ b\ h^2 - 0.003\ b\ h + 0.031\ b + \ 9\ 10^{-5}\ h^2 - 0.003\ h + 0.03 \qquad (4.1)$$

Table 4.5: The Validity of the Derived Equation of αm.

b (cm)	**h (cm)**	**αm**	**αm'**
20	20	0.1469	0.146
22	22	0.2146	0.1959
24	24	0.3034	0.27
26	26	0.417	0.3727
28	28	0.5598	0.5082
30	30	0.7364	0.681
32	32	0.9515	0.8953
34	34	1.2103	1.1554
36	36	1.5184	1.4657
38	38	1.8816	1.8304
40	40	2.3059	2.254
42	42	2.7978	2.7407
44	44	3.364	3.2948
46	46	4.0116	3.9207

Table 4.6: The Effect of l1 Increment on The Validity of The Derived Equation of αm.

b (cm)	**h (cm)**	**L1 (cm)**	**αm**	**αm'**	**diff**
20	20	300	0.1469	0.146	0.0009
22	22	320	0.2076	0.1959	0.0117
24	24	340	0.2847	0.27	0.0147
26	26	360	0.3807	0.3727	0.0081
28	28	380	0.4984	0.5082	-0.01
30	30	400	0.6407	0.681	-0.04
32	32	420	0.8104	0.8953	-0.085
34	34	440	1.0109	1.1554	-0.144
36	36	460	1.2455	1.4657	-0.22
38	38	480	1.5177	1.8304	-0.313
40	40	500	1.8311	2.254	-0.423
42	42	520	2.1896	2.7407	-0.551
44	44	540	2.5972	3.2948	-0.698
46	46	560	3.058	3.9207	-0.863

Table 4.7: The Effect of L2 Increment Validity of The Derived Equation of αm.

b (cm)	h (cm)	L1 (cm)	L2 (cm)	αm	αm'	diff
20	20	300	300	0.1469	0.146	0.0009
22	22	320	320	0.2015	0.1959	0.0056
24	24	340	340	0.2684	0.27	-0.002
26	26	360	360	0.349	0.3727	-0.024
28	28	380	380	0.4445	0.5082	-0.064
30	30	400	400	0.5563	0.681	-0.125
32	32	420	420	0.6856	0.8953	-0.21
34	34	440	440	0.8338	1.1554	-0.322
36	36	460	460	1.0021	1.4657	-0.464
38	38	480	480	1.1919	1.8304	-0.639
40	40	500	500	1.4044	2.254	-0.85
42	42	520	520	1.6411	2.7407	-1.1
44	44	540	540	1.9031	3.2948	-1.392
46	46	560	560	2.1918	3.9207	-1.729

For distribution in percent of interior negative factored moment to column strips:

$$\frac{L2}{L1} = 0.5{:}\ 75 + 15 * \alpha\frac{L2}{L1} \qquad if\ \alpha\frac{L2}{L1} > 1\ then\ \alpha\frac{L2}{L1} = 1 \tag{4.2}$$

$$\frac{L2}{L1} = 1{:}\ 75$$

$$\frac{L2}{L1} = 2{:}\ 75 - 30 * \alpha\frac{L2}{L1} \qquad if\ \alpha\frac{L2}{L1} > 1\ then\ \alpha\frac{L2}{L1} = 1 \tag{4.3}$$

