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Institute of Graduate Studies

Civil Engineering

# INVESTIGATION OF THE STRUCTURAL BEHAVIOR OF STEEL FIBER REINFORCED CONCRETE SHEAR WALLS EXPOSED TO HORIZONTAL LOADS WITH ANSYS PROGRAM

**Jihad Mahmoud ALI**

Master’s Thesis

Supervisor

Prof.Dr. Zeki HASGUR

Istanbul, 2022

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The thesis titled "INVESTIGATION OF THE STRUCTURAL BEHAVIOR OF STEEL FIBER REINFORCED CONCRETE SHEAR WALLS EXPOSED TO HORIZONTAL LOADS WITH ANSYS PROGRAM" prepared by JIHAD MAHMOUD ALI and submitted on 20/05/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering

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

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Jihad Mahmoud ALI

Signature

# ABSTRACT

## INVESTIGATION OF THE STRUCTURAL BEHAVIOR OF STEEL FIBER REINFORCED CONCRETE SHEAR WALLS EXPOSED TO HORIZONTAL LOADS WITH ANSYS PROGRAM

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Reinforced concrete walls are considered one of the most important applications in the field of buildings construction, especially tall buildings, because of their ability to withstand high stresses caused by loads. Therefore, the purpos of this research is to investigate the capabilities of shear walls reinforced with fiber steel to discover the amount of deformations that occur in the presence of horizontal forces. The work in the research was divided into two phases. The first phase is to test the samples of concrete cubes to obtain the necessary data for the mechanical specifications of the samples. The second is the work of simulations using the ANSYS program. Walls of different heights were tested and subjected to different values of lateral forces to simulate normal use in civil engineering works. The results showed that the maximum horizontal load for walls reinforced with fiber steel exceeds the horizontal load values for ordinary concrete walls, safe in terms of bending capacity or shear strength. FE analytical tests performed for the two studied cases indicate that the load deformation response and final load behavior in concrete shear walls are in agreement. The study also showed that the optimal cohesion is when steel fibers are added to the concrete of the shear wall with a high loading effect. The midline distortion of the numerical model was compared with the experimental data, which showed the same distortion behavior.

**Keywords:** SFRC, Shear Wall, Finite Element

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# ABBREVIATIONS

| | | |
|---|---|---|
| B.E.M. | : | Boundary Element Method |
| D.O.F | : | Degree Of Freedom |
| F.E.M. | : | Finite Element Method |
| FSI | : | Fluid-Structure Interface |
| PGA | : | Peak Ground Acceleration |
| PCA | : | Portland Cement Association |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| $P_j$ | : | Generalized force of the $j^{th}$ normal mode |
| {R} | : | Earthquake influence vector |
| [R] | : | Coupling matrix |
| t | : | Time |
| T | : | Natural time period |
| $T_c$ | : | Convective mode time period |
| $\{U\},\{\dot{U}\},\{\ddot{U}\}$ | : | Nodal displacement, velocity, and acceleration vectors |
| $\ddot{U}$ | : | Ground acceleration |
| $V_s$ | : | Shear wave velocity of soil |
| $W_i$ | : | Weight of impulsive fluid |
| $W_R$ | : | Weight of roof |
| $W_W$ | : | Weight of wall |
| y | : | Liquid level at which wall is investigated measured from base |
| {Y} | : | Generalized coordinate vector |
| $Y_j$ | : | Generalized displacement of $j^{th}$ mode |
| Z | : | Axial global coordinate |
| $\bar{z}$ | : | Axial local coordinate |
| $\nabla^2$ | : | Laplace operator |
| $\{\varepsilon\}$ | : | Strain vector |
| $\{\sigma\}$ | : | Stress vector |
| $\{\delta_T\}$ | : | Displacement vector |
| $\{\dot{\delta}_T\}$ | : | Velocity vector |
| $\{\ddot{\delta}_T\}$ | : | Acceleration vector |
| $\zeta$ | : | Damping ratio |
| $\xi$ | : | Free surface displacement |
| $\rho$, $\rho_f$, $\rho_s$ | : | Mass density of shell, liquid, and soil, respectively |
| $\upsilon$ , $\upsilon_s$, $\upsilon_w$ | : | Poisson's ratio of shell, soil and water, respectively |
| $\Phi$ | : | Liquid velocity potential function |
| $\{\phi\}_j$ | : | $j^{th}$ mod shape vector |

| | | |
|---|---|---|
| $[\phi]$ | : | Mode shape matrix |
| $\Delta t$ | : | Increment in time |
| $\alpha$ , $\delta$ | : | Newmark direct integration method parameters |
| $\boldsymbol{\gamma}$ | : | Specific weight of liquid |
| f | : | Natural frequency |
| $\{f_s\}$ | : | Elastic force vector |
| g | : | Acceleration of gravity |
| $G_s$ | : | Shear modulus of soil |
| $h_c$ | : | Height of convective mass |
| J | : | Number of mode of vibration |
| $j^{th}$ | : | Mode of vibration |
| k | : | Flexural stiffness of tank wall |
| [K] | : | Stiffness matrix |
| $K_s$ | : | Soil spring constant for elastic half space model |
| $k_p$ | : | Flexibility of base pad |
| L | : | Length of shell element |
| $l_x$ | : | Clear length = $2L_x$ -$2H_t$ |
| [M] | : | Mass matrix |
| $M_c$ | : | Convective mass |
| $m_f$ | : | Impulsive mass of fluid |
| $M_i$ | : | Impulsive mass |
| $M_j$ | : | Generalized mass of the $j^{th}$ normal mode |
| $m_s$ | : | Soil added mass for elastic half space model |

# 1. INTRODUCTION

A shear wall is a structural member that resists cracking through in-plane shear. Shear walls can be subjected to horizontal (Wind or Earthquake) forces and vertical (gravity). The structural barriers are planned and specified to have the requisite stiffness, strength, and flexibility to provide life-safety performance in a building exposed to horizontal forces [1]. The aspect ratios of shear walls determine whether they are long or short. In the plane of loading 6, the aspect ratio is defined as the ratio of its height to length. They're known as quick or squat shear walls when the h/l ratio is less than two. Shear dominates their design rather than flexure [2][3]. If a ductile failure mode is needed, aspect ratios below 2 indicate the shift from slender to short Behavior, and walls with such dimensions require substantial consideration in design. They are long or thin shear walls for h /1> 2. Flexure is dominant in their structure [2]. Shear wall collapse is often flexure-controlled. However, it depends on various factors such as aspect ratio, wall geometry, and loading circumstances. The failure modes' damage patterns might be diagonal tension, compression, or sliding deformation [4]. Shear walls' stiffness and lateral load capacity were the focus of most early research. Some researchers used test data to produce empirical equations for design parameters, while others created behavioural models that predict their lateral load capacity using fundamental mechanics concepts. In recent building codes and performance assessment guidelines, the lateral strength, stiffness, and ductility qualities of individual structural parts and their nonlinear response features and nonlinear analytical modelling parameters have become more critical [5]. Three techniques are used in most extant research on analytical modelling of nonlinear Behaviour of shear-controlled walls. To estimate wall shear strength, the first method is to use strut-and-tie modeling [6], the second method is to use fibre-based or multiple-spring models [4] that account for shear-flexure interaction, and the third method is to use finite element modelling [7]. Despite the merits and limitations of these modelling tools, they are seldom used in the design or performance evaluation of buildings with squat walls or shear-controlled wall segments. They aren't included in most commercially available nonlinear analysis software. Despite substantial studies into thin wall behaviour and construction, little is known about squat walls with shear-controlled responses. Furthermore, shear-controlled wall response estimates based on design code strength calculations and backbone curves given in assessment/rehabilitation recommendations are not always accurate.

## 1.1 STEEL FIBER REINFORCED CONCRETE

Fiber Reinforced Concrete (FRC) is concrete combined with fibrous material. The effect of these materials is to increase the structural integrity. The fibre reinforced concrete as a composite material contains short discrete fibres which is randomly oriented and uniformly distributed [8]. The composite material of hydraulic cement is steel fibre reinforced concrete (SFRC). It is a delicate and coarse aggregate correlated with discrete steel fibres. SFRC is widely used in concrete structures used to increase the tensile strength of the concrete. Also, adding of steel fibre is used to prevent the formation of micro-openings caused by micro cracks. These additives provide lower stress at the end of the damages based on steel fibre transportation of tensile forces, minimizing crack growth and enhancing the concrete material to endure loads even after a visible crack occurs. The substantial failure mode depends on several parameters such as concrete dimensions and loading pace that cause rebar to slide out of concrete or steel to shatter after reaching its maximum strength. Adding fibres can enhance the concrete strength and increment the strength of the concrete [9]. Fibres reinforced concrete contains concrete mixed with distributed fibres. Combining fibres with concrete generates increased power and enhances the crack pattern. The fibre-reinforced concrete fault behaviour observes several small cracks instead of one or two larger cracks in traditional concrete. Fibres are added for the long term durability of concrete [10]and add a new significant feature to the concrete, as shown in Figure 1.1 shows the test specimen under loading [11].

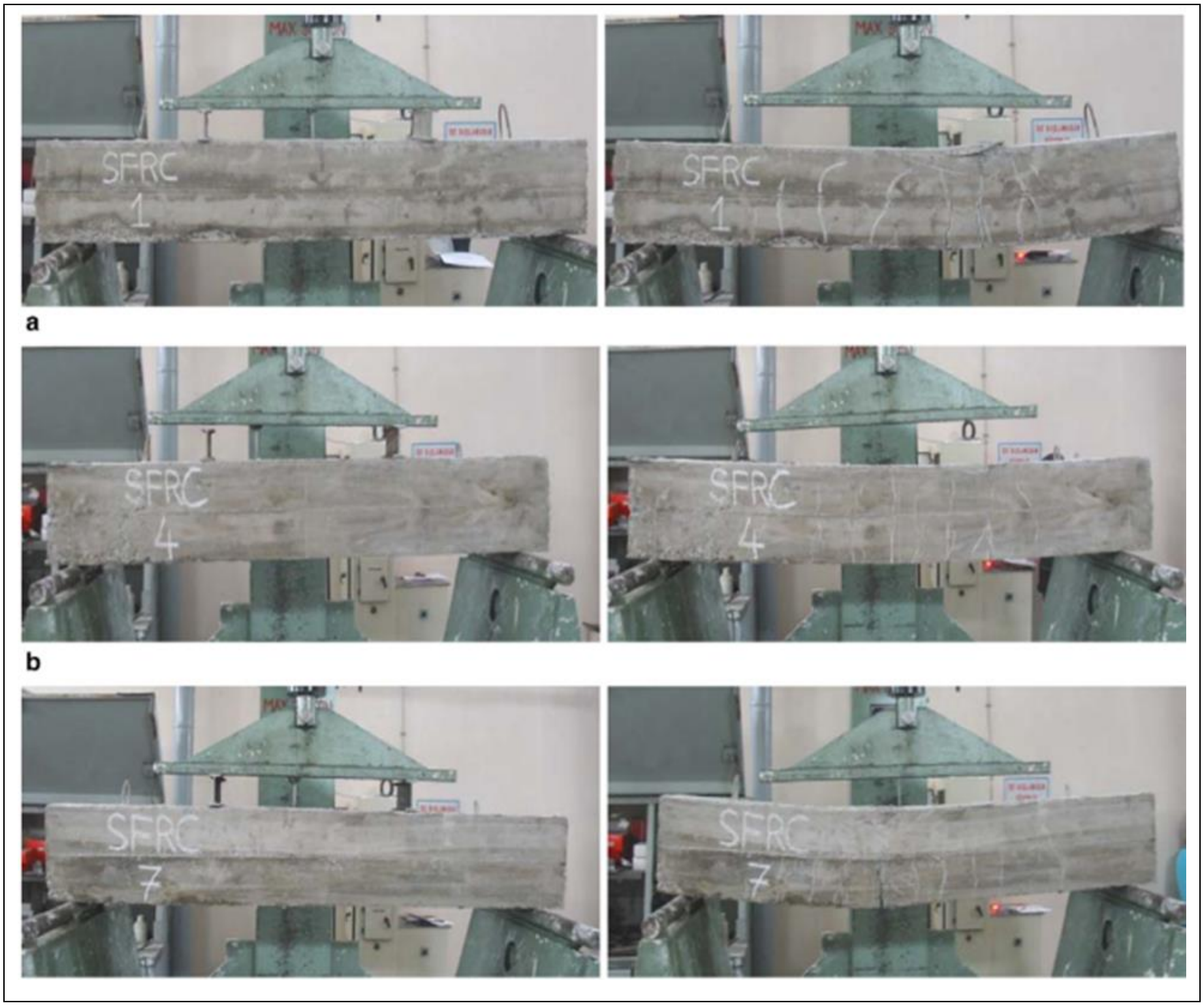


**Figure 1.1:** Appearances of Some of the Bending Experiments on the 4-point Beam-Loading Setup

In the above figure:(a) RC beam with no SFs in the beam-loading setup; (b) SFARC beam with 30 kg/m3 of SFs in the beam-loading structure and (c) SFARC beam with 60 kg/m3 of SFs in the beam-loading form.[11].

The fibres can be produced from many different materials. The ACI 544 classifies the fibre types into four rescores [12]. They are used to improve the concrete properties and cementations composites. There are many types of synthetic fibre which is used to incorporate the cement matrices involved: polyvinyl acetate (PVA), polypropylene (PP), polyethene (PE), acrylics (PAN), polyester (PES), polyamides (PA), carbon, and aramid. Some examples of different commercially available fibres can be shown in Figure 1.2[13]. Both geometrical and mechanical properties of fibre vary based on their effects and provide a unique property of concrete. Some types of fiber are used to enhance the toughness and reduce crack widths, but other fiber types reduce shrinkage cracking [14].

**Figure 1.2:** Examples of Commercially Available Fibers [14]

Many factors affect fibre reinforced concrete reliability, such as orientation, fibre type and percentage of fibres. The mix workability is decreased if the quantity and size of particles increase greater than 5 mm. The aspect ratio (l/d) is another important factor. It has a major effect on workability of the fibers. The fibers workability decreases with increasing aspect ratio.

## 1.2 PROBLEM STATEMENTS

There are two significant loads to consider; gravity and lateral loads. While gravity loads generally act downward, a lateral load is deemed to work in the horizontal direction. To control the crack behaviour generated by these loads, Steel Fibers (SF) have been explored extensively in recent decades to control fracture behaviour and maintain ductility under tension. It has been shown that the usage of these fibres at the right dose may transform brittle structural components into ductile ones. There are many types of research addressing this subject, many mechanical models had been proposed, and many code equations have been introduced, but still many problems to be resolved. Many methods have been suggested to increase the shear action. The challenge is; if we enhance the concrete by adding steel fibres, then what are the mechanical behaviours of concrete walls? Also, what is the deformation's response and strengths related to these lateral loads for different wall heights?

## 1.3 OBJECTIVES AND SCOPES

Steel fiber's influence on the residual strength of the shear wall will be experimented. In order to achieve this objective, SFRC is exposed to different reinforcements are studied through the:

a) Comparison between the shear wall behavior with SFRC due to different steel-fiber conditions and shear wall behavior at normal condition.

b) Investigation of the effect of steel fiber volume fraction on punching shear capacity.

## 1.4 THESIS ORGANIZATION

This thesis has five chapters. Chapter one includes an introduction to shear wall behaviour under horizontal loads and the effect of steel fibre on the Behavior.

Chapter two presents a general view of steel fibre's effects on concrete Behavior in different studies collected from various researches.

The experimental program, including the studied parameters, the work methodology, and the testing of SFRC specimens, are presented in Chapter three.

Chapter four discusses the result and the calculation of the work. Chapter five is the conclusion

# 2. LITERATURE REVIEW

Buildings should have sufficient capacity to resist any lateral loads such as earthquake and wind forces. Different lateral resisting systems are used to increase the stiffness capacity; the most common lateral bracing system in the buildings is the reinforced concrete shear wall system. This system has many forms depending on the position and function of walls like core walls, coupled walls, and planar walls. This system is the most appropriate in moderate sized building up to 20 floors. Shear wall system is not preferred in the case of tall buildings, because this system will use a lot of concrete and reinforced steel bars when comparing to other lateral bracing systems like Moment resisting frames. The shear wall system is not also preferred in the open spaced structures due to architectural functions [15].

Due to small drift between floors and good stability in buildings, which will make the buildings more rigid, shear walls offer good performance in resisting lateral loads. Although the internal base shear force in most cases, this form of construction is used. more than that of other resisting systems, the capacity of the shear wall system can accept this large force induced by earthquakes. Windows and doors are required to be existed at shear walls due to architectural functions, these openings is causing a variation in relative stiffness of wall with openings that extend from that of a solid wall to that of a flexible frame. Furthermore, the concrete mixes are fully investigated to obtain the optimum mix that could enhance shear walls resistance to lateral forces [16].

## 2.1 ADVANTAGES OF USING STEEL FIBERS IN CONCRETE

Because of its strong tensile strength, steel is often utilized with concrete. We may change the characteristics of steel depending on the aim of its usage in concrete. There are several methods for achieving the necessary strength and durability. One of them is fiber reinforced concrete. Fiber-reinforced concrete is utilized for a variety of purposes. Depending on the application, the fibers may be utilized with or without reinforcement. The addition of fibers to concrete mortar is not just for the aim of increasing tensile strength. Fibers are mostly used in concrete to prevent fracture growth and make the material lighter. SFRC stands for dispersed fiber composite concrete. These fibers transmit stresses, which is beneficial in preventing fracture formation. The mixing of fibers with concrete is a critical step in preventing needless strength loss. If the fibers aren't blended appropriately, the region where these steel fibres aren't accessible might lose strength in that location.

Additionally, the concrete's workability may be harmed. Steel fibre reinforced concrete has a greater modulus of elasticity or young's modulus than regular concrete. Aspect ratio, fibre volume, mixing, and fibre orientation should all be evaluated before the mix. The additive may also obtain the necessary concrete quality with SFRC. Steel fibres are tiny, spherical, discontinuous fibres with an aspect ratio of 20 to 100 and a diameter of 0.25 to 0.75mm scattered in concrete during the mixing process. Steel fibres are bundled together using water-soluble adhesive and separated during the concrete mixing. Steel fibres have tensile strengths ranging from 280 to 420 MPa, a Poisson's ratio of 0.30, a young's modulus of 200 Gpa, a 3.6 per cent ultimate elongation, and a specific gravity of 7.8. They also have a specific gravity of 7.8 and a Poisson's ratio of 0.30. Steel fibres are manufactured utilizing a cut wire/cold drawn manufacturing technique to produce steel fibres. Following the submission of the application, the product must be purchased. There are many different shapes and sizes of steel fibres available, including round, rectangular (0.3 to 0.5 mm thick), and deformed bundled forms. Shorter fibres are used to decrease cracking, and longer fibres create a strong link between the fibres and the concrete, as seen in the example below. A mixed design may be used [17].

a) Steel fibres are generally spread throughout a cross-section, whereas reinforcing bars or wires are only used when necessary.

b) Steel fibres are shorter and more densely spaced than continuous wire reinforcing bars.

c) Steel fibres are often added to concrete in small amounts, and they have been demonstrated to help minimize plastic shrinkage cracking.

d) Steel fibres usually have little effect on the free shrinkage of concrete, but at high enough doses, they can increase cracking resistance crack widths.

e) Steel fibres do generally not appreciably alter the free shrinkage of concrete, but at sufficiently high dosages, they can increase crack resistance and decrease fracture breadth.

f) Steel fibres in concrete can help with cracking, impact resistance, and fatigue resistance.

### 2.1.1 Quality and Durability of Steel Fiber Concrete

After all of the concrete particles have been mixed, fibers are often added in the batching plant. Some individuals may ask for fiber on the work site, but the expert should have more control over how much fiber is installed. The steel fiber maker might also provide advice on how and how much to combine in order to achieve the desired outcomes. Adding too much fiber, it may surface after the concrete is finished, so be mindful of how much to mix [18].

Corrosion in steel fibre concrete structures is less severe than in typical reinforced concrete structures due to cracks. According to the study, even when the concrete is significantly saturated with chloride ions, well-compacted steel fibre concrete exhibits low abrasion of the fibres at the surface. Engineers presented research on the corrosion of steel fibre concrete owing to fissures [19].

If fibres are added to the concrete mix, it is essential to recognize and maintain it. The slack will be altered, and it is suggested that a super plasticizer be added to increase slack and make the concrete more malleable. Because not all steel fibres may be utilized as a substitute for rebar, the unique structural engineer must confirm that the loads have been examined and studied before starting [20].

## 2.2 EXPERIMENTAL AND ANALYTICAL RESEARCH

Mohamed Husain et al. [21] utilize ABAQUS to construct a 3D high-reliability dynamic nonlinear finite element model to analyze the seismic response of shear walls with FRP wraps under monotonic stresses. They also carried out an experiment to back up their conclusions. ABAQUS and the numerical concrete damage plasticity (CDP) constitutive model were used to test and simulate three shear wall specimens, SW1, SW4, and SW8. Five distinct types of walls were used in the experiment: three with staggered apertures (SW23, SW45, and SW67), one with regular slots (SW8), and one with none (SW8) (SW1). The failure processes of structural walls were studied using these 14-scale examples. The test setup, wall reinforcing features, and measurements are shown in Figure 2.1. Figure 2.2 also shows the finite element model.

