



REPUBLIC OF TURKEY
ALTINBAŞ UNIVERSITY
Institute of Graduate Studies
Civil Engineering

**THE BEHAVIOR OF CONCRETE SMALL FLAT
PLATE REINFORCED WITH DIFFERENT RATIOS
OF STEEL FIBER**

Raghad Ali AL-SAADI

Master's Thesis

Supervisor

Prof. Dr. Tuncer ÇELİK

Istanbul, 2022

**THE BEHAVIOR OF CONCRETE SMALL FLAT PLATE REINFORCED
WITH DIFFERENT RATIOS OF STEEL FIBER**

Raghad Ali AL-SAAD

Civil Engineering

Master's Thesis

ALTINBAŞ UNIVERSITY

2022

The thesis titled “THE BEHAVIOR OF CONCRETE SMALL FLAT PLATE REINFORCED WITH DIFFERENT RATIOS OF STEEL FIBER” prepared by RAGHAD ALI AL-SAADİ and submitted on 07/12/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

Prof. Dr. Tuncer ÇELİK

Supervisor

Thesis Defence Committee Members:

Prof. Dr. Tuncer ÇELİK

Department of Engineering and
Architecture,

Altınbaş University

Prof. Dr. Zeki HASGÜR

Department of Engineering and
Architecture,

Altınbaş University

Prof. Dr. Erdem DAMCI

Department of Civil Engineering,

Istanbul University-Cerrahpasa

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

Submission date of the thesis to Institute of Graduate Studies: ____/____/____

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.

Raghad Ali AL-SAADI

Signature

DEDICATION

To the soul of my mother and father...

To my kind brothers and sister...

To my husband Dr. Akan, My son Ibrahim...

To My daughters: Tabarak, Israa...

I present this work and Humble efforts...

With love and respect...



ABSTRACT

THE BEHAVIOR OF CONCRETE SMALL FLAT PLATE REINFORCED WITH DIFFERENT RATIOS OF STEEL FIBER

Al-Saadi, Raghad Ali

M.Sc., Civil Engineering, Altınbaş University,

Supervisor: Prof. Dr. Tuncer ÇELİK

Date: December/2022

Pages: 68

Due to the experimental nature of the investigation, it is not possible to quantify the punching shear transfer mechanisms. In addition, these calculations do not account for the impact of fiber length, fiber shape, or fiber length-to-diameter ratio on the punching shear resistance of slabs. These factors have a major effect on the binding strength of steel fibers in concrete, which has an effect on the strength of the concrete, which affects the punching shear capacity of SFRC slabs. In the case of thin slabs with a large span-to-thickness ratio, flexural deformation dominates the slab's behavior. In this study, the modal features of small-scaled concrete slab models were explored using the commercial program ANSYS 16 and compared to earlier studies. The ANSYS results revealed that the geometry model used to perform a mode shape animation is inimitable. This study examines the deformation differences between two types of SFRC and the influence of these changes on slabs. The final finding was that the addition of steel fibers considerably improves the punching and shear resistance of the slabs. Utilizing steel fibers with a fibre volume between 30 and 60 kg/m³ increases the punching shear resistance of the slabs in direct proportion to the fiber volume.

Keywords: Small Plate Slabs, Crimped Steel Fibres, Hooked End Steel Fibres

TABLE OF CONTENTS

	<u>Pages</u>
ABSTRACT.....	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
ABBREVIATIONS	xii
LIST OF SYMBOLS	xiii
1. INTRODUCTION	1
1.1 OVERVIEW	1
1.2 STEEL FIBER REINFORCED CONCRETE	3
1.3 PROBLEM STATEMENTS	4
1.4 OBJECTIVES AND SCOPES	5
1.5 ORGANIZATION OF THE THESIS	5
2. LITERATURE REVIEW	6
2.1 INTRODUCTION.....	6
2.2 PUNCHING SHEAR	6
2.3 PUNCHING SHEAR PERSPECTIVE	7
2.3.1 Punching Shear in Reinforced Concrete Slabs.....	7
2.3.2 Calculations in Punching Shear.....	8
2.3.3 Design Considerations for Punching Shear in Slabs.....	8
2.4 EVALUATION OF SHEAR FAILURES	9
2.5 DETAILING MATTERS.....	9
2.6 WORKABILITY PART OF FLAT SLAB	10
2.7 ADVANTAGES OF FLAT SLABS	11
2.8 THICKNESS OF FLAT SLAB	11
2.9 TECHNIQUES OF FLAT SLAB DESIGN.....	12
2.9.1 Considerations in Design of Flat Slab.....	12

2.10 FLAT SLABS AND PUNCHING SHEAR: REINFORCEMENT SCHEMES.....	13
2.11 CURRENT WORK.....	13
2.12 LITERATURE SURVEY	14
3. RESEARCH METHODOLOGY.....	24
3.1 INTRODUCTION.....	24
3.2 MIX DESIGN AND MATERIALS PROPERTIES	25
3.2.1 Mixture	25
3.2.2 Steel Fiber Properties	25
3.3 CONCRETE MECHANICAL PROPERTIES	27
3.4 THE FINITE ELEMENT METHOD.....	28
3.5 USING SOLID WORK METHOD	29
3.6 APPLYING ANSYS METHOD.....	31
3.7 PRE-PROCESS IN THE ANSYS ENVIRONMENT	31
4 RESULTS AND DISCUSSION.....	37
4.1 RESULTS OF CONCRETE CUBES	40
4.1.1 Compressive Test Results	41
4.2 RESULTS OF CASE STUDIES.....	42
4.2.1 Results of Group A.....	43
4.2.2 Results of Group B.....	49
5. CONCLUSION AND RECOMMENDATION.....	56
5.1 FUTURE WORKS.....	56
REFERENCES.....	57

LIST OF TABLES

	<u>Pages</u>
Table 3.1: Mixture Design	25
Table 4.1: Procedure of the study	38
Table 4.2: Samples Data Specification	39
Table 4.3: The Average Results.....	42

LIST OF FIGURES

	<u>Pages</u>
Figure 1.1: Punching Shear Failure in a Bridge Deck	2
Figure 1.2: Collapse of large area of flat slab due to punching shear.....	3
Figure 1.3: Different shapes of steel fibers.....	4
Figure 2.1: Punching Shear Appearance in flat slab [4]	7
Figure 2.2: Type of Flat Slabs [14].....	11
Figure 3.1: Steel Fiber.....	26
Figure 3.2: Mixer Type.....	26
Figure 3.3: Casting the Mold	27
Figure 3.4: Test Machine.	28
Figure 3.5: Model A.....	30
Figure 3.6: Model B.....	30
Figure 3.7: Transfer Model A	32
Figure 3.8: Transfer Model B	33
Figure 3.9: Meshing Model A.....	34
Figure 3.10: Section of Meshing Model A	34
Figure 3.11: Meshing of Model B.....	35
Figure 4.1: Cubes After Compression	41
Figure 4.2 :Total Deformation of Group A.....	43
Figure 4.3: The Result of Load for The First Force.....	44

Figure 4.4: The Result of Load for The Second Force	44
Figure 4.5: The Result of Load for The Third Force	45
Figure 4.6: The Result of Load for The Fourth Force	45
Figure 4.7: The Result of Load for The fifth Force	46
Figure 4.8: The Result of Load for The Sixth Force.....	46
Figure 4.9: The Result of Load for The Seventh Force	47
Figure 4.10: Results of A0 Displacement	47
Figure 4.11: Results of A1 Displacement	48
Figure 4.12: Results of A2 Displacement	48
Figure 4.13: Results of A3 Displacement	49
Figure 4.14: The Result of Load for The First Force.....	50
Figure 4.15: The Result of Load for The Second Force	51
Figure 4.16: The Result of Load for The Third Force	51
Figure 4.17: The Result of Load for The Fourth Force	52
Figure 4.18: Total Deformation of Group B	52
Figure 4.19: Results of B0 Displacement	53
Figure 4.20: Results of B1 Displacement	53
Figure 4.21: Results of B2 Displacement	54
Figure 4.22: Results of B3 Displacement	54

ABBREVIATIONS

SFRC : Steel Fiber Reinforced concrete

FRC : Fiber Reinforced Concrete

FS : Feature Selection

FE : Finite Element

FEM : Finite Element Method

RT : Random Tree

NSC : Normal Strength Concrete

LIST OF SYMBOLS

A	: Area
d	: Effective depth
E_c	: Modulus of elasticity for concrete
C_{eq}	: Equivalent side dimension of the column
c	: Column dimension
δ	: Displacement
δ_1	: Displacement at the centre of the panel
δ_2	: Displacement at a distance 10 cm from the centre of the panel
δ_u	: Deflection at ultimate
δ_y	: Deflection at yielding
δ_{cr}	: Deflection at first crack
P_y	: Yield load
P_u	: Ultimate load
P_{flex}	: Flexural capacity
ρ	: Reinforcement ratio
Σ_c	: Perimeter of column
C°	: Temperature in Celsius

1. INTRODUCTION

1.1 OVERVIEW

Flat concrete plate of small size considered a slab hold by column without beams. This type of plate represents drop panels, and capital, are highly involved in building that had critical space, and such thing is required in car parking and tunnels. This type of structure is often governed by two-way shear failure and often occurs suddenly and catastrophically, therefore this type of failure should be carefully investigated and avoided. Shear pressures are generally resisted by concrete in terms of concrete strength, as well as traditional flexural and shear reinforcing with varying levels of activity. Using fibers is one of the most active techniques to increase slab strength behavior [1]. For a very long time, various fibers have been included into concrete to improve its mechanical qualities, especially its resistance to the spread of cracks. Because shear stresses are concentrated at the column-slab connection, concrete flat plates may collapse suddenly under loads much below their flexural strength, making this a major challenge in their design. When the flexural strength of a slab is determined to be adequate but the punching shear strength is not, and when increasing slab depth or using greater concrete strength throughout the slab is not necessary, shearhead reinforcement is accustomed to boost the punching shear strength. A shearhead is an independently specified device embedded in the concrete at the junction that reduces the effect of vertical forces by distributing the load from the floor across a larger area of the column. tested three 150mm slabs with a 19mm steel plate placed over the column and flush with the slab's compression surface to increase the column's effective size [3]. In 1970, three thin slabs of concrete were assessed. Two had shearheads, and one had a duct (7.5mm) at the end of the shearhead arm [4]. examined 2005 samples from five different locations. Crucial components are the width of the shearhead and the flat steel strip welded to the steel channel shape [5]. Included an investigation into the open wide collar shear strengthening technique and a numerical study of a flat plate construction with a specific embedded shearhead using the finite element method. She theoretically analyzed the outcomes of using three distinct types of steel plate for shear reinforcement (a square steel plate with scattered shear connectors on its surface, a square plate with rounded edges and distributed shear connectors, and a cross-shaped steel plate.). Because of the brittleness of concrete, punching failure is one of the most severe and catastrophic failures in building construction. a two-way shear failure in a flat plate placed next to a column or at a certain distance from the column face that

causes the whole collapse of a structure. A concentrated load or column support zone is where punching shear failure, a brittle local event, often occurs. This kind of failure is catastrophic since there is no preceding, outward, visible indicators of failure. A column is often punched through some of the adjacent slab in a flat slab punching shear failure. An example of a punching shear failure is shown in Figure 1.1[6].



Figure 1.1: Punching Shear Failure in a Bridge Deck

When choosing the flat slab's thickness at the slab-column intersection, this form of failure is among the most important factors to take into account. The precise prediction of punching shear strength is thus a fundamental challenge for the design of flat slabs, and the safe design of concrete flat slabs is of vital significance.

Many strategies have been put out to avoid punching shear failure. One of these methods is the use of reinforcement bars perpendicular to the crack direction, which may be produced in a number of ways, such as shear reinforcement, the corrugated studs' system, the continuous stirrup system cages, and concealed beams, as shown in Figure 1.2. In recent years, it has been popular to add fibers to concrete to improve behavior while maintaining a low typical reinforcement ratio. The concerns of concrete brittleness are exacerbated in the event of an unintentional fire [7].



Figure 1.2: Collapse of large area of flat slab due to punching shear

1.2 STEEL FIBER REINFORCED CONCRETE

Cement, gravel and sand aggregates, different kinds of fibers, and water make up the majority of Fiber Reinforced Concrete (FRC). Steel Fiber Reinforced Concrete (SFRC), which is the concrete produced by combining steel fiber with concrete, is another kind of fiber that is thought to originate from artificial sources in addition to fiber [8].

To increase the concrete's tensile strength, SFRC is often utilized in building projects. Due to the steel fiber's ability to carry tensile stresses, the inclusion of steel fiber also reduces the creation of micro apertures that result in microcracks. This reduces crack propagation and increases the concrete sample's ability to bear loads. Even once weaknesses were apparent, one of the s biggest benefits was there are two categories of steel fibers: smooth and deformed. As seen in Figure 1.3, it comes in a variety of forms, including round, rectangular, and hook-shaped. Also, the steel and concrete were mechanically distorted in order to strengthen the bonding strength. According to engineering theory, deformed steel fibers are more efficient because their surface area rises, enhancing the cement-matrix connection and so boosting pull out resistance.

On the other hand, the concrete and the kind of straight fibers (not distorted) are only joined by friction and chemical adhesion. Steel fiber diameters vary from 0.5 to 1.2 mm and lengths from 10 to 65 mm [9].

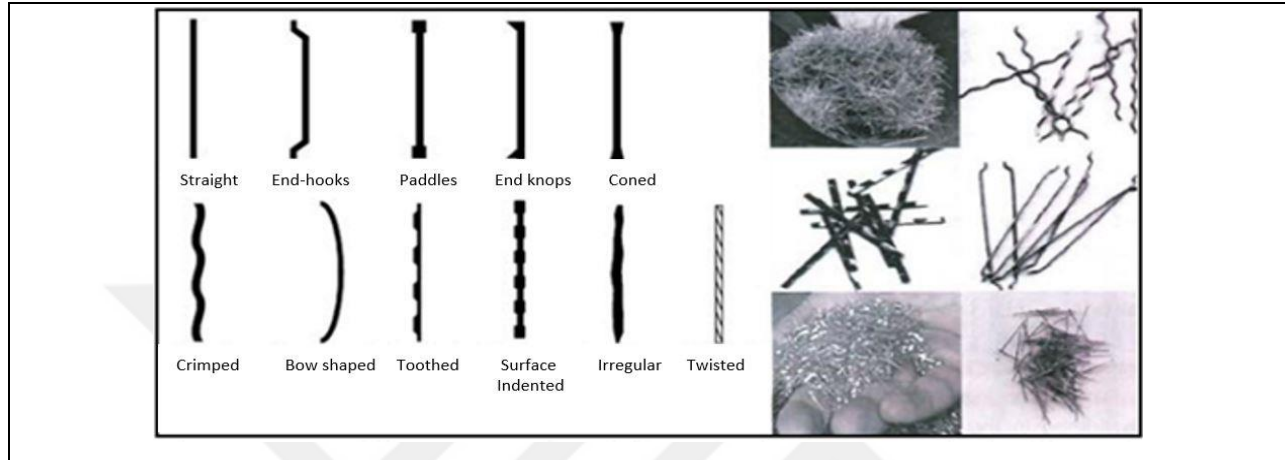


Figure 1.3: Different shapes of steel fibers

1.3 PROBLEM STATEMENTS

The failure of the slab-column connection is caused by yielding reinforcement, crushing of concrete, and generated internal diagonal cracking, the failure can be caused by either too much flexing or by shearing forces. The punching shear strength is defined for the slab-column connection as the net ultimate reaction at the column's contra flexural points. When a reinforced flat slab structure made of normal strength concrete (NSC) is under a significant gravity load, punching shear fractures appear at the slab tension surface near the column. A truncated conical or pyramid failure surface forms around the column as they spread at 20° to 50° angles across the slab thickness. Unbalanced moments, in addition to vertical loads, may make the slab-column connections vulnerable. These moments might be brought on by unequal spans on each side of the column or lateral stress from earthquakes or wind, for example. Many coding equations and mechanical models have been created, but there are still many problems to be solved, such as how to simultaneously increase concrete's strength and ductility. A number of methods have been proposed for improving ductility of partially loaded panels and preventing two-way shear action. Although shear reinforcements and steel studs are often used nowadays, fibrous concrete (mostly SFRC) shows a significant improvement.

1.4 OBJECTIVES AND SCOPES

On the basis of the above, experiments are conducted to determine how steel fiber affects the flat plate's residual strength. This goal will be accomplished by studying the effects of various load levels on SFRC flat plate:

- a) Comparison of the punched shear behavior of the SFRC slab under various loads with the behavior of the slab at ambient conditions.
- b) Examination of the impact of the volume percentage of steel fiber on punching shear capacity.

1.5 ORGANIZATION OF THE THESIS

This thesis has five chapters.

Chapter one provides a primer on the behavior of flat plates under punching shear strength and information on how fire and steel fiber affect the behavior.

Chapter two gives a broad overview of steel fibers and the impact of fire on the behavior of concrete in various studies gathered from various researchers. Alternatively, a comparison of prior, comparable works.

Chapter three The experimental plan, which included the investigated factors, the process, and testing of SFRC flat plates specimens.

Chapter four discusses the result and the calculation of the work.

Chapter five is the conclusion

2. LITERATURE REVIEW

2.1 INTRODUCTION

In low to medium-rise multistory buildings, reinforced flat plate structures are frequently utilized; they consist of a floor or roof of constant thickness carried directly by prism columns. The droplet panels, column assets, and spandrel beams are omitted, and the flat plate slab has proven to be more cost-effective when building tall apartment buildings. It is also preferable in bridge decks than multistory buildings like offices and parking garages because it makes it possible to arrange pillars and partitions easily and adaptably, which reduces the overall height of tall buildings. Around the column connection, there is a buildup of shear, which can result in abrupt punching shear failure at loads significantly below the slab flexural strength, is the key design issue with concrete flat plates. Usually unexpected, punching failure of the slab causes the flat plate constructions to gradually collapse [1].

The native and fragile essence of the punching shear disappointment in the form of paragraph punching it through slab across a truncated cone is caused by a diagonal crack around the column. modern flat bowl flooring systems Installing new services frequently necessitates creating openings close to columns. The apertures are required for electrical ducts, ventilation, air conditioning, and sanitary details. The slab-column joining's punching shear capacity is further diminished as a result of the inaugural's removal of some of the volume of real necessary for resisting shear force and imbalanced moment. As a result, the connection is more susceptible to breaking under pressure[2].

2.2 PUNCHING SHEAR

When concentrated loads are applied to structural elements such as slabs and foundations, shearing failure mechanisms such as punch shearing occur. Concentrated loads act on a smaller region of the structural parts. In most instances, the response that follows the column operating in opposition to the slab is this one. The slab will eventually give out. Disappointment may be caused by the weight punching through the slab, which is a unique possibility. A pillar, particularly one on a fabric basis, and helm loads are two instances of focused loads on a slab. This same kind of failure could potentially occur in other ways. Turning the building over, we find a level slab sustained by

a pillar with a significant shear force concentration at the column head. shears for having cut when the total shear and utter force is greater than the shear resistance of the slab, the slab will be driven down around the column, or you can think of it as the slab being punched through by the cornerstone [3]

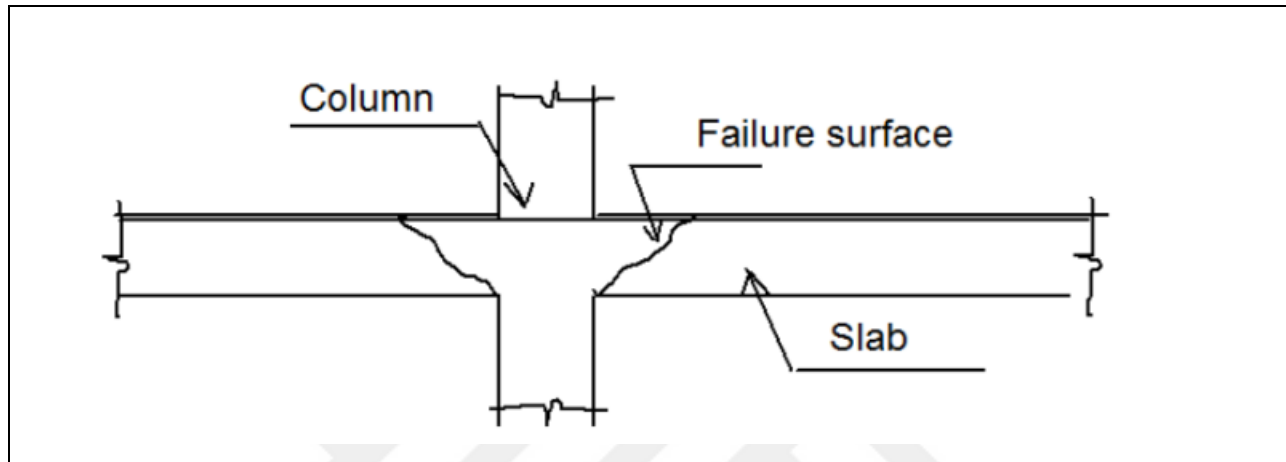


Figure 2.1: Punching Shear Appearance in flat slab [4]

2.3 PUNCHING SHEAR PERSPECTIVE

Normal flooring slab, flat lintels, and the basis slabs underneath the pillar all experience punching shear failure. In pad fundamentals, when weight and depth are not crucially important, its contents are met by adequate depth. [5].