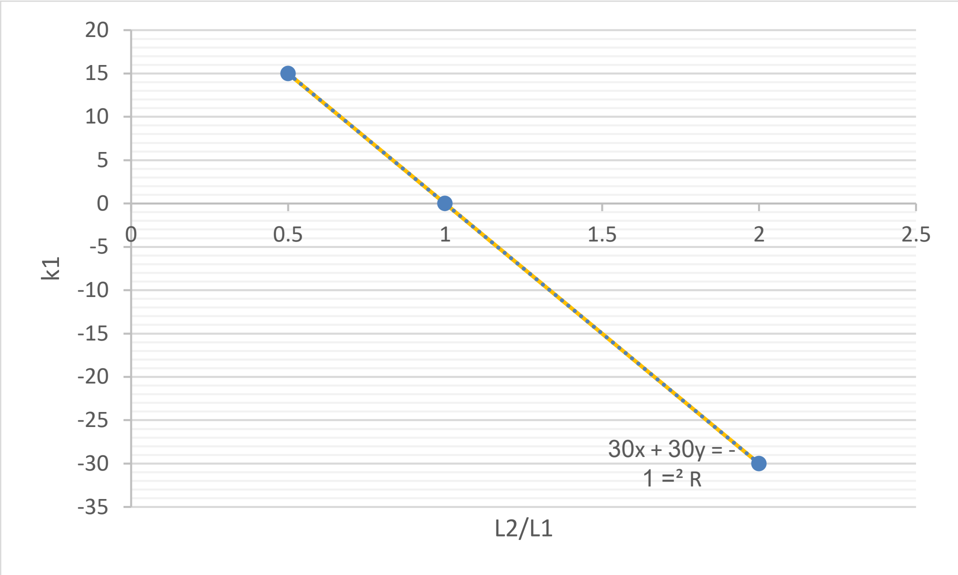

Figure 4.8: The Fitting of L2/L1 and k1 for Negative Interior Moment Coefficient.

$$Df(-) = \ 75 + (-30\frac{L2}{L1} + 30) * \alpha\frac{L2}{L1} \tag{4.4}$$

For distribution in percent of interior positive factored moment to column strips:

$$\frac{L2}{L1} = 0.5{:}\ \ 60 + 30 * \alpha\frac{L2}{L1} \qquad if\ \alpha\frac{L2}{L1} > 1\ then\ \ \alpha\frac{L2}{L1} = 1 \tag{4.5}$$

$$\frac{L2}{L1} = 1{:}\ \ 60 + 15 * \alpha\frac{L2}{L1} \qquad if\ \alpha\frac{L2}{L1} > 1\ then\ \ \alpha\frac{L2}{L1} = 1 \tag{4.6}$$

$$\frac{L2}{L1} = 2{:}\ \ 60 - 15 * \alpha\frac{L2}{L1} \qquad if\ \alpha\frac{L2}{L1} > 1\ then\ \ \alpha\frac{L2}{L1} = 1 \tag{4.7}$$

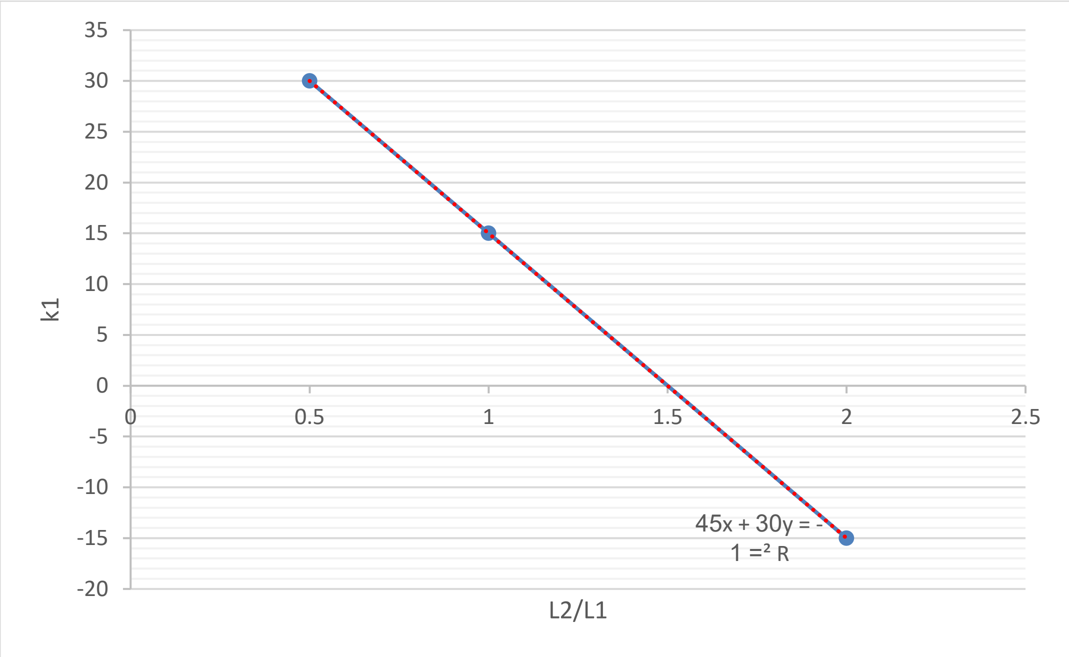

Figure 4.9: The Fitting of L2/L1 and k1 for Positive Interior Moment Coefficient.