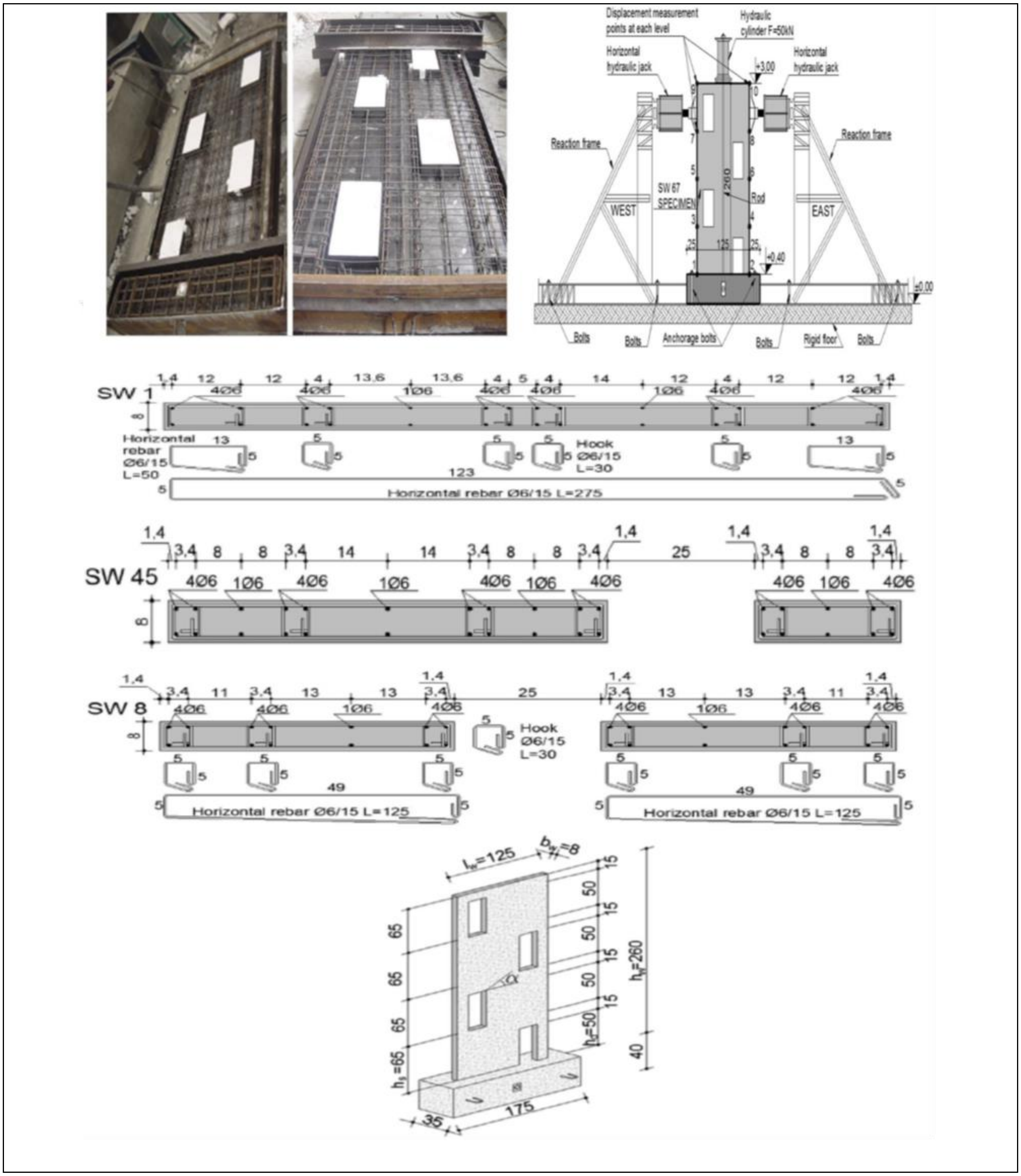


**Figure 2.1:** Test Setup and Rebar Details [21]

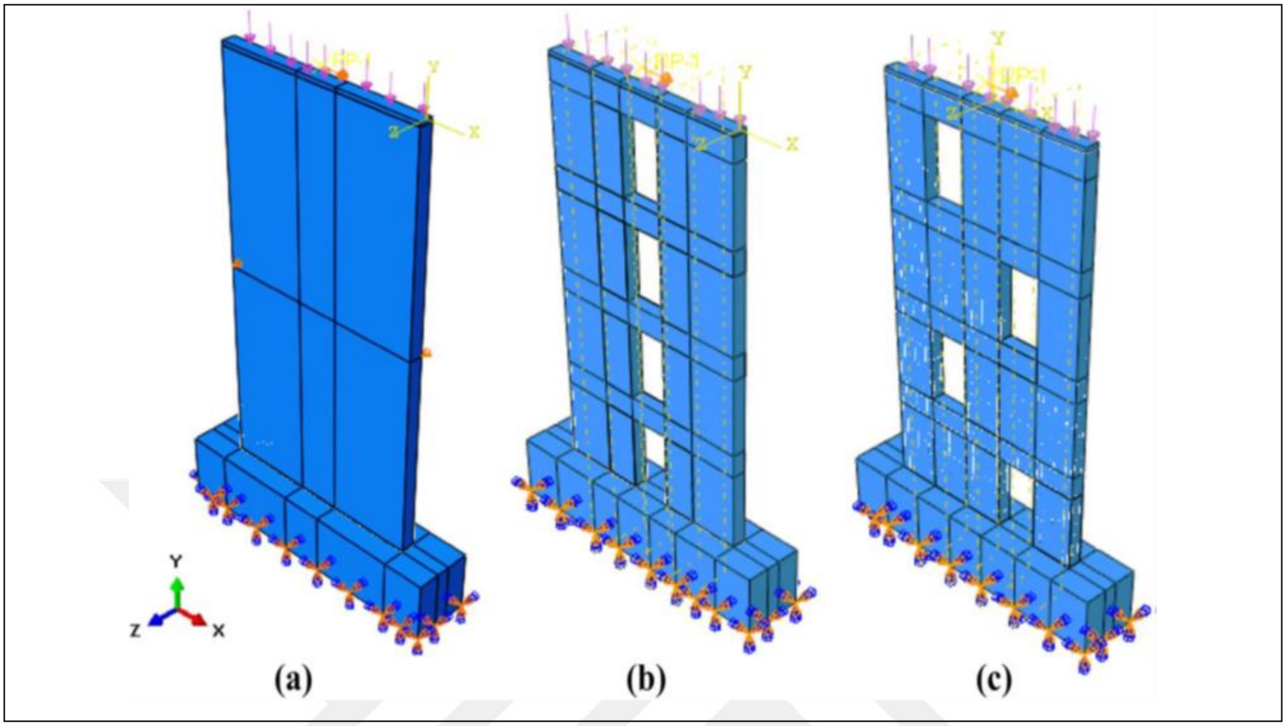


**Figure 2.2:** Loading and Boundary Conditions of Wall Specimens [21]

They came to the conclusion that strengthening RC shear walls with apertures using CFRP laminates was a smart idea. Under hysteretic and monotonic lateral stresses, the inclusion of CFRP laminates considerably enhanced the seismic performance of RC walls. When the number of CFRP layers was doubled, the hysteretic and monotonic lateral responses of the reinforced wall's resistivity, flexibility, and dissipated energy were greatly improved.

Staggered-opening walls do not collapse in the same way as ordered-opening walls do. Shear stresses they crushed the concrete in the coupling beams, resulting in a brittle collapse in walls with regular gaps and the horizontal reinforcement in these beams being exposed. Tensile failure of walls with staggered apertures at the base was induced by the vertical support, followed by concrete crushing.

The forces and horizontal displacements measured in the failure mode of staggered aperture walls were greater than those found in the failure mode of regular aperture walls. [4]. Although the higher load-bearing bearing capacity and the expansion of the oblique shear fracture could be controlled, the R-SW8-3 and R-SW4-3 specimens did not have the expected ductility. The use of lateral laminates, which could produce good flexibility while still having a reasonably high load-bearing capacity, was the most effective strategy for improving flexibility.

Peibo You et al. [22] The softened strut and tie model (SSTM) for SFRC shear walls with CFST columns was proposed by the researchers after examining the walls' shear mechanism. When combined with the SSTM, which comprised diagonal, horizontal, and vertical means, it was possible to evaluate the contributions of concrete, reinforcement, and steel fibre to the shear strength of the SFRC web of the shear wall. Figure 2.3 illustrates specimen placements.

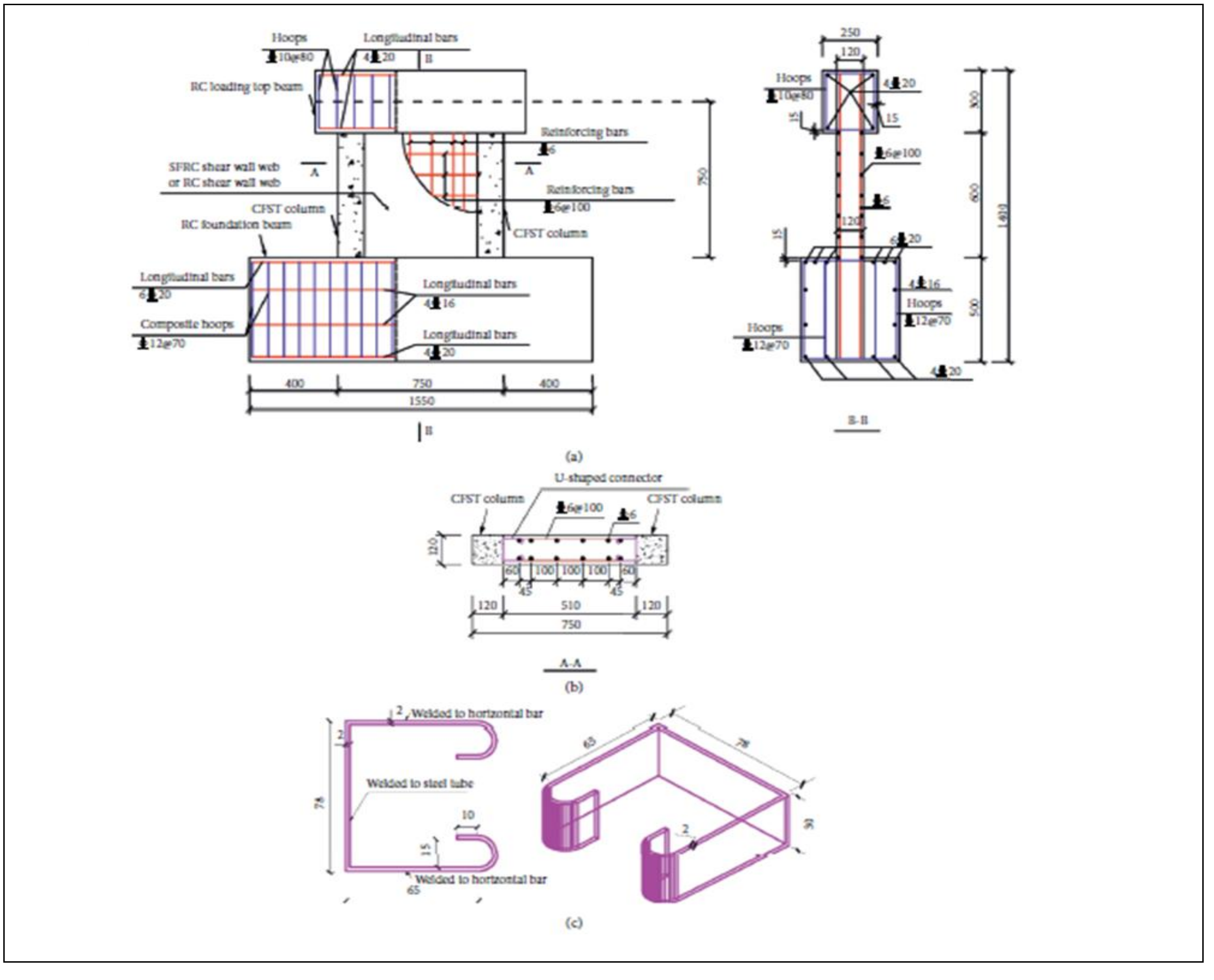


**Figure 2.3:** Specimen Configuration (unit: mm).

The above figure shows (a) Elevation. (b) A-A section. (c) One-dimensional and three-dimensional graph of U-shaped connector [22].

The load exerted on the specimens included horizontal and vertical one, and the test setup is shown in Figure 2.4 (a) and (b).

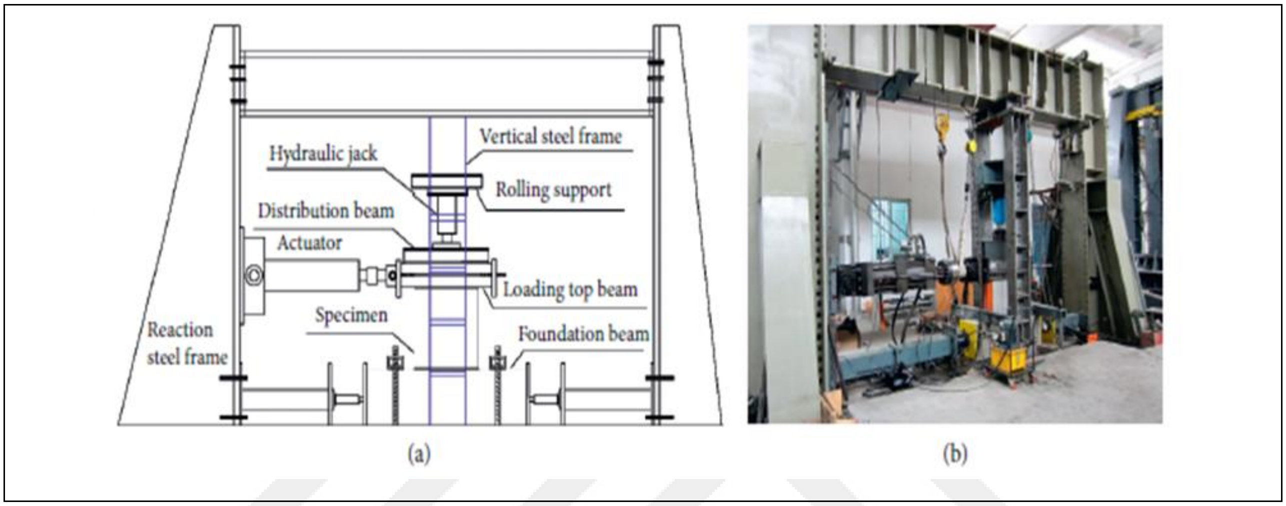


**Figure 2.4:** Test setup. (a) Schematic view. (b) Test scene [22].

The whole SFRC shear wall with CFST columns specimens revealed a shear-dominant failure mode in recent testing, with all drawings having a typical diagonal cracking pattern. In the web of a shear wall, steel fibre may effectively regulate fracture breadth and crack dispersion. Because it considers diagonal, horizontal, and vertical processes, the SSTM may be used to describe the shear mechanism of an SFRC shear wall with CFST columns.

In the shear strength study of an SFRC shear wall with CFST columns, steel fibers randomly injected in concrete may be employed as longitudinal and transverse reinforcement. In addition, the steel fibers' effect on wall shear strength is quantified in this study. It is possible to use current experimental data to forecast the shear strength of SFRC walls, RC walls, and diagonal compression failures based on the suggested model.

Tolou Kian. et al. [23] Reinforced concrete (RC) shear walls were studied for self-centring and damage resistance. This study looks at the cyclic Behaviour of one standard and three unique shear walls made of fibre-reinforced concrete and fitted with steel and self-centring reinforcement such as shape memory alloy, glass fiber reinforced polymer, and high strength steel. In addition, finite element models of the specimens were created, verified, and utilized to analyze their seismic activity during the 1985 Nahanni earthquake.

The seismic provisions for building reinforced concrete structures in North America were planned and built using four narrow shear wall examples. As illustrated in figure 2.5, the shear walls had an aspect ratio of 2.0 and were supported as cantilevers while being subjected to displacement reversals.

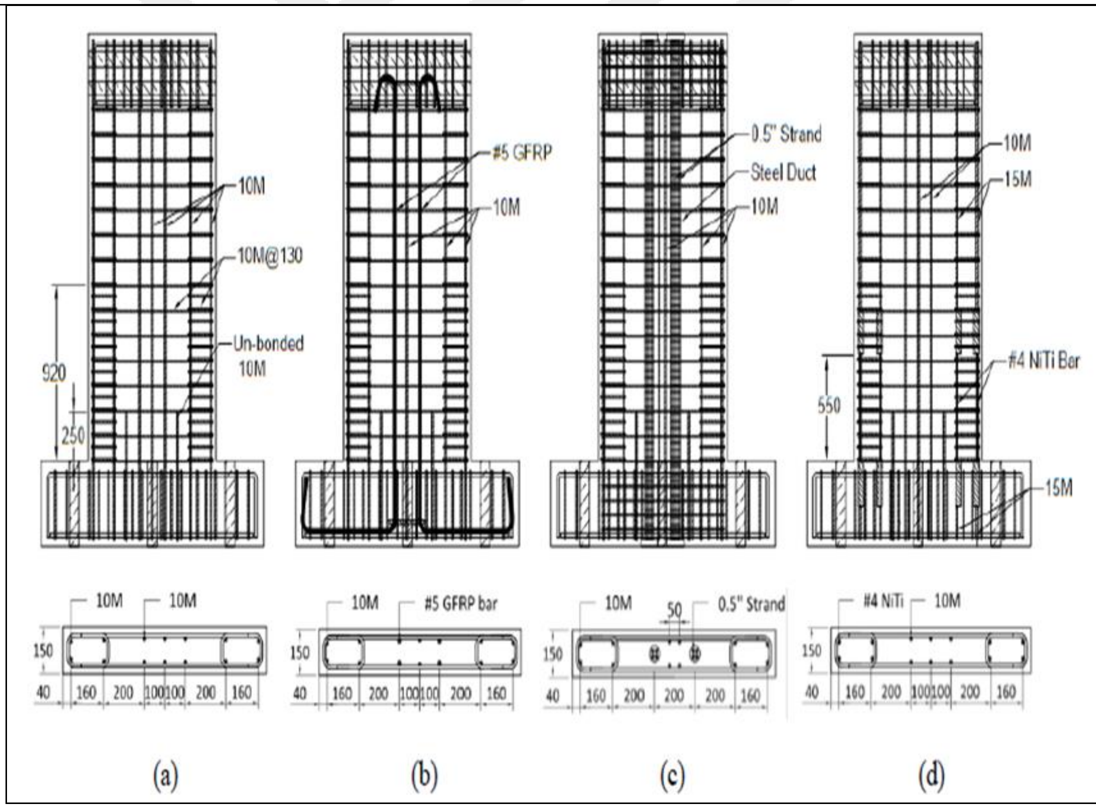


**Figure 2.5:** Reinforcement Layouts of Specimens: (a) CW, (b) GFRP-ECC, (c) PT-SFRC, (d) SMA-SFRC [23]

They concluded that the novel shear walls had better self-centring under cyclic stresses than the control shear wall. The specimens' strength and maximum and residual drift ratios were predicted correctly by the FE models of the shear walls studied by VecTor2.

Ke Shi et al. [24] In experimental research, the seismic Behaviour of the SFRHC shear wall was examined utilizing CFST columns. The seismic performance of seven composite shear walls was evaluated using pseudo-static testing to determine the structures' energy consumption, flexibility, and stiffness degradation. A conventional RHC shear wall and six SFRHC shear walls with two CFST columns created seven specimens. Axial compression ratio (0.1 and 0.2), frame type (with or without CFST columns), steel fiber volume percentage (0, 0, 5, 1, and 5) as well as shear span ratio (1.0 and 1.5). A cross-sectional view of a 975-mm-high composite shear wall is shown in Figure 2.6.

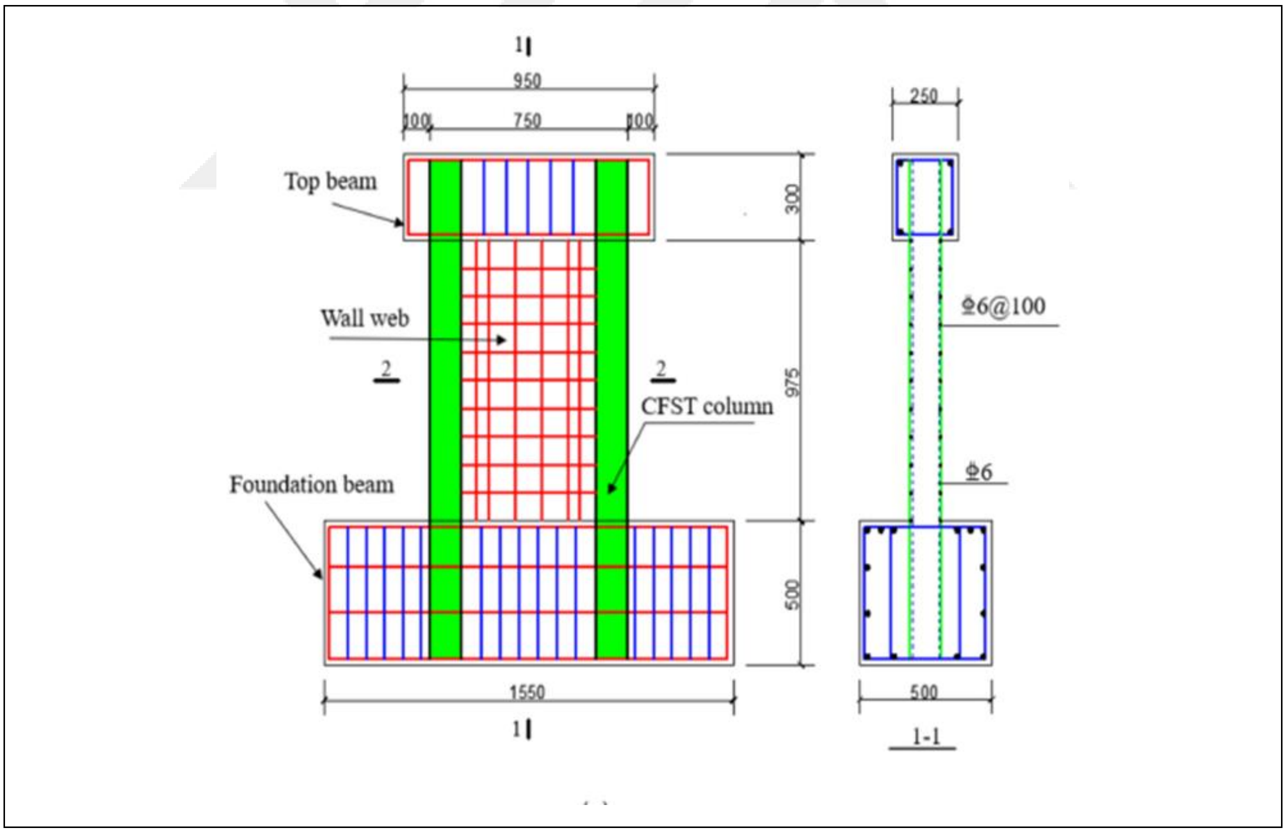


**Figure 2.6:** Specimen Geometry [24].

All shear wall specimens were subjected to horizontal low-cyclic loading with constant axial force, as shown in figure 2.7.

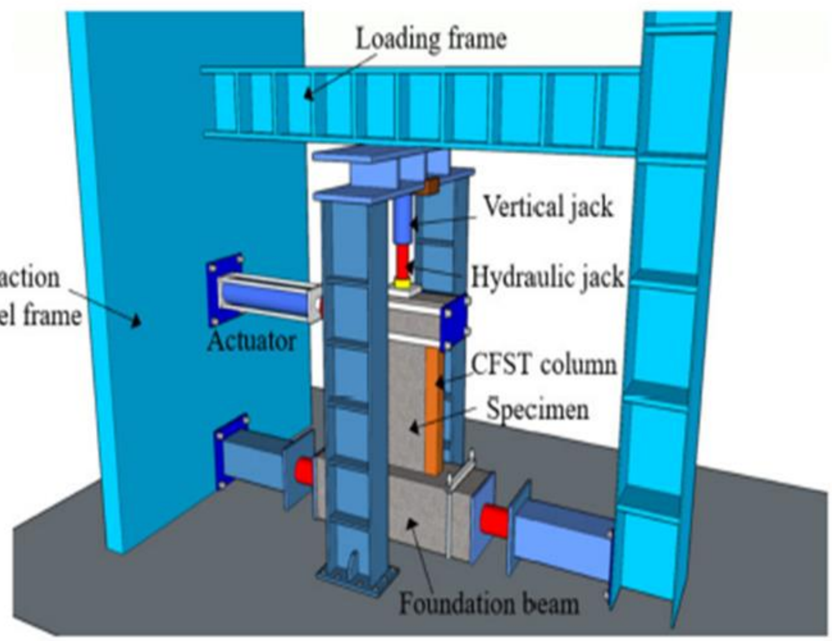


**Figure 2.7:** Test Setup [24].

Compared to standard shear walls, composite shear walls beat them in every way: the energy dissipation capacity was enhanced by 66 percent, while the cracking force, yielding force, peak force, deformation capacity, and flexibility were all improved. Because of their confinement effect on the web, CFT columns have the potential to have a significant influence on SFRHC shear walls.

Steel fibre improved the specimens' energy dissipation capacity, ductility coefficient, and load-bearing capacity. The failure mode of the shear wall was altered from shear to bending during the test due to the fracture resistance of steel fibre. According to research that compared the seismic performance of CFST-3 and CFST-5 specimens, increasing the axial compression ratio of shear walls may improve cracking, yield and peak force while not affecting energy consumption. It does, however, restrict the models' potential to be applied in a variety of scenarios.