2.3.1 Punching Shear in Reinforced Concrete Slabs

A 2D counterpart of the shear seen in beams Possibly applicable to comprehend punching shear in reinforced concrete slabs. Such disappointment comes as an unanticipated breach. The assistance of chief reinforcement cannot tame this argument. As a result, through the action of shear, the ultimate load volume of the structure is reduced below the flexural capacity. Punching shear, however, is less dangerous as compared to beam shear. When cutting-edge slabs are exposed to significant concentrations of stresses, punching shear occurs. Wheel loads on bridge slabs or weights from above falling on the columns supporting the slab ground are examples of these load categories [6].

2.3.2 Calculations in Punching Shear

The estimates for shear wall used in the design are based on the power of the punch shear that is punching against the breadth of the slab well before foundation. Sole if shear is the only force present in the system can this occur. There is no way to question that there is a technique for moment in the pillar or pedestal. The applied quantities of shear and moments are based on the punching shear failure cone to get the Highest Punching Shear[7].

2.3.3 Design Considerations for Punching Shear in Slabs

The Punches by using the following control methods, failure of the structure can be avoided: Make sure the concrete is properly inspected to determine its strength. Check to see if the amount of reinforcing is suitable if the concrete lacks sufficient strength. It is advised to alter the construction's form if it is not logical. The following techniques can be used to change the structure's form: Increasing the slab's depth You can increase the size of the columns. a variety of drop boards widening column heads are introduced. Repetition of other liberal designs can be referred to as inflow of foreign code. The areas where reinforcement has to be provided are based on various failure zones that run lengthwise through the area. It is usually easy to traverse disappointment lines. They are aware of the potential sources of disappointment. As a result, every potential letdown plane needs to be armor-plated. The project strength must not be exceeded by the average shear stress on the control surface. This project's strength is frequently compared to its tensile forte. The punched shear design facilitates the effects of moment transfer at the column or slab junction. The assessment of punching shears is based on various factors. These parameters are units that are located a specific distance from face of column. The most significant different portions are located on the face of column and at a distance of $d/2$ from each lateral. The structure will be at risk of punching failure if the shear pressure at these parts exceeds the permissible stress value. From one unique code to another, the project formulas and parameter coldness would differ. However, the assessment of punched shear failure is based on a concept. [8].

2.4 EVALUATION OF SHEAR FAILURES

Shear failure in level slab is exceedingly serious and can cause full structures to collapse, not just a portion of the slab. Concerning the program that is being rummaged-sold for exclusive "headed" bars to project traditional links for patented products, controlled bars may have a more effective port than traditional links. This may allow for a relaxation of the spacing requirements for traditional relations or an increase in the amount of all-out shear that can be handled. Software shouldn't be used to support the use of conventional relations unless it is obvious that it is completely compliant for old-style linkages. The argument for the shear capability of a branded system is not based just on calculations but also on testing that benefits from the enhanced anchoring of such systems[9].

2.5 DETAILING MATTERS

The mechanical performance is impacted by the detailing process, and the specification will have an effect on the actual capacity of the unit. Because of this, publications from The Organization of Structural Engineers for those who are still in charge of specifying reinforced concrete, the standard methods of detailing physical concrete, which establish available best practice, are crucial reading. Moving away from such tried-and-true standard details without a comprehensive understanding of the principles such elements address may have an impact on the overall structure's security. It's important to read The Common tactic of describing structural actual. As part of the Standard way of specifying structural concrete, traditional linkages must be fixed. Fixed (lacer) bars must extend at least one port length further than the preceding link if they are required. The overall distance of the fixing saloon must be specified and then followed on site; it is unclear how this requirement was conveyed to the contractor. The influence of drainage and service riser holes next to the column must be taken into account when building level slabs since they will modify the shear capacity and call for special attention. The standard way of detailing physical concrete covers detailing for holes, including linkages. ensuring that strengthening is properly installed on site traditional linkages that are attempted to be normalized out on a radial grid determination produce non-compliant spacing. Such links ought to be laid out normally on an orthogonal grid as advised by the conventional approach of detailing. [10].

2.6 WORKABILITY PART OF FLAT SLAB

Slabs seem to be carefully suitable for the majority of constructions, such as asymmetrical column setups, similar floor tiles that may occur, and stairways, among others. There are numerous advantages to smearing flat slabs, including thorough solution, flat fascia, and formability. Level 1 slabs provide engineers and architects a great deal of creative latitude despite their high cost. Flat slabs provide several benefits for the whole construction project, particularly for reducing bad setup and shortening build times, in addition to possible design and layout efficacy. If at all feasible, avoid using drop panels and make the most of the breadth of flat slabs. To preserve the advantages of level soffits for the ground surface, drop boards should be cast as a part of the column. The following characteristics should be taken into consideration while employing slab thickness to maximize equality [11]:

- a) Procedure related to design.
- b) Presence before absence of holes.
- c) Significance of deflections.
- d) Previous layout application knowledge.

Flat Slab Construction Types

The following are the several types of slab buildings. [12]:

- a) Simple level slab.
- b) A flat slab with a drop panel.
- c) Flat slab with pillar heads.
- d) Flat slab with both drops boards and column heads.

Usages of Drop Boards [13]:

It tends to increase the shear strength of the slab, as well as its negative immediate capacity. It stiffens the slab, reducing ricochet.

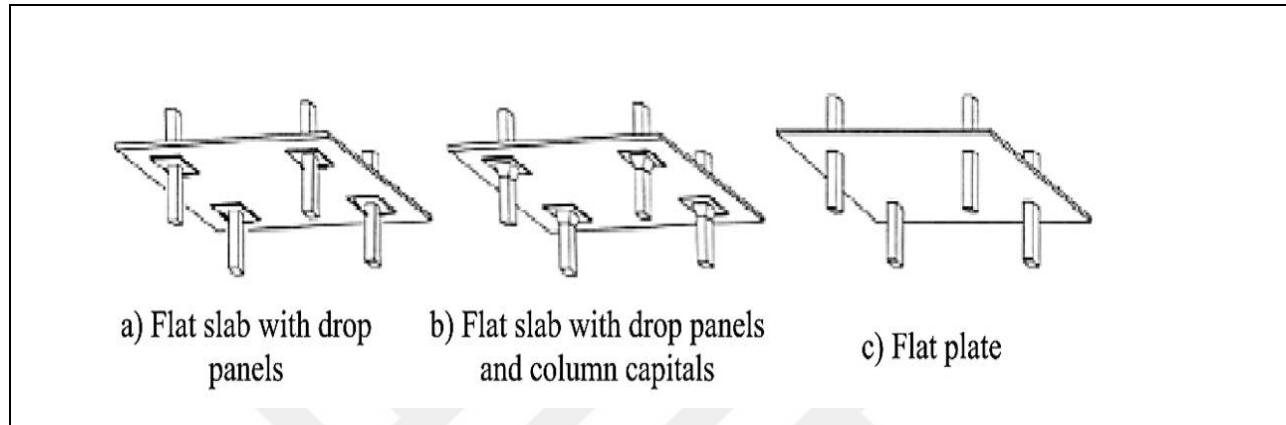


Figure 2.2: Type of Flat Slabs [14]

2.7 ADVANTAGES OF FLAT SLABS

Plane Slabs deprived of droplet frames can be constructed at a rapid pace because the building's outline is simple and reduced. A combination of early arresting and flight systems can also result in a quick turnaround. In the absence of a false ceiling, pre-stressed concrete construction can dramatically lessen floor height. The use of level slab building limits the placement of lateral services and splitters. This may be beneficial in cases where the building height is lower and the cladding costs are lower than in pre-fabricated facilities. Flat slab construction is the best option if the client intends in order to create changes to the interior and needs to use the lodging to suit their needs hence, it provides the proprietor that flexibility. The utilization of a square frame as well as the absence of ray, which makes service harnessing and partition allocation complicated, allow for this flexibility[15].

2.8 THICKNESS OF FLAT SLAB

Flat slabs are an additional very appealing benefit because thin slab allows for a higher ground to ceiling height and thus lower cladding costs for the owner. However, because supplemental additional forces are required to address design issues, there is a significant lower limit to slab

width. It apart from that, more leeway should be allowed to enable for major changes at a later date [16].

2.9 TECHNIQUES OF FLAT SLAB DESIGN

There are several procedures and techniques involved in designing flat slabs and subsequently analyzing those slabs in flexures. The following techniques are some of them:: [17]:

- a) The evidence-based method.
- b) The sub-frame technique.
- c) The yield line technique.
- d) Finite-element analysis.

Empirical techniques are employed for relatively small edges., but for more irregular edges, the sub-frame method is rummage-sale. The designs are conceived using suitable technology, but the details are completed using sub-frame methodologies for actual intricate designs, which can be very costly. To achieve the most expense and uniform cavalry installation, use the yield streak method. Because this process only employs a collapse device, a thorough inspection of distinct cracking as well as deflection is needed. Finite-component analysis is thought to benefit structures with unusual supports, large openings, or the ability to withstand heavy loads. Once selecting material items or attempting to install loads on structures, wonderful care is taken. Ricochets and ruptured width can also be calculated using finite-element analysis [18].

2.9.1 Considerations in Design of Flat Slab

- a) The center of each board usually has the most deflections. Predicting deflections is difficult, and determining them necessitates some form of elastic appraisal. A special way to evaluate center deflection when designing the structure layout and then implementing it with the deputize frame method is to use at least two concurrent column plank flooring[19].
- b) Exclusive punching shear bolstering systems. In the case of thin flat slab construction, punching shear cavalries are required.

- c) Main ensure optimization- Having to cut project went, particularly yield line output, are best optimized than some other design methods.

2.10 FLAT SLABS AND PUNCHING SHEAR: REINFORCEMENT SCHEMES

Because of the large span needed, steel and concrete level slabs are the most common floor system used in residential car parks, buildings, and many other structures. Ground systems for maintaining the height between floors and ceilings are simple to construct. Clients and designers prefer flat slabs because they save money by expediting the construction process. Threshold slabs, on the other hand, have a significant structural manufacturing flaw in that they are prone to punching shear failure at the junctions of pillars and editorials. The main concern when using flat slabs seems to be shear transfer from the slab to the cornerstones. A article skull or fall panel ropes this same flat slabs and provide punching shear resistance around the column. However, from an architectural standpoint, saving space between floors is not recommended. The most serious type of disappointment will be shear disappointment caused by punching shear on the columns. A pretty standard shear failure is defined by a slanting fracture that starts at the bottom of the slab and develops to the top at such an angle of degree towards the horizontal, arising in truncated pyramid separation of the slab around the pillar. The unique reaction of punching spalling causes the same liberal collapse of a structure. The concrete strength, slab depth, and column size, followed by the area of tautness reinforcement, determine the punching sheer and utter capacity of a slab without shear reinforcement. Any starts close to the pillar's perimeter, such as inter-building services, can also reduce shear capacity.

2.11 CURRENT WORK

The study analyzed the impact of punching shear on flat slab structure with different types of steel fibers. The study showed and evaluated the related factors that include geometrical factors that the depth and dimensions of the slab and also physical properties like the compressive strength of the concrete and the reinforcement system. The study examined the effect of various types the steel fiber content on the strength of the slab against the applied shear under various loading. The study aimed to improve the design of flat slab against the failure by punching shear by enhancing the way of reinforcement used for each adopted case.

2.12 LITERATURE SURVEY

(Y. Reichman & M. Adan, 2014) The study revealed that the structural demonstration of a regular type of office building was investigated. The structural scheme's ability to withstand seismographic excitation was investigated, as was its loudness to protect a liberal collapse caused by first-floor column disappointment caused by explosion. A new design approach is proposed to improve the building's performance while lowering the cost of the structural scheme due to flaws in the tower's performance. The importance of design which can prevent progressive collapse has indeed been recognized in recent decades as a result from several disastrous construction failures caused by terrorist attacks or unintended gas blasts around the world. Cutting-edge This daily paper progressive failure analysis is carried out in accordance with the UFC [1] design standard, using the nonlinear dynamic analysis method. The nonlinear dynamic examination approach was used for the current study, which stretches the best insight hooked on physical marvels and structural behavior.

The seismic investigation was carried out in accordance with ASCE [2] using the Modal Analysis. To present these issues, a 17-story RC workplace building with such a bright facade and three cellar stories was used. A commonly occurring system for this type of building would include level slabs supported on pillars, no beams before moment frame connections, and a central essential to provide seismic resistance. The structure's progressive failure analysis reveals that the failure of one of the external columns in the primary floor would result in a progressive failure of the slabs throughout the entire height of the building, which could enlarge to other parts. Low redundancy is present in a single core horizontal weight resisting system, which is an ineffective that necessitates design for a huge seismic load and thus provides lower safety per ASCE [2]. As a result, that propose a modification to the side force resisting system that is shown to significantly enhance the structure's sensitivity to seismic stimulation while also preventing progressive collapse.

In addition to the central dock, the improved system includes the addition of external beams to form moment frames around the perimeter of the building. Because the modified scheme used less concrete, steel reinforcing, and basic materials than the original scheme, it is less expensive. [20]

(Ng Saeralyn & Heng Koh, 2021) The study revealed that Since the early 20th century, flat reinforced concrete slabs have been in use. and is frequently practical in residences, workplace, and similar houses as they are imposed and reasonably priced to build. Failures under load can affect the construction, causing it to fail due to critical moment transmission at the floor connection. Although there is a scarcity of prior education on basic guidelines and specifications for designing level slabs when exposed to line loads, the constants given in standard design codes are mostly for the concrete surface exposed to bending stress alone. The designer frequently overlooks the line load caused by the permanent brick partition installed on the level slab. As a result, this education has been made available in order to create the project table for reinforced real slabs subjected to UDL, additionally to research the structural performance of the flat slab under line weight. This is comparative study. The flat slabs were analyzed using physical analysis and design software. The armor-plated concrete level slab was analyzed and designed using Euro code 2 (EC2). Data from the ESTEEM software were entered into the Excel Spreadsheet to create a design table for an armor-plated tangible level slab made subject to a consistently load applied. The ESTEEM apps were utilized to examine structural behavior of a flat slab subjected to line load. The overall conclusion of this study demonstrates that the measurements and loadings on floor slabs are highly related to the construction's behavior. [21].

(Alaa C. Galeb, 2015) The best design of armor-plated concrete level slabs was a challenge that the genetic approach resolved, according to the results. Level slabs with and without edge beams, flat-plate with and without edge beams, and flat-plate with and without edge beams are the four case studies that are covered. Real estate, steel, and formwork costs are represented by the cost function. The amount of flexural reinforcement at hazardous slab parts, drop panel sizes, the effective depth of the slab, and edge rays all seem to be design factors.

There are restrictions on the same slab's size and the placement of the reinforcing steel. The results show that for flat slabs without additional support beams, (1/39-1/27), for flat slabs with support struts, (1/43-1/302), for plain without steel beam, (1/30-1/232), and for flat-plates with edge rays, (1/35-1/24), the ideal value of (efficient depth / range length) is between these ranges. Additionally, it has been shown that for the same span length, slabs without steel beams are the most affordable option[17].

(Mohamed Ibrahim, et al., 2022) According to the study, slab selection and design are major sources of concern in traditional building projects. In most cases, slab design and selection are motivated primarily by cost and, of class, care. When constructing ground slabs, it really is frequently regarded as a cost-effective and time-saving option. In this education, "Comparative Education of Slab with Ray and Flat Plate Scheme," the comparison between slab with beam system and flat plate (i.e. Binary Way Slab without Rays) is carried out on the basis of economics. The focus of this research is essentially the comparison of binary slab systems in span length footings; In contrast, a cost comparison is performed using the total cost. On the other hand, they are comparable in terms of overall. The "ETAB program," aimed at both slab schemes, was employed for design purposes. We have three replicas for every slab (6m, 7m, and 8m), and flat plates are less expensive for spans of 6m to 7m, while slabs with rays are less expensive for spans of 8m. The cost of a level plate slab for extended spans is higher than that of a slab with beam because load increases with increasing span distance and in a flat plat slab all load is resisted solely by the slab, so the moment on the slab is greater than that of a slab with beam. As a result, the deflections increased, as did the need for more reinforcement and an increase in depth when compared to the slab with beam. These comparison findings provide a clear picture that can be used to select the most cost-effective slab scheme. [22].

(Ali Nadjai, et al., 2018) In line with the study's findings, fire conflict requirements are becoming increasingly important in the project due to the increasing use of tangible flat slabs, particularly in multi-story buildings. Because they are based on remote member tests, current design rules are conservative because they do not profile for the continuous motion of flat slabs throughout actual constructions. The issues encountered in the industry as a result of such design standards are discussed, as is the need for more reflective experimental models rather than analytical models. To perfect the thermo-motorized behavior of flat slabs in high temperatures, the general-purpose FE program ABAQUS is being rummaged through. Creative meeting-avoidance strategies and methods for lowering computational costs are presented. Experiment results from a fire test on constrained tangible flat slabs verify the model's existing as well as structural response. Additional enhancements to increase the precision and dependability of such replicas are debated. The anticipated outcome is to provide a kinds of research base to improve the existing building code, design guidelines for the passion design of concrete level slabs, and extra accurate reasoned

guidelines for developers, resulting in substantial cost savings. The paper summarizes preliminary results from this system[23].

(N. Girish & N. Lingeshwaran, 2018) According to the research, when building a steel and concrete level slab, shear failure is one of the most important types of failure to consider because it is brittle. To that end, this research investigates how reinforced actual flat slabs fare when subjected to varying degrees of punching shear strengthening. Shear stirrups and structural shearbands were used to cover punching shear reinforcement in two of the slab samples. Dimensions of 1000mm in length and 185mm in breadth were used for the slabs used in the tests. A column 300mm in length, breadth, and intricacy joins the identical slabs at their midpoint. Steel dishes with 150mm lengths and widths and a 25mm thickness were used to endorse the test specimens just on four corners of the slab. The column expression is stacked on top of the test specimens. All of the following phenomena were observed and documented: deflection, tugging, and fracture energy [24].

(D. Oliveira, 2014) There was found to be no flexural present time transferring from the slab to the column, and the investigation showed the structural features and ultimate punching shear and total confrontation of inner reinforced real flat slab-pillar connections, with a unique hole adjoining to the column. The eccentricity of the weight (M (instant transmitted to column) / V (shear) ratio at the connection - 0.50 m or 0.25 m) and the existence or absence of a hole were the only remaining factors. Slab-column joints were checked for internal variables, and research was conducted on internal factors such as load, cracking, deflection, concrete, and reinforcement stresses. The behavior and rupture weight of the slab was affected by a number of factors, including the presence of a hole next to a smaller column dimension, the hole dimension, the flexural validation rate at the time of placement, the difference in the relation M_u/V_u as a function of load, and the eccentricity of the weight. Simplified versions of the most often provided estimates were compared to test findings; alternative estimates were also offered. Despite having some rough origins in EC2 [12] [5] showed less conservative traditional estimates and more non-conservative non-conventional ones. It is recommended that all ciphers be adjusted so as to take into consideration the additional time required to process data due to the anomaly at the crucial border while working with slabs containing fleabags[25]

(Ghafur Ahmed & Omer Aziz, 2011) The research revealed that the threshold bolstered real slab system has been the subject of numerous studies since the turn of the century; several experimental and logical works have been approved for investigating the various aspects of punching failures in flat-plates. A comprehensive survey of the punching shear strength thesis over a century was conducted, with 60 investigations. The studies were chosen to include various plate models, difficult parameters, and various types of concrete: regular strength, high strength, ultra-high presentation, and fiber glass. The numerical analysis was carried out on 313 slab specimens collected from 26 studies; a mathematical model was carried out to demonstrate the sensitivity degree of various parameters on punching shear strength. Three reckonings were proposed using SPSS and the NLREG Programs. The results of future equations were compared to the results of practice codes (ACI 318-08, EC2-04, and JSCE-02). Keywords: flat plate slabs, punching shear strength

1. Presenting the flat plate floor system, which is growing increasingly popular for medium-rise multi-story structures such as housing., Offices and car parks with relatively light loads are made up of slabs and columns only, with no beams, drop panels, as well as column capitals. Flat plates, unlike ordinary reinforced real structures, are frequently subject to complex stress states below regular load conditions. One of the primary design issues for level plate structures is the generation of shear forces and/or bending instants at the impacts between both the slab and the sponsoring columns, which leads to trying to punch shear failure. [26].