$$Df(+) = \ 60 + (-30\frac{L2}{L1} + 45) * \alpha\frac{L2}{L1} \qquad (4.8)$$

By taking Xn when L2/L1=1:

For negative moment in interior strip:

Table 4.8 : The Negative Interior Moment Coefficient with The Increment in B and H (L2/L1 ≤1).

b (cm)	h (cm)	L2/L1					
		0.5	0.6	0.7	0.8	0.9	1
20	20	76.095	76.051	75.92	75.701	75.394	75
22	22	76.469	76.41	76.234	75.94	75.529	75
24	24	77.025	76.944	76.701	76.296	75.729	75
26	26	77.795	77.683	77.348	76.789	76.006	75
28	28	78.812	78.659	78.202	77.44	76.372	75
30	30	80.108	79.903	79.29	78.269	76.839	75

Table 4.9: The Negative Interior Moment Coefficient with The Increment in B and H (L2/L1 ≤1) "Table Continued"

b (cm)	h (cm)	L2/L1					
32	32	81.715	81.446	80.64	79.297	77.417	75
34	34	83.666	83.319	82.279	80.546	78	75
36	36	85.993	85.553	84	81	78	75
38	38	88.728	87	84	81	78	75
40	40	90	87	84	81	78	75
42	42	90	87	84	81	78	75
44	44	90	87	84	81	78	75
46	46	90	87	84	81	78	75
48	48	90	87	84	81	78	75
50	50	90	87	84	81	78	75

Table 4.10: The Negative Interior Moment Coefficient With The Increment in B and H (L2/L1 >1).

b (cm)	h (cm)	L2/L1									
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
20	20	74.518	73.949	73.292	72.547	71.715	70.769	69.788	68.693	67.51	66.24
22	22	74.354	73.59	72.708	71.709	70.593	68.819	68.007	66.538	64.951	63.247
24	24	74.109	73.056	71.841	70.464	68.925	66.262	65.361	63.336	61.149	58.8
26	26	73.77	72.317	70.64	68.739	66.615	62.99	61.695	58.9	55.882	52.639
28	28	73.323	71.341	69.054	66.462	63.565	58.877	56.856	53.044	48.927	45
30	30	72.753	70.097	67.032	63.559	60	57	54	51	48	45
32	32	72.046	69	66	63	60	57	54	51	48	45
34	34	72	69	66	63	60	57	54	51	48	45
36	36	72	69	66	63	60	57	54	51	48	45
38	38	72	69	66	63	60	57	54	51	48	45
40	40	72	69	66	63	60	57	54	51	48	45
42	42	72	69	66	63	60	57	54	51	48	45
44	44	72	69	66	63	60	57	54	51	48	45
46	46	72	69	66	63	60	57	54	51	48	45
48	48	72	69	66	63	60	57	54	51	48	45
50	50	72	69	66	63	60	57	54	51	48	45

4.2 STATISTICS OUTPUT

The mean of the values of L2/L1 taken:

$$\bar{x} = \frac{0.5+0.6+0.7+0.8+0.9+1+1.1+1.2+1.3+1.4+1.5+1.6+1.7+1.8+1.9+2}{16} = 1.2 \qquad (4.9)$$

Table 4.11: The Standard Deviations of The Negative Interior Moment Coefficient with The Increment in B and H.

b (cm)	h (cm)	Std
20	20	3.24
22	22	4.35
24	24	6.00
26	26	8.28
28	28	11.22
30	30	12.22
32	32	12.63
34	34	13.19
36	36	13.76
38	38	14.15
40	40	14.28
42	42	14.28
44	44	14.28
46	46	14.28
48	48	14.28
50	50	14.28