The sheer span ratio of shear walls may be increased to enhance specimen ductility and energy dissipation. A study compared the seismic performance of CFST-3 and CFST-6 specimens and found that it did. Meanwhile, the breaking strength, yield strength, and peak strength have all been reduced (all by greater than 35% in certain cases).

Khaled Farouk et al. [25] The influence of fibre-reinforced plastic (FRP) on the ultimate load capacity of concrete shear walls with apertures was investigated in a nonlinear static study utilizing the finite element analysis tool ABAQUS, which was conducted in nonlinear fixed research. The results of an experimental and numerical assessment of a concrete shear wall were compared to determine if the numerical model needed to be corrected. Following the Finite Element Model (FEM) establishment, the effects of creating cut-off apertures and the strengthening effects of adding fibre reinforced plastic (FRP) were explored.

The 750 mm wide, 750 mm high, and 70 mm thick wall was monolithically joined to an upper and lower beam. Figures 2.8 and 2.9 show the top beam test arrangement (1150mm long, 150mm deep, and 200mm thick)

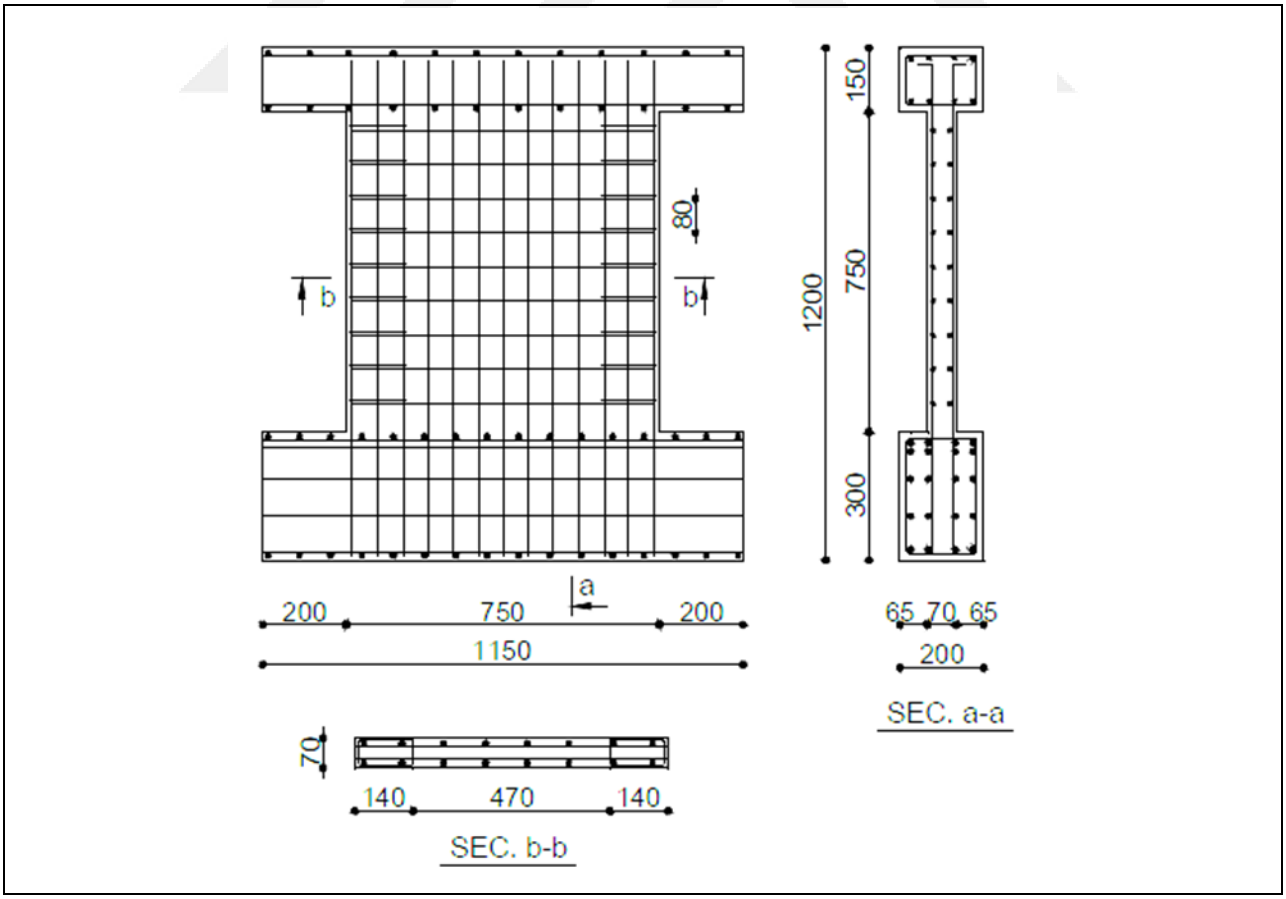


**Figure 2.8:** Rebar Details and Wall Dimensions (mm)[25].

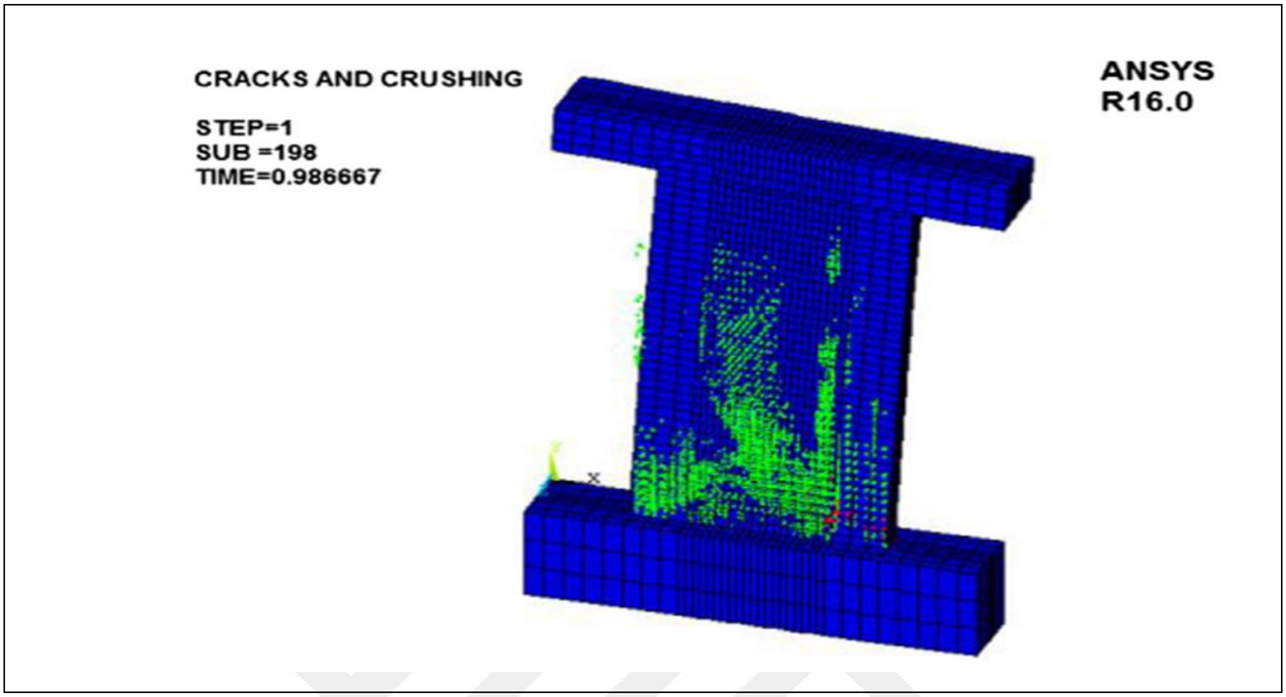


**Figure 2.9:** Crack Behavior [25].

The top and bottom sections of the aperture are wrapped in unidirectional CFRP with the fibres orientated horizontally, and two piers are used in the strengthening approach. As indicated in figure 2.10, the thickness of CFRP employed to reinforce the shear walls is C1, C2, and C3, equivalent to 0.05, 0.08, and 0.12 mm, respectively.

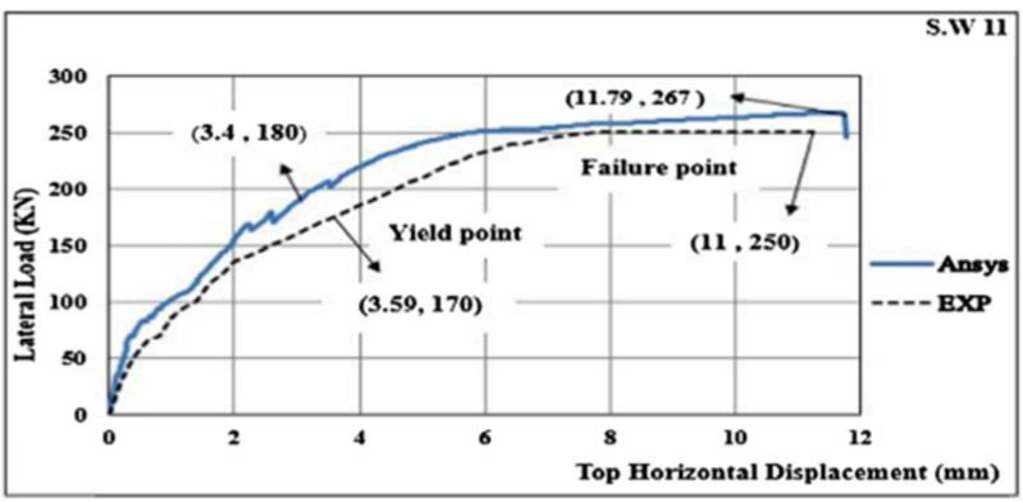


**Figure 2.10:** CFRP Effects [25].

The capacity of the finite element technique process to offer a fair forecast for the Behavior of RC shear walls was shown by a comparison of experimental and numerical data. Creating 11.11 per cent or less of the total wall area apertures resulted in a 37.1 per cent loss in load capacity.

In the failures of RC shear walls with load-interrupting holes, the size and position of the openings had a crucial effect. However, increasing the number of gaps to 25% of the total wall surface (ample space) decreased capacity by 61.9 per cent. Furthermore, in models with large openings, changing the location of the aperture in the height of the walls did not influence the ultimate load capacity of the walls, even though the crack was larger. Due to the gap, the integrity of shear walls was changed from shear action to frame action. Instead of the individual flexural step of the walls, the overturning moments were partly mitigated by an axial compression–tension pair that ran throughout the wall system and across the floor.

Depending on the size and position of the gap in the RC shear wall, shear strengthening around the apertures may significantly boost the wall's capacity. The increase in power resulting from the usage of FRP sheets ranged from 1 per cent to 39 per cent in some instances. When the hole was located at the top of the walls, the capacity increase was the greatest (39 per cent). According to the research, fences with bottom holes had just a 6 percent boost in strength.

The thickness of FRP and the location and size of apertures were critical contributors in the failures of both reinforced and un-strengthened RC shear walls with openings. In models with wide gaps, However, in models with smaller apertures, increasing the CFRP plate thickness significantly increased displacement linked to the maximum load despite increasing the ultimate load and its accompanying displacement.

by Fu-Pei Hsiao et al. [26]. The seismic performance of reinforced concrete framed shear walls strengthened using Carbon Fiber Reinforced Polymer (CFRP) strips was investigated. Epoxy-bonded CFRP was placed at diagonal locations in shear walls for shear wall shear strengthening. Six framed shear walls of various sizes were put to the test.

Six specimens, including three mid-rise framed walls (MW1, MW1C, MW1C2), and three low-rise framed walls (LW1-LW1R, LW1C, LW1Ca) were tested, as shown in figures 2.11 and 2.12 below.

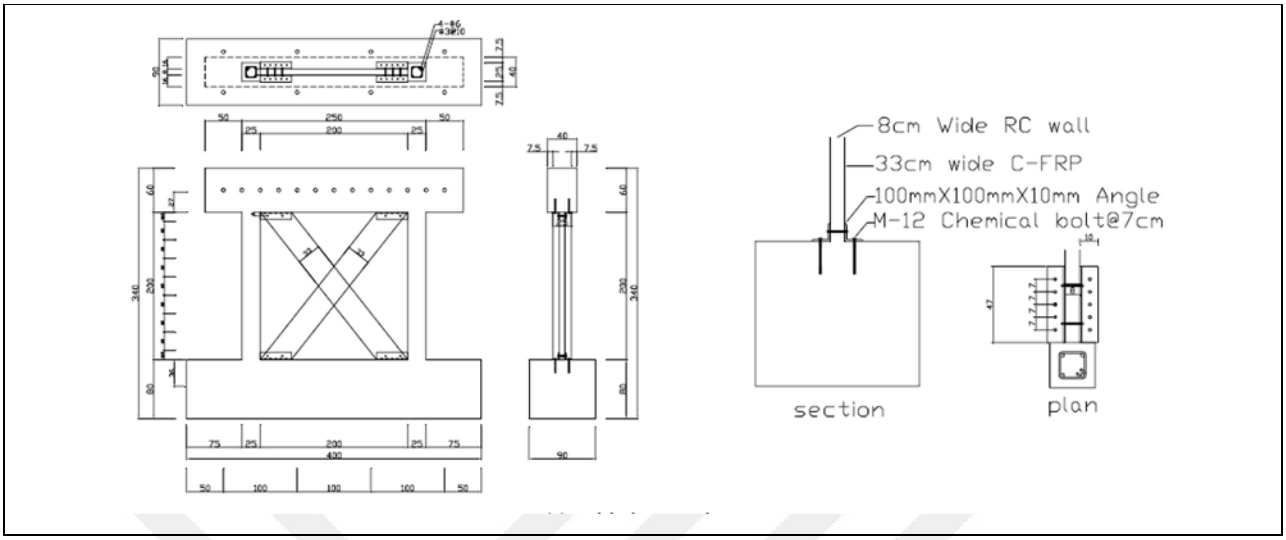


**Figure 2.11:** Mid-rise Specimen [26].

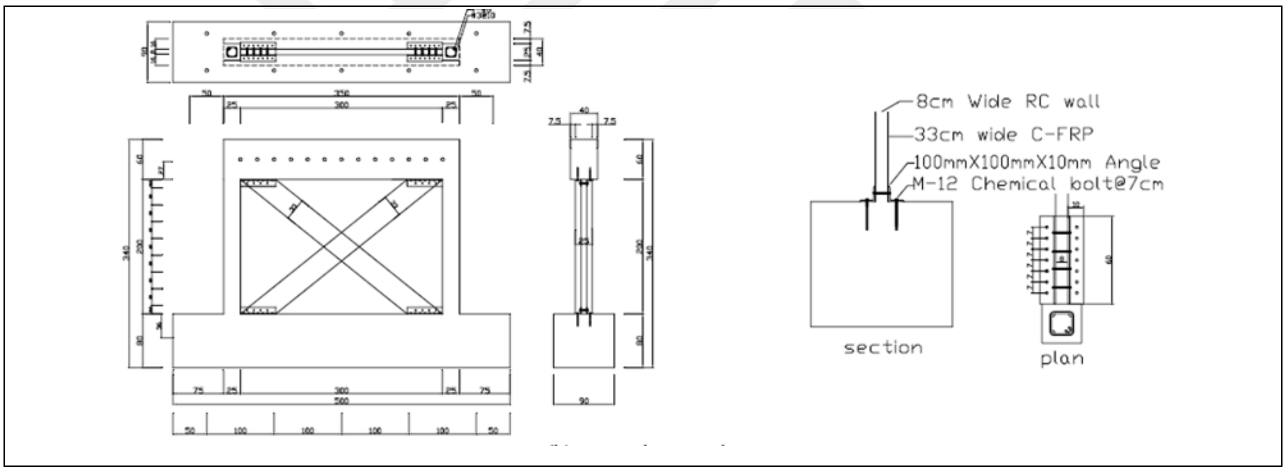


**Figure 2.12:** Low-Rise Specimen [26].

They that the location of fixed steel angle affects the performance of retrofitted specimen. The steel angles closely contact with boundary columns will induce failure of the columns, and the ultimate displacement and ductility of specimen will reduce. Alternatively, the separation of boundary columns and steel angles will induce larger energy dissipation.

The seismic performance of the low-rise framed shear walls strengthened with CFRP strips is greatly improved. However, the addition of CFRP strips to mid-rise shear walls strengthened them insignificantly, and the failure specimen immediately retrofitted with CFRP strips improved just somewhat. When the inclination angle of CFRP approaches 100 degrees, the performance of the modified specimen is severely degraded. It is suggested that the inclination angle be between 80 and 100 degrees.

Mojtaba Harati et al. [27] conducted an experiment on RC shear walls utilizing post-earthquake reports made after big earthquakes, as well as checking and scrutinizing the seismic performance of RC frames with shear walls. Shaking tables are often used to provide dynamic loads to shear walls, as seen in figure 2.13.

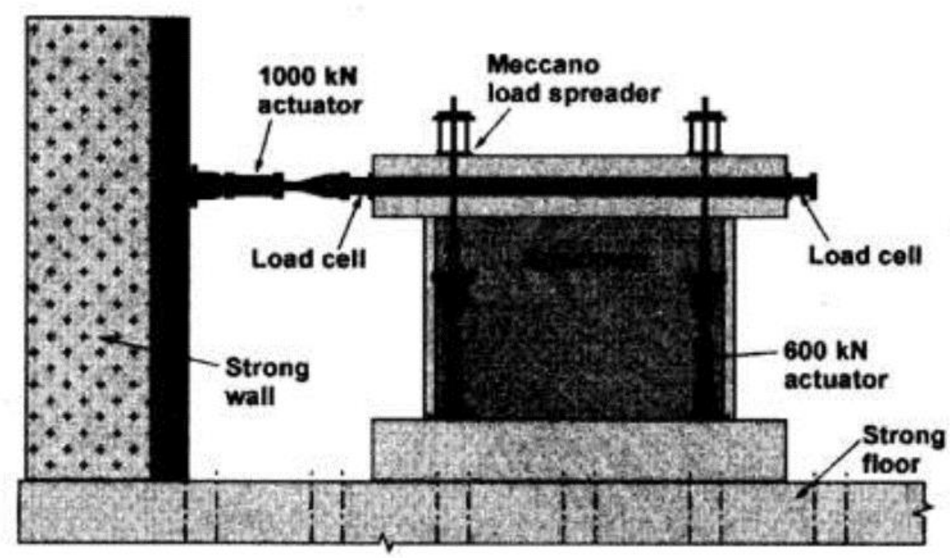


**Figure 2.13:** Shaking Table[27].

Shear walls were separated into two categories in this investigation, one with bending performance and the other with shear performance. Shear walls with bending Behavior are intended to have optimal structural Behavior and high seismic performance. These members are normally thought to behave appropriately, and they are not at all fragile, contrary to popular belief and seismic regulations. Shear-controlled shear walls, on the other hand, frequently have poor seismic performance, resulting in an unsuitable brittle collapse. However, by using tools such as diagonal bars and the other approaches indicated, the squat walls' performance may be brought closer to that of a flexural-dominated RC shear wall's optimal bending seismic performance. As a result, if shear wall elements are to be used as seismic lateral resisting structures, it should be highlighted that they should be constructed in a flexural way. If this is not practicable, the wall components should be constructed such that the shear wall system is not affected by shear and brittle performance.

Bessason, Bjarni, and colleagues [28] developed a nonlinear finite-element model that was calibrated using experimental data and then used to calculate the load-deformation curves of reinforced-concrete shear walls with various reinforcing configurations. The shear wall geometry is common in residential structures in Iceland. Figure 2.14 shows a tested shear wall with boundary components and a FE model of the laboratory test utilizing the estimated load deformation curves in earthquake response analysis using recorded strong motion data from the June 2000 South Iceland earthquakes.

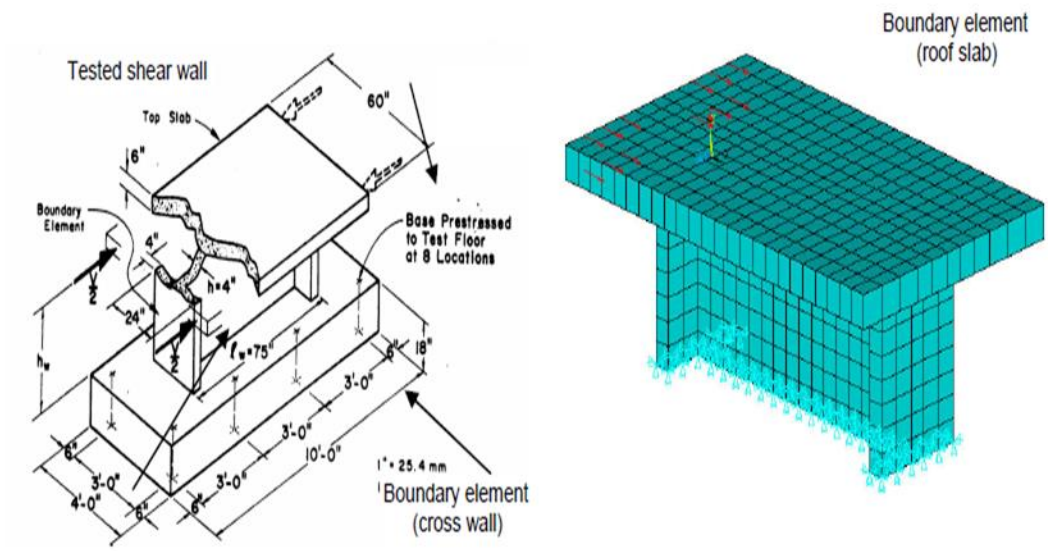


**Figure 2.14:** Tested Shear Wall with Boundary Elements and FE Model of the Laboratory test [28].

Ahmed Abu Altemen et al. [29] studied the effect of adding steel fiber on the ultimate punching strength, using tested three small high strength concrete slabs. The slabs were 500 mm square, and of 60 mm thickness, as shown in figure 2.15.

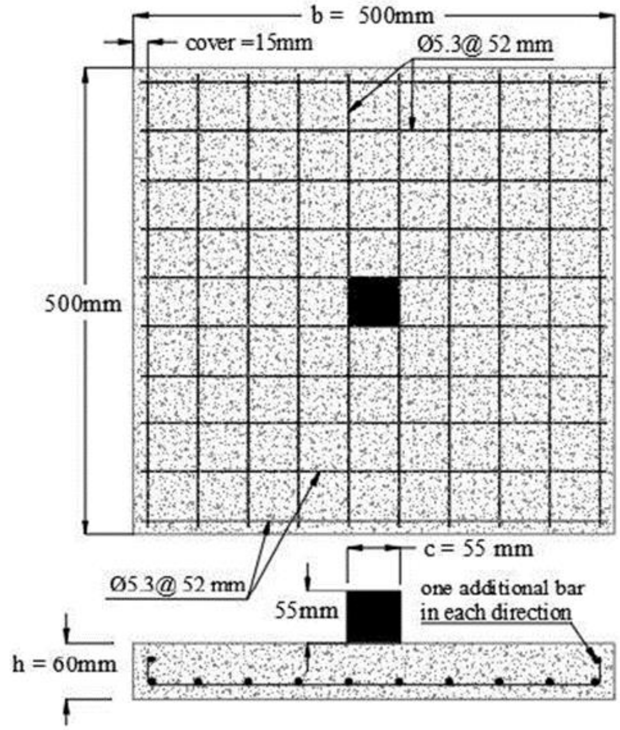


**Figure 2.15:** Slab Geometry.[29]

The slabs were 500 mm square, and of 60 mm thickness, reinforced by two steel fiber dosages 0.75 % and 1.25 %, in addition to conventional reinforcement bars of moderate ratio.