(Georgewill V.A., et al., 2019) According to the findings of the study, in this study, the punching shear failure of a flat slab structure was examined. First, the advantages of a level slab system over a traditional framed structure were evaluated. Because of the complex mechanisms that occur during punching shear disappointment, it has remained the subject of extensive experimental, analytical, and experimental investigations. This research is focused on finite element models developed by previous scientists. Two concrete failure standards were compared: total straining cracked model (T-S model) and damaged plasticity replicas (DPM). One of the advantages of the T-S model is that cracks in real life are represented by constitutive friendships. The sufficient grounds of fractured cement in the pole-cracked regime is captured by T-S. The available finite element models revealed that DPM in ABAQUS has remained widely used in the prediction of punching shear failure. The use of finite element technique has resulted in a better understanding of the post - punching occurrence[27].

(Mohamed Fadlallah, 2021) According to the results of the investigation, nine replicas of the incessant slabs were tested to failure, both with and without apertures. The key objectives of this article are to learn about how openings affect flat slab behavior and how steel may be used to recover the load capacity of flat slabs following the installation of begins. Both the American Concrete Institute's ACI 318-19 and the Egyptian Code's ECP 203-2007 have been used to conduct inspections of the maximum allowable opening size. In this study, the Finite Element Method was used (FEM) in ANSYS12, and the findings of the FEM were compared to the results of the experiments. It was discovered that steel reinforcements placed next to apertures in otherwise level slabs did not improve the slabs' performance to that of a slab without openings. As much as 28% more ductility is added to the concrete surface with the application of strengthen. Due to the minimal deformation for this slab and the opening's manifestation of superior stresses in the steel reinforcement, this site is not preferred without reinforcing. While ACI 318-19 mandates that openings be no wider than $1/8$ of a column strip, it has been noted that in certain cases, openings as wide as the pillar strip itself are perfectly safe[28].

(Pingyu Yan & Yong C. Wang, 2014) According to the study, the new shearhead scheme between a steel tubular pillar and a reinforced real flat slab has stayed developed. In comparison to traditional flat slab construction with steel and concrete edges, this shearhead system allowed for thinner floor width, easier manufacturing, and a shorter development time. Two full-gauge tests were performed, one with a four-sided steel pipe and the other with a round steel tube. For validation of the mathematical imitation model, the tests were simulated using the finite-component package Abaqus, which included charge then load-strain arcs, crack advancement then trying to punch punching shear facades. A sensitivity education for the numerical perfect was carried out to examine the effects of different material properties then mesh sensitivity in instruction to select the greatest appropriate modelling parameters by means of Abaqus. [29]

(Mostafa Abdelhakim, et al., 2021) The research presents a perfectly suitable simulation of one method R.C level slab with overhang and square going to open strengthened utilizing NSM techniques demonstrated using finite element analysis. In the analysis, the ANSYS computer package version 12 was used, and four models' slabs were performed, each with a span of 2000mm and a breadth of 1000mm. The overall width of the slab is 120mm, with a clear span (the distance between supports) of 1200mm and a long span length of 700mm. Reinforced steel net 10@160mm

(710/m) upper and lower. The opening measurements were (200*200 mm), and the having opened positions were carefully chosen within the maximum bad (hogging) instant area, 100mm away from the intermediate provision. The impact of inaugural presence on R.C flat slabs was discussed in this investigation, as were the effects of using CFRP and Reinforcing steel saloons as NSM strengthening resources around opening. Models were validated to failure below p1 and p2 line filling with 500mm long awake the external support then at a distance of 100mm from the cantilever edge. According to the findings, the ultimate load of the slab decreased due to the presence of a having opened, then increased due to the strengthening[30].

(Nuno Gouveia, et al.,2013) The study demonstrated that the mixed to concrete, discrete steel fibers "work" as a sullied reinforcement, capable of bridging flexural and/or shear blows. As a result, strengthening fibers could eventually replace a portion of the traditional strengthening bars, allowing for cost savings. This work presents the results of an experimental investigation into the punching behavior of normal-force Steel Fibre Reinforced Concrete (SFRC) flat slabs. Six specimens were validated using different fibre capacity contents (0, 0.5 percentage, 0.75 percentage, 1 percentage, and 1.25 percentage) lengthways with the experimental challenge of determining the mechanical characteristics of SFRC, namely its compressive and ductile strength, as well as tensile behavior via a method called of flexural test results. Consequences showed that both, an increase of the slab load capacity, and of its distortion, when compared by the reference slab, where SFRC was not used. Finally, the results were likened with different design suggestions[31].

(D.V. Bompa & A.Y. Elghazouli, et al, 2016) The study investigates a building of diagonal members composed of body reinforced concrete limit stone blocks both with and without bracings connected to steel cornerstones via completely integrated shear-heads. The explanation of the findings showed six large-scale tests on this type of cross-structural system. The testing results provide a critical analysis of the entire weight actions of the samples tested, as well as the ultimate punching shear strength achieved prior to failure just outside the shear-head area. Recent findings enable analysis methods to depict rotational reaction and flexural strength as simple functions of the length of the shear and utter embedment, the floor plan, and the extent of the section. Furthermore, the test results support the definition of a rummage-sale shear-head reliant switch periphery when combined with the analytical floor designs for full punching shear strength

valuation. The paper also examines the accuracy of strength forecasts used in current design methodologies for traditional reinforced concrete members. This proved that the most recent design processes either lack direct guidance for shear-head subscriptions or result in excessively conservative force forecasts. Finally, analysis design cultures that take shear-head system characteristics into account are suggested in order to offer a trustworthy assessment of hybrid rudiment ultimate punching shear strength. In comparison to conventional reinforced concrete project provisions, the optional approach more realistically captures the influence of the engrained length of the due to sheer -heads for such hybrid representatives than before without tensile wall[32].

(Shasha Lu, et al., 2020) As this research demonstrates, accurate predictions of punching shear volume are essential prior to trying to build flat slabs of steel fiber-reinforced-plated concrete (SFRC). Using machine learning to improve the precision of evidence-based calculations looks to be a much better strategy in this context. Therefore, this study suggested a new model that utilizes seedling forecasting analytics (i.e., random forest (RF), random tree (RT), and classification then regression trees (WAGON)) and a novel feature selection (FS) strategy to assess the post-punching capability of SFRC flat slabs. In addition, the current study employs a sequences FS model approach to automatically establish a platform for predictive analytics. For the suggested models' training phase, data from relevant works was collected to produce a set of 140 samples with six prominent parameters (depth of the slab, effective complexity of a slab, same length of the section, same compressive of the actual, reinforcing similarity, and fiber volume). The aforementioned air-to-air datasets were then used to train and evaluate the sequential FS. The effectiveness of the suggested replication was measured by using a few numerical indicators on both the training and testing data, such as the determination coefficient (R^2) and the root mean square error (RMSE). Results showed that the FS-RT model performed better than the FS-RF and FS-CART models when predicting future weather. With values of R^2 between 0.9476 and 0.9831 and RMSE between 14.4965 and 24.9310, the FS-RT hybrid approach performed best. In his study, he discovered that the FS-RT, FS-RF, and FS-WAGON pairing methods may be used to estimate the SFRC flat slabs [33].

(Hamidah Saman, et al., 2018) The research found that when fiber is used as a production ingredient in concrete, the tensions are steadily increased. Demand for innovative technology that

offers a secure, well-organized, and affordable design for present and future applications is growing as a result of rapid material price rises. The price of concrete is decreased by using ridged slabs, but the strength of the building decreases as a consequence of the material savings. Concrete reinforced with steel fibers (SFRC) may tolerate higher weight than unreinforced concrete because it retains part of its tensile strength before breaking. The ridged slab may help with material savings in the interim. The bending strength of concrete slabs with two and three ribs and steel fiber reinforcement was examined in this work under static loading across spans of 1500 mm and 1000 mm x 75 mm, respectively. Instead of using cautious bars with tangible scores of 30 N/mm², 40 kg/m steel fiber of the whole actual volume was employed as reinforcement. Tests for three-point bending on the slab were performed. In order to demonstrate the conclusion and compare the deflection between a switch and a ribbed slab, a weight vs deflection curve was produced. This study demonstrates that, despite a 20% reduction in concrete volume, SFRC Ribbed Slabs can resist the same amount of load as conventional slab structures[34]

(Mindaugas Petkevičius & Juozas Valivonis, 2010) In this article, we take a look at the latest theoretical and experimental findings about the durability of steel-reality composite slabs. Standardized steel sheets (of the Holorib kind) and fiber-reinforced concrete were employed to create the examples. Steel fiber was added to the concrete layer of two slabs, but not the others. We performed static, short-term load tests on slabs. The profiled steel canvas and concrete coating form a shear connection that affects the straightness of composite slabs. The built-up saloons theory is used to analyze the strength of flat sections in composite slabs. This method is used to assess the impact of a cracked concrete layer on the structural strength and plastic deformation in the compression zone of this layer. It also assesses the stiffness of completely separate coatings as well as the rigidity of the shear and utter bond between the profiled steel canvas as well as the concrete coating. Experiments were carried out to determine the shear characteristic of the bond between both the steel tarps and the concrete layer. As a result, specimens were made from the same concrete mix as the slabs. The horizontal section of the slabs was theoretically examined. Theoretical and experimental findings are in good agreement with one another. [35].

(Rainer Zinn, et al., 2014) Experts from Principia and Stangenberg worked with the Swiss Federal Atomic Safety Inspector General on this study, the findings suggest (ENSI). The IMPACT III project included scaled-down impact testing of concrete structures. Now that we have the modeling

of test X3, we can compare the test results from August 2013 with the numerical outcomes. The project's overarching goal is to make nuclear facilities safer, and its specific goal is to demonstrate the efficacy of current modeling methods in simulating the reaction of a reinforced concrete structure to a forgiving missile strike. In fact, the object being fired is a 50-kilogram, 140 m/s steel pipe. The board is a sturdy supporting structure that holds a 250 mm thick, 2.1 m by 2.1 m armor-plated concrete divider in place. For reinforcement, longitudinal and transverse reinforcement bars are utilized. It was permitted to use Abaqus calculations both before and after the test (Principia). In the Abaqus simulation, the concrete, rebars, and projectile are all simulated using solid rudiments, a damaged malleability formulation, and embedded beam rudiments. Non-linear, covered shell elements for reinforcement on both sides are included in the SOFISTIK model of the board, along with approximately incorporated quasi-shear deflections of nuclear weapon parts[36].

(Mirsayapov Ilshat, et al., 2020) The purpose of this study is to research the differences between the methods used to calculate the slab for punching on the fillet places by columns in accordance with Russian, Belarusian, and European standards and the existing physical solutions of the "slab-column" unit under various styles of static and repetitive loading using various strengthening elements and types of concrete. The results of controls conducted using different criteria vary considerably. In this study, the primary objective was to develop a method for determining how to punch flat reinforced concrete slabs using a frame-rod work model and prestressed concrete demolition designs while operating under compressive power flow. The findings are significant for the building industry because they may be used to refine a technique for estimating fracture in flat reinforced concrete slabs subjected to tensile, shear, and compressive forces at fillet sites with the columns. Flat slabs help maximize the use of available space by allowing utilities to be hidden under the floor[37].

3. RESEARCH METHODOLOGY

3.1 INTRODUCTION

The strength of two-way FRC panels was investigated through experimental work utilizing a model of FRC panels in this study. Whenever slabs are reinforced with a high reinforcement ratio, the connection between the slab and the column is subject to a great deal of stress, and the slab is more likely to fail as a result of punching shear than bending. Because of the complexity that comes with the use of several materials in the construction of concrete structures, it is not always possible to find effective solutions to applied problems using conventional analytical methods. Loading circumstances, a well-established stress-strain relationship, and an accurate depiction of the boundary condition all contribute to the complexity. One alternative strategic numerical approach that can be used to approximatively solve more complex problems is the Finite Element Method, which uses a realistic representation of a geometric problem to generate a set of algebraic governing equations that are solved by the computer for each structural member. Cracking in concrete, yield strength in longitudinal and transverse reinforcement, displacement and strain conditions, and normal shear stresses can all be better understood with the use of this solution approach. In addition, the algorithm for the nonlinear analysis of the coffered ceiling will be described in this section. This chart represents a synopsis of the chapter's contents.

The engineering profession makes extensive use of RC structures in a wide range of contexts and uses. The majority of the time, these structures are designed or studied using conventional experimental procedures, which entail analyzing experimental data that was gathered in a laboratory setting. Instead, let's look at the flip side of the coin. There are many real-world situations that are extremely challenging to resolve using conventional analytic methods. It's possible that this is because illustrating the boundary and load stipulation or the relatively constitutive stress-strain connection between materials like concrete and steel reinforcement is challenging. Approximate solutions to considerably more realistically challenging situations have been achieved through the use of a new numeric method. The nonlinear FE investigation of structural members provides valuable information about strains, displacements, the supply of ordinary and shear stresses in concrete, crack profiles at various loading stages, and forces in

reinforcements both in the main direction. This is the essence of an engineering problem's finite element (FE) solution.

3.2 MIX DESIGN AND MATERIALS PROPERTIES

3.2.1 Mixture

The objective was to introduce a mixture, as shown in Table 3.1, because previous tests and researches have demonstrated that fibers are more active when combined with fine aggregate.

Table 3.1: Mixture Design

Materials	Quantity per 1 m ³
Cement	453 (kg)
Sand, 0-4 mm	624 (kg)
Coarse aggregate, 22 mm	1242 (kg)
Water	181 (l)

3.2.2 Steel Fiber Properties

The experiment utilized Portland cement of the 53 grades, which is equivalent to (ASTM type I) while working with steel. Figure 3.1 depicts the geometry and forms used for the steel fiber, which is crimped and has a tensile strength of 1000 MPa. Specifically, fiber density was 7.8 grams per cubic centimeter. The dry ingredients (sand, gravel, cement, and silica fume) were first blended together in a diagonal rotations' mixer, which has three paddles for optimum mixing. It was necessary to combine the components to create a uniform blend, thus that was what was done. In this process, water is added gradually, and fibers are added last. After the fibers have been incorporated, the material is ready for casting. As can be seen in Figure 3.2, the mold was then generously lubricated to prevent the concrete sample from adhering to the mold and to facilitate its removal.



Figure 3.1: Steel Fiber



Figure 3.2: Mixer Type



Figure 3.3: Casting the Mold

3.3 CONCRETE MECHANICAL PROPERTIES

The tests for the cylinders were carried out on the same day as the tests for the slabs that corresponded to them. Figure 3.4 depicts the testing apparatus that was utilized for all of the cylinder tests. (ASTM, C39, 1997) Compressive strength of concrete cylinders may be determined by following the procedure outlined in this article. After the sample is ready, On the machine, it will be positioned in the center and subjected to a compressive axial force until it cracks.



Figure 3.4: Test Machine.

3.4 THE FINITE ELEMENT METHOD

As far back as the 1950s, the Finite Element Method (FEM) had been developed for linear analyses, and then expanded in the 1960s to handle nonlinear problems. Cracks or crashes in the concrete, yielding in the reinforcing steel, or a lack of steel-concrete cohesiveness are the most common causes of non-linear behavior in reinforced concrete structures [8,5]. Temperature, deformation, creep, and shrinkage all have significant effects on the behavior of reinforced concrete. The importance of emphasizing that the temperatures and stress parameters in this study are representative of usual conditions for reinforced concrete [8]. Approximate solutions to partial differential equations can be found using finite element analysis, a form of numerical analysis. In

addition to multi-DOF FE integration solutions for structural members. Since the 1960s of the past centuries, The FE method, which was created in the 1950s for linear structural analysis, has recently been used to solve nonlinear issues as well. Material non-linearity (nonlinear material behavior) and geometric non-linearity together account for the nonlinear behavior of any structural element (large deformation in the structure). An FE with a large number of DOFs is used in the FE method, a type of numerical methodology for continuous systems. To connect neighboring FE, a series of nodes are drawn along their perimeters. The behavior of nonlinear materials, for example, cracks in tensile areas can abruptly change the stiffness of an element, the crushing of concrete components, tension steel reinforcement yielding, and deformation in the plastic level of concrete and reinforcement, is the primary cause of nonlinearity in the analysis of RC structures.

There are five main components to any FE analysis, and they are:

- a) A structure is made and cut into FE that are, then linked at their nodes.
- b) It is assumed that the physical behavior of an element is performed by a shape function, which is a continuous function in approximation.
- c) Calculating the deflection due to external pressures and stiffness the stress, stiffness, and force vector equations are analyzed and ranked.
- d) Once the FE equations have been assembled to describe the full problem, using the global stiffness matrix and force vector, it is possible to develop the global stiffness matrix and force vector.
- e) Load, symmetry, and beginning conditions are applied as boundary conditions.

3.5 USING SOLID WORK METHOD

Modeling is a representational example of a building's construction and the presentation of an issue system. A model is like the system it represents, but more simplistic. The primary goal of any model is to enable an analyst to foresee how different inputs will influence the output. The model should closely resemble the real system and incorporate as many salient elements as possible; yet, it shouldn't be so complex that it's hard to understand and test. The ideal design strikes a happy medium between robust functionality and user friendliness. Solid Work is the commercial software

used to DRAW THE SAMPLES. Following the current method, In the following chapters, we will describe how the current work will be carried out. The following graphics, provided by Nguyen-Minh et al. in 2011[38], depict the model employed in this thesis.