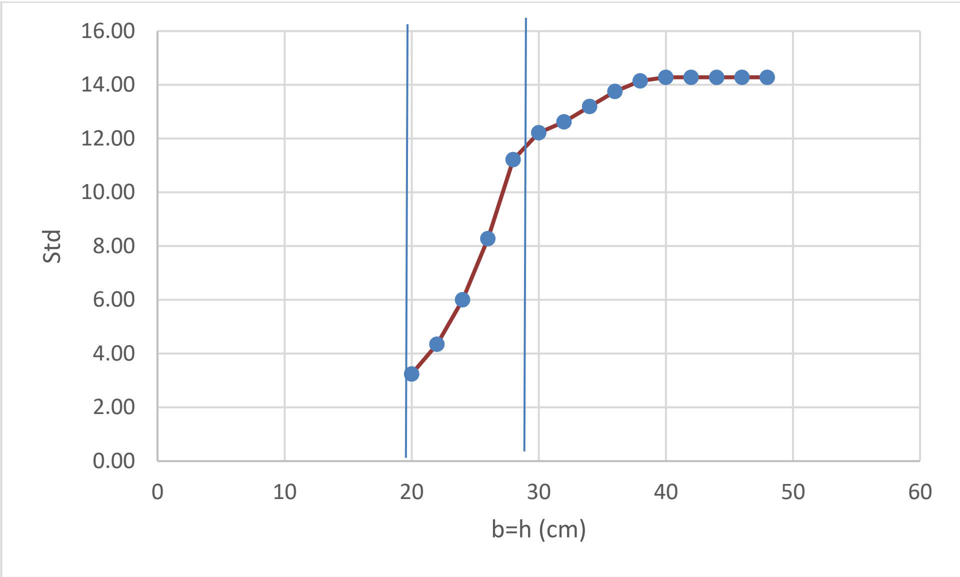

Figure 4.10: The Standard Deviations of The Negative Interior Moment Coefficient with The Increment in B and H.

For positive moment in interior strip:

Table 4.12: The Positive Interior Moment Coefficient with The Increment in B and H (L2/L1 ≤1).

b (cm)	h (cm)	L2/L1					
		0.5	0.6	0.7	0.8	0.9	1
20	20	62.19	62.365	62.453	62.453	62.365	62.19
22	22	62.938	63.173	63.291	63.291	63.173	62.19
24	24	64.05	64.374	64.536	64.536	64.374	62.19
26	26	65.59	66.037	66.261	66.261	66.037	62.19
28	28	67.624	68.233	68.538	68.538	68.233	62.19
30	30	70.215	71.032	71.441	71.441	71.032	62.19
32	32	73.429	74.504	75.041	75.041	74.504	62.19
34	34	77.331	78.717	79.411	79.411	78	75
36	36	81.985	83.744	84	81	78	75

Table 4.11: The Positive Interior Moment Coefficient with The Increment in B and H (L2/L1 ≤1) "Table Continued"

b (cm)	h (cm)	L2/L1					
38	38	87.457	87	84	81	78	75
40	40	90	87	84	81	78	75
42	42	90	87	84	81	78	75
44	44	90	87	84	81	78	75
46	46	90	87	84	81	78	75
48	48	90	87	84	81	78	75
50	50	90	87	84	81	78	75

Table 4.13: The Positive Interior Moment Coefficient with The Increment in B and H (L2/L1 >1).

b (cm)	h (cm)	L2/L1								
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
20	20	61.927	61.577	61.139	60.613	60	59.299	58.511	57.635	56.671
22	22	62.586	62.116	61.528	60.823	60	59.06	58.002	56.827	55.534
24	24	63.564	62.916	62.106	61.134	60	58.704	57.246	55.626	53.844
26	26	64.919	64.025	62.907	61.565	60	58.211	56.199	53.963	51.503
28	28	66.709	65.489	63.964	62.135	60	57.56	54.816	51.767	48.412
30	30	68.989	67.355	65.312	62.86	60	57	54	51	48
32	32	71.818	69	66	63	60	57	54	51	48
34	34	72	69	66	63	60	57	54	51	48
36	36	72	69	66	63	60	57	54	51	48
38	38	72	69	66	63	60	57	54	51	48

Table 4.12: The Positive Interior Moment Coefficient with The Increment in b and h (L2/L1 >1) "Table Continued"

b (cm)	h (cm)	L2/L1								
40	40	72	69	66	63	60	57	54	51	48
42	42	72	69	66	63	60	57	54	51	48
44	44	72	69	66	63	60	57	54	51	48
46	46	72	69	66	63	60	57	54	51	48
48	48	72	69	66	63	60	57	54	51	48
50	50	72	69	66	63	60	57	54	51	48

Table 4.14: The Standard Deviations of The Positive Interior Moment Coefficient With The Increment in B and H.

b (cm)	h (cm)	Std
20	20	2.25
22	22	2.99
24	24	4.10
26	26	5.64
28	28	7.64
30	30	8.93
32	32	10.32
34	34	12.05
36	36	13.26
38	38	14.03
40	40	14.28