The concluded that the Inclusions 1.25 percentage of steel fiber by volume of concrete led to enhance the ultimate punching shear resistance by 17% compared with the associated plain concrete slabs, but it is less than its effect on low strength concrete slabs, moreover steel fiber is reducing the deformation induced from different load stages, and decreases the diameter of critical shear crack.

For two steel fiber percentages, there were no effects shown on the inclination of the punching shear cracks.

All the tested slabs showed punching failure, but the slabs showed small horizontal plateau before reaching the displacement that corresponding to ultimate load.

Khaled Soudki et al. examined the influence of CFRP strips applied externally on the punching shear of inner slab-column connections. Six 1220 mm-by-1220 mm square slabs with concentric columns were made using six 100 mm-thick slabs and a 150 mm-thick column. Figure 2.15 shows that a test criterion was the arrangement and number of CFRP strips externally attached to the slab tension face.

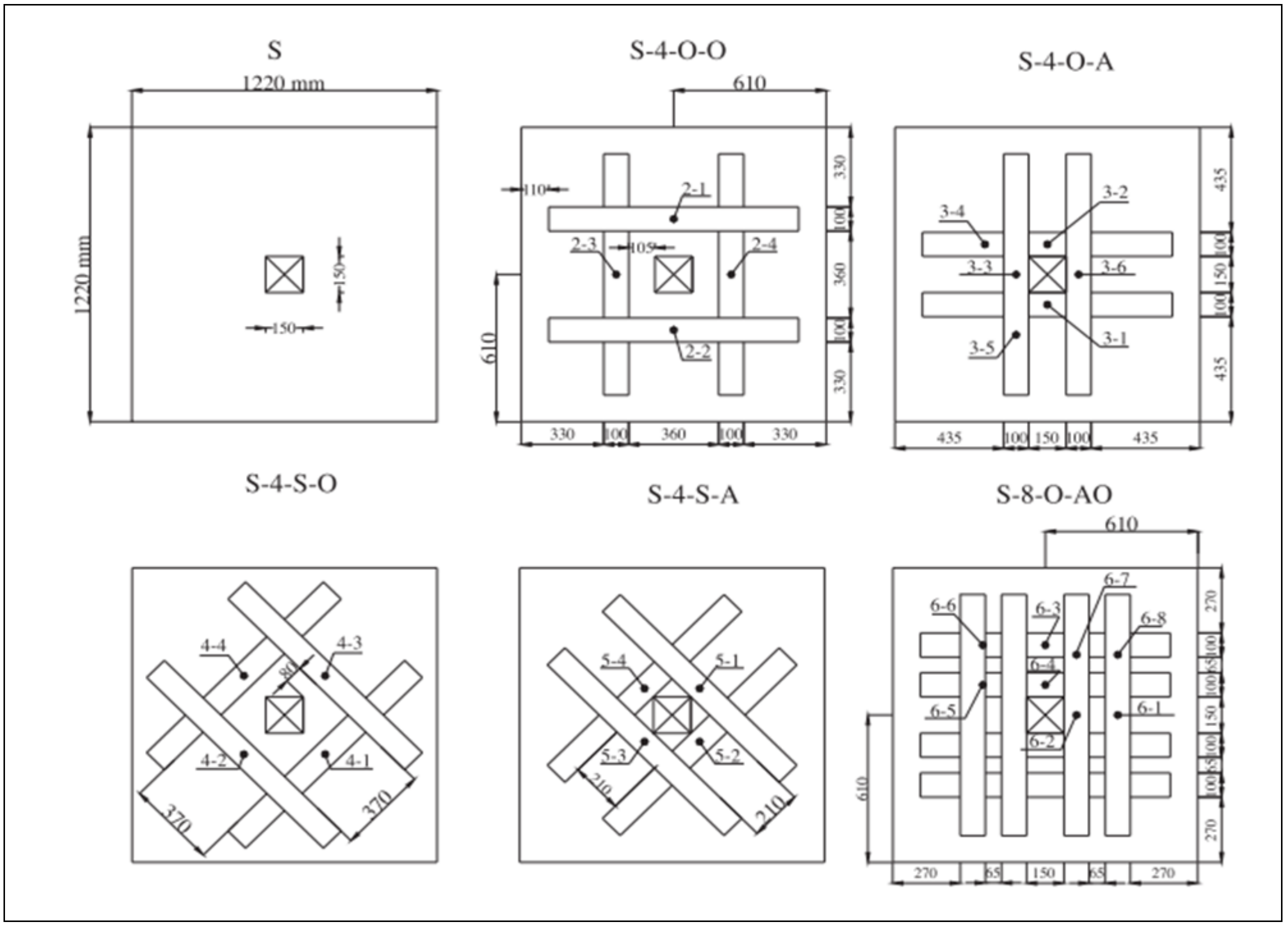


**Figure 2.16:** CFRP Strengthening Schemes [30].

a) In punching shear mode, all six slabs failed. When compared to the control slab, the reinforced slabs had a larger punching capacity. Strengthening using CFRP strips resulted in a 29 percent improvement in punching capacity

b) The reinforced slabs were substantially stronger and had smaller deflections than the control slabs.

c) Strengthening near the columns enhanced the punching capacity, whereas strengthening away from the column face increased the stiffness.

d) The skew orientation away from the column perimeter seems to be the most economical design for CFRP strips.

e) Increasing the number of CFRP strips did not significantly boost the slabs' capacity.

f) The experimental findings and the predicted punched shear capacities of the tested slabs, estimated using a newly developed analytical model in which the two-way shear is defined as a function of the connection's flexural strength, are reasonably consistent.

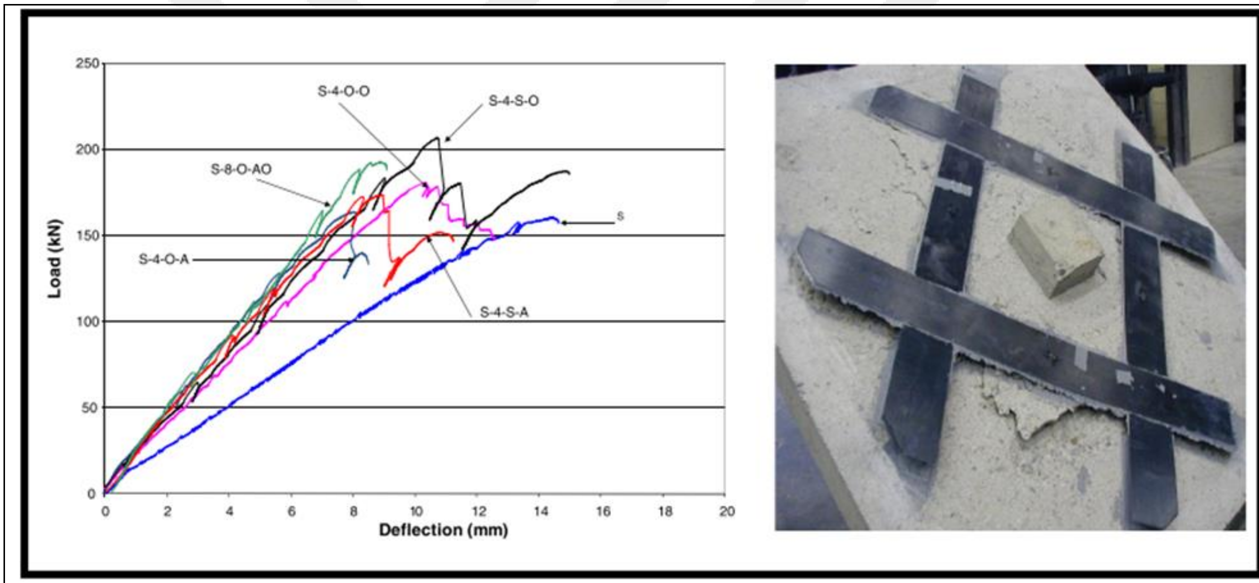


**Figure 2.17:** Load Effect Behavior [30]

Musitefa Adem Yimer et al. [8] looked at the impact of axial load changes on the seismic Behavior of SFRC beam-column joints. Figure 2.19 (a), (b), and (c) exhibit nonlinear finite element analysis using a damaged plasticity model in ABAQUS/Standard (c).

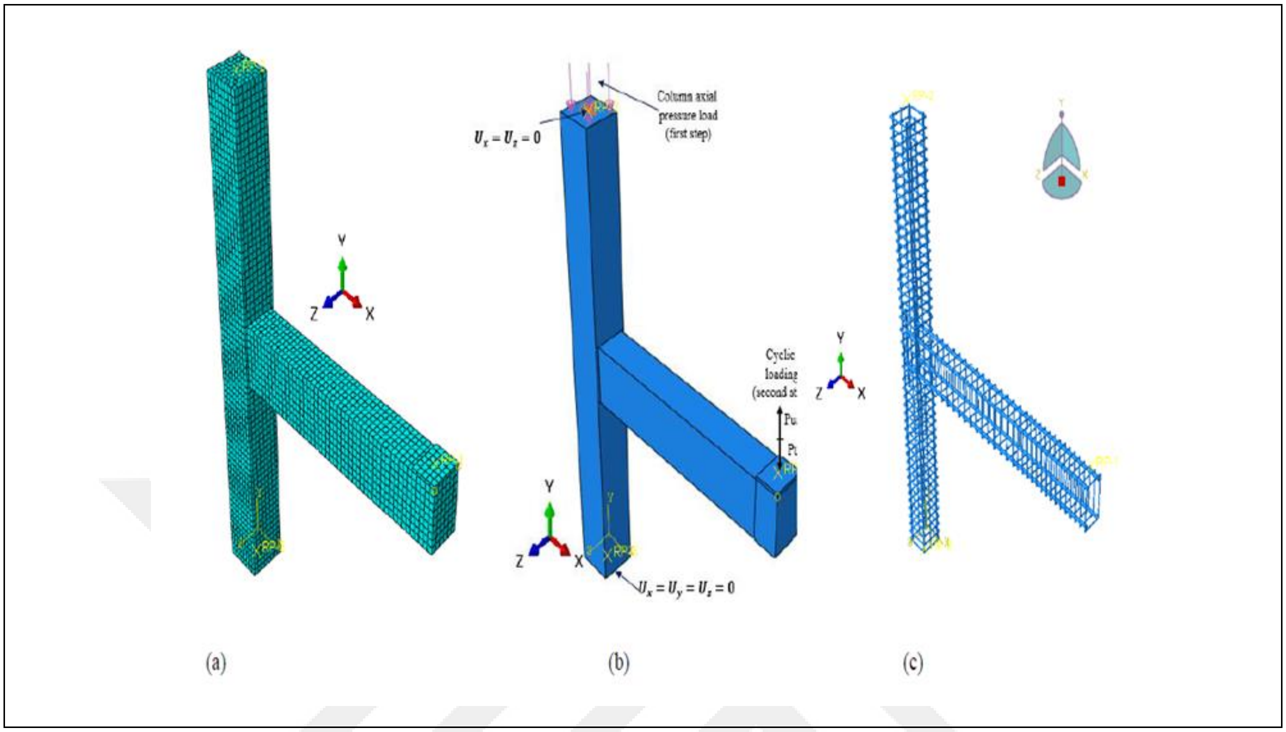


**Figure 2.18:** Boundary Conditions, Meshing and Loading of the FE Model [8]

To test the finite element model, researchers utilized data from a variety of fields. Figure 2.20 shows the results of simulating six SFRC specimens under reversed cyclic stress with varying column axial load ratios and a 2% volume percentage of steel fibre. The criteria include maximum load-carrying capacity, stiffness degradation, energy dissipation, and failure mode.

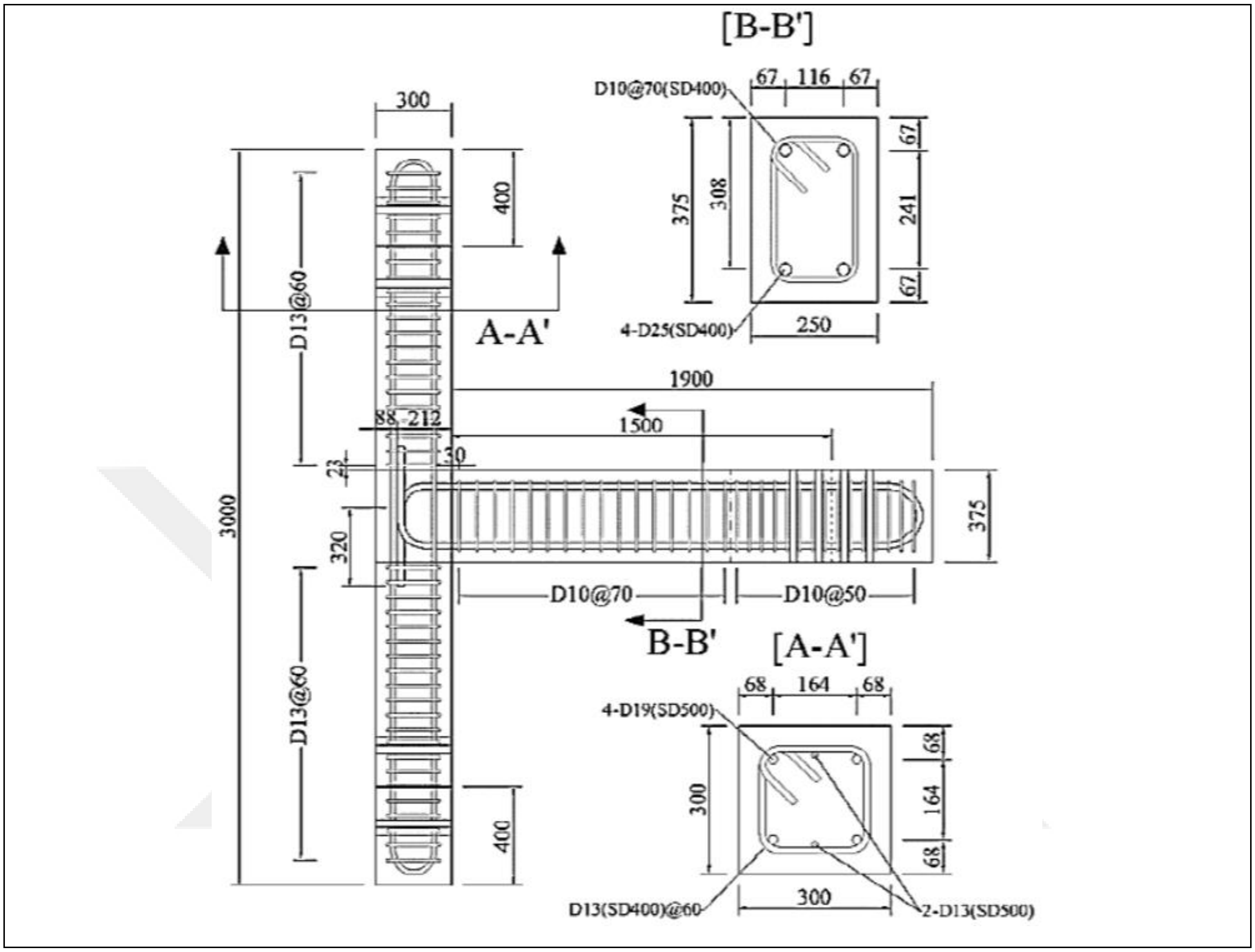


**Figure 2.19:** Details of the Specimen [8].

In their study, the researchers observed that increasing axial stress dramatically reduced both fracture formation and damage accumulation. A further point to note is that when the axial load ratio surpasses 50 percent of the column capacity, there are no fractures in the joint area; instead, only flexural cracks at the beam-column interface are seen, with an increase in the number of cracks in the beam with increasing axial load.

The maximum load-carrying capacity of the beam-column joints might be enhanced by increasing the column axial load level from 5% to 30% of the axial column capacity. The maximum load-carrying capacity of the joints does not vary appreciably when the axial load on the column is increased by more than 30% compared to when there is no axial force. At the commencement of the loading operation, expanded column axial load levels boost collective energy dissipation capability. Nonetheless, owing to axial failure and local concrete crushing, they have a modest negative impact as the loading stages progress.

The development of cross diagonal fractures was inhibited when the column axial load level was increased, resulting in a slight improvement in joint stiffness. This is due to the axial load's confining action against joint shear. The cyclic stiffness reduced somewhat when the axial load reached 50% of the column's capacity, owing to the column's degradation induced by local concrete crushing. Consequently, the findings imply that increasing the axial load on the column enhances the confinement of the SFRC beam-column junction. However, a restriction may be needed.

The studies showed the efficiency and Behavior of concrete shoulders made of ordinary and fibre concrete (concrete experiences that use steel fibres). Furthermore, the current research looks into the effectiveness of polymeric as a reinforcement solution for concrete shoulders subjected to repetitive loads. Fifteen shoulders were separated from homologous organization and hybrids, and two of them were examined as control samples (the first under monotonous load for taking final load, and the second under repetition load) and classified into four categories. Under repeated loading, hybridization of fibrous concrete reinforcement (using steel fibers) resulted in moderate increases in crushing loads.

## 2.3 SHEAR WALL ANALYSIS

Shear walls are in-plane lateral forces, wind loads, and earthquake forces intended to be resisted by in-plane lateral forces, wind loads, and earthquake forces. It is capable of withstanding the loads that result in Cantilever Action. In other words, shear walls are vertical components of a vertical load-bearing structure. Wind, earthquakes, and uneven settlement loads cause huge twisting (torsional) forces, compounded by the weight of the building and its inhabitants. These forces have the ability to destroy a structure. By connecting or inserting a stiff wall across a frame, the geometry is preserved and rotation at the joints is avoided. Walls are essential in high-rise constructions subjected to lateral wind and seismic stresses. They also provide the strength and stiffness required to prevent lateral displacements. The shape and placement of the base shear have a considerable impact on the structure's performance. [31].

Walls are largely resistant to two types of forces: in-plane shear and in-plane bending for the creation of Moment in the shear direction. Furthermore, as a building state element, the shear wall tends to resist plane shear in the vertical direction, as well as the buckling impact of dead pressures coming from the top. As a consequence, under any of the three circumstances, a shear wall might collapse. The modes of failure include flexural shear failure, shear force failure, and vertical shear failure. One of the primary issues in the design of each horizontal system is attempting to save the center of stiffness near the center of gravity in order to decrease the torsional Moment caused by uneven wind loads. When contemplating the usage of shear walls, it is vital to consider not only the center of stiffness, but also the consequences on architectural design and other construction systems. A good lateral regime, on the other hand, should contain strength throughout the external surfaces that actively resist torsion. As a result, the two moment frames on the outer walls were kept, and shear walls were examined for numerous inside sites [32].

### 2.3.1 Shear Walls Functions

A shear wall is a structural element that resists lateral pressures or forces parallel to the wall's plane. Due to Cantilever Action, the Shear wall resists loads on thin walls with substantial bending deformation. The vertical components of a flat force-resisting design are shear walls, or vertical elements of a horizontal force-resisting structure. A rigid vertical diaphragm may be used to convey lateral stresses from outside walls, floors, and roofs to the ground foundation in a direction parallel to their planes while building a system. A reinforced-concrete wall is one example. Aside from the weight of the structure and its occupants, lateral pressures such as wind, earthquakes, and uneven settlement loads create violent twisting (torsional) forces.

As a consequence, shear failure of the structures occurs. Shear walls are crucial in high-rise constructions exposed to lateral wind and seismic pressures. Core walls are made up of channel sections, whereas shear walls are usually planar or flanged. They're also strong and rigid enough to keep lateral displacements in check. The shape and position of the shear wall have a considerable influence on the structure's Behaviour. From a structural aspect, the shear walls should be situated in the centre of each side of the building. Because it takes quite a lot of space, this is seldom feasible. Thus, they are positioned at the ends. It is advisable to use walls that do not have any holes.

As a consequence, barriers around elevator shafts and stairwells are often used. Also, walls on the sides of buildings with no windows may be used. The following is a summary of all shear functions:

a) Ability to withstand lateral loads, seismic loads, and vertical forces.

b) Reduces the amount of lateral sway in which of the buildings.

c) Give buildings a lot of strength and stiffness in the direction of their orientation.

d) The loads are transferred into the Foundations via the rigid vertical diaphragm.

e) Provide a lot of strength and stiffness in the direction of orientation.

f) Significantly lessens lateral sway.

g) Reinforcements that are evenly distributed.

h) Minimize structural and non-structural element damage.

The design classes of the shear wall is determined by [34]:

a) The thickness of the wall.

b) The diameter of the bars in which the wall thickness is found

c) Minimal reinforcement of the gross area in which the section is located.

d) The thickness of the curtain reinforcement.

The ACI 318-14 "Building Code Requirements for Structural Concrete" [35] can be used to figure out the minimum reinforcement requirements for a shear wall. These requirements include the percentage of reinforcement and the spacing of the reinforcement. People who work on buildings and other structures have to follow this Code. This Code addresses structural systems such as shear strength; shear walls; shells (structural forms); spans; splicing; strength; strength analysis; stresses; structural analysis; structural concrete; structural design.

**Step 1:** calculate the horizontal reinforcement

horizontal reinforcement ρ= A horizontal /h*s2

use ACI 318-14 (11.6.2(b)), ACI 318-14 (11.7.3.1)

**Step 2:** calculate the Vertical Reinforcement

Vertical reinforcement ρ= A Vertical /h*s2

Use ACI 318-14 (11.6.2(a)), ACI 318-14 (11.6.2(a)), ACI 318-14 (11.7.2.1)

**Step 3:** calculate the Neutral Axis Depth

For neutral axis, the formula ACI 318-14 (Eq.5.3.1f) and ACI 318-14 (Table 22.2.2.4.3) can provide the Depth value based on effective flexural depth (d) ACI 318-14 (11.5.4.2) and ACI 318-14 (Table 21.2.2).

**Step 4:** calculate the Moment capacity

The lateral load at nominal moment capacity to nominal shear strength ratio calculated using ACI 318-14 S18.10.4.

Step 5: calculate the Shear Capacity

The shear capacity can be found in ACI 318-14 (Table 11.5.4.6), ACI 318-14 (11.5.4.7) and the factored Moment at the ultimate section can be calculated based on ACI 318-14 (Table 21.2.1) and ACI 318-14 (11.6.2).

## 2.4 TYPES OF SHEAR WALLS

A shear wall is a moment-resisting construction constructed of structural steel or reinforced concrete walls and braced plywood. Shear Wall Made of Reinforced Concrete - A typical form of reinforced concrete shear wall used in residential construction. Both the horizontal and vertical orientations have been strengthened. The bars at the extremities of each division, on the other hand, are tightly spaced and anchored. Consequently, boundary members or barbells are used to describe the end zones of RC shear walls. The wall thickness of an RC shear wall varies depending on several criteria, including the structure's thermal insulation needs, the building's age, the building's rank of floors, and so on [36].

a) Concrete Block Shear Wall

Hollow concrete blocks and steel reinforcing bars were used to construct this structure. Reinforcement is commonly utilized to increase the resistance of concrete rigid block masonry to seismic loads. In vertical and horizontal orientations, reinforcement bars are distributed via concrete block gaps. After the bars are put in concrete block masonry and allowed to dry, fresh concrete grout is poured into the vacant region [37].

**Figure 2.20:** Concrete Block Shear Wall

b) Steel Shear Wall

A horizontal floor beam is made up of a steel plate wall, a boundary column, and, in the case of a horizontal floor beam, a horizontal floor beam. Steel shear walls function more like plate girders. In horizontal circumstances, steel plate walls function as the web of a plate girder, boundary columns as flanges, and beams as plate girder stiffeners [38].