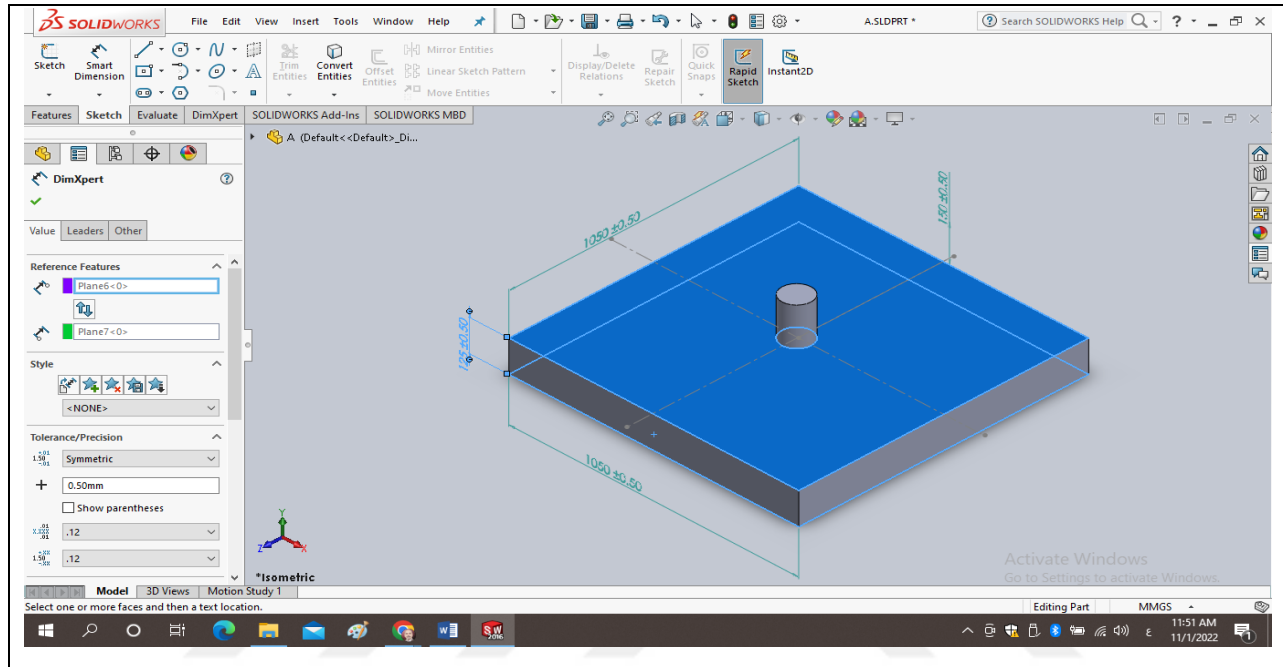


Figure 3.5: Model A

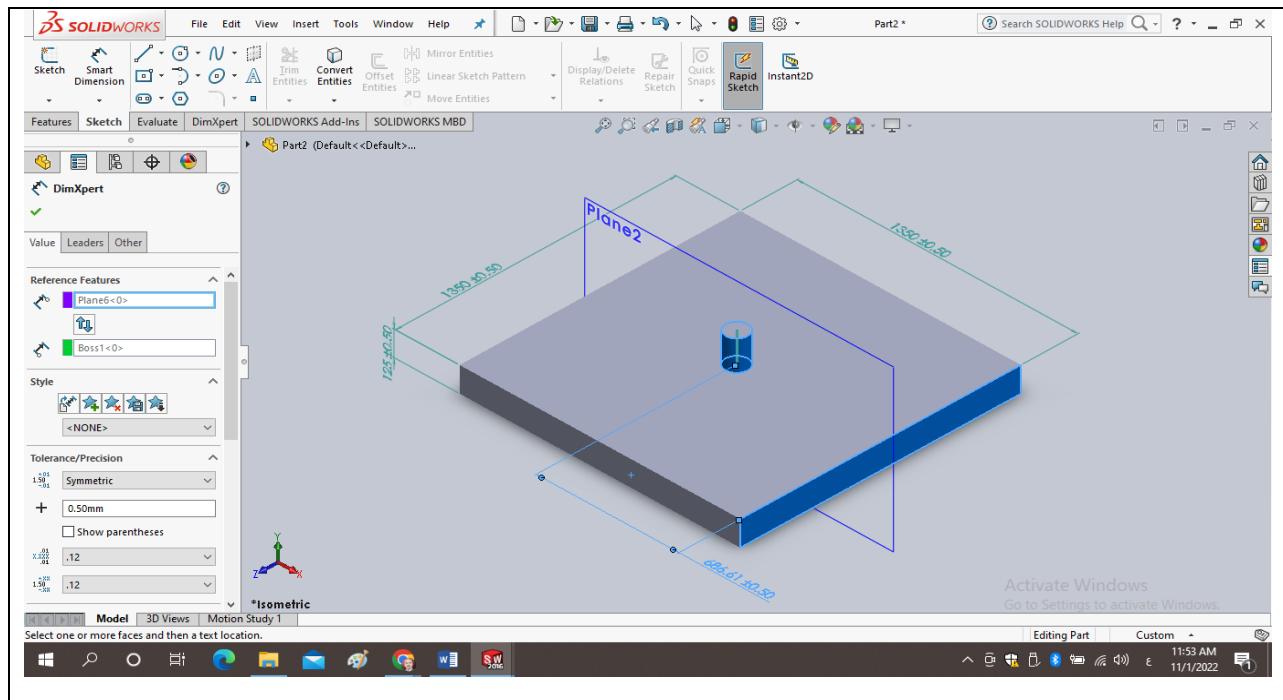


Figure 3.6: Model B

3.6 APPLYING ANSYS METHOD

The FE modeling program ANSYS can be used to numerically solve a wide range of engineering problems. For the analysis of the present study, the FE ANSYS program is used. ANSYS is a wide purpose computer package software designed to simulate interactions in the areas of physics, vibration, heat transport, structural, fluid dynamics, and electromagnetics. Static (linear and nonlinear) and dynamic structural problems are included in the analysis capabilities of ANSYS, as are steady-state and transient problems, heat transfer, mode-frequency and buckling eigenvalues, static or time-varying magnetic and other field analyses, and the coupling between many field types. The software has also been updated to incorporate design optimization. The first version of the ANSYS program was made available to the public in 1971. By combining the steps of defining the model, creating the mesh, setting the boundary conditions, and applying the loads, ANSYS provides a significant advantage over its competitors in the field of finite element analysis. These phases are known as pre-processing, solution, and post-processing, respectively. The model verification process can be aided by the dynamic generation of a screen on an interactive graphics interface in real time as data are entered. All of the processes required to solve the problem are included in the solution routines, whether that be conducting an analysis in the structural field or any number of other fields to construct a new analysis or to restart an existing analysis. Additionally, they went over an analysis technique, load step, sub step, convergence criterion, and tolerance. At this point, you can extract stress or strain contours and see the shape of the deformed structure in a number of different plots using standard post-processing procedures. The outputs of the numerical model at various times are examined by the time history post processor. Universities and consultancy organizations alike made extensive use of the ANSYS for academic purposes. As one of the most popular FE programs, ANSYS enjoys widespread recognition.

3.7 PRE-PROCESS IN THE ANSYS ENVIRONMENT

Parameterization procedure in the ANSYS environment, the chosen material model was identified by numerical calculation of the model's database. The optimization or assessment procedure begins with the first data of material parameters. Depends on study limitations and objectives. All studies cited in the definition of restrictions and goals must be part of the same configuration; this is the first function in preliminary research. What follows is a breakdown of the stages:

Step 1: we'll talk about the geometry of transfer slabs

The development of a model will demonstrate how the nodes and elements of the model are defined geometrically. The two most important tools for creating geometry in ANSYS are: Nodes, which can be seen of as points in a coordinate system, are where the DOF are specified. The degrees of freedom (DOFs) for the point illustrate the conceivable motion of this point as a result of the loading on the structure. The degrees of freedom also stand for the transfer of forces and moments from one component to another. Elements are the second distinguishing characteristic, the fundamental constituents of finite element analysis. Node degrees of freedom are connected by a mathematical connection. Several different families of elements exist. Lines (trusses and beams), areas (plates in two or three dimensions), and solids all fall under this category (bricks or tetrahedral). The specifics of the analysis dictate the choice of element. These methods of model creation are used in the ANSYS software. The following figures depict the outcomes of using the geometry presented therein.

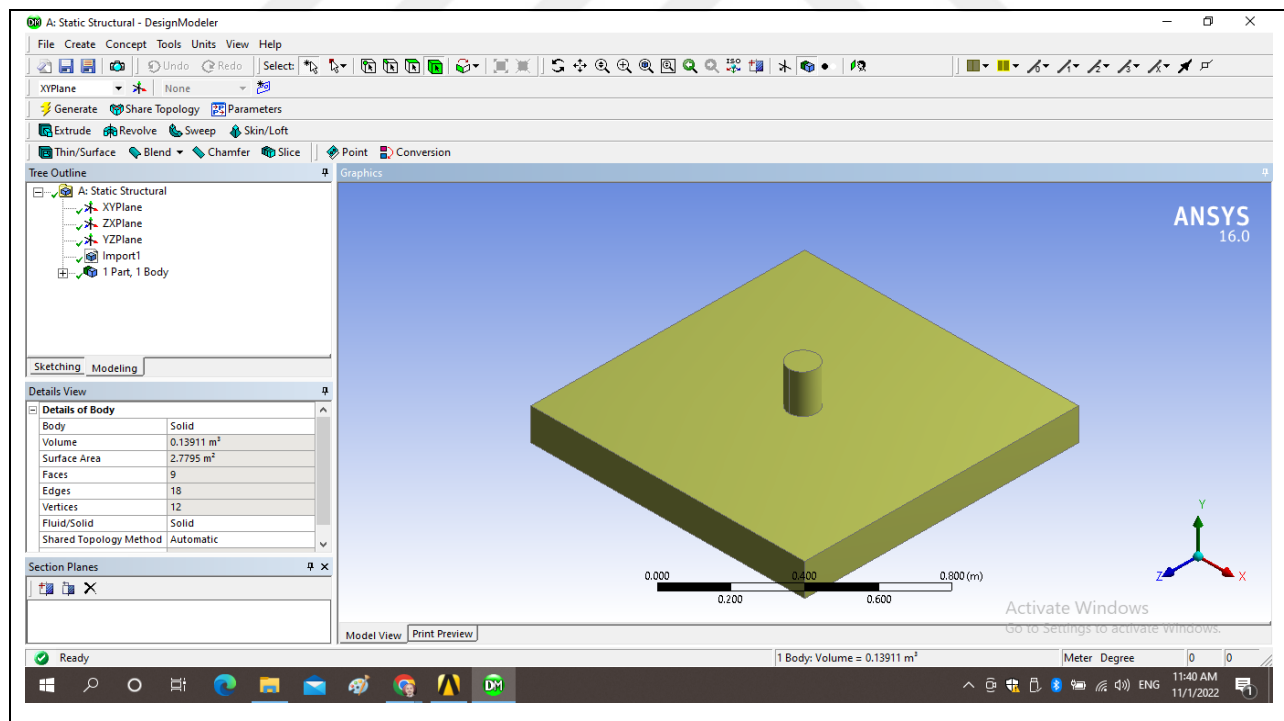


Figure 3.7: Transfer Model A

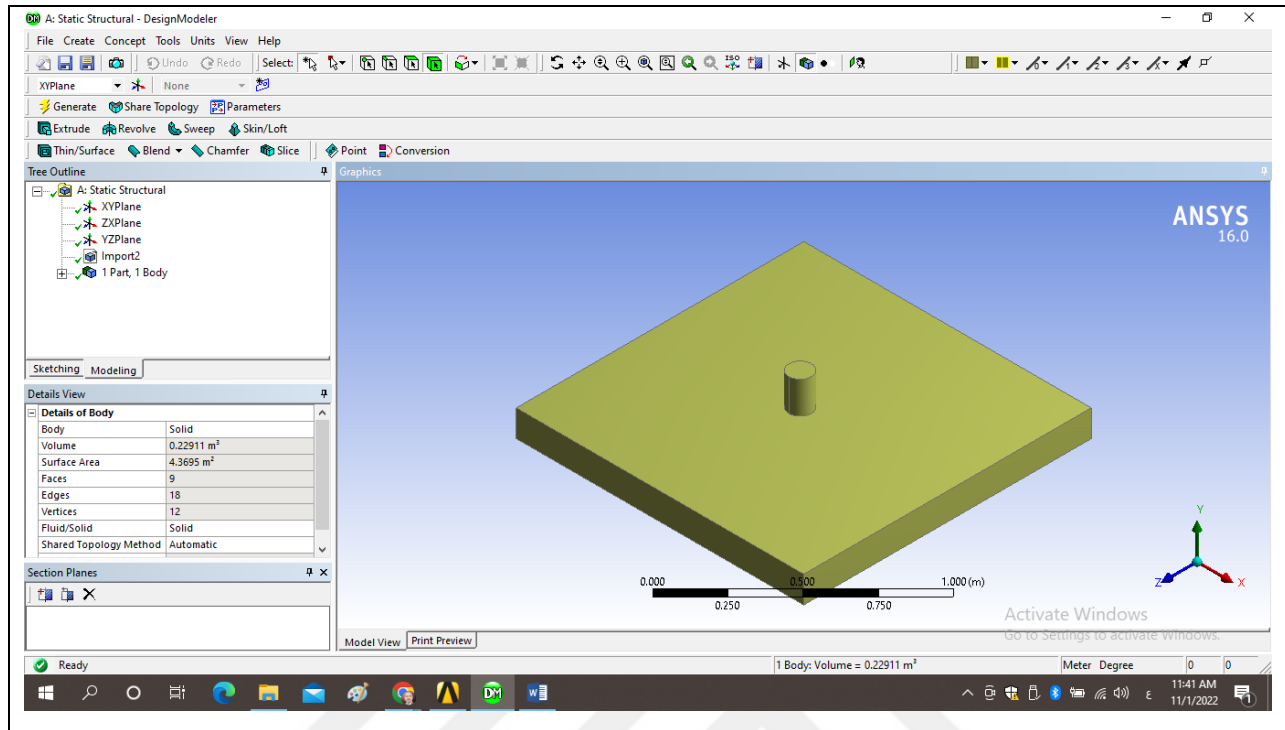


Figure 3.8: Transfer Model B

Step 2: Meshing process

The following process is geometric meshing. Utilizing the ANSYS Meshing program, a computational mesh for the structural analysis may be generated throughout the entire slab volume. Setting the element quality and setting Mesh Controls are important steps in the approach for building a mesh of nodes and elements. With ANSYS, you have access to a wide variety of mesh manipulation options. Many of the most frequently used mesh settings and meshing processes can be accessed quickly and easily via the ANSYS Mesh Tool (Main Menu > Pre-processor > Meshing > Mesh Tool). Due to its operation-spanning nature, the Mesh Tool is an interactive "tool box" that remains open until the user chooses to close it or exit PREP7. All of the features accessible via the Mesh Tool can also be accessed through the standard ANSYS ordering and menus; however, accessing them directly from the Mesh Tool is more convenient.

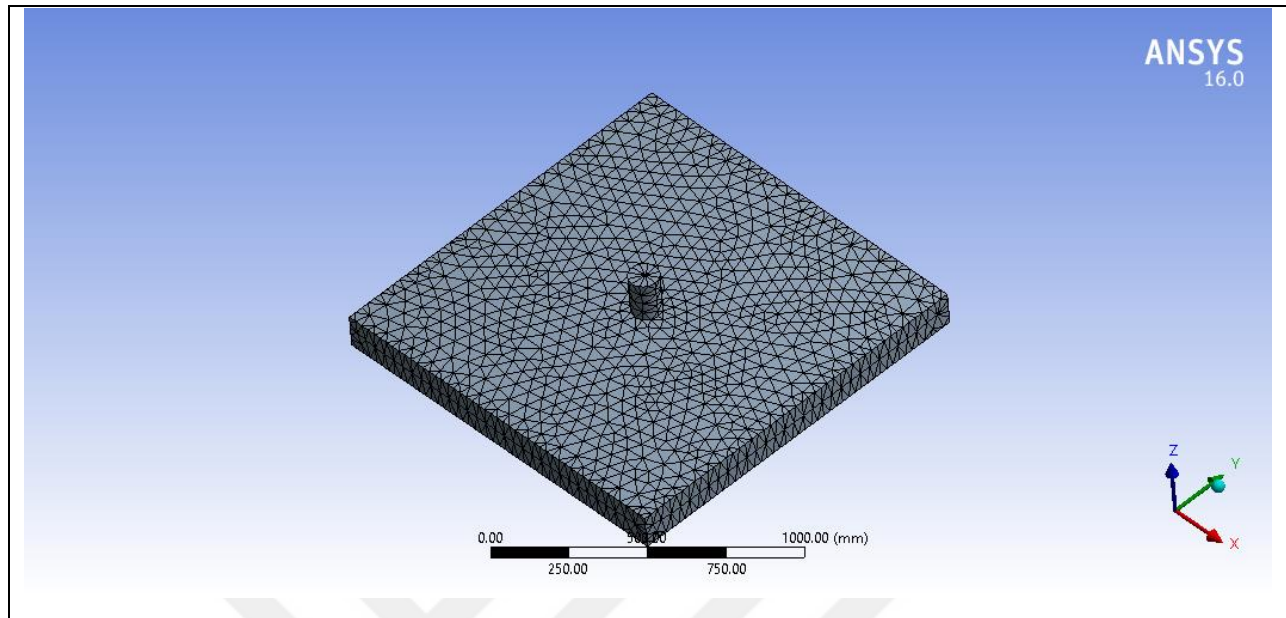


Figure 3.9: Meshing Model A

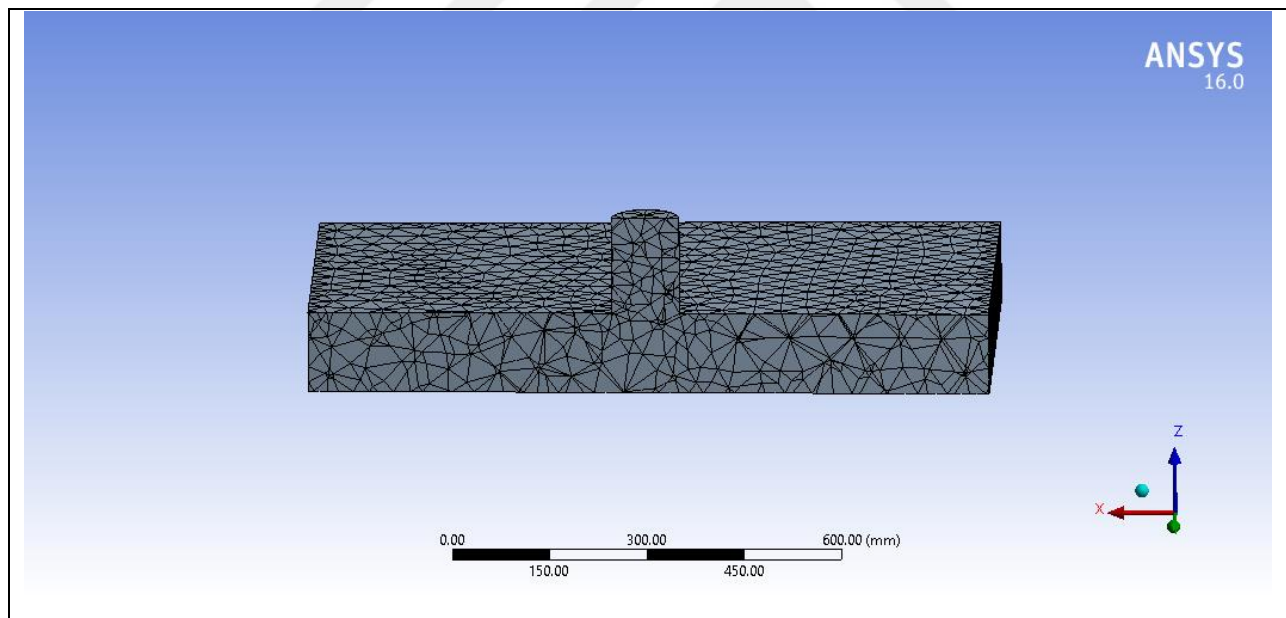


Figure 3.10: Section of Meshing Model A

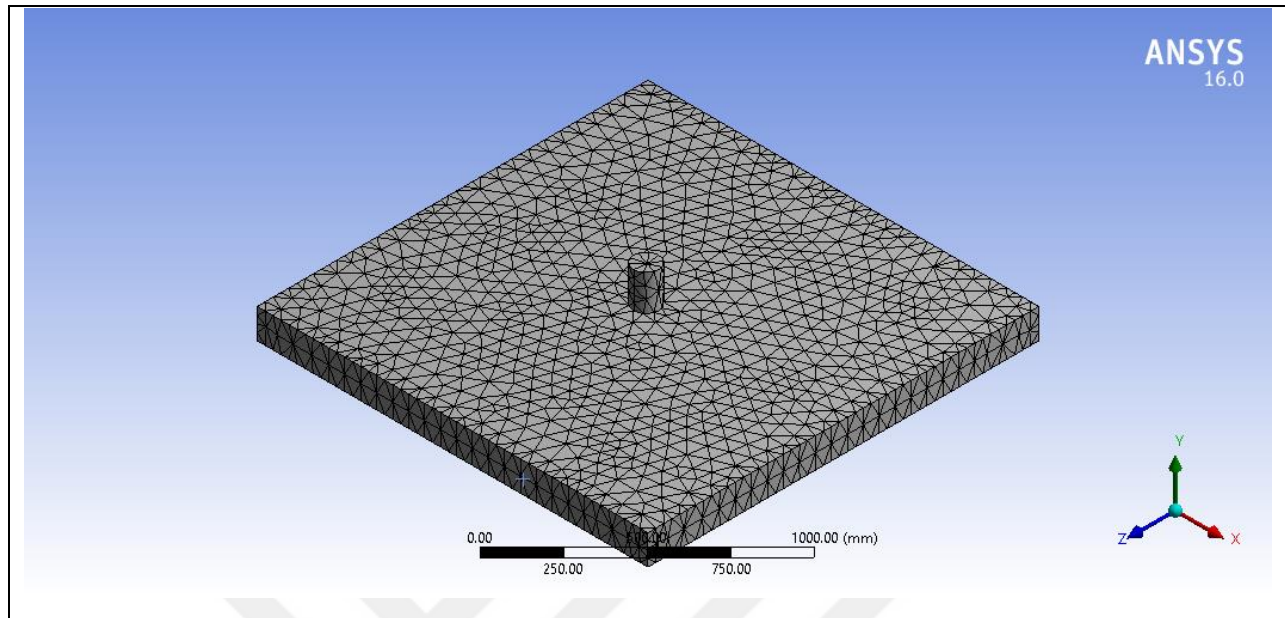


Figure 3.11: Meshing of Model B

There are two possible shapes for a 3-dimensional mesh: triangles and quadrilaterals. An unstructured mesh is produced when triangles are used as elements, while a structured mesh is produced when quadrilaterals are used. Either the element count (the total number of elements) or the element size can be chosen when making a mesh. Edge sizes of mesh elements can be adjusted for both geometric edges and meshed faces/volumes using the size functions. The results of the meshing suggest that the case study be discretized. Due to the finite elements analysis, it provides, it is the most crucial aspect of any analysis. Therefore, a significant amount of effort is spent on meshing complicated models. As can be seen, the boundary layer has a number of different discretization, allowing us to perform more nuanced studies and obtain more precise findings. The complexity of the meshing is an indication of the work involved. Problems in meshing the geometry Mesh generation is notoriously difficult due to a number of well-known factors like near-tangencies, topological organization, etc. The complexity of a mesh is measured by how well it translates these difficulties into a numerical metric. In a similar vein, it's not hard to construct a model with nearly impossible to mesh linear curves and planar surfaces. To that end, the metric can be used to spot non-functioning or otherwise subpar components that could have far-reaching effects on the system as a whole.