Table 4.13: The Standard Deviations of The Positive Interior Moment Coefficient with The Increment in B and H “Table Continued”

b (cm)	h (cm)	Std
42	42	14.28
44	44	14.28
46	46	14.28
48	48	14.28
50	50	14.28

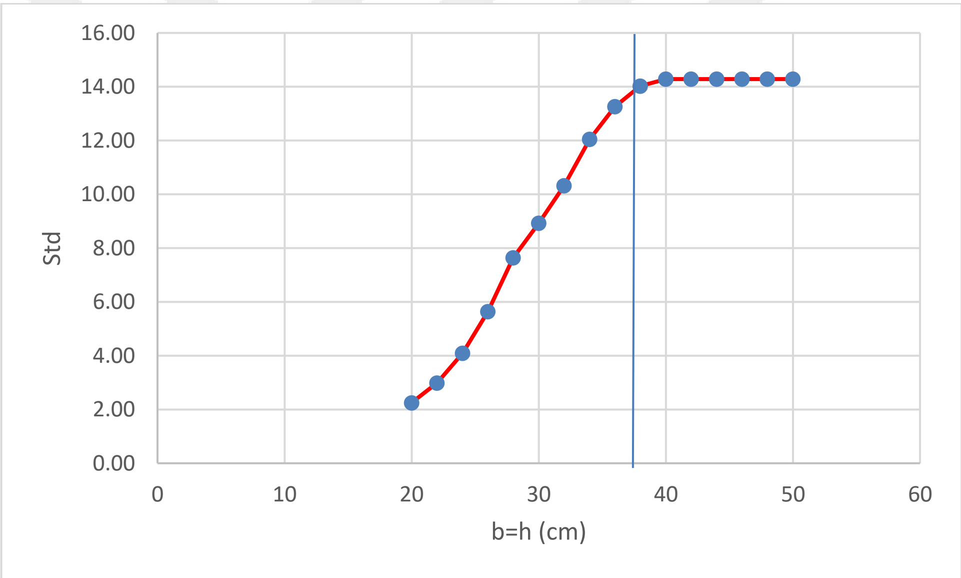

Figure 4.11: The Standard Deviations of The Positive Interior Moment Coefficient with The Increment in B and H.

The Std for negative interior moment coefficients indicates the variation in coefficient when the design staff change the L2/L1 value below or great than 1.25, these case found when b and h equal to 28 cm or below. If b and h assigned as more than 28 cm and below 38 cm. the change in coefficients be in less variation while for the case of b and h equal to magnitude great than 38 cm the variation become zero and the coefficient in the related table of ACI code been taken when αm L2/L1 ≥ 1. For positive interior moment coefficient, the variation in the coefficient increase until b and h equal to 38 cm at which the coefficient in the related table of ACI code been taken when αm L2/L1 ≥1.

If the height of beam assigned in the design as 1.5 time of the width, the variation of the coefficients for interior moment reach the values when αm L2/L1 ≥1 at less choices of L2/L1 at which b=28 cm and h=42 cm.