**Figure 2.21:** Steel Shear Wall

c) Plywood Shear Wall

Plywood sheets and studs are used to construct this sort of wall. Plywood sheets convey shear stress, while studs resist tension and compression.

Mid-Ply Shear Wall — This shear wall has an additional plywood sheet in the middle of the standard plywood wall and a succession of pairs of studs above the mid-play [39].


**Figure 2.22:** Plywood Shear Wall

d) RHCBM (RC Hollow Concrete Wall Masonry)

Reinforced Hollow Concrete Block Masonry (RHCBM) components can withstand earthquakes by acting as load-bearing walls for gravity loads and shear walls for lateral seismic pressures. This structural system is named after the shear wall–diaphragm concept, which gives three-dimensional structural stability to structures. The following are the structural characteristics:

a. Each masonry element is horizontally reinforced with steel bars and concrete/grout fills as continuous RC bands at the plinth, sill, lintel, and roof levels, employing U-shaped concrete blocks in the masonry course.

b. A grid of reinforcement may be incorporated into each masonry element without additional shuttering, reducing the risk of reinforcement corrosion.

c. The structural integrity in all three dimensions is achieved by continuing the reinforcing bars into the roof slab and lateral walls in both vertical and horizontal orientations, respectively.

**Figure 2.23:** RC Hollow Concrete Wall Masonry

## 2.5 SHEAR WALL APPLICATIONS

A wind-resistant structural component for multi-story or tall structures, as well as regular buildings in high-wind zones, is the shear wall. These walls often begin at the foundation and run the length and breadth of the building. Because [40], shear walls are often employed.

a. Wind and earthquake loads are resisted lateral by shear walls. Shear wells provide additional stability in the case of a construction collapse.

b. They have been tested for use in reinforcing structures or anchoring utility services such as telephone lines, water pipelines, and electrical lines.

c. Shear walls prevent the wall from bending towards the base due to gravity forces produced above it.

d. In construction, shear walls separate the boundary well from the roof structure.

e. A seismic building's shear wall provides wind and seismic loads lateral resistance. It gives additional stability in the case of a building breakdown.

f. Shear walls are used in every building project as stand-alone structures or as part of an engineered form system.

g. They provide lateral resistance to wind and seismic loads. Shear walls are used as a part of an engineering system, resulting in the strength of the surrounding columns being transmitted.

h. Shear walls are a component portion of an engineered scheme, resulting in resistance being transferred into the surrounding columns.

i. Shear walls provide structural strength and stiffness in the direction of their fomentation, reducing lateral motion and, as a result, damage to the structure and its contents.

j. Their overturning implications are severe because shear walls are subjected to high horizontal earthquake stresses.

## 2.6 SHEAR WALLS AND EARTHQUAKE RESISTANCE

Shear walls are one of the most frequent strategies to withstand lateral loads in buildings. Shear walls have a high plane stiffness and strength, allowing them to endure massive horizontal stresses while supporting gravity loads. As a result, the building's lateral wobble is considerably reduced, as is the risk of harm to the structure and its contents. If shear walls, slabs, and footings are strong enough, they will eventually transmit the horizontal case load to the next element in the load path below them, such as floors. [41].

Shear walls also provide lateral rigidity, avoiding excessive shaking of the roof or level above. The floor and ceiling will not collapse off their supports in the future if the shear walls are sufficiently rigid. Non-construction state damage is also less severe in buildings with suitable stiffness. Because shear walls endure enormous horizontal earthquake stresses, their overturning consequences are significant. [42].

To reduce the effects of twists in structures, shear walls are symmetrically aligned in plan. Shear walls may provide an effective lateral load resisting system by minimizing lateral displacement under earthquake pressures when they are positioned in advantageous places inside a structure. As a result, it is critical to determine the most effective, accepted, and optimum location for the shear wall [32]. The use of shear walls can successfully reduce construction displacement and story drift. This will reduce the damage caused by lateral forces such as an earthquake. Previous research has shown that shear walls behave differently depending on their construction position. The open frame, the shear wall for the core symmetrically, the shear wall for the periphery symmetrically, and the shear wall at the boundary asymmetrically have been seismically analyzed in this article utilizing the response vision approach [43]. Wind and tremors generate lateral loads above structures that must be resisted. These forces can be opposed in two ways: the functioning of moment frames and the use of shear walls This example demonstrates how such tactics work to sustain buildings under lateral stresses [44]. Shear walls are often formed of concrete or steel and ring the structure's core, which is where the elevators and stairs are placed. The shear walls provide lateral resistance that is not provided by a frame in which the components are nailed together, which helps to withstand the impacts of wind and earthquake. A shear capable of being used is used in this activity, along with a square of cardboard affixed to the frame [34].

Another way to withstand lateral stresses is to stiffen the connections while the frame is still being built. The positions where the beams and columns meet are kept for 90 degrees by employing moment connections. The provides structural rigidity, resulting in lateral load resistance. These connections may be just above one bay (on each level), resulting in the ground collapsing with no lateral resisting mechanism, even if the other levels remained firm. It may be regarded as a braced frame. Rubber bands may be utilized to create diagonal pieces that can bear both lateral and vertical stresses. Students may utilize pictures of the bracing in different portions of the structure to determine which is stable and which is not, improving their comprehension. They should understand that every ground needs at least one method to prevent it from collapsing under lateral / shear forces [45].

# 3. FINITE ELEMENT AND MATERIAL BEHAVIOUR MODELLING

The finite element method (FEM) is a widely used approach in civil engineering and other technical fields to assess a broad variety of problems statistically. This chapter explains how the project's guidelines for examining the Behaviour of a shear wall subjected to lateral stress were developed. The sharing wall is numerically analyzed using a detailed FEM model developed with the help of the ANSYS Finite Element program's algorithms. To meet the continuity criteria between the wall elements (i.e. concrete and reinforcement elements), coincident nodes of the wall element are bound to be connected in the direction normal to the interface. Still, relative movements are permitted to occur in the tangential directions. The characteristic of a bilinear stiffness matrix simulates the braces' uniaxial "tension only" behaviour, i.e. the stiffness is eliminated if the element enters into compression. The nonlinear components are used to simulate the impacted forces[46][47]. This chapter is concerned with the processes that are used to simulate the Behavior of the Shear wall. The shear wall will be subjected to various loads based on the essential parameters such as shape and dimensions and types of reinforcement. The methodology procedure in this work will test the model by discretizing the partial differential equations into a finite set of the control volumes, which are termed meshes and cells. The main issues in this process is how to specify the shear wall data specification. The researcher used a previous experimental work to solve this problem. The shear wall component taken from experimental data, and the same data used to validate the developed model. The solver will prepare the general conservation equations. All the dimensions and unites taken as a metric unites in the simulation process. The partial differential equations are solved numerically to render the solution field based on structural analysis. The processes used throughout this project are shown in Figure 3.1's flow chart. Simulation research was conducted to look at the factors that may impact the model's mechanical characteristics, such as the change in loading level. This project aims to develop a numerical model that can forecast the features of shear wall displacements and internal forces as a result of the applied load.

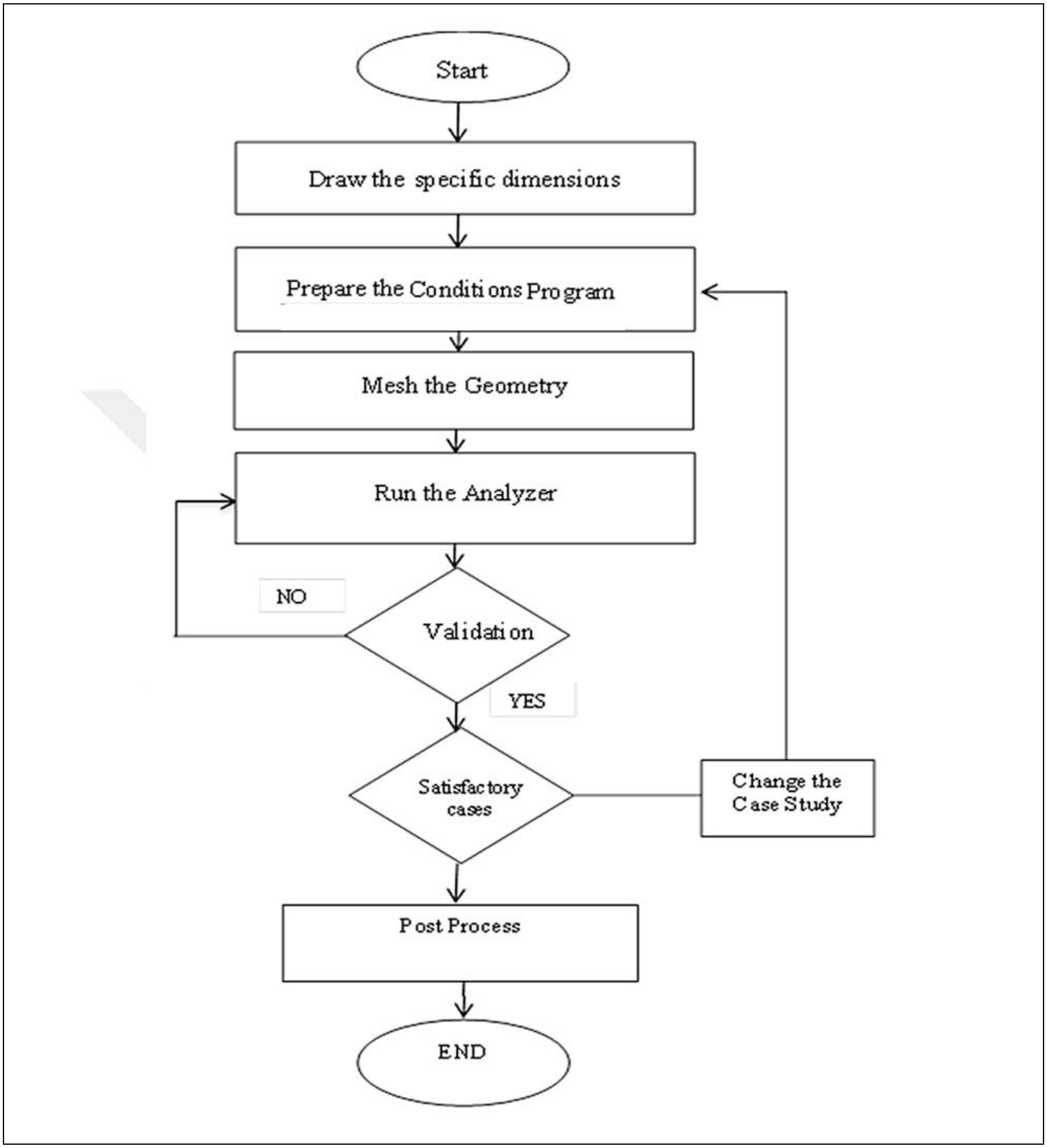


**Figure 3.1:** Flowchart of the Project

## 3.1 PREPARING AN ANALYTICAL MODEL

Making a study of moving earth necessitates a thorough application of the problem to the system. The system requires the geometrical parameters of the device to be studied for this purpose, which can be entered into the system via (IGS files). This method allows for the production of a set of points and lines in the shear wall, from which the user can construct more complex geometrical structures such as areas, volumes, or combination parts. In SolidWorks, a model is normally started with a 2D drawing and then evolved into 3D geometry. Geometry such as points, lines, arcs, and conics make up the sketch. The steps to construct the geometry in SolidWorks are as follows:

Step 1: open the SolidWorks software application and select a (Part File) for each style of shear wall. The researcher used various shear wall types with varying diminutions to demonstrate the effect of shear wall shape design in this study.

Step 2: All of the information gathered in the previous step will be loaded into SolidWorks tools. The dimension of the shear wall section will be provided to SolidWorks program in this stage. The surface curve is determined by the connection between the points of the section.

Using the same standard simple shape geometry of the share wall will provide the base of the  wall components which will be used in the first step of simulation process to investigate the responses and reactions of the wall against the forces.

Step 3: Convert the geometrical drawing to the IGS extension file.

The following stage is to split the reaction regions, after which estimates of load distribution depending on the type of analysis. Making objects on surfaces is the simplest approach to set their mesh. Lines (or points) can be used to define surfaces. Another approach of generating a flow area is to merge a number of lines into a single line and then create a surface on that line that can be divided based on the proper value of finite components.

## 3.2 PRE-PROCESS IN THE ANSYS ENVIRONMENT

The procedure of parameters identification of the selected material model from the ANSYS file was carried out in the ANSYS setting via numerical calculation of the database of the model. Initial data of materials parameters represents the basis for the optimization or the evaluation process. The required for initial studies depend on the constraints and goals of study. The first role in initial study is all studies referenced in defining constraints and goals must belong to the same configuration. The phases considered below[48]:

### 3.2.1 Specify Geometric Data Specification

The first stage to investigate the shear wall model involves specifying the shear wall and other components characteristics. It's an important part of simulation procedure to gain accurate results of the model behaviour. The following steps present the ANSYS procedure:

**Step 1: Define element types**

In this step, there are many options that contribute to build the model, where the three-dimensional model is considered, which may consist of one or more materials (in this study, the sample was considered to consist of steel structure materials, be evaluate the inputs on the basis that the shear wall consists of specific proportions of steel material. The selected model is made of three vectors, and the change in the effect of forces on the model used in these three vectors as a directional base.

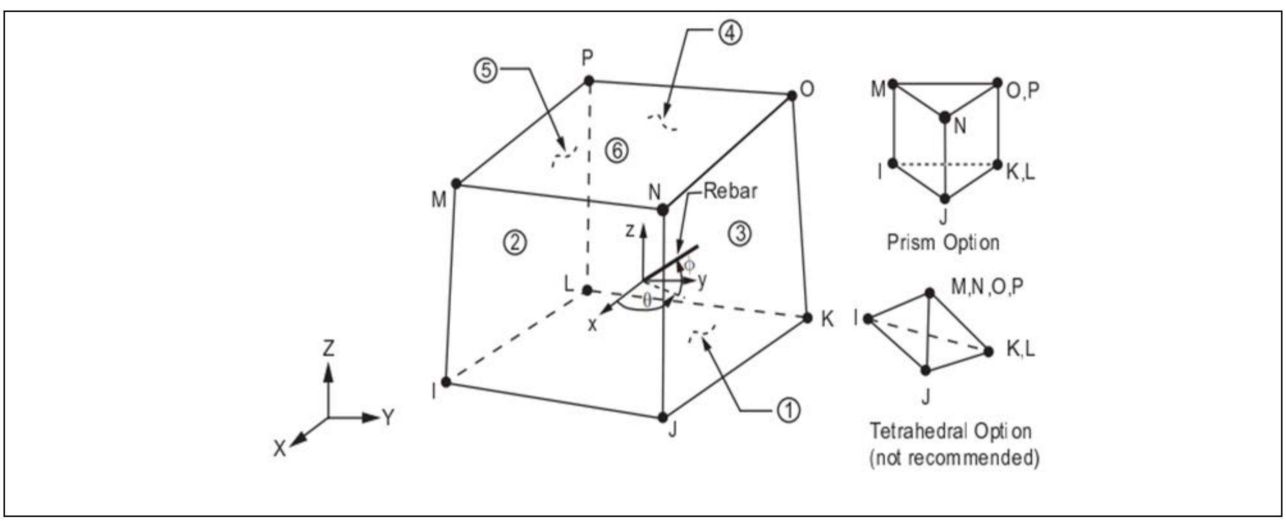


**Figure 3.2:** Solid Input Representation in ANSYS [49]

The additional shear walls data and technical specifications such as shear transmission coefficients, tensile stress, and compressive values are entered as indicated in the table 3.1 for solid shear wall materials.

**Table 3.1:** SOLID Shear Wall Material Options [50]

| Mechanical properties | Symbol | Steel |
|---|---|---|
| Young's modulus (GPa) | $E$ | 207.0 |
| Shear modulus (GPa) | $G$ | 80.0 |
| Poisson's ratio | $\nu$ | 0.3 |
| Density (Kg/m$^3$) | $\rho$ | 7600 |
| Yield strength (MPa) | $S_y$ | 370 |
| Shear strength (MPa) | $S_s$ | 370 |

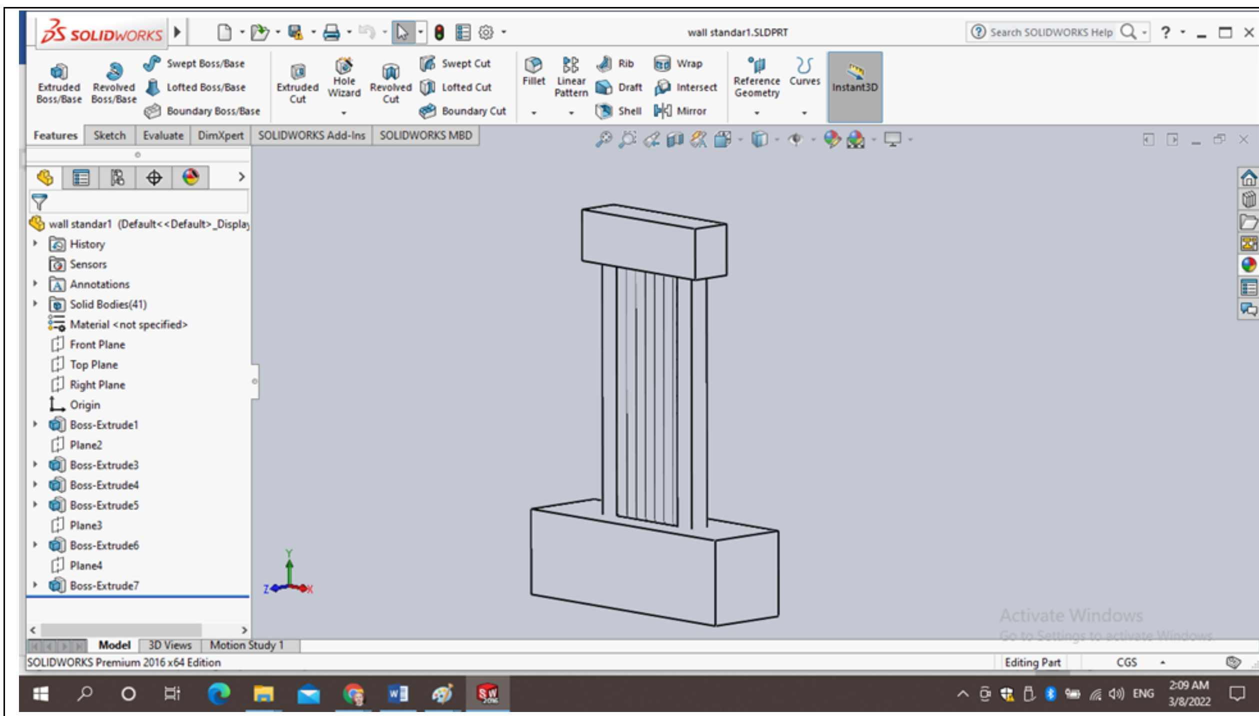


**Figure 3.3:** Solid Input Representation in ANSYS

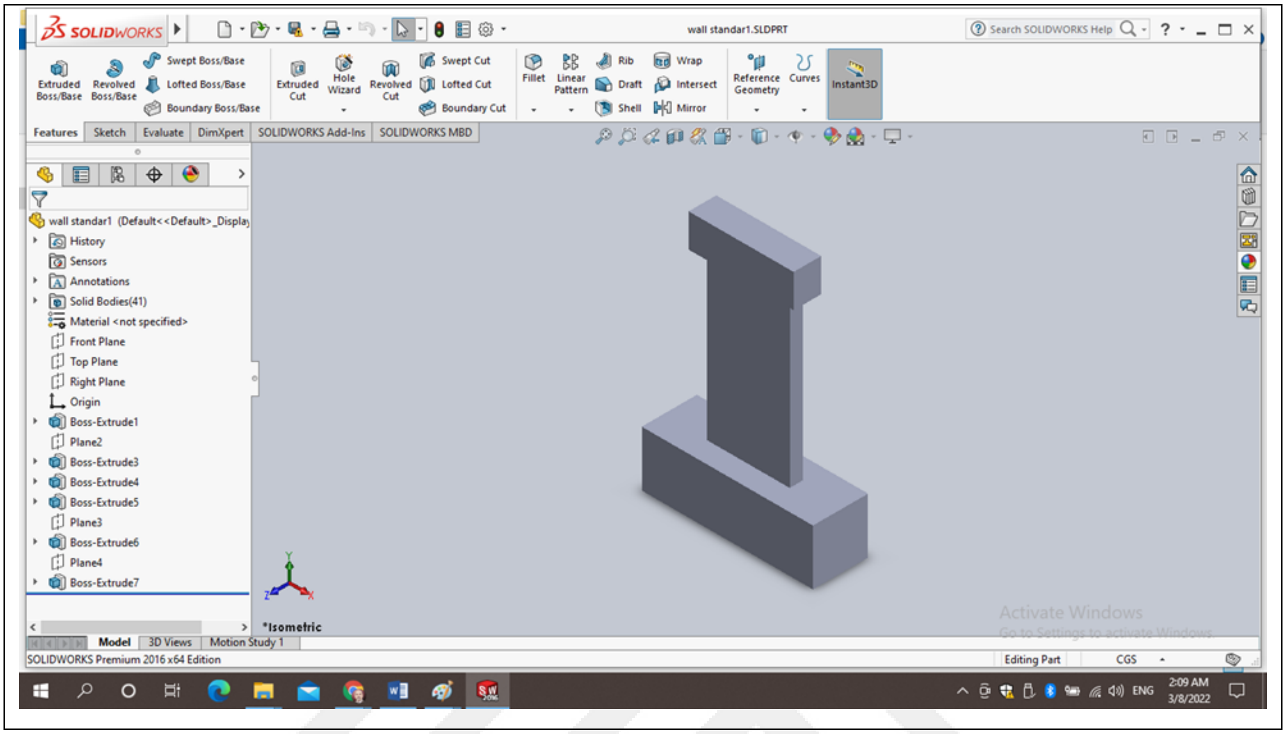


**Figure 3.4:** Case 1 of Wall Shape

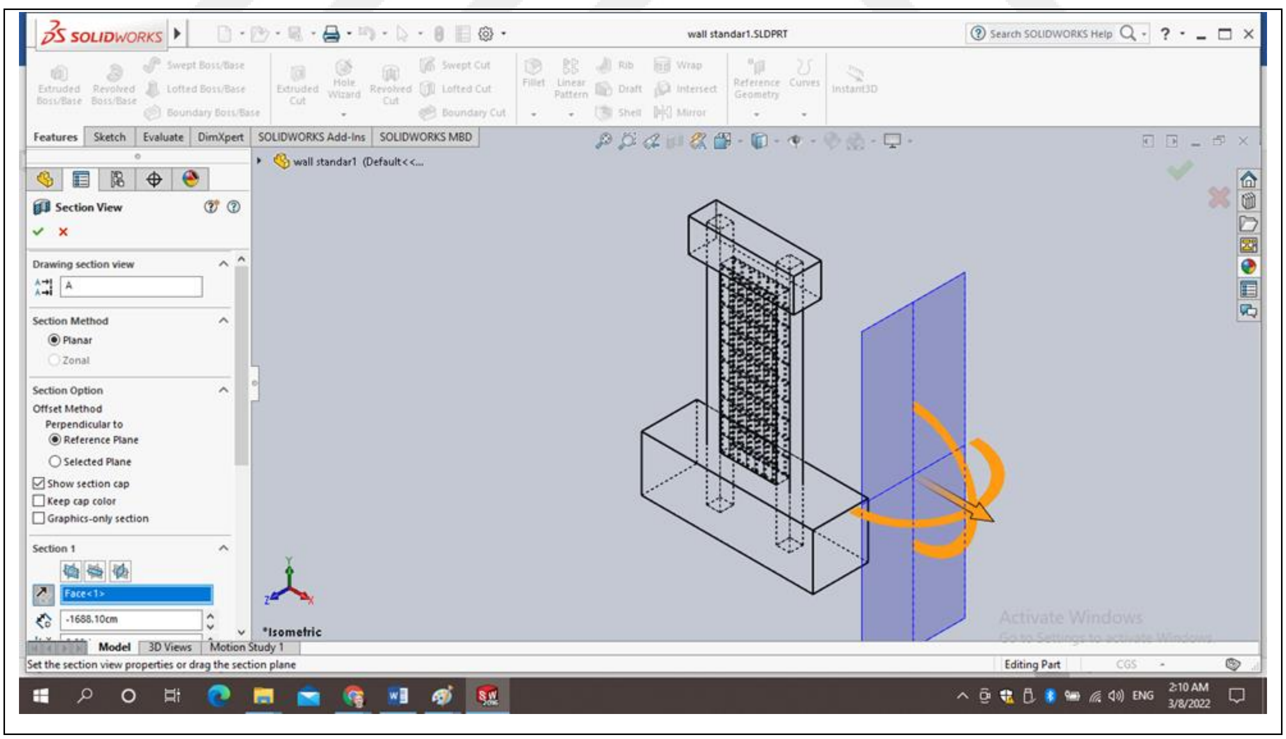


**Figure 3.5:** Structural Reinforcement of the Shear Wall

The additional concrete data and technical specifications such as shear transmission coefficients, tensile stress, and compressive values are entered as indicated in the table 3.2 for solid concrete materials.