Step 3: Define the applied loads

A simulation is constructed by imposing loads on the model because the value, nature, position, and direction of the load are vital in understanding the behavior of the model response. The ANSYS application allows for the classification, quantification, and localization of loads to be determined either before or after the Mesh procedure. Because there are real-world objects—with real-world attributes like densities—involved in the loading process. According to the real model that was used for this investigation, the center of the model was chosen as the loading location. After calculating the impact of the load on both sides of the sample using the infinite elements of the body, the results will be distributed on the elements and nodes of the Mesh in the body. However, the model's reaction varies with the load because of the inclusion of the effect of temperature in the computations. The outcomes of each test can be altered by adjusting the load and temperature values. A table of Excel values can be created based on the values obtained for later use in analyzing the performance of the model under scrutiny. Images of each test can be obtained, allowing you to visually examine the values and methods used to alter the model. the current stage's instructions. It is clear that based on heat circumstances and static load conditions, the static structural possibilities can supply an inset selection. The options for the support type are also found to be fixed in relation to the materials employed. This work's changes reflect the effects of varying loads and temperatures on the concrete body.

Step 4: SOLVING PROCESS

When the resolution calculations are applied, the loads from the solid model are immediately transferred to the finite element model, placing a SOLVE order entails navigating as follows: Main Menu > Solution > Solve > Current LS. The model generation process, which includes meshing, is finished after preprocessing. The solution stage is presented by ANSYS. ANSYS's solution phase includes a menu where users can choose several settings. Analysis Options and Solution Controls allow for their customization. Utilizing stress mapping commands from an ANSYS model allows for investigation of the mapped stress levels in the receiving model. It may solve the problem by adding all the desired degrees of freedom to the target model while simultaneously removing any extraneous burdens. If the material properties are linear, then the mapped stress values are actual, and may be listed and shown across the model.

4. RESULTS AND DISCUSSION

In order to determine which types of concrete mixes are the most effective at loads, the purpose of this chapter is to show the combined experimental load and displacement based on the various types of concrete mixes. The first technique relies on the results of experiments carried out in a laboratory using cubes, whereas the second way makes use of a model derived from earlier research and the ANSYS computer software. The work consisted of conducting experiments on concrete cubes containing varying proportions of gravel, sand, and cement by weight, in addition to varying levels of crimped steel fibre content. The following is a description of the experimental program that can be used: The volumetric proportion of steel fibers in the material is most important criteria. The tests were carried out in accordance with Table 4.1.

Table 4.1: Procedure of the study

GROUP	Sample	Type of test method	Type of mixing process	Type of SFRC
GROUP 1	A0	experimental and simulation test	Plain concrete	
	A1	Simulation test	Concrete with SFRC	end-hooked fiber
	A2	Simulation test	Concrete with SFRC	end-hooked fiber
	A3	Simulation test	Concrete with SFRC	end-hooked fiber
GROUP 2	B0	Experimental and simulation test	Plain concrete	
	B1	Simulation test	Concrete with SFRC	end-hooked fiber
	B2	Simulation test	Concrete with SFRC	end-hooked fiber
	B3	Simulation test	Concrete with SFRC	end-hooked fiber
GROUP 3	A0	Experimental and simulation test	Plain concrete	
	A1	Simulation test	Concrete with SFRC	Crimped fiber
	A2	Simulation test	Concrete with SFRC	Crimped fiber
	A3	Simulation test	Concrete with SFRC	Crimped fiber
GROUP 4	B0	Experimental and simulation test	Plain concrete	
	B1	Simulation test	Concrete with SFRC	Crimped fiber
	B2	Simulation test	Concrete with SFRC	Crimped fiber
	B3	Simulation test	Concrete with SFRC	Crimped fiber

Table 4.2: Samples Data Specification

		SFRC weight (Kg/m ³)	Dimensions (mm)	Force KN
GROUP 1	A0	0	1050X1050X125	0 to 250
	A1	30	1050X1050X125	0 to 300
	A2	40	1050X1050X125	0 to 300
	A3	60	1050X1050X125	0 to 300
GROUP 2	B0	0	1350X1350X125	0 to 250
	B1	30	1350X1350X125	0 to 300
	B2	40	1350X1350X125	0 to 300
	B3	60	1350X1350X125	0 to 300
GROUP 3	A0	0	1050X1050X125	0 to 250
	A1	30	1050X1050X125	0 to 300
	A2	40	1050X1050X125	0 to 300
	A3	60	1050X1050X125	0 to 300
GROUP 4	B0	0	1350X1350X125	0 to 250
	B1	30	1350X1350X125	0 to 300
	B2	40	1350X1350X125	0 to 300
	B3	60	1350X1350X125	0 to 300

4.1 RESULTS OF CONCRETE CUBES

A concrete cube test's primary objective is to verify that the material in question possesses the required level of compressive strength. The quality of the concrete cannot be guaranteed by the provider if it does not meet the design strength requirements, or if the concrete has not been tested. Taking a sample of the mixed concrete, allowing it to cure, and then crushing it in order to determine its compressive strength are the steps involved in the concrete cube test. The Cube Test specimens are carried out using three different samples for every category of concrete. Because the amounts of cement, aggregates, and water that are essential to produce concrete with the requisite consistency and to achieve the stipulated strength are comparable, the materials and proportions that are utilized in each series of tests are also comparable. At room temperature, preparation of all of the materials that go into making concrete. According to the mixing design described in chapter three, the amounts of cement, aggregates, and water that should go into each mix should be figured up using weight and volume calculations. The operation of mixing is carried out using a mixer machine weigh batcher in accordance with IS 456-2000 in such a way as to prevent the loss of water. First, in a dry environment, the cement and fine aggregate were mixed together until the mixture had a color that was consistent throughout. After adding the coarse aggregate and completely mixing it, the water should be added, and the mixture should continue to be well mixed for at least three minutes, or until the concrete that is produced has a uniform look. After molding the required number of test specimens, each batch of concrete produced around 10 percent more concrete than was necessary. Compression tests on concrete cubes of 15 centimeters cubed have been carried out in accordance with IS 456-2000. The concrete test cubes were molded by pouring fresh concrete in the mound and compacting it in accordance with the requirements outlined in IS 456-2000. Curing done as specified in IS 456-2000. Since the time when water was added to the dry components, the cubes have been stored in humid air with a relative humidity of at least 90 percent and a temperature of 27 degrees Celsius, plus or minus two degrees Celsius, for a total of twenty-four hours, plus or minus a half an hour. After that, they were taken from the mounds, maintained in clean, fresh water, and stored at a temperature of 27 degrees Celsius, plus or minus 2 degrees Celsius, until they were required for testing. The disinfecting water has to be replaced once per week.

4.1.1 Compressive Test Results

The results of this test, which is one of several that are conducted on concrete, are considered to be the most essential since they provide a general sense of the qualities that concrete possesses. One may conclude, based on the results of this one test, whether or not the concreting was done correctly. Concrete's capacity to bear loads without cracking or otherwise deforming under pressure is measured by the material's compressive strength. The Compressive Strength of concrete is defined as the Characteristic strength of concrete cubes measuring 150 millimeters on day 7 and 28 after curing. Small changes in the ratio of water to cement, the proportioning of ingredients, the amount of rise in a slump, and other factors can have an influence on the intended strength of concrete, which in turn can have an impact on the strength and stability of buildings. As can be seen in figure 4.1, the outcomes of the tests revealed the compressive strength of the concrete mixes as well as the kind and form of the deformations that manifest themselves as a consequence of having a high compressive strength.



Figure 4.1: Cubes After Compression

The reason for choosing compressive strength is due to the compressive strength is comparatively higher than the tensile strength for both ductile and brittle materials. Compressive strength resists compression, whereas tensile strength resists tension. In our case studies, the main load effect on the samples as a compression load, for that, the compression test is used as an independent input value to ANSYS program. The tested cubic number was eight and the average results shown in table 4.3.

Table 4.3: The Average Results

Concrete's 28-day compressive strength f'_c (MPa)	28.4	Concrete Quality: C25
Concrete's 28-day compressive strength f'_c (MPa) with 30Kg/m ³ SFRC	29.2	Concrete Quality: C25
Concrete's 28-day compressive strength f'_c (MPa) with 40Kg/m ³ SFRC	31.7	Concrete Quality: C25
Concrete's 28-day compressive strength f'_c (MPa) with 60Kg/m ³ SFRC	33.9	Concrete Quality: C25

4.2 RESULTS OF CASE STUDIES

The test slabs' cracking behavior in response to a change in fiber volume is graphically depicted. The decrease becomes more noticeable with increasing loads. Steel fibers significantly improve the punching shear capacity of test slabs, and this improvement is related to fiber volume. For both Group A and Group B slabs, punching shear resistance is improved by the addition of steel fibers to the concrete at a rate of 30 to 60 kg/m³. Steel fibre reinforced concrete slabs (SFRC) have a higher punched shear capacity than conventional concrete slabs because the fibers in the concrete act as bridges to transmit tensile stress from crack faces on opposing sides of the slab until the fibers are completely pulled out or destroyed. Because of this, the tensile zone of SFRC slabs continues to carry weight even as cracks are initiating and spreading. As a result, the tensile strength of the concrete is improved, and the punching shear resistance of the slabs is enhanced as a byproduct. In order to measure the deformation in the slabs, experimental findings were created by applying the loads to the small slab, and the researcher uses these results as a validation model. Comparison of numerical results is made with those obtained by L. NGUYEN-MINH et al.,in

(2011) [38] and the effects of applying the loads in a step-like fashion (i.e., in a ratio from 25 KN to 350 KN) are explored. The FE study confirms what was hypothesized to happen, which is that the deformation of a slab grows as the deformation itself increases.

4.2.1 Results of Group A

Three-dimensional, miniature slab models were used to replicate the behavior of concrete slabs. Modal analysis is the method of investigating the dynamic properties of a system via the lens of the frequency domain. For instance, it can be used to learn more about how a mechanical structure reacts to stress. It is essential to take into account elements and a linear dynamic technique to discover displacement patterns while constructing a structure for loads. When something is in motion, it will take on a number of different "mode forms," or configurations. The patterns of displacement are frequently of great importance. A structure with N degrees of freedom will have N identical mode shapes. It is possible to create a novel displacement pattern by increasing the normalized displacement and superimposing it on top of existing mode shapes. Modal analysis simplifies difficult structures by breaking them down into a set of independent, single-degree-of-freedom systems. The photos below show the results of the study's initial testing of the slab structural shell.