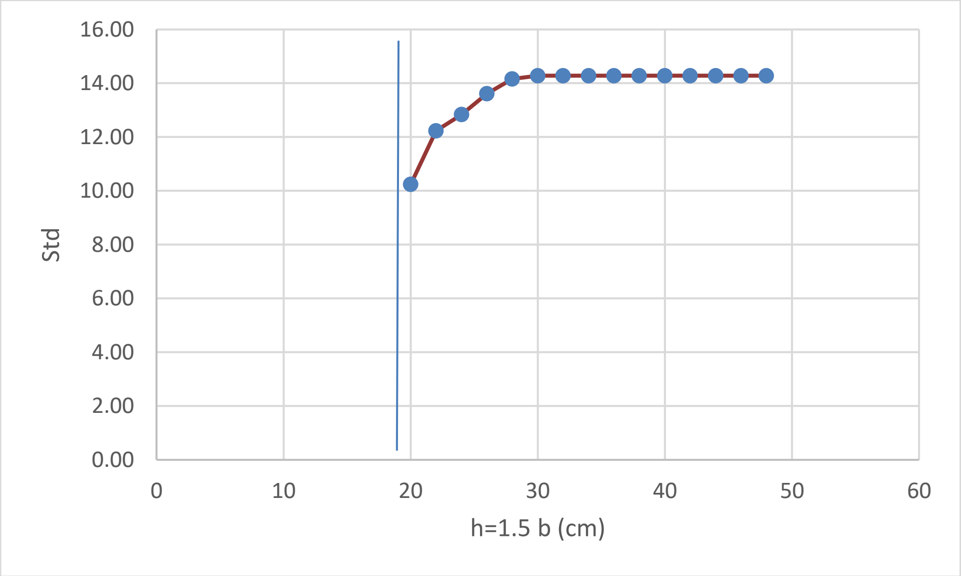

Figure 4.12: The Standard Deviations of The Negative Interior Moment Coefficient with The Increment in B and H (h=1.5 b).

The interior moment coefficient positive and negative can be identified simply by mixing the two derived equation that built by the analytical steps in the study, the equation derived set as:

$$R = \frac{L2}{L1} \quad (4.10)$$

For –M interior

$$Df(-) = \ 75 + (-30\ R + 30) * \alpha\ R \quad (4.11)$$

$$\alpha m = 9\ 10^{-5}\ b\ h^2 - 0.003\ b\ h + 0.031\ b + \ 9\ 10^{-5}\ h^2 - 0.003\ h + 0.03 \quad (4.12)$$

$$Df(-) = \ 75 + (-30\ R^2 + 30\ R) * (9\ 10^{-5}\ b\ h^2 - 0.003\ b\ h + 0.031\ b + \ 9\ 10^{-5}\ h^2 - 0.003\ h + 0.03) \quad (4.13)$$

For +M interior

$$Df(+) = \ 60 + (-30\ R^2 + 45\ R) * (9\ 10^{-5}\ b\ h^2 - 0.003\ b\ h + 0.031\ b + \ 9\ 10^{-5}\ h^2 - 0.003\ h + 0.03) \quad (4.14)$$

The limit of coefficients for –M interior and +M interior were explained in figure 4.13:

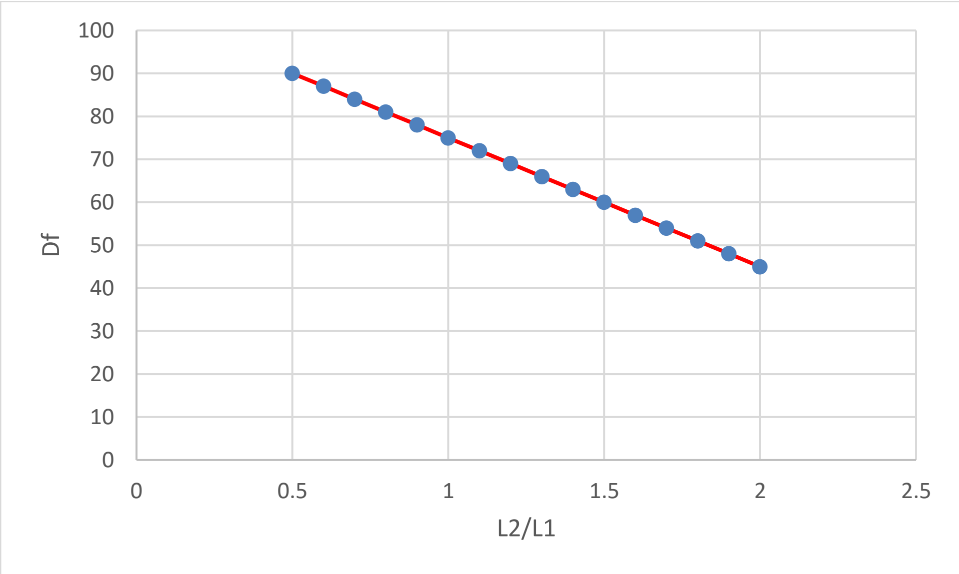

Figure 4.13: The Limit of Coefficients for M Interior.

4.3 ANSYS SIMULATION RENDERING IMAGES

For the simulation results that adopted I the study to support the analysis route, the normal stress in each direction was showed in figures 4.14 and 4.15, the color showed the variation in the compression and the tension stresses in the strips and explained the internal joints facing more stresses as satisfying with the moment distribution coefficient by ACI code.