**Table 3.2:** SOLID Concrete Material Options

| Constant | Meaning |
|---|---|
| 1 | Shear transfer coefficients for an open crack. |
| 2 | Shear transfer coefficients for a closed crack. |
| 3 | Uniaxial tensile cracking stress. |
| 4 | Uniaxial crushing stress (positive). |
| 5 | Biaxial crushing stress (positive). |
| 6 | Ambient hydrostatic stress state for use with constants 7 and 8. |
| 7 | Biaxial crushing stress (positive) under the ambient hydrostatic stress state (constant 6). |
| 8 | Uniaxial crushing stress (positive) under the ambient hydrostatic stress state (constant 6). |
| 9 | Stiffness multiplier for cracked tensile condition, used if KEYOPT(7) = 1 (defaults to 0.6). |

The ANSYS configuration of practical model implementation is shown in Figure 3.6.

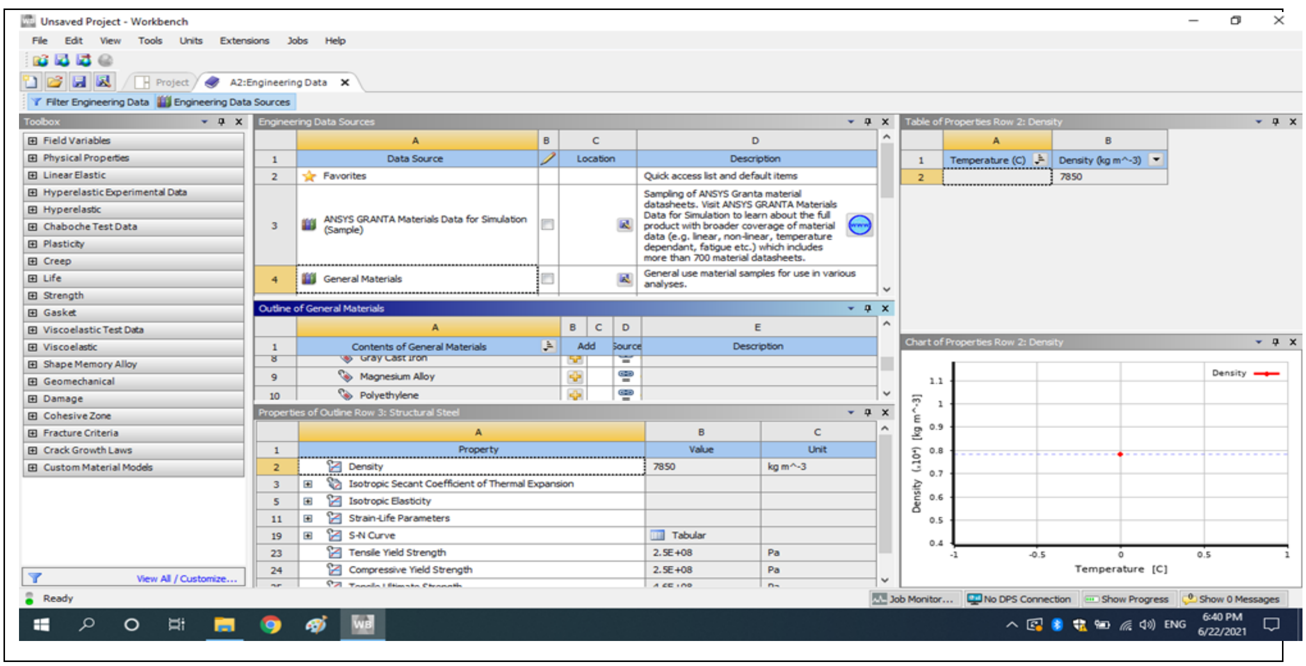


**Figure 3.6:** Configuration of Elements Type Definition

**Step 2: specify the material characteristics**

The used material characteristics in the model is inserted through a sequence of operations in ANSYS program. The inserted data can be specified from the model geometry that connect with the system, then insert the data specification of material as shown in figure 3.5. To enhance the analysis of the structure, the ANSYS program can be enhanced with all the information about the specifications of concrete, rebar and other added materials by insert process to the model as shown in the figure. This method is suitable to insert the value of the added fiber and its properties, and thus studying its response under the influence of different loads and different temperatures. Three types of material have been used in this model, the first material is the concrete, the second is the steel bars which is used to reinforce the concrete, and finally the steel fiber which is used in different percentages with the concrete mixture.

The ANSYS configuration of practical model implementation is shown in Figure 3.7.

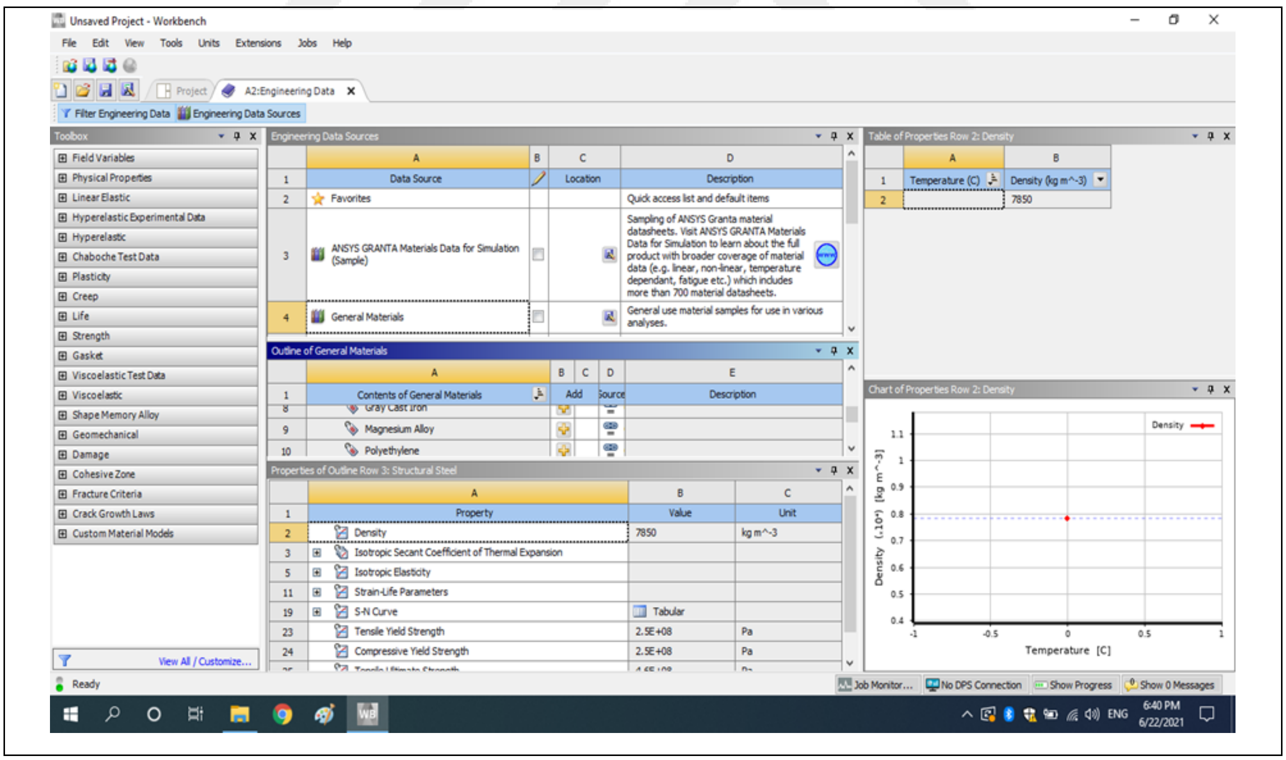


**Figure 3.7:** Configuration of Elements Type Definition

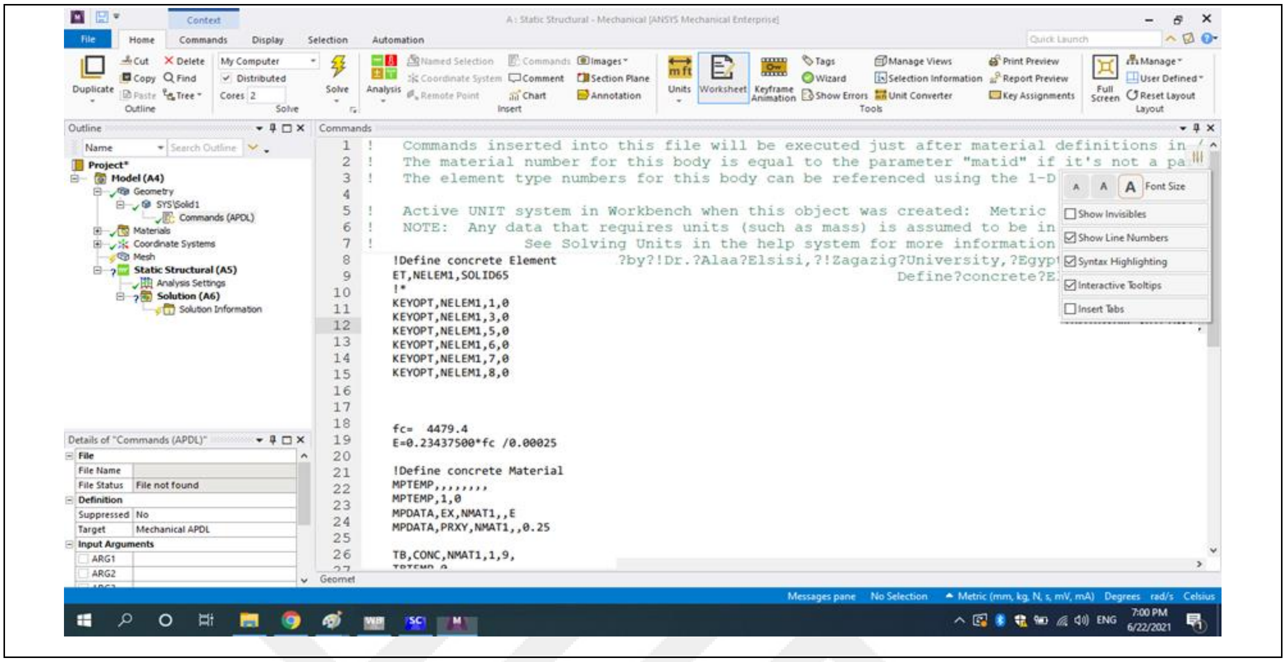


**Figure 3.8:** Initiate Data Specification

## Step 3: Specify material models

The regulation of the material model was made through an automatic batch; it was likely to do the entire calculation using this way. A benefit of this process was the ease of calling an external script to assess the resemblance between the original data and the calculated results.

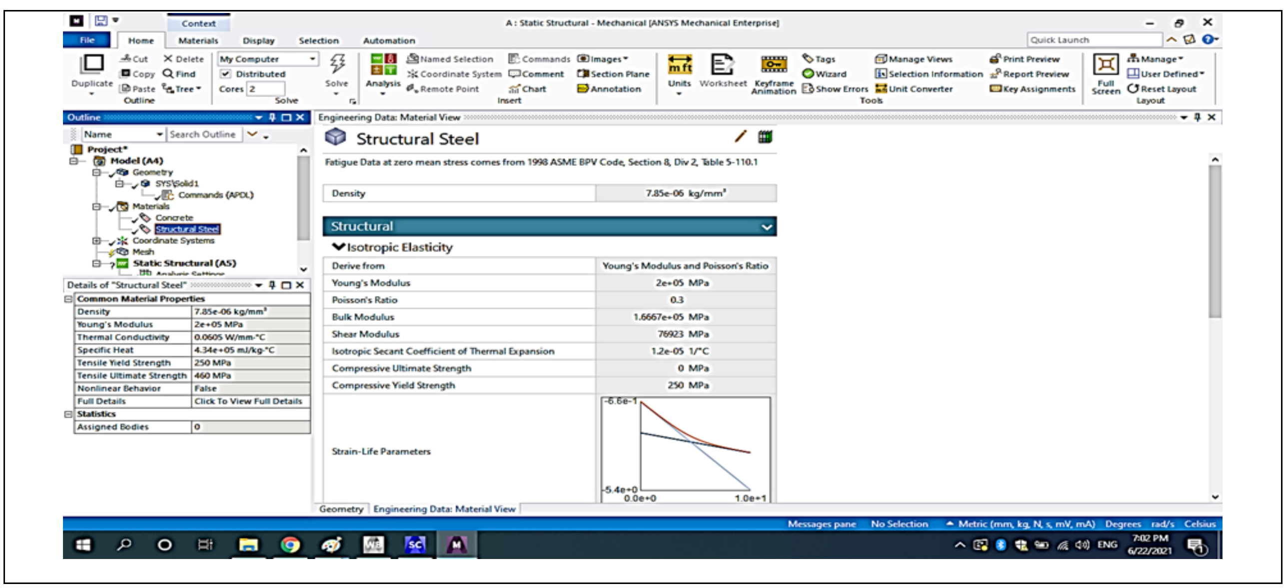


**Figure 3.9:** Material Constitutive Options

A wide range of material constitutive possibilities (like anisotropic hyper elasticity, shape memory alloy, re-dependent plasticity. Hyper elasticity, plasticity and viscoelasticity) etc. The programmed set therefore completed the gathering of the geometry of the computational model, the meaning of the material model, the launch of the nonlinear calculations, and the calling of the external script which allowed the calculation of the objective function value. Steel bars of steel reinforcement modeling approach were introduced for linear isotropic model with 2x105 MPa and poison ratio of 0.3 and nonlinear inelastic yield stress. Nonlinearity was added through linear interpolation of the material characteristics with respect to stress, and the models have an integral form based on classical linear viscoelastic situations. The resulting viscoelastic model is based on the classic rheological linear viscoelastic modeling method. The modeling procedures are shown in Figures 3.10 and 3.11.

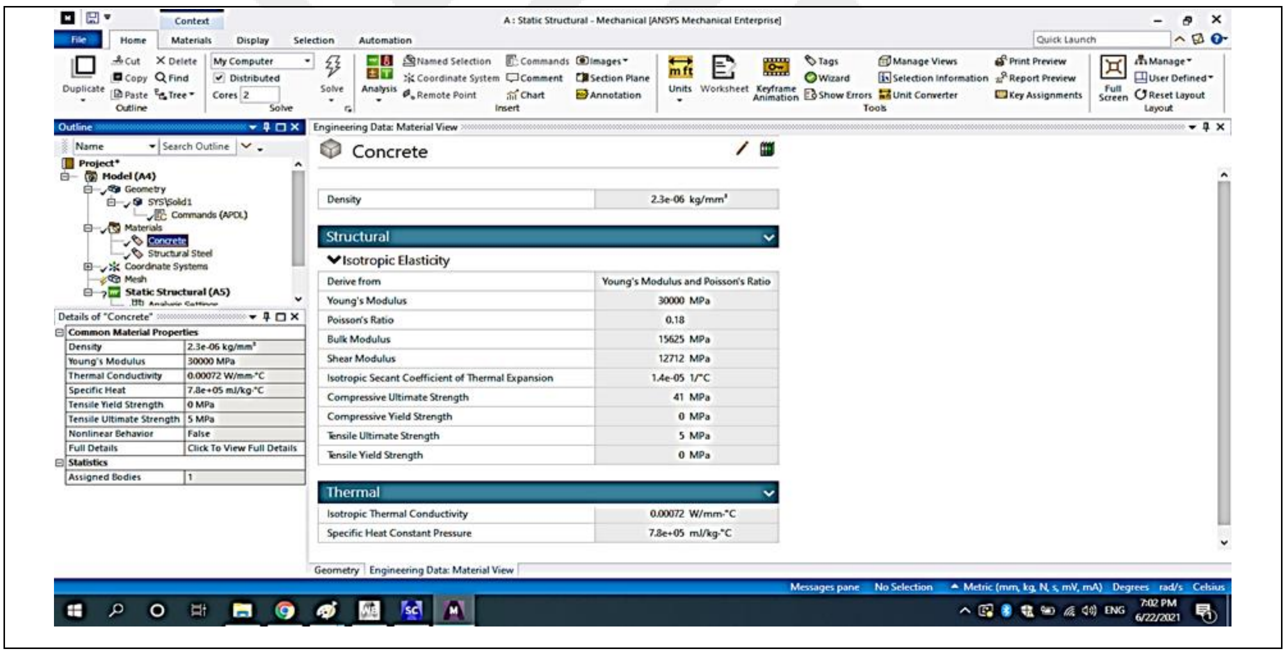


**Figure 3.10:** Initialise Oil Tanks Material Parameters

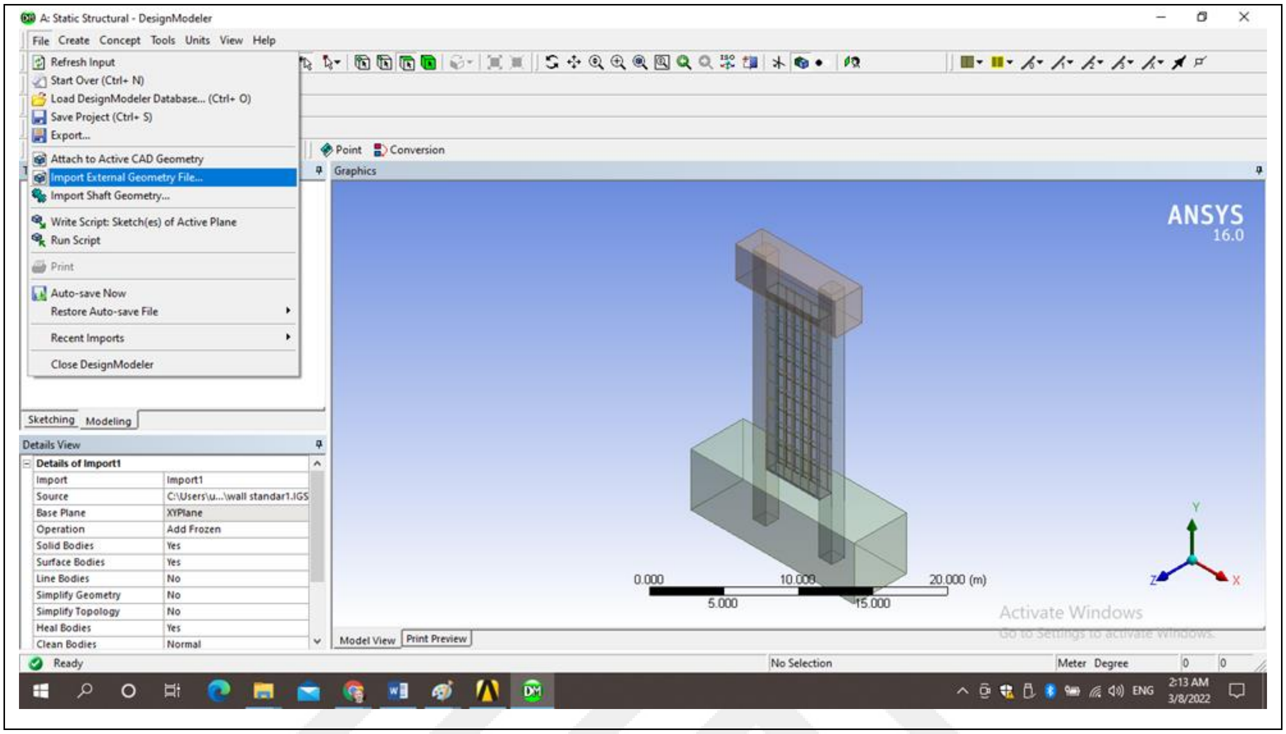


**Figure 3.11:** Initiate data specification

**Step 4: Independent material properties**

In this section, the researcher develops a laboratory experiment in order to investigate the effect ah steel fiber on concrete performance. The process to achieve this goal is by the steps below:

a. Mix design and materials properties

According to earlier researches and studies fibers are more active with a mixture with fine aggregate, therefore; the plan was introducing a mixture with 63.24 % of fine aggregate and 36.75% of the total mix percentage as shown in the Table 3.3.

**Table 3.3:** Mix Design.

| Mix code | Fiber type | Vf % | Cement (kg) | Sand (kg) | Gravel (kg) | Super plasticizer (kg) | fiber (kg) | Water (kg) | Silica fume (kg) |
|---|---|---|---|---|---|---|---|---|---|
| A | none | 0 | 10.5 | 26.5 | 17 | 0.5 | 0.0 | 3.5 | 0.8 |
| B | Steel | 0.75 | 10.5 | 26.5 | 17 | 0.5 | 1.3 | 3.5 | 0.8 |

a. Cement: The type of cement used in this study was Kubaisa obtained from western of Iraq.

b. Superplasticizer: due to the high percentage fine aggregate, the workability of the designed mixture are too lows, therefore, a high water reducer is used in constant percentage for all mixture. A superplasticizer under traditional from Sika are used, which is complies with ASTM C 494 Types A.

c. Fine aggregate: graded river sand brought from local source. The size of particles is ranging from 0.075 mm to 4.75 mm was used.

d. Coarse aggregate: a crashed stone with a gap graded of crashed stone are used. The maximum size of the particles was 9.5 mm, there are a gap between particles of 4.75 mm and 9.5 mm, this means that even the coarse aggregate has higher fine aggregate.

e. Steel fibre: a 3 cm hooked at their ends steel fibre with a diameter of 0.75 mm and aspect ratio 40 was used in this study as shown in Figure 3.12. Several researchers have examined the impact of the aspect ratio of steel fibers on split tensile strength. They revealed that specimens with aspect ratio 125 demonstrated higher split tensile strength than that of specimens with aspect ratio 50, and also observed that larger-aspect ratio had a narrow crack and better resistance capabilities than those of smaller-aspect ratio steel fibers. noted that steel fibers with a high aspect ratio had a significant effect

f. Densified Silica fume is a non-crystalline amorphous polymorph of silicon dioxide, silica. It's an ultrafine powder made up of spherical particles with an average particle diameter of 150 nanometers that's collected as a by-product of silicon and ferrosilicon alloy manufacture..

g. Water: tap water was used throughout this work for both mixing and curing of concrete.

| Aspect Ratio | Fiber Percentage | Split Tensile Strength (MPa) |
|---|---|---|
| 0 | 0 | 11.5 |
| 30 | 1 | 12.73 |
| 50 | 1 | 15.4 |
| 30 | 2 | 15.59 |
| 50 | 2 | 17.45 |
| 30 | 3 | 17.82 |
| 50 | 3 | 19.10 |

**Figure 3.12:** Steel Fiber.

b. Mixing

As a first step, the dry materials (sand, gravel, cement and silica fume) was mixed in Diagonal rotations mixer that has three paddles for blending the materials. The materials were mixed to get homogeneous mixture. The water is added slowly to the mixture, and then super plasticizer is added, the fibers is added at the end slowly soon after adding the fibers the mixture is be ready for casting. The mold was oiled well to prevent the concrete attaching the mold and make it easy to extract the sample as shown in figure 3.13.