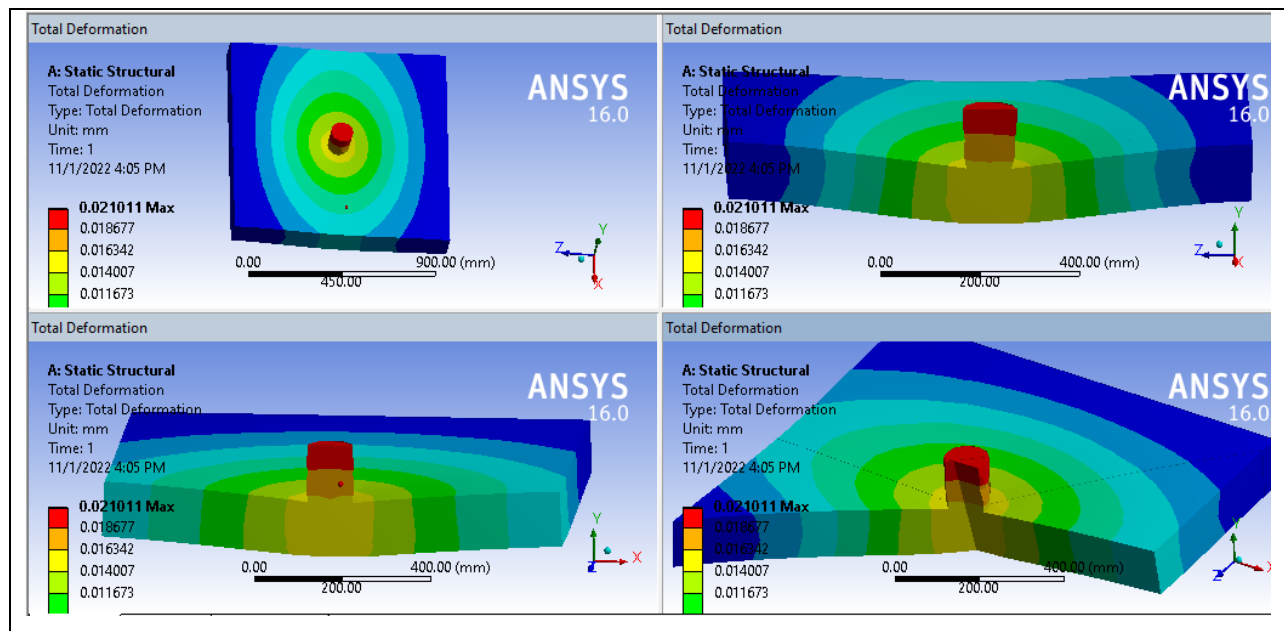


Figure 4.2 :Total Deformation of Group A

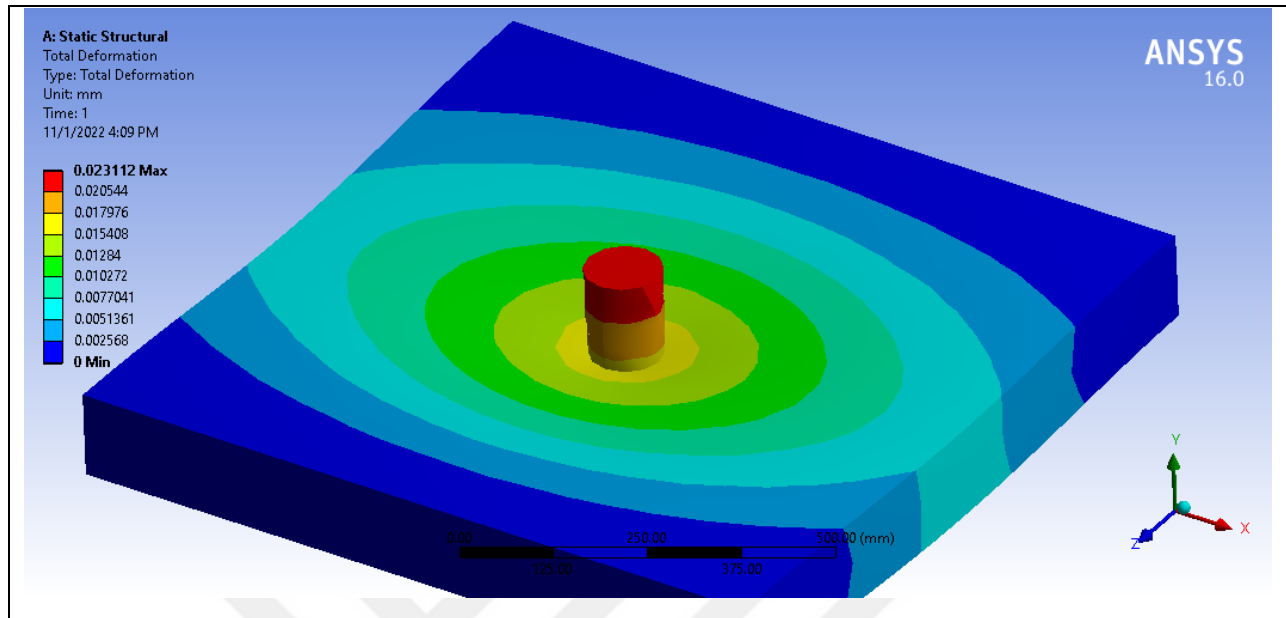


Figure 4.3: The Result of Load for The First Force

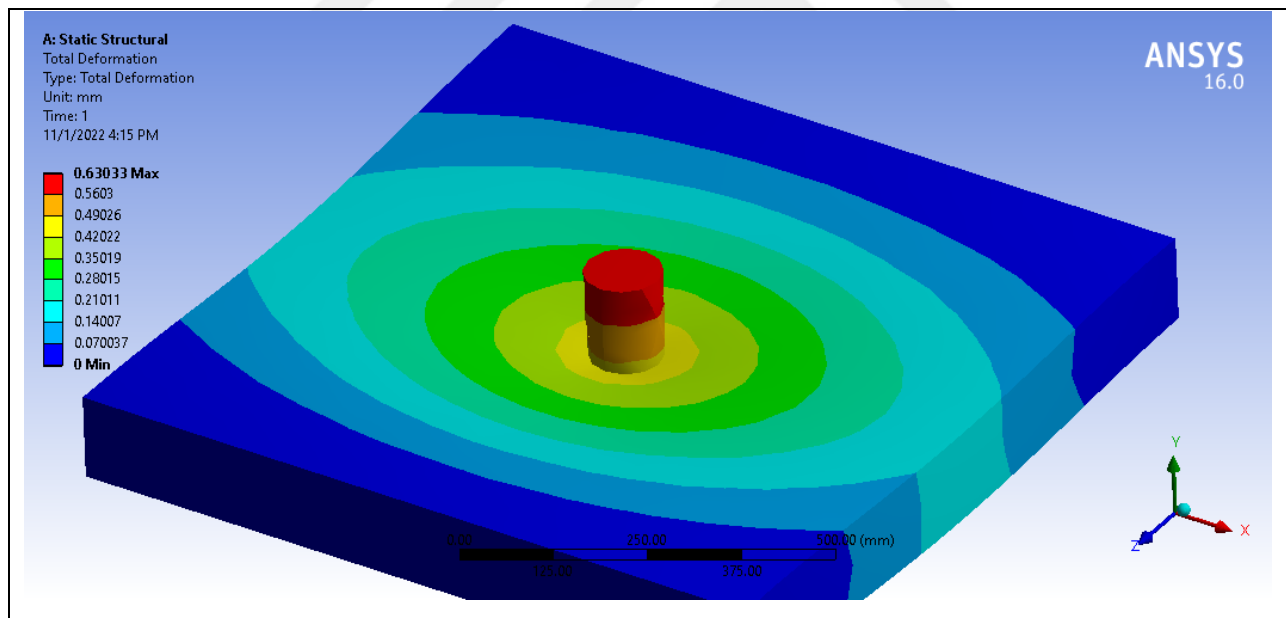


Figure 4.4: The Result of Load for The Second Force

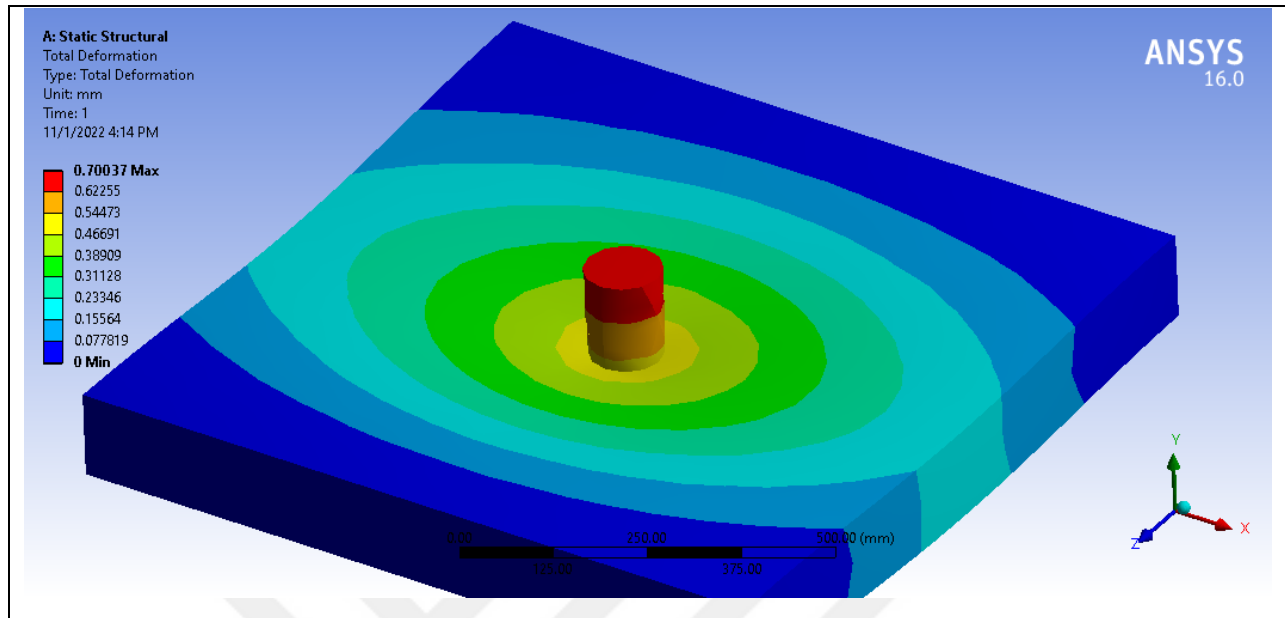


Figure 4.5: The Result of Load for The Third Force

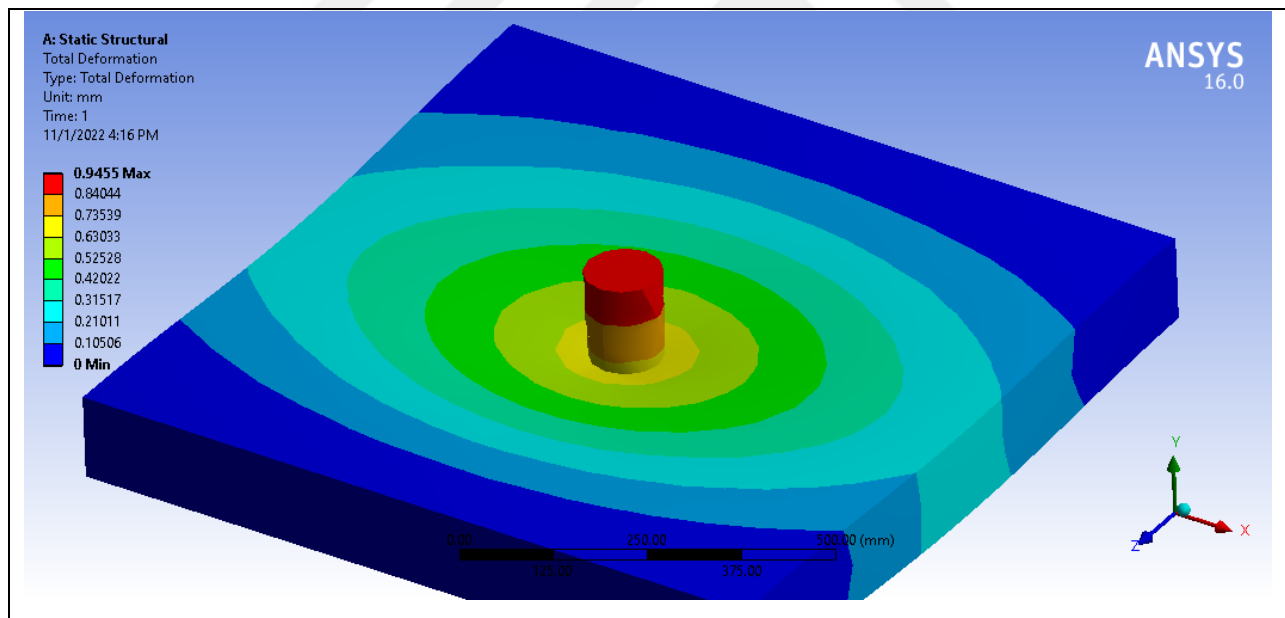


Figure 4.6: The Result of Load for The Fourth Force

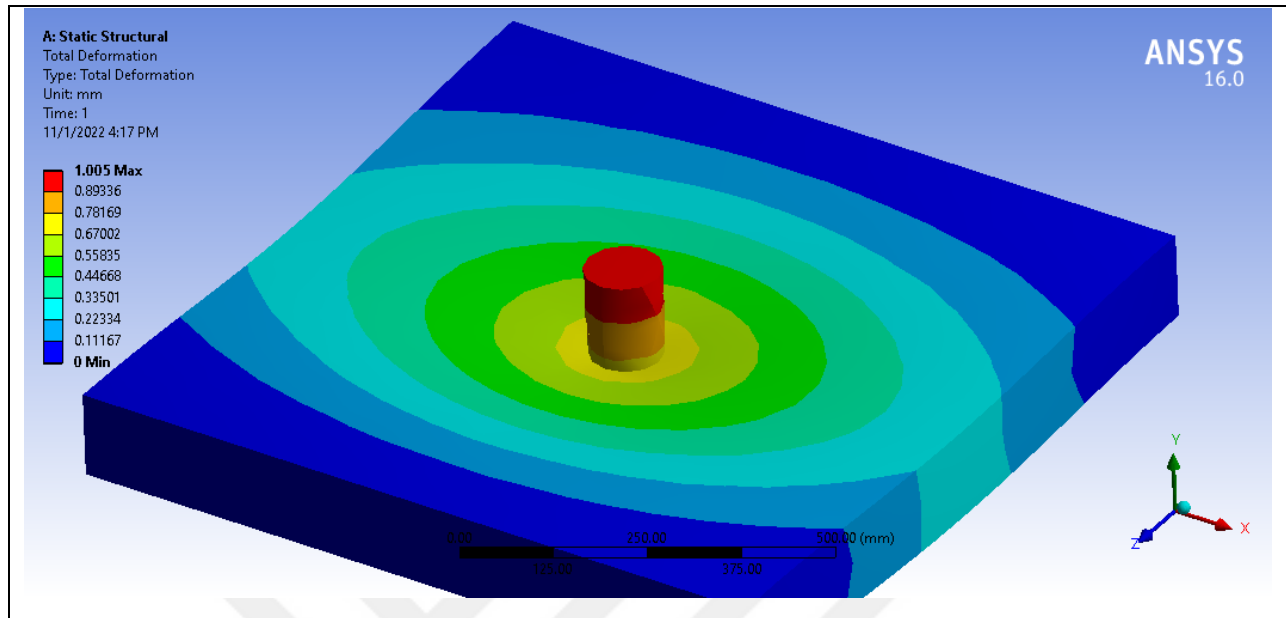


Figure 4.7: The Result of Load for The fifth Force

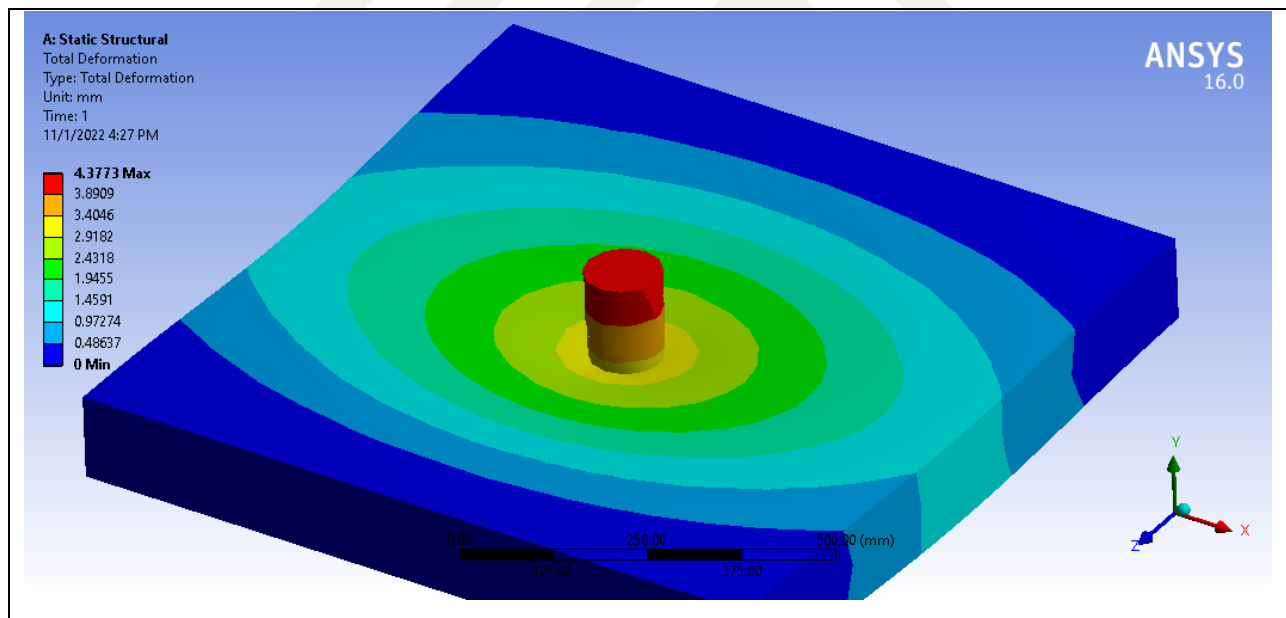


Figure 4.8: The Result of Load for The Sixth Force

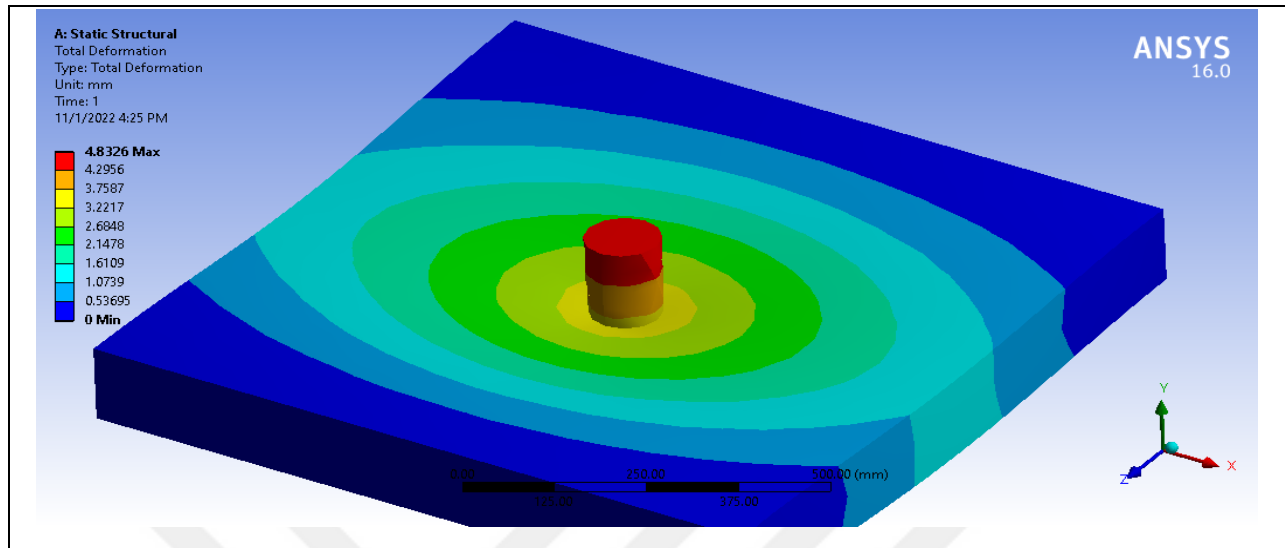


Figure 4.9: The Result of Load for The Seventh Force

When the ultimate load is compared to the nominal shear stress, a decrease in strength is observed for higher percentages of steel fiber-reinforced concrete (SFRC), whereas an increase in strength is observed for lower SFRC percentages. We are able to draw the conclusion from this information that the steel fiber is not lodged in the concrete. The following figures reflect the results of tests conducted on an entire complement of slabs:

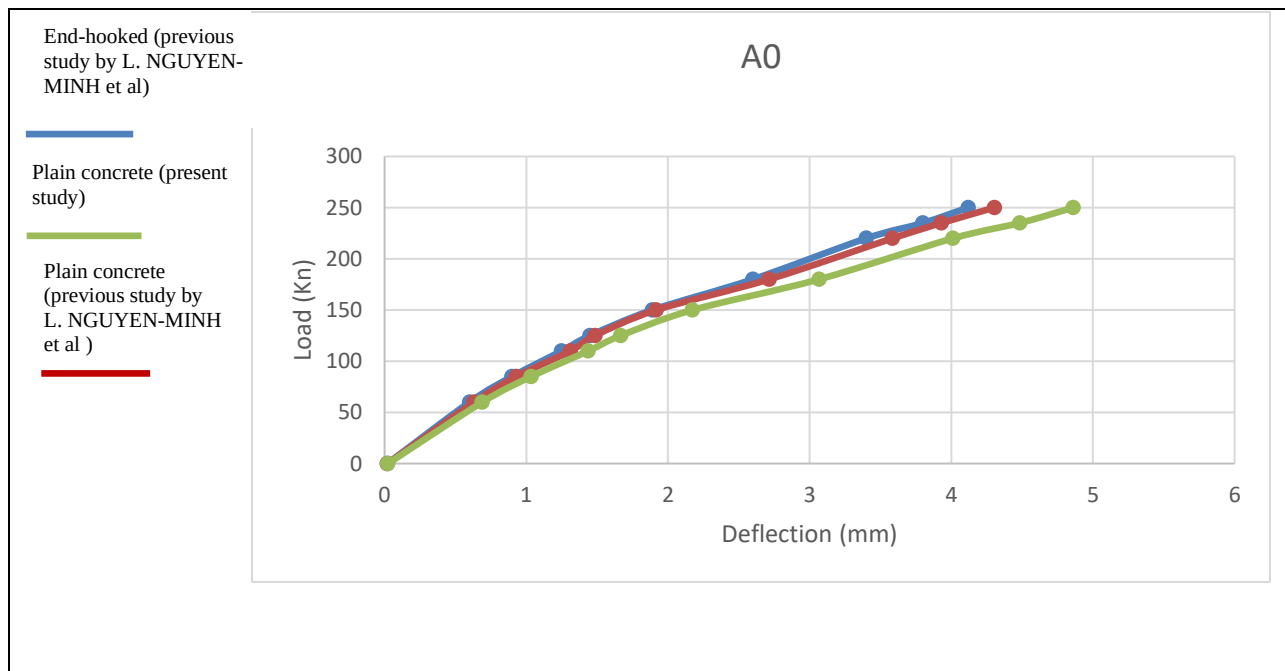


Figure 4.10: Results of A0 Displacement

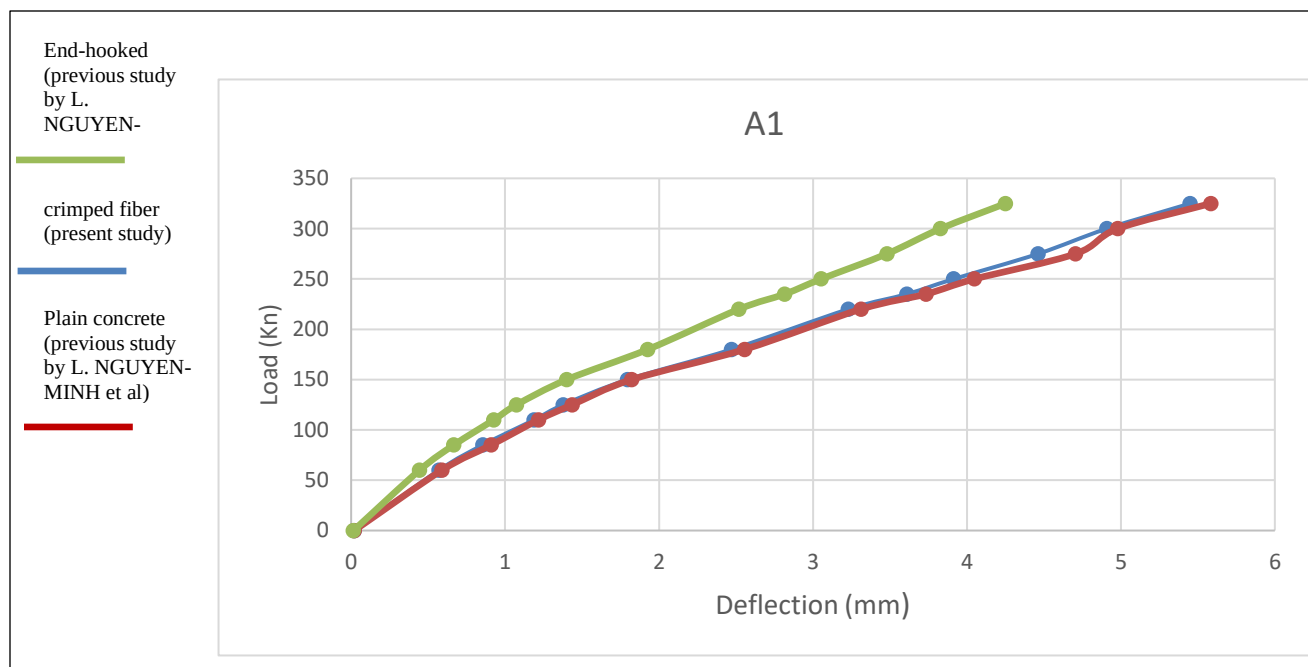


Figure 4.11: Results of A1 Displacement

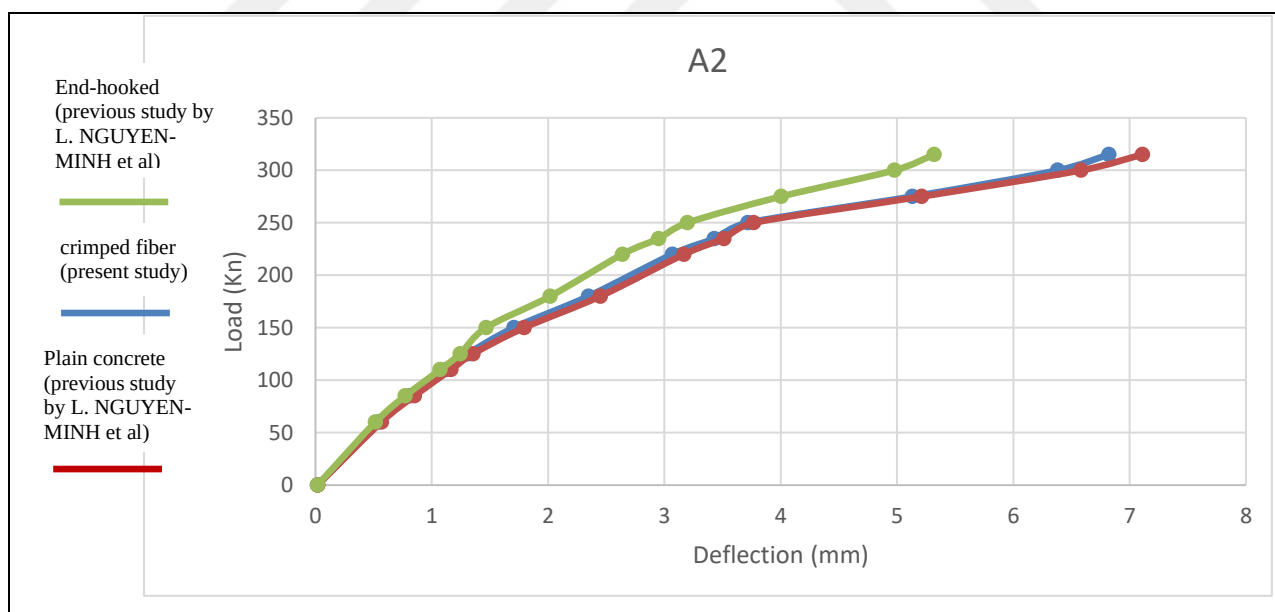


Figure 4.12: Results of A2 Displacement

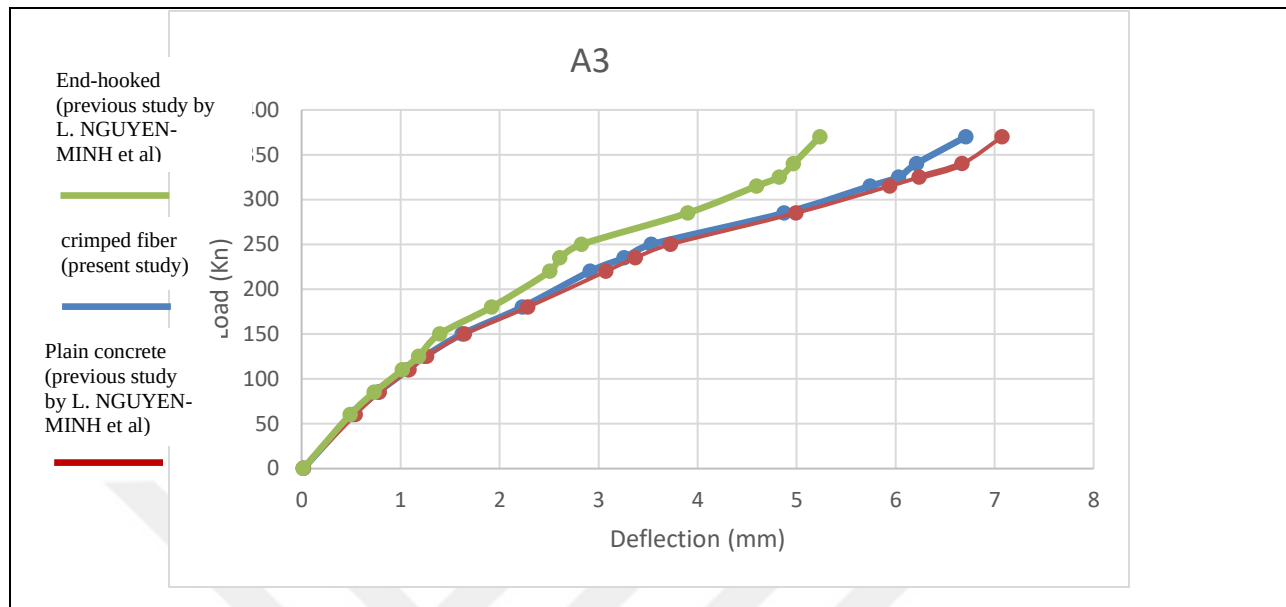


Figure 4.13: Results of A3 Displacement

The test slabs' punching shear resistance is graphically shown in this article. It is without dispute that the insertion of steel fibers to slabs increases their punching shear capacity significantly, and that this enhancement is directly proportional with the volume of the fibers. By adding steel fibers to the concrete at a weight of 30 to 60 kg/m³, it is feasible to improve the punching shear resistance of Group A slabs. The capacity of the steel fibers to bridge fractures across the whole concrete volume and to transfer tensile stress via the fissures' two opposing sides accounts for the increased resistance to punching shear in SFRC slabs. The slabs' total punching shear resistance is increased as a consequence. Because of this, even throughout the period of fracture initiation and propagation, the tensile zone of SFRC slabs continues to withstand load. The concrete's tensile strength is thereby increased, and as an unforeseen side effect, the slabs' punched shear resistance is also enhanced.

4.2.2 Results of Group B

For the purpose of modeling the behavior of concrete slabs, three-dimensional, tiny slab models were utilized. The technique of analyzing the dynamic properties of a system via the lens of the frequency domain is referred to as modal analysis. For example, it can be used to gain a better understanding of how a mechanical structure responds when it is subjected to stress. When building a structure to support loads, it is critical to take into consideration a linear dynamic method

in addition to the structure's components in order to identify patterns of displacement. When anything is moving, it will experience a variety of what are known as "mode forms," which can also be thought of as configurations. The patterns that are created by the displacement are frequently of utmost significance. If a structure has N degrees of freedom, then it will have N mode shapes that are similar to each other. By raising the normalized displacement and superimposing it on top of the existing mode shapes, it is feasible to generate a new displacement pattern. Modal analysis is a technique that can be used to simplify complex structures by decomposing them into a collection of autonomous systems with a single degree of freedom. The findings of the preliminary examination of the slab's structural shell can be seen in the photographs that are provided below.

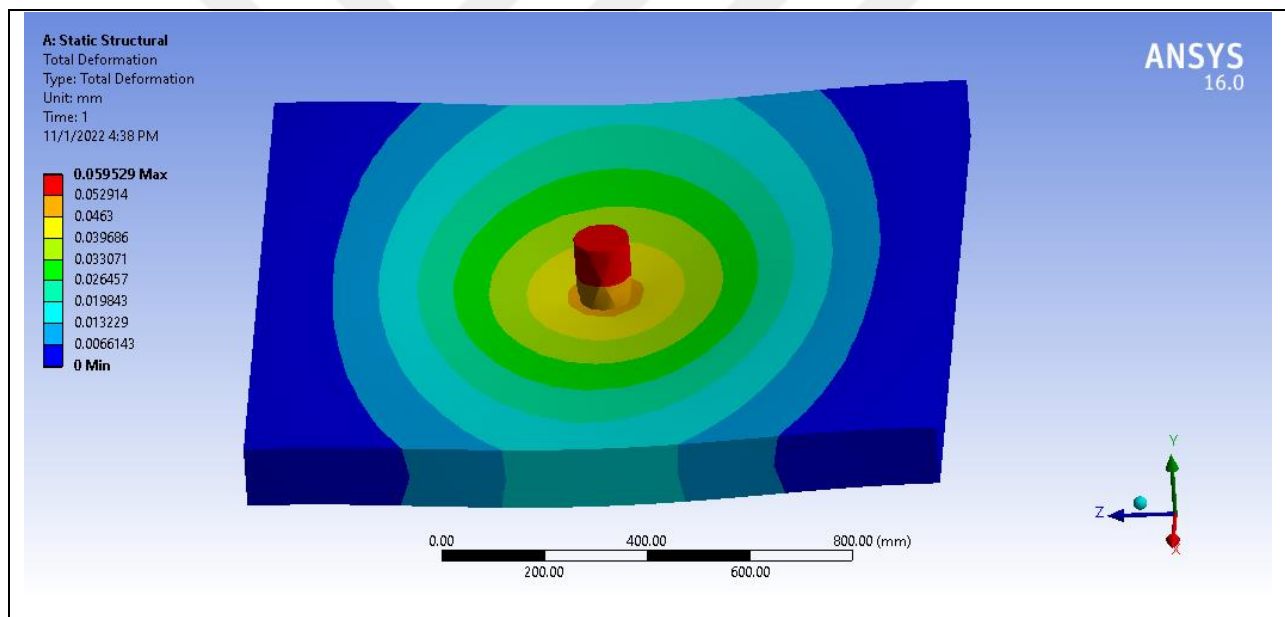


Figure 4.14: The Result of Load for The First Force

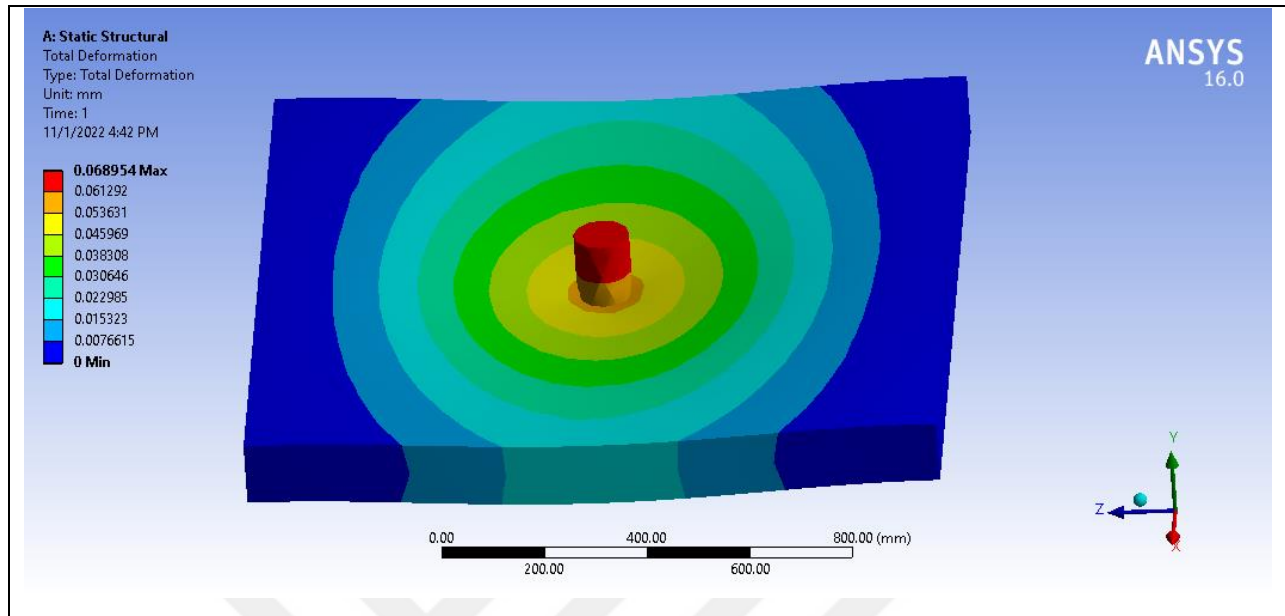


Figure 4.15: The Result of Load for The Second Force

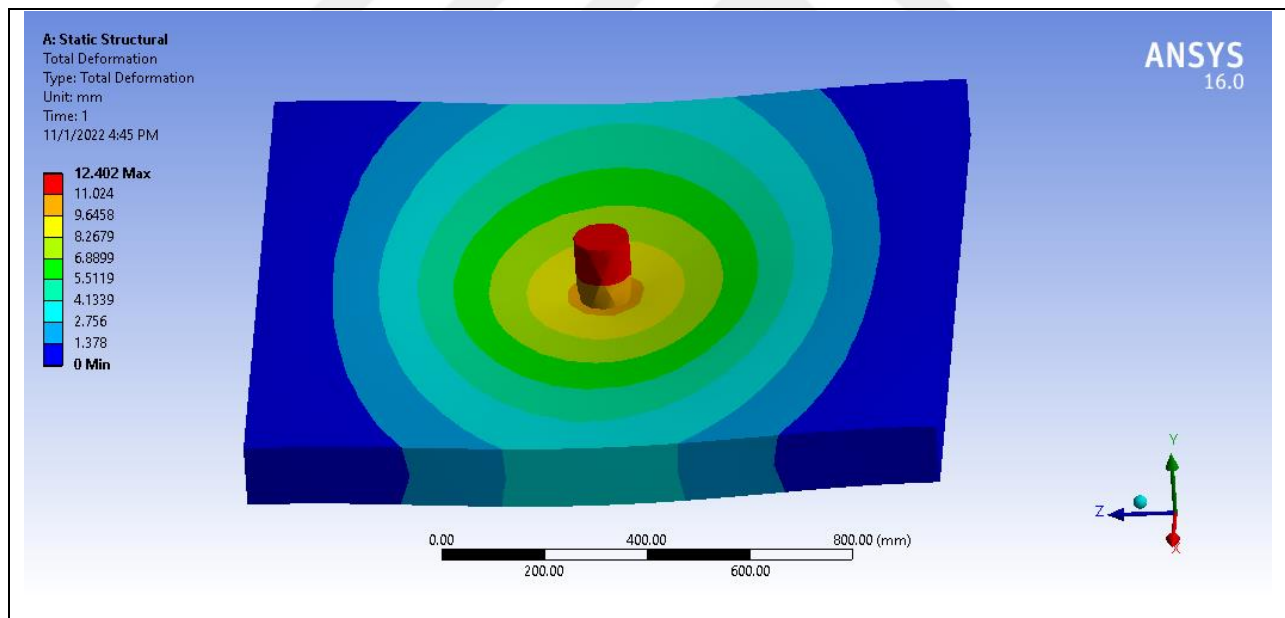


Figure 4.16: The Result of Load for The Third Force

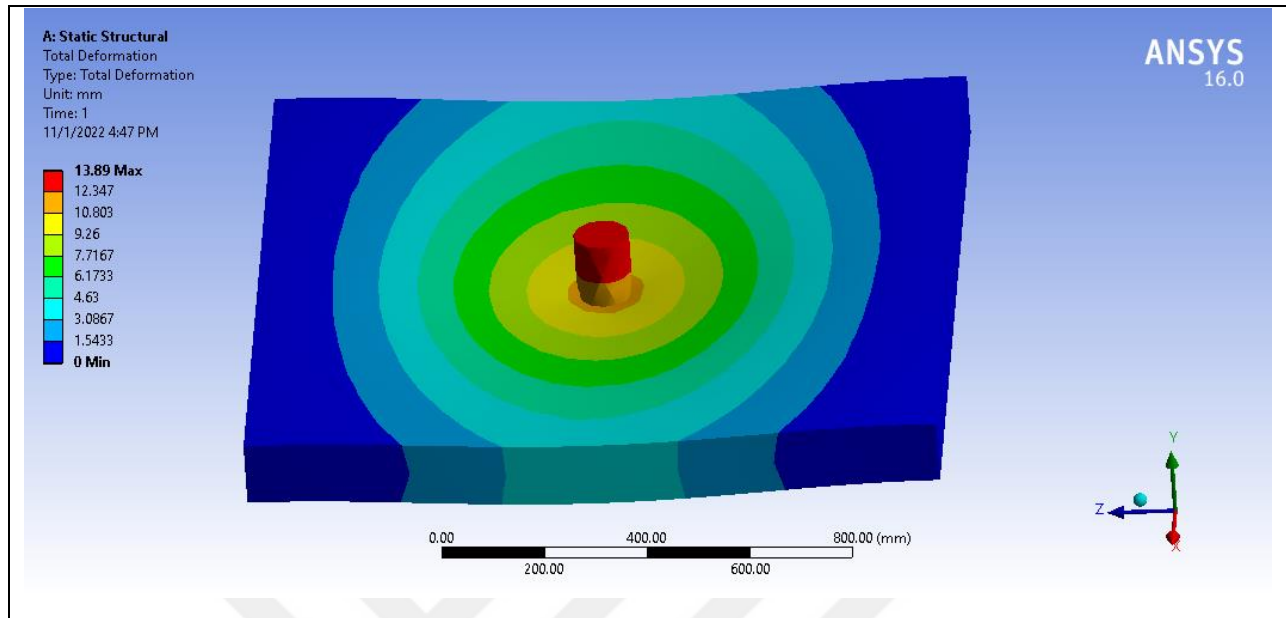


Figure 4.17: The Result of Load for The Fourth Force

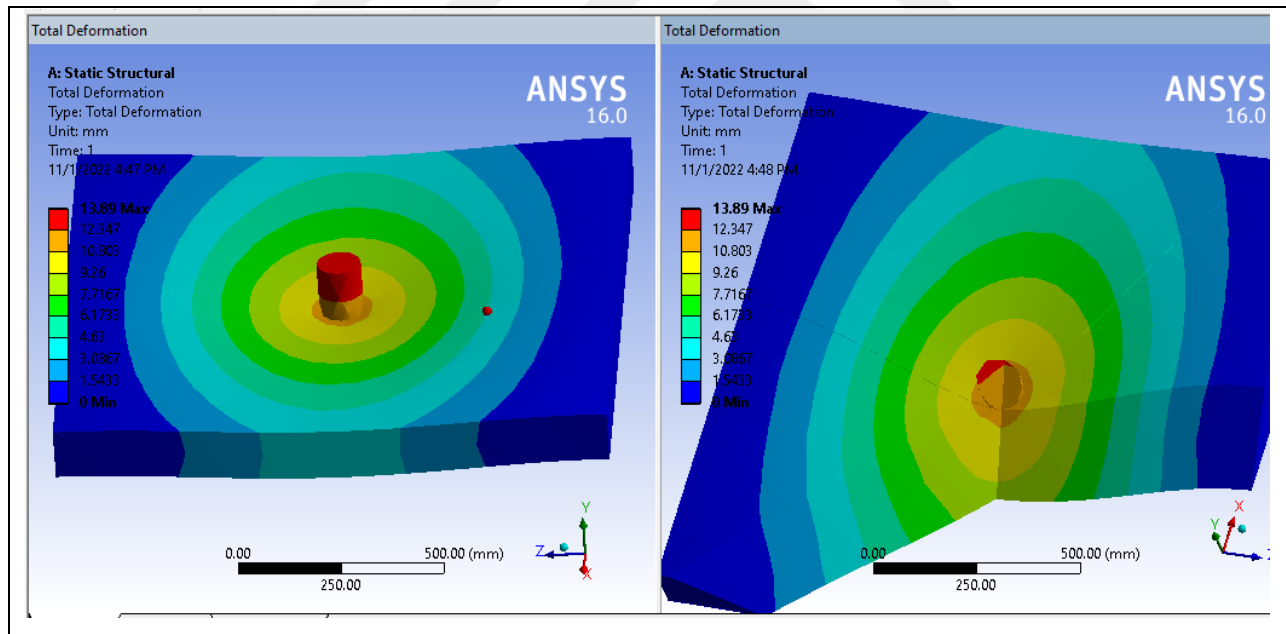


Figure 4.18: Total Deformation of Group B

When the ultimate load is compared to the nominal shear stress, a drop in strength is seen for higher percentages of steel fiber-reinforced concrete (SFRC), whereas an increase is seen for lower SFRC percentages. Because of this, we can conclude that the steel fiber is not embedded in the concrete. Test results for the full complement of slabs are depicted in the figures below:

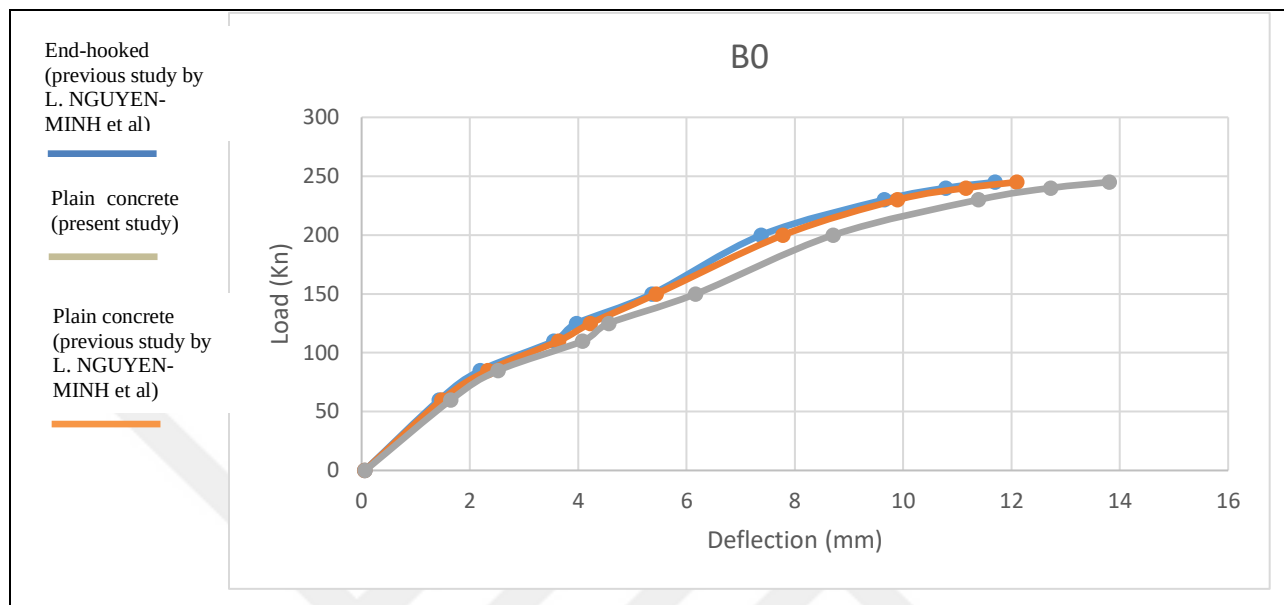


Figure 4.19: Results of B0 Displacement

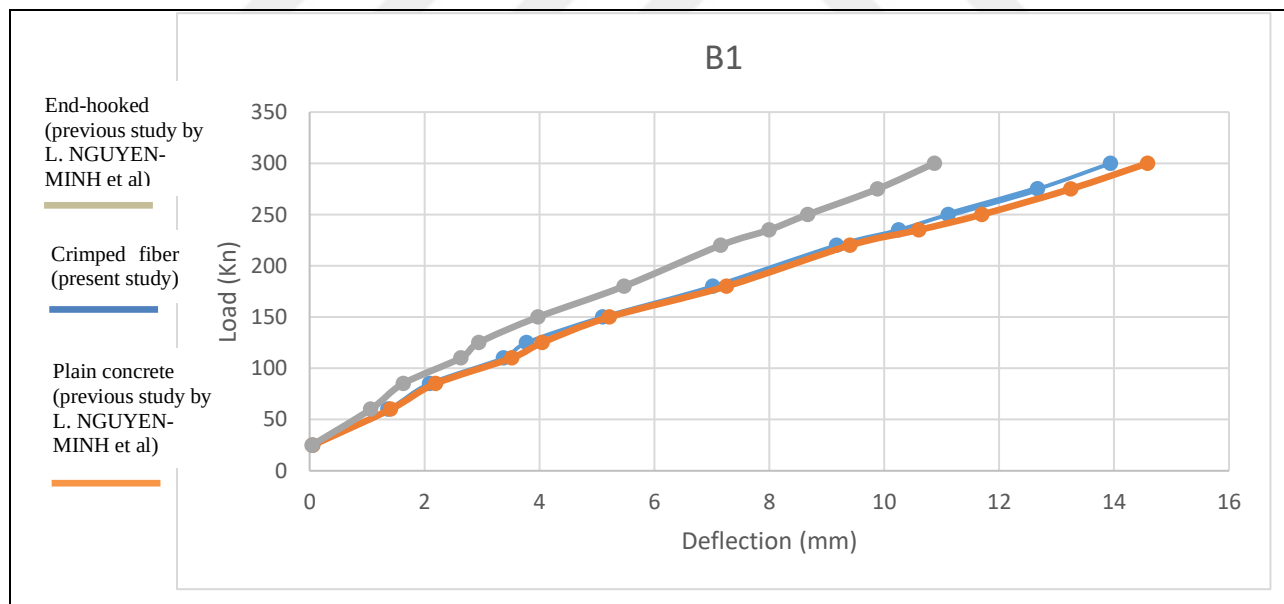


Figure 4.20: Results of B1 Displacement

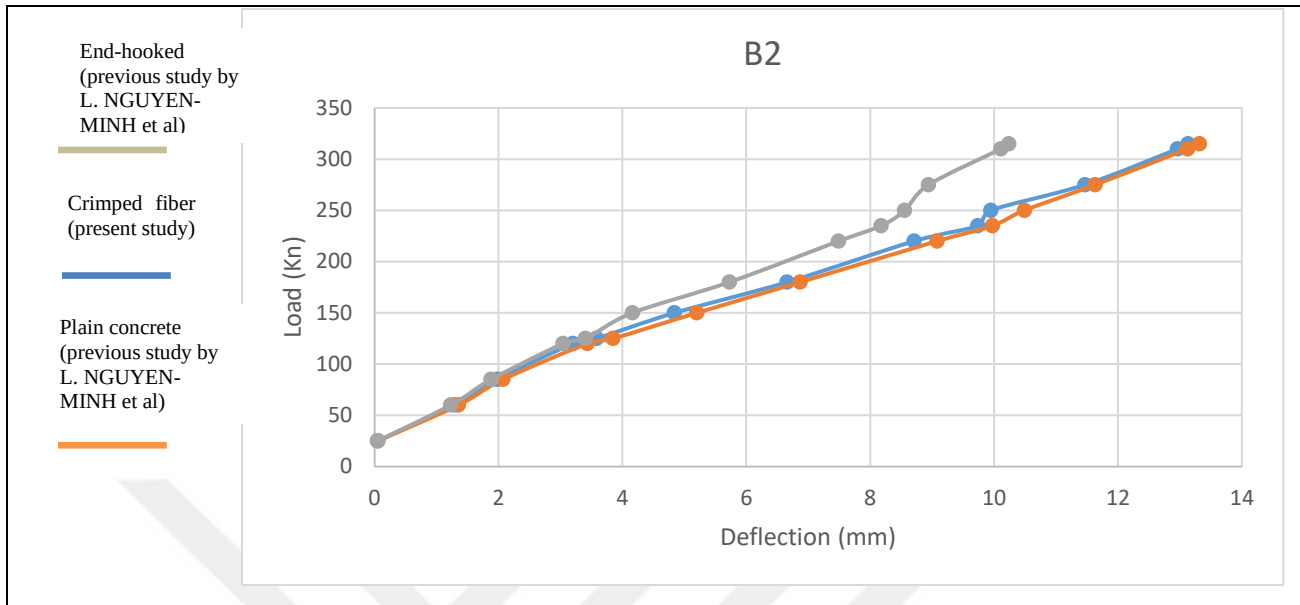


Figure 4.21: Results of B2 Displacement

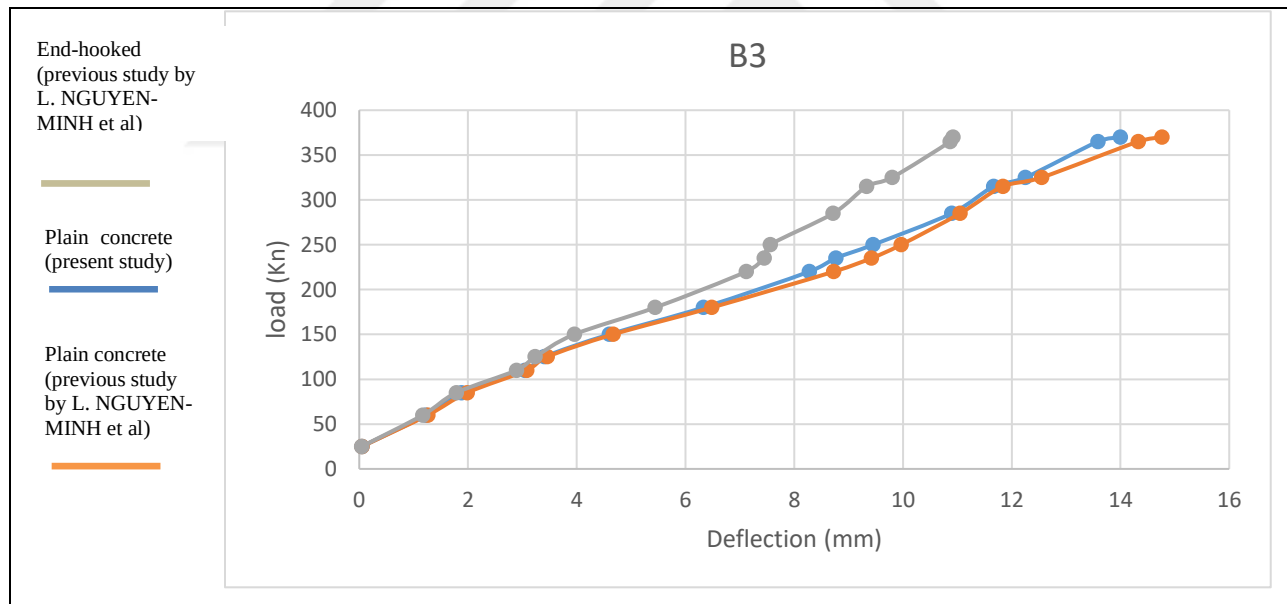


Figure 4.22: Results of B3 Displacement

The punching shear resistance of the test slabs is shown visually. It is evident that the insertion of steel fibers significantly increases the punching shear capacity of slabs, and that this enhancement is correlated with the volume of the fibers. To increase the punching shear resistance of the Group B slabs, steel fibers weighing 30 to 60 kg/m³ can be added to the concrete.

The capacity of the steel fibers to bridge fractures across the whole concrete volume and transfer tensile stress via the fissures' two opposing sides accounts for the increased resistance to punching shear in SFRC slabs. As a result, the tensile zone of SFRC slabs continues to support load throughout the onset and propagation of cracks.

As a consequence, the concrete's tensile strength is increased, and as a byproduct, the slabs' punched shear resistance is improved.



5. CONCLUSION AND RECOMMENDATION

It is not feasible to quantify the punching shear transfer processes quantitatively since the work is experimental. The influence of the fibers' length, shape, or the proportion of their diameter to length on the punching shear resistance of slabs are also not taken into consideration by these calculations. In actuality, these factors significantly affect the steel fibers' ability to bond to concrete, which in turn affects concrete strength, which in turn impacts the ability of SFRC slabs to withstand punching shear. The behavior of the slab is dominated by flexural deformation in the case of thin slabs with a high span-to-thickness ratio. In this case, this presumption could be accurate. While shear deformation has a major role in the behavior of slabs with a relatively low span-to-thickness ratio, shear deformation is less important. These assumptions may be drawn from the research's results based on the findings that were found:

- a) The inclusion of steel fibers considerably increases the slabs' punching and shear resistance. Steel fibers with a fiber volume of 30 to 60 kg/m³ improve the punching shear resistance of the slabs in a manner that is directly proportional to the fiber volume.
- b) It is possible to simulate the behavior of steel fiber reinforced concrete slabs using the three-dimensional nonlinear finite element model used in the current research work. The findings of the experiment and the projected behavior were in generally acceptable agreement, according to FE analysis.
- c) The optimal enchainment was achieved when steel fibre was applied to the concrete slabs when the slabs were being subjected to a high stress.
- d) The optimal enchainment was achieved in both situations with the identical improvement behavior brought about by the addition of the steel fiber.

5.1 FUTURE WORKS

As part of the ongoing research, a new examination for concrete material needs to be conducted in order to expose the booth types on other SFRC depending on various conditions.

REFERENCES

- [1] M. Karki and R. Suwal, “Comparative Study of Flat Slab Structures,” no. December, pp. 259–265, 2019.
- [2] D. da S. Lourenço, E. A. P. Liberati, M. G. Marques, L. C. de Almeida, and L. M. Trautwein, “Reinforced concrete flat slabs with openings at different distances from the column,” *Rev. IBRACON Estruturas e Mater.*, vol. 14, no. 1, pp. 1–18, 2021, doi: 10.1590/s1983-41952021000100011.
- [3] E. Lantsoght, “Literature Review of Punching Shear in Reinforced Concrete Slabs for CEE 8956, Special Research Problem School of Civil and Environmental Engineering,” no. June, 2009.
- [4] H. K. Ammash, M. J. Kadhim, and D. S. Ellk, “A New Punching Shear Equation of Normal and High Strength Reinforced Concrete Flat Slabs,” *J. Eng. Dev.*, vol. 16, no. 4, pp. 47–65, 2012.
- [5] O. Sucharda, M. Smirakova, J. Vaskova, P. Mateckova, J. Kubosek, and R. Cajka, “Punching Shear Failure of Concrete Ground Supported Slab,” *Int. J. Concr. Struct. Mater.*, vol. 12, no. 1, 2018, doi: 10.1186/s40069-018-0263-6.
- [6] M. R. Abdulkadir, Z. A. Aziz, and J. H. Muhammad, “Non Linear Finite Element Modeling of Reinforced Concrete Flat Plate Slabs with openings,” *Sulaimani J. Eng. Sci.*, vol. 4, no. 4, pp. 41–49, 2017, doi: 10.17656/sjes.10045.
- [7] G. Marčiukaitis and R. Šalna, “Calculation of Punching Shear Strength of Steel Fiber Reinforced Concrete Flat Slabs,” *Procedia Eng.*, vol. 172, pp. 1110–1114, 2017, doi: 10.1016/j.proeng.2017.02.182.
- [8] A. Muttoni and A. Windisch, “Punching shear strength of reinforced concrete slabs without transverse reinforcement,” *ACI Struct. J.*, vol. 106, no. 3, p. 381, 2009.
- [9] K. Nassim, Y. Bouafia, and B. Khalil, “Reliability and punching shear resistance of slabs in non linear domain,” *Gradjevinar*, vol. 67, no. 11, pp. 1051–1062, 2015, doi: 10.14256/JCE.1295.2015.
- [10] C. Paper and M. W. Mpw, “The influence of design concept and detailing on the response of concrete structures to deterioration,” no. November, 2016.
- [11] A. Bashandy, F. Eid, M. Arab, and A. Elkassas, “Resisting Punching Shear of Flat Slab,” *Int. J. Adv. Res. Eng. Technol.*, vol. 9, no. February, p. 19019, 2022.
- [12] S. Borkar, K. Dabhekar, I. Khedikar, and S. Jaju, “Analysis of Flat Slab Structures in Comparison with Conventional Slab Structures,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 822, no. 1, 2021, doi: 10.1088/1755-1315/822/1/012049.

- [13] S. Borkar, K. Dabhekar, I. Khedikar, and N. Vaidya, "Review on 'Comparative study of flat slab structure and conventional slab structure,'" IOP Conf. Ser. Mater. Sci. Eng., vol. 1197, no. 1, p. 012072, 2021, doi: 10.1088/1757-899x/1197/1/012072.
- [14] I. S. Abbas, "BEHAVIOR OF TWO-WAY CONCRETE SLABS REINFORCED WITH FIBERS," no. November, 2020, doi: 10.13140/RG.2.2.11763.55846.
- [15] A. S. Patil, A. B. Daphal, S. S. Gavasane, and S. S. Ghorpade, "Analysis Of Behavior Of Flat Slab And Conventional Slab Structure Under Seismic Loading," no. January, pp. 0–6, 2021.
- [16] B. Atomic, "PERFORMANCE OF FLAT SLAB STRUCTURES UNDER STATIC AND LATERAL LOADS as per IS:456-2000," no. September, 2020, doi: 10.13140/RG.2.2.11539.71207.
- [17] E. Alaagaleb@gmail.com and M. A. Jennam, "Optimum Design of Reinforced Concrete Flat Slabs," vol. 33, no. 9, pp. 2049–2065, 2015.
- [18] M. S. Al-Ansari and M. S. Afzal, "Structural Analysis and Design of Flat Slab with Irregular Column Layouts using Simplified Design Method," Int. J. Civ. Eng., vol. 7, no. 7, pp. 44–52, 2020, doi: 10.14445/23488352/ijce-v7i7p107.
- [19] S. Bhagat and Parikh K.B., "Comparative Study of Voided Flat Plate Slab and Solid Flat Plate Slab," Int. J. Innov. Res. Dev., vol. 3, no. 3, pp. 22–25, 2014.
- [20] Y. Reichman and M. Adan, "Improved design of concrete flat-slab buildings for seismic effectiveness and prevention of blast induced progressive collapse," NCEE 2014 - 10th U.S. Natl. Conf. Earthq. Eng. Front. Earthq. Eng., no. March, 2014, doi: 10.4231/D3XK84Q9T.
- [21] N. Y. X. Saeralyn and H. B. Koh, "Analysis and Design of Reinforced Concrete Flat Slab Subjected to Line Load," Civ. Eng. Built Environ., vol. 2, no. June, pp. 0–13, 2021, doi: 10.30880/rcebe.2021.02.01.31.
- [22] M. Burhan, "Comparative Cost Study of Reinforced Concrete Flat Slab and Slab with Beam Floor Systems," no. May, 2022.
- [23] P. Weerasinghe, P. Mendis, K. T. Q. Nguyen, and T. Ngo, "Fire Performance of Concrete Flat Slabs," 10th Int. Conf. Struct. FIRE, no. June, p. 85923, 2018.
- [24] N. Girish and N. Lingeshwaran, "A Comparative Study of Flat Slabs Using Different Shear Reinforcement Parameters," Int. J. Eng. Technol., vol. 7, no. 2.20, p. 321, 2018, doi: 10.14419/ijet.v7i2.20.16725.
- [25] D. C. Oliveira, R. B. Gomes, and G. S. Melo, "Punching shear in reinforced concrete flat slabs with hole adjacent to the column and moment transfer," Rev. IBRACON Estruturas e Mater., vol. 7, no. 3, pp. 414–467, 2014, doi: 10.1590/s1983-41952014000300006.

- [26] G. H. Ahmed and O. Q. Aziz, "Punching Shear Strength of Concrete Flat Plate Slabs During (1906-2009), Review and Analysis *," *Zanco J. Pure Appl. Sci. / Salahaddin Univ.*, vol. 23, no. 2, 2011, doi: Zanco Journal of Pure and Applied Sciences.
- [27] V. A. Georgewill, B. E. Ngekpe, I. Z. S. Akobo, and G. W. T. Jaja, "Punching Shear Failure of Reinforced Concrete Flat Slab System-A," *Eur. J. Adv. Eng. Technol.*, vol. 6, no. 2, pp. 10–16, 2019, doi: 10.13140/RG.2.2.21115.57121.
- [28] M. Gamal, M. Ibrahim, and M. Mansour, "Strengthening of Reinforced Concrete Slabs with Openings using Near Surface Mounting," no. July, pp. 1–8, 2021.
- [29] P. Yan and Y. C. Wang, "Behaviour of steel tubereinforced concrete flat slab shearhead systems," *Proc. Inst. Civ. Eng. Struct. Build.*, vol. 167, no. 11, pp. 667–677, 2014, doi: 10.1680/stbu.12.00091.
- [30] S. Bar, "Strengthening of reinforced concrete beams with openings using near surface mounting (CFRP, CFRP STRIPS," no. July, pp. 0–11, 2021, doi: 10.1312/182.
- [31] N. Dinarte Gouveia et al., "Punching of steel fibre reinforced concrete flat slabs see profile punching of steel fibre reinforced concrete flat slabs," no. April, pp. 1–5, 2013, doi: 10.13140/2.1.3906.9442.
- [32] D. V. Bompa and A. Y. Elghazouli, "Structural performance of RC flat slabs connected to steel columns with shear heads," *Eng. Struct.*, vol. 117, no. May, pp. 161–183, 2016, doi: 10.1016/j.engstruct.2016.03.022.
- [33] S. Lu, M. Koopialipoor, P. G. Asteris, M. Bahri, and D. J. Armaghani, "A novel feature selection approach based on tree models for evaluating the punching shear capacity of steel fiber-reinforced concrete flat slabs," *Materials (Basel)*, vol. 13, no. 17, 2020, doi: 10.3390/ma13173902.
- [34] A. S. Samsudin, M. H. Mohd Hashim, S. H. Hamzah, and A. Abu Bakar, "Bending Strength of Steel Fibre Reinforced Concrete Ribbed Slab Panel," *Sci. Res. J.*, vol. 15, no. 1, p. 15, 2018, doi: 10.24191/srj.v15i1.9353.
- [35] M. Petkevicius and J. Valivonis, "Analysis of bending capacity of composite steel-concrete slabs with steel fiber reinforced concrete," *10th Int. Conf. Mod. Build. Mater. Struct. Tech.*, no. October, pp. 744–751, 2010.
- [36] R. Zinn et al., "Analysis of combined bending and punching tests of reinforced concrete slabs within IMPACT III Project," *Proc. Int. Conf. Struct. Dyn., EURODYN*, vol. 2014-Janua, no. August 2015, pp. 3533–3540, 2014.
- [37] M. Ilshat, N. Georgy, and K. Midkhat, "Strength of reinforced concrete flat slabs for punching," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 890, no. 1, 2020, doi: 10.1088/1757-899X/890/1/012076.

- [38] Nguyen-Minh L, Rovňák M, Tran-Quoc T, Nguyenkim K. " Punching shear resistance of steel fiber reinforced concrete flat slabs". Procedia Engineering. 2011 Jan 1;14:1830-7.