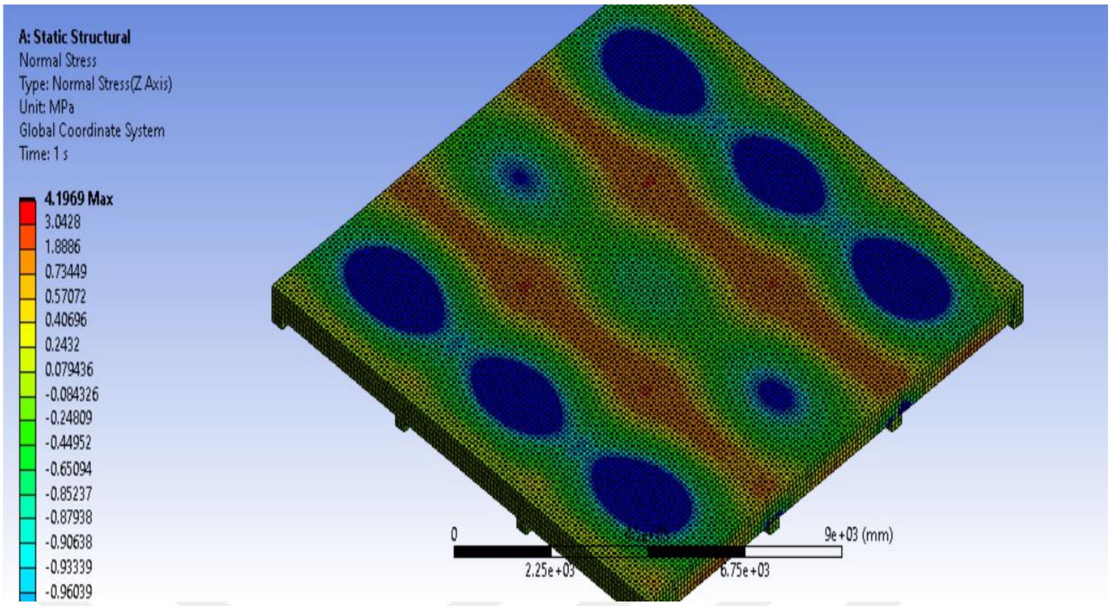

Figure 4.14: Normal Stresses Distribution of The Slab and The Beams In X-Direction.

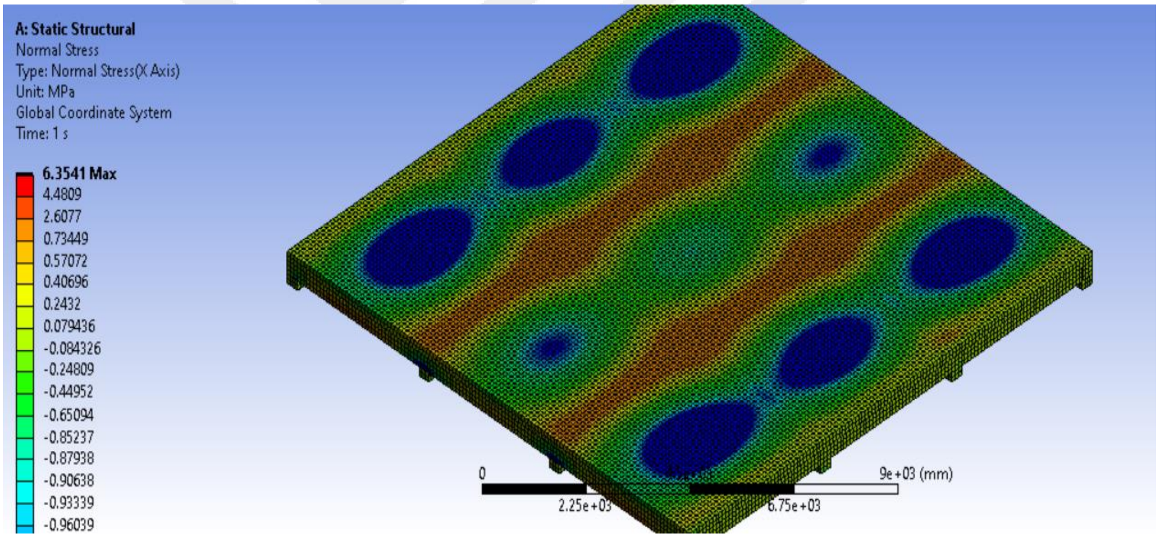

Figure 4.15: Normal Stresses Distribution of The Slab and The Beams in Y-Direction.