**Figure 3.13:** Mixer Type

**Figure 3.14:** Oiling the Mold

Then the concrete is poured in the mold with using vibrator, exterior vibration for the panels and cubic.

c. curing process

The sample was taken to a water tank with heater to begin the curing process with an average temperature of 25 °C and it remains there for 28 days.

d. concrete mechanical properties

Cubic's tests were carried out on the same day as the corresponding shear wall test. The test machine for all the cubic testes is shown in figure 3.15.

e. Compressive strength

(ASTM,C39, 1997) Describes the procedure of calculating the compressive strength of concrete cubic. After preparing the sample putting it in the center of the machine, a compressive axial load shall be applied till failure occurs.


**Figure 3.15:** Cubic's Test Machine.

## Step 5: Meshing process

The geometry must then be meshed. It is necessary to utilize the ANSYS Meshing program to produce a computational mesh for the structural analysis across the shear wall volume. Setting the element quality and Mesh controls should be part of the method for creating a mesh of nodes and elements. There are several mesh controls available in ANSYS. The ANSYS Mesh Tool (Main Menu> Preprocessor> Meshing> Mesh Tool) offers a quick and easy way to access several of the most often used mesh settings and meshing processes. The Mesh Tool is an interactive "tool box" that you may use from the Moment you start the operation until you shut it or depart PREP7. While all of the features accessible via the Mesh Tool are also available through regular ANSYS commands and menus, using it is a convenient shortcut. Among the many features provided by the Mesh Tool:

a. Control the Mesh size

b. Specify mesh type

c. Specify element shape

d. Reining the mesh

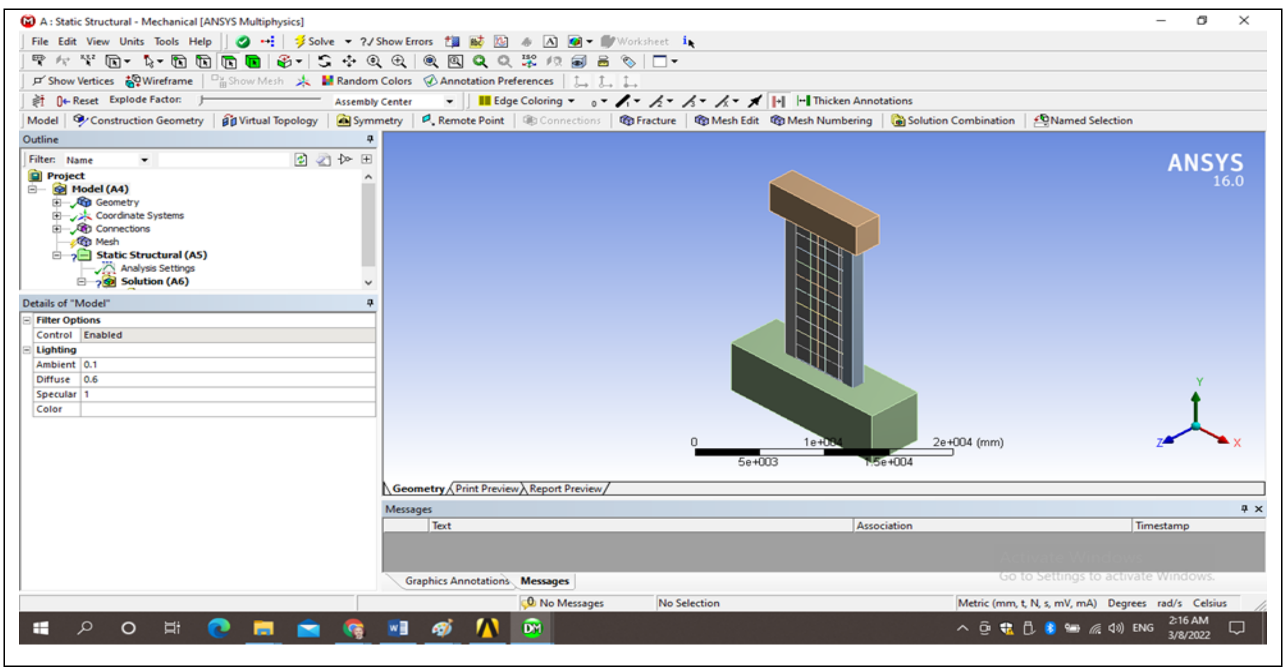


**Figure 3.16:** Mesh Process

The 3-D mesh elements can be of two types namely Triangular and Quadrilateral. Use of triangular element creates an unstructured mesh whereas; the use of a quadrilateral element creates a structured mesh. The element count (number of elements) or element size may both be chosen when creating a mesh. The size functions enable us to regulate the size of mesh-element edges for geometric edges as well as meshed faces and volumes. The case study's discretization is suggested by the meshing findings. Because it provides the finite element analysis, it is the most significant portion of an analysis and may decide its efficiency and efficacy. As a result, the meshing of complicated models takes a lot of time. The mesh result is displayed in Figure 3.17 in our example study.

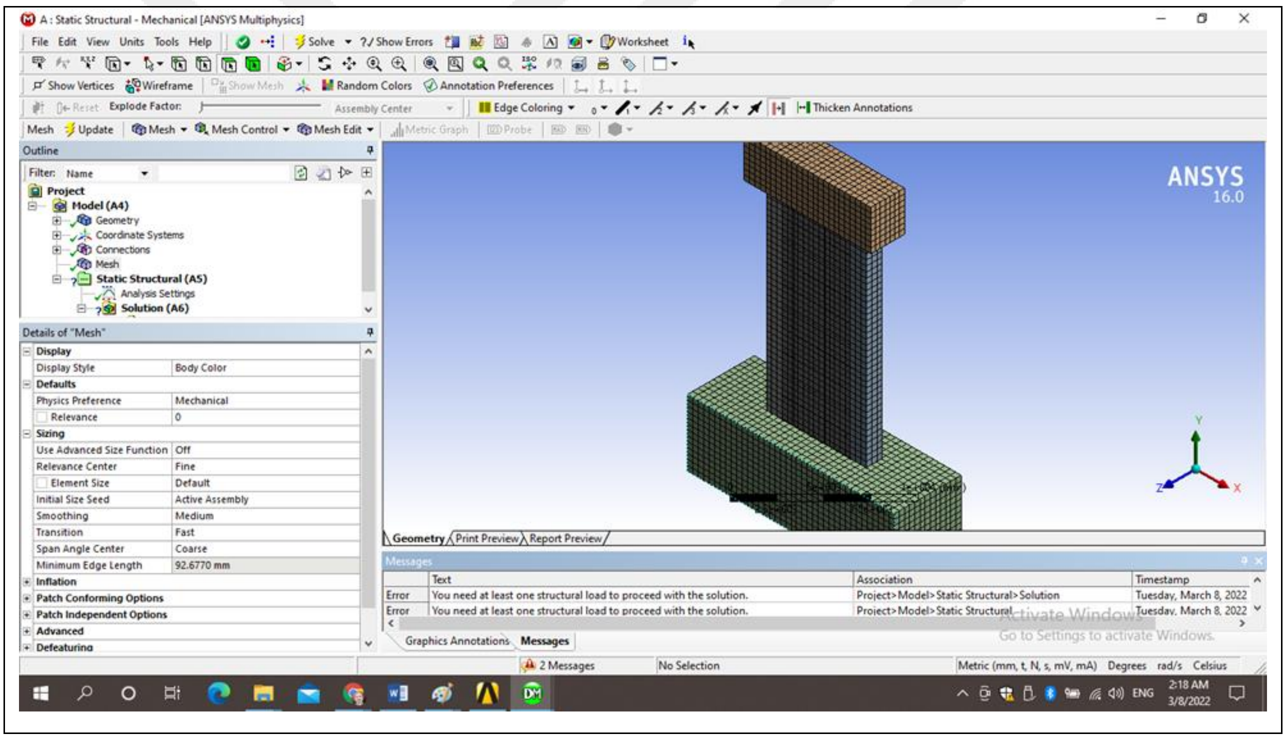


**Figure 3.17:** Enhance Mesh Process

Its observe that the boundary layer contain a multi types of discretization which is enable us to analyses the boundary layer in more specific detail to get a higher accuracy results. The meshing complexity measures the degree of difficulty Faced in meshing the geometry. Numerous aspects are recognized to make mesh generation challenging including near-tangencies, topology arrangement, etc. The conversion of these complexities into a measure that quantifies them is called meshing complexity. For example, many geometry comprises very mathematically complicated curves and surfaces, which are meshed in a trivial manner. Similarly, linear curves and flat surfaces may be used to create a model that is almost hard to mesh. In this case, the metric may be used to detect invalid as well as potentially low-quality parts, which might result in a bigger solution. Based on skewness statues, the typical ANSYS mesh quality shows (0.5 to 0.8) as a satisfactory result, and the researcher achieves (0.79) mesh quality.

**Step 6: Define the applied loads**

The process of applying the loads on the model is one of the most important process in building the simulation, as the value, type, location and direction of the load are essential in studying the Behavior of the model response. It is possible in the ANSYS program to determine the type, quantity and locations of loads before or after the Mesh process. Because the loading process is filled with objects that have physical properties, such as specific densities. In the model for this study, the place of loading was determined in the middle of the model and according to the actual model that was adopted. the forces will be distributed on the elements and nodes of the Mesh in the body and thus transfer the effect of the forces to those elements by a series of calculations based on the infinite elements of the body to find the effect of the load on both sides of the sample. On the other hand, the effect of temperature is included in the calculations, which causes changes in the model's response based on the load. It is possible to change the load value and the temperature value in each test to obtain the results. The results values can be stored in form of Excel tables to use them by studying the Behavior of the examined model. It is also possible to obtain images of each test to see the method of change and its values on the model visually. Figure 3.18. shows the instructions for this stage. It is seen that the static structural options can be provide an inset choices based on thermal conditions and static load conditions. Also, it is seen that the options contain the type of support are fixed correlated with the type of used materials. The variations in this work represent a different type of loads subjected to the concrete body.

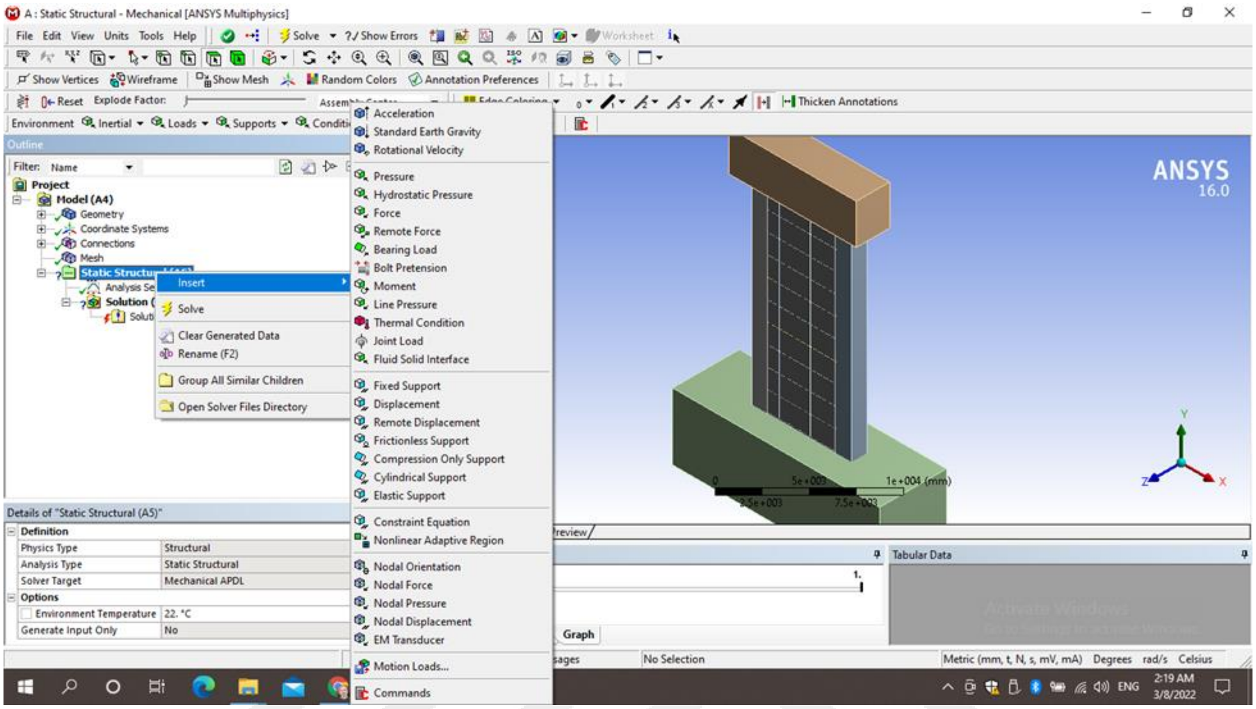


**Figure 3.18:** Applied Load on Shear Wall Elements

## 3.3 SOLVING PROCESS

When the resolution calculations are applied, the loads from the solid model are immediately transferred to the finite element model. As indicated in Figure 3.19, SOLVE commands include (Main Menu> Solution> Solve> Current LS). The model creation, which includes meshing, is finished after preprocessing. The solution phase is presented by ANSYS. During the solution process, ANSYS enables you to pick specific choices. Analysis Options or Solution Controls are used to specify them. Users may view the mapped stress values in the receiving model by using commands to map stresses from an ANSYS model. It can add all degrees of freedom to the receiving model, eliminate any additional burdens, and solve the problem. The mapping stress values must exist to list and display as results over the model if the material attributes are linear.

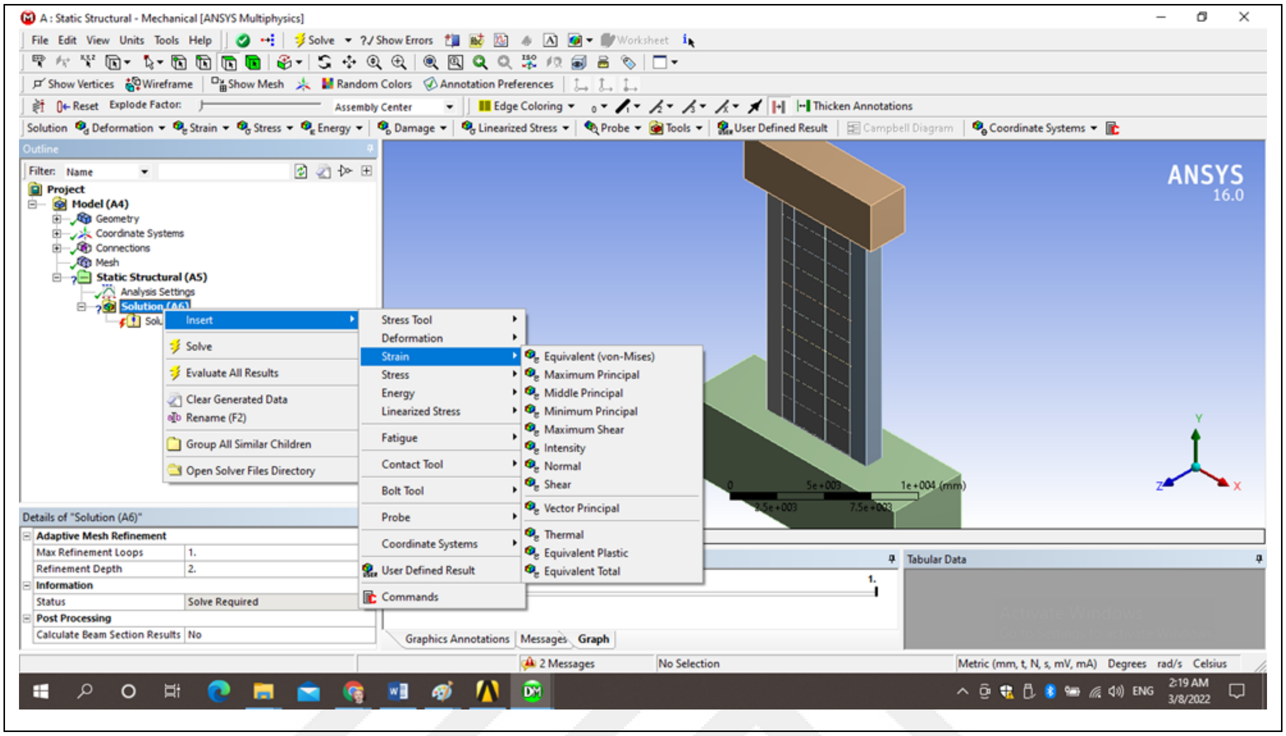


**Figure 3.19:** Stress Command In Ansys Solver

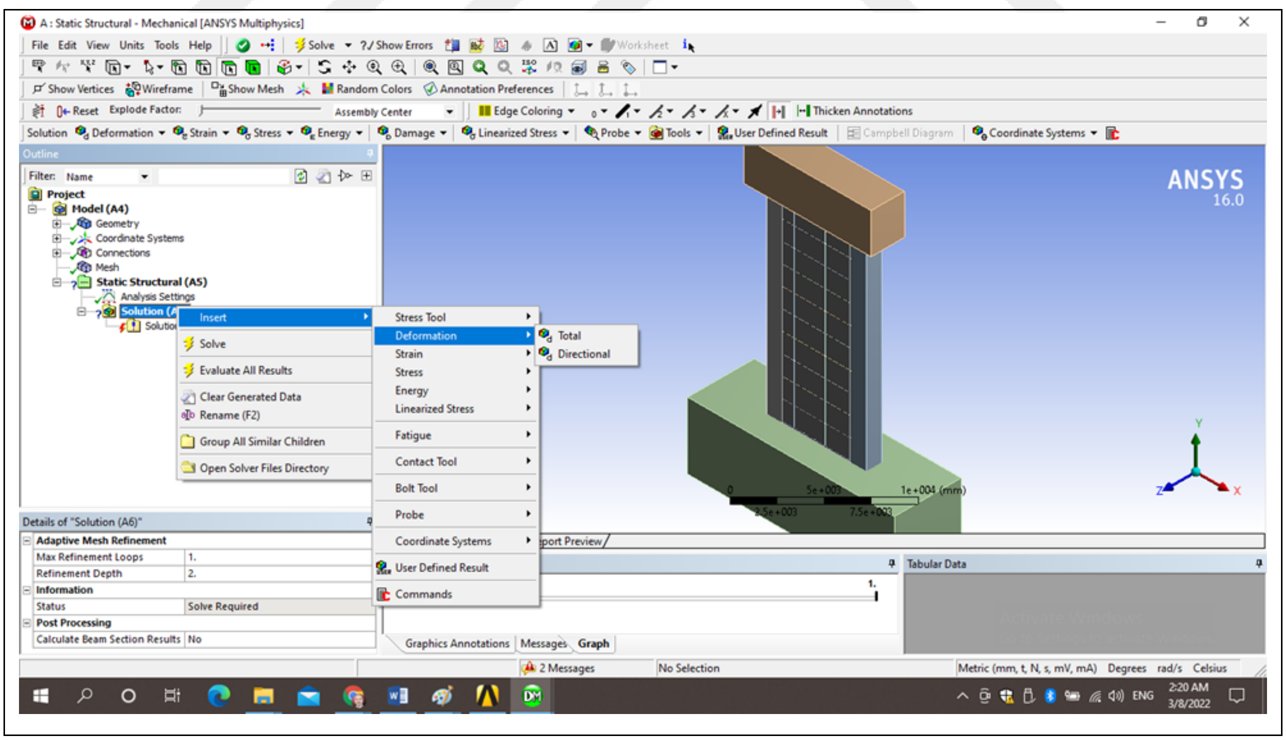


**Figure 3.20:** Deformation Command in ANSYS SOLVER

# 4. RESULTS AND DISCUSSION

This chapter is intended to present the collected experimental load and deformation based on different shear wall models using ANSYS software. The shear wall is analyzed for various rights conditions. The results of the free vibration for the shear walls are provided, as are the linear and nonlinear results involving the frequencies and mode shapes.

The model drawn and transferred to the ANSYS software program as shown in Figure 4.1.

## 4.1 THE CASE STUDIES

The experimental program can be described as follows: the main parameters are deformation mode. Total of thirty-two simulation test are suggested for investigation; they were marked as groups in which each group contains test type and the needed variation with number of needed testes as in Table 4.1. The simulation tests are selected as a model with different dimensions based on previous studies.