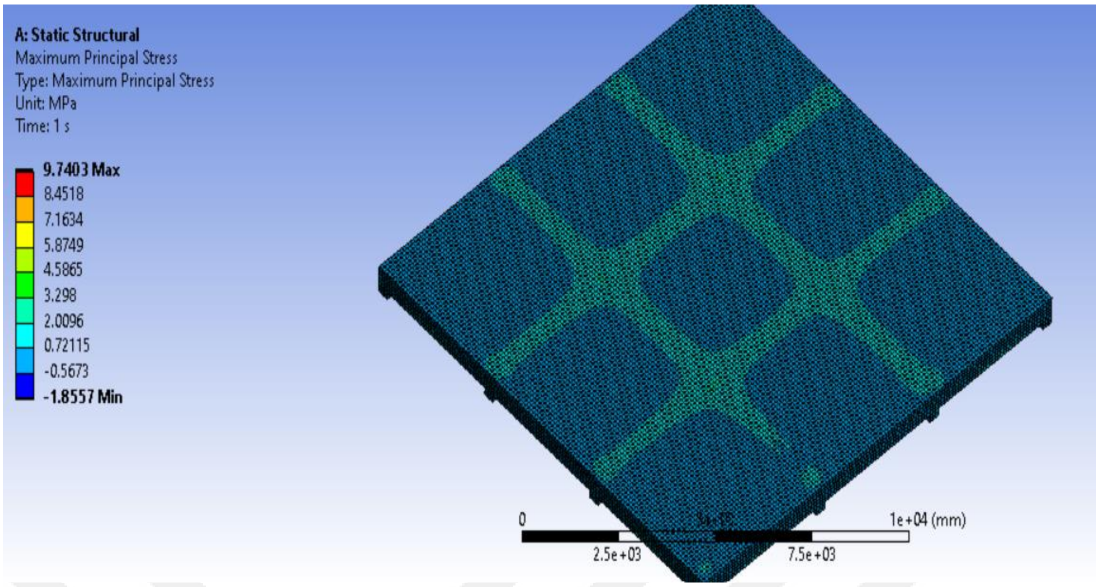

Figure 4.16: The Principal Stresses in The Slab and Beams.

5. DISCUSSION AND CONCLUSIONS

5.1 CONCLUSIONS

The study explained in tables the coefficients taken for negative and positive moment according to ACI code. The study built analysis way by identifying the affectivity of two main part from the beams under the slab and other two parameters of the slab. The beams parameters were the width b and the height h while the slab parameters were the panel length at each direction L1 and L2. The effectivity of b and h showed direct proportion for the index factor αm in which these factor based on the division of the moment of inertias for the beam at each side of the panel strip to the slab. The height of beam showed by the study in contribution more than 60% while the width contributed by less than 40%. The L1 and L2 effectivity were so small according to the beam contribution. The study for that derived equation for assigning the αm magnitude and also derived equations for the coefficients of the moments negative and positive at interior panel. The study used the statistics process to find out the standard deviation of according to the change of b and h when they equal. The study results showed the variation state according to the b and h values. The Std for negative interior moment coefficients indicates the variation in coefficient when the design staff change the L2/L1 value below or great than 1.25, these case found when b and h equal to 28 cm or below. If b and h assigned as more than 28 cm and below 38 cm. the change in coefficients be in less variation while for the case of b and h equal to magnitude great than 38 cm the variation become zero and the coefficient in the related table of ACI code been taken when αm L2/L1 ≥ 1. For positive interior moment coefficient, the variation in the coefficient increase until b and h equal to 38 cm at which the coefficient in the related table of ACI code been taken when αm L2/L1 ≥ 1. If the height of beam assigned in the design as 1.5 time of the width, the variation of the coefficients for interior moment reach the values when αm L2/L1 ≥ 1 at less choices of L2/L1 at which b=28 cm and h=42 cm. the ANSYS program was used to simulate the slab case under specific conditions. The normal stress was shown by colored image for each direction. The compression and tension stresses by the rendering colors in the program showed considerable amount of moment in the interior panel for the two directions.

5.2 FUTURE WORK

The coming work can use the results of this study to model more cases of slabs with and without beams. The modeling of slab with opening can be adopted as future idea to examine the effect of the opening on the strength of the slab. The slab reinforcement and the ways on increasing the strength of one-way and two way slabs can be also thinking in to set better analysis and design for these structural members.

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