**Table 4.1:** Study Groups

| group | dimensions | |
|---|---|---|
| case 1 | Height: (750x750x100) mm | For validation |
| case 2 | Height: (10x2x0.25) m | |
| case 3 | Height: (5x2x0.25) m | |

The cases dimensions shown in Figures 4.1 to 4.3 below:

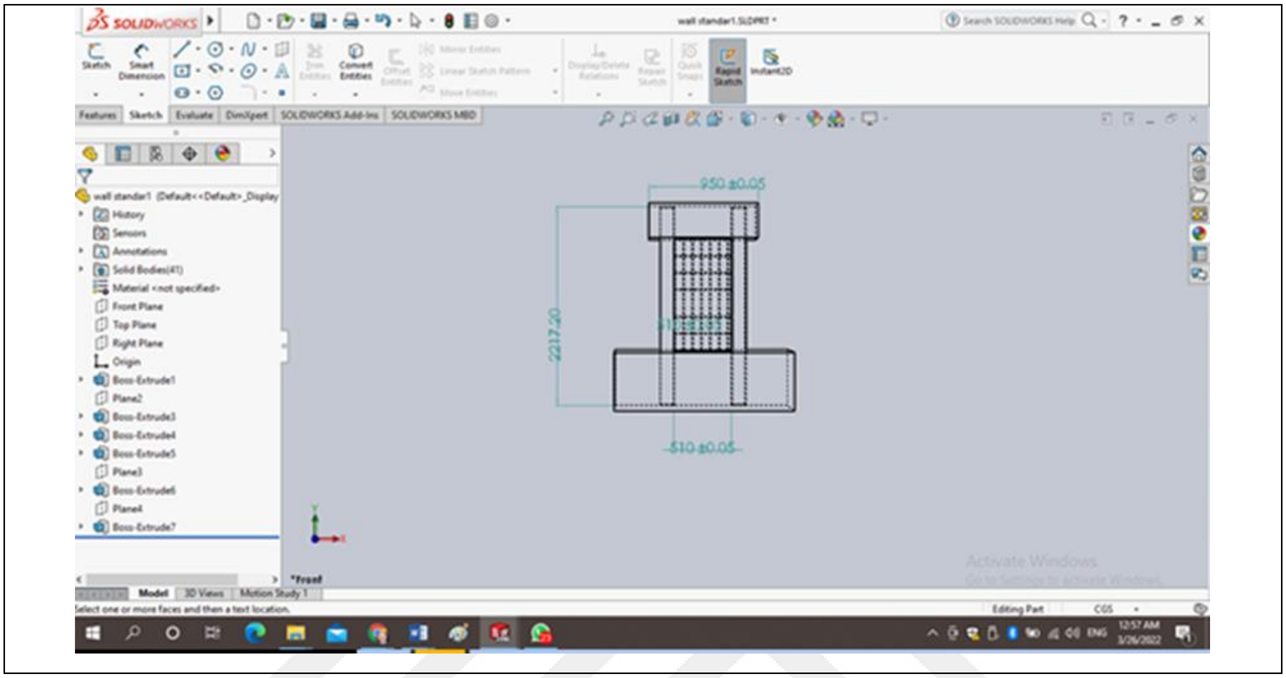

**Figure 4.1:** Shear Wall Dimensions' case 1

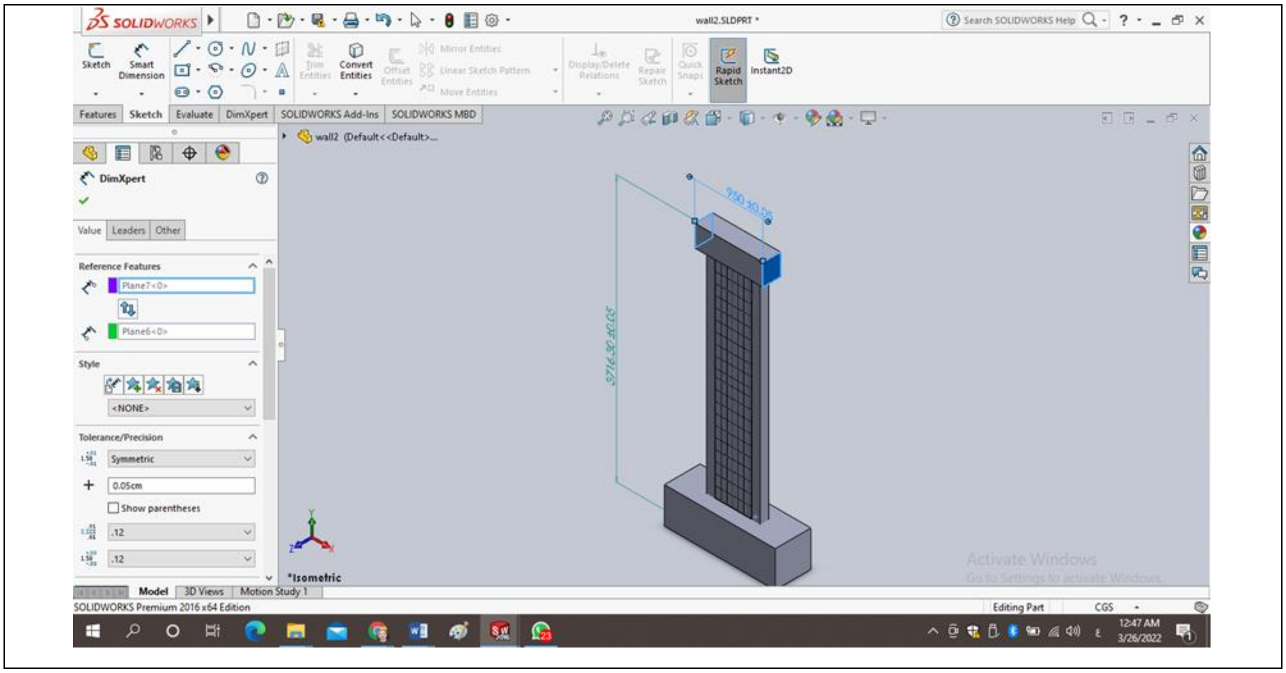

**Figure 4.2:** Shear Wall Dimensions' case 2

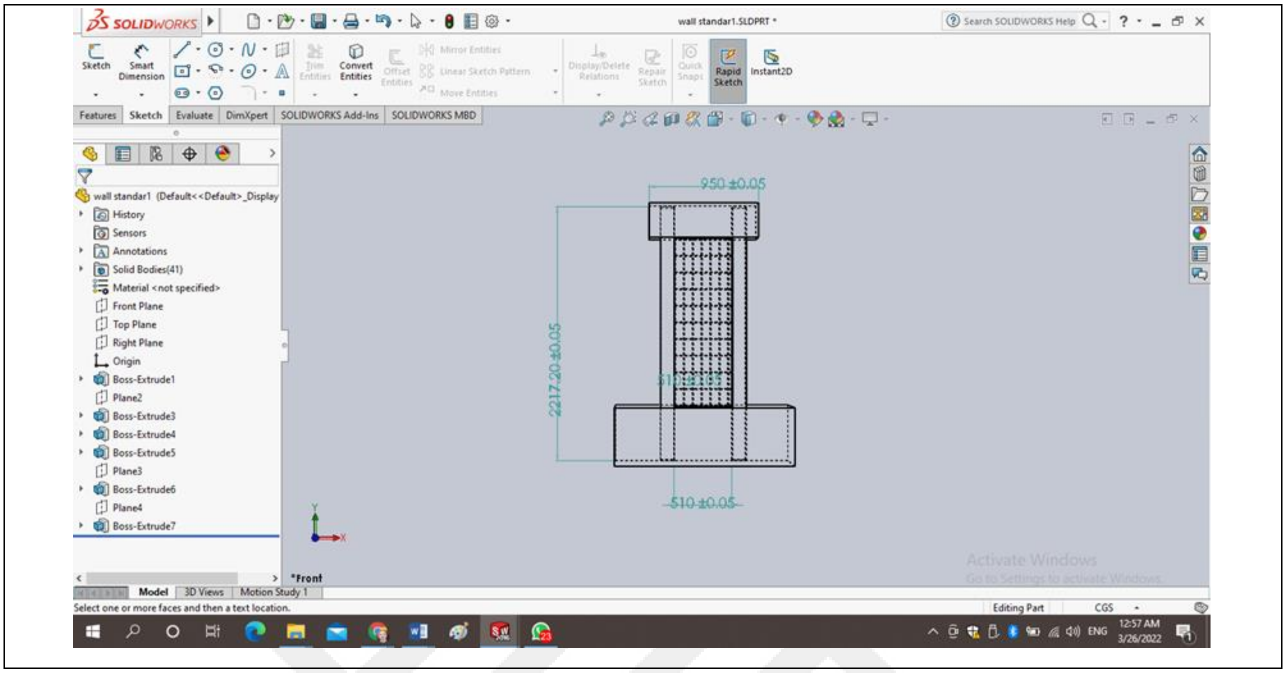


**Figure 4.3:** Shear Wall Dimensions' case 3

The properties of tested cubic concrete samples are shown in Table 4.2. Total of twenty-four test are suggested for investigation as in Table 4.2. The tests showed that steel-reinforced concrete gives greater resistance to compression than ordinary concrete under the same conditions as the cement mixture. The percentage of steel fiber was added based on previous studies, and the addition was 1%, which studies showed to be the best percentage that can impart high mechanical properties to the concrete mixture.

**Table 4.2:** Characteristics of the Tested Cubic Concrete Samples

| Test code | concrete conditions |
|---|---|
| JH 1-1 | Traditional concrete |
| JH 2-1 | concrete with steel |

The results of the two types of concrete spacemen can be shown in Figure 4.4 in sequent for all tested specimens. Also compressive strength results of each type are presented in Table 4.1.


**Figure 4.4:** Results of the Two Types of Concrete Space Sequentially For all Tested Samples

After conducting a laboratory test for two types of girl toys, the results showed that increasing the percentage of steel fiber by 1% increased the compressive strength reliability about 13.95% as shown in table 4.3.

**Table 4.3:** Properties for Reinforced and Concrete Compressive Stress.

| | |
|---|---|
| The 28 days compressive stress of concrete $f'_c$ (MPa) | 38.20 |
| The 28 days compressive stress of concrete with steel fiber reinforced (Vf:0.75) $f'_c$ (MPa) | 43.53 |

These information will be the input representation of AANSYS program and the drawn models saved in IGES form and imported to ANSYS program.

## 4.2 VERIFICATION AND VALIDATION

The study's validation and verification are presented in this part. Based on the test circumstances of a prior study, the concrete shear wall is modelled. The experimental data gained is used to validate the models in this work, as well as to select an acceptable model with a right model configuration and a suitable mesh technique that can be constructed and employed on the boundary condition of interest. The findings of all of this research show how to develop a correct model and also how to explain concrete Behavior based on the chosen model.

### 4.2.1 Model Validation

The validation approach compares the findings based on a particular chosen model to guarantee that the structural simulation model is developed in the proper circumstances and will be solved in a good representation of reality.

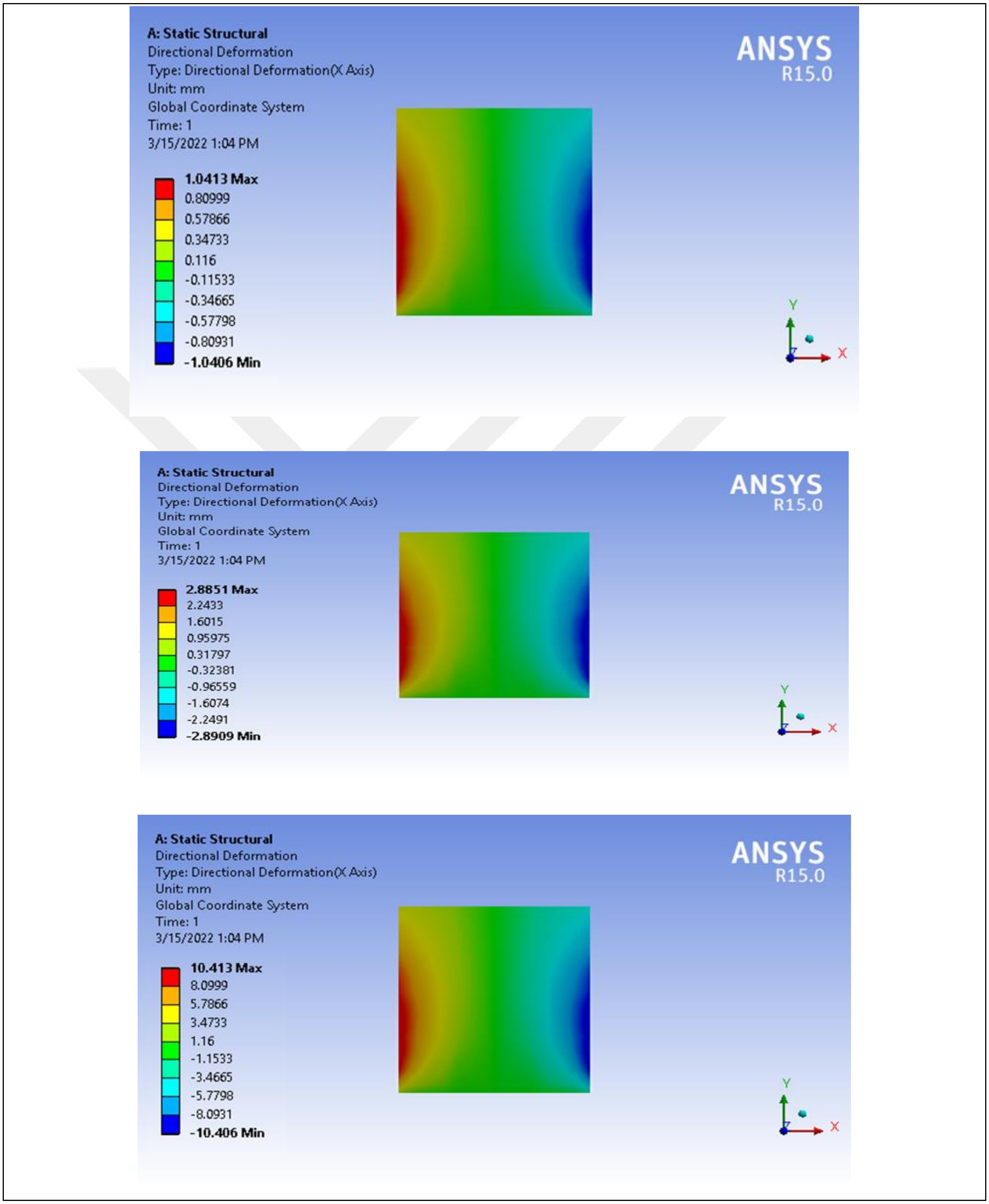


**Figure 4.5:** Static Structure Result

The researcher uses the results of laboratory experiments which is developed by Lefas et al, as a validation model and the experimental results have been performed by applying the horizontal loads on the shear wall in order to measure the deformation in the shear wall.

The numerical results of are compared with Lefas et al, presenyed in [51] results with horizontal load is applied as step (i.e. ratio from50 KN to 250 KN) to obtain and get results for deformation variation. The results of the FE analysis are generally consistent with the expected Behavior, namely that the deformation of a shear wall is a function of deformation increases.

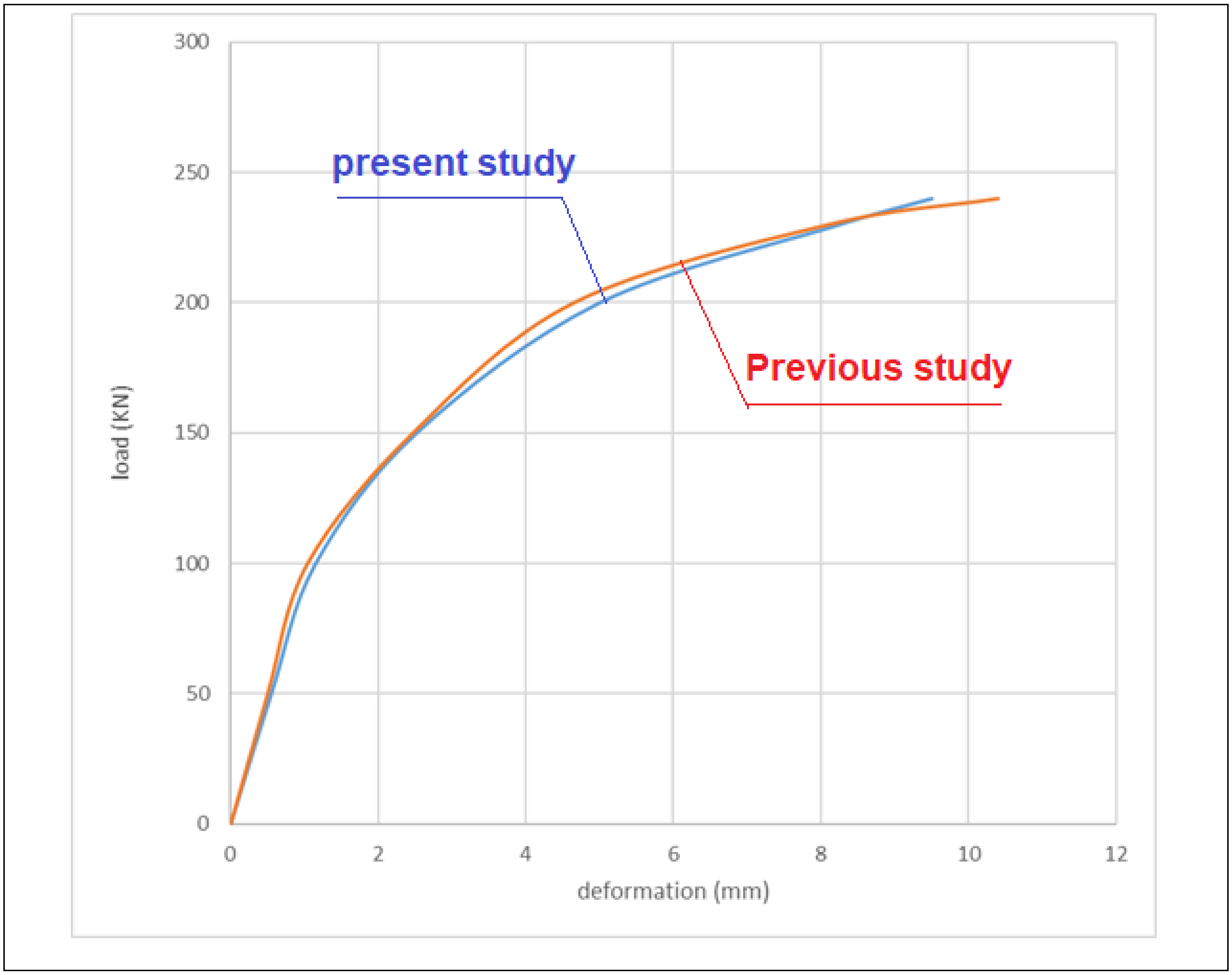


**Figure 4.6:** Plot the Test Results for both of Lefas et al, [51] with the Present Results

In any case, the FE method can accurately forecast the structural Behavior of shear walls sitting on elastic foundations, making it useful in professional engineering work. The proposed model may be used to shear walls on elastic foundations with any form of common boundary and contact unilateral circumstances or loading combinations. It is also possible to evaluate the impact of the environment on the settling of the shear walls.

**Table 4.4:** Comparison between the Present Study Results and Previous Study

| load(KN) | present study | previous study | error % |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 50 | 0.5 | 0.55 | 0.090909 |
| 100 | 1.04 | 1.15 | 0.095652 |
| 150 | 2.47 | 2.52 | 0.019841 |
| 200 | 4.65 | 5 | 0.07 |
| 230 | 8.1 | 8.25 | 0.018182 |
| 240 | 10.4 | 9.5 | 0.094737 |

### 4.3 SIMULATE HIGH RISE SHEAR WALL

The initial step of 3D modelling involves creating volume by dimensions for concrete body. Due to symmetry in both members' geometries, steel supports and reinforcements, will be modeled, which will be used with the FE analysis. This requires applying additional boundary constrains, perpendicular to the axis of symmetry.

### 4.3.1 Comparison between Load deformation Shear Wall

This section shows the typical load versus deformation characteristics of a concrete shear wall. The model deformations displacements are measured in the X-direction, at the center of the FE model, displaying Ux. The applied load is represented by the X-axis in kN, while the deformation is represented in mm. The load vs. displacement curve is used to compare solid and the shear wall findings with simulation results. Figures 4.7 to 4. 9 show the difference between a typical concrete shear wall and a steel-reinforced concrete shear wall in 3D FE Model analysis, and all load-deformation curves for the tested shear wall exhibit identical behavior. In comparison with the experimental values, all the FE numerical models approximately display large deformation at the ultimate stage.

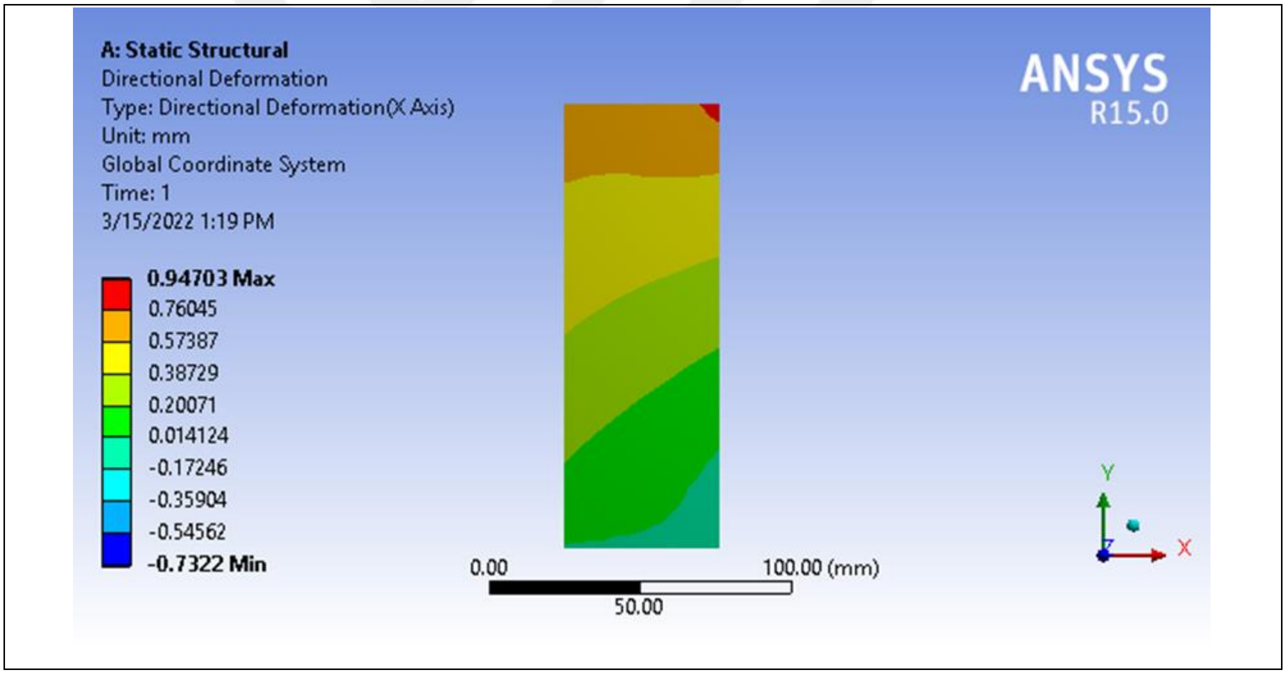


**Figure 4.7:** Load Effect on 10m Shear Wall Height

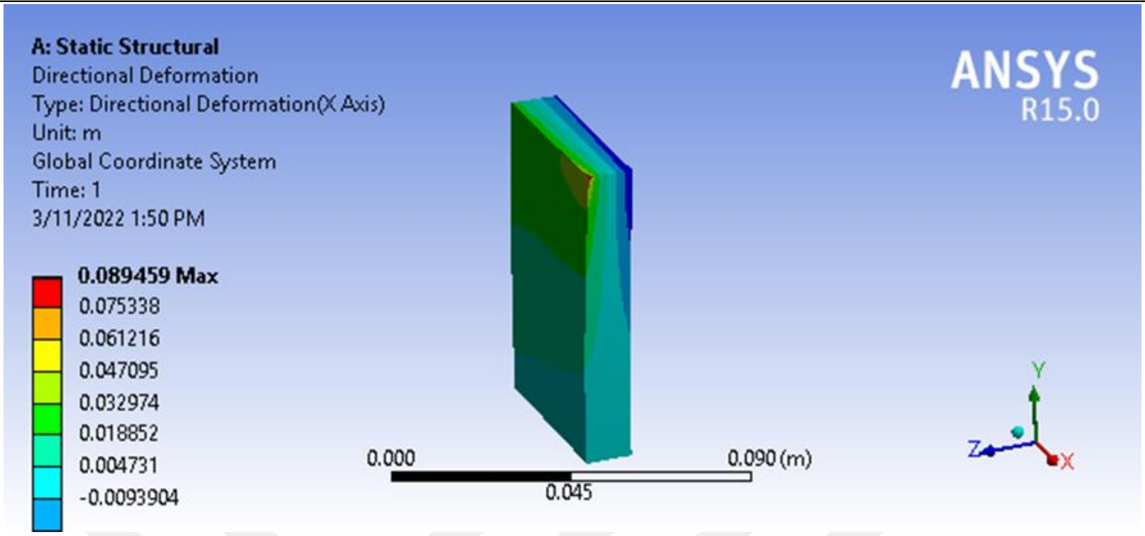


**Figure 4.8:** Load Effect on 5m Shear Wall Height

The load – deformation curves from the FE research 3D FE model shown in Figure 4.7. The load – deformation curves match well for both cases in FE analysis 3D FE Model, after which the FE analysis 3D FE Model deformations curve is bigger in case of 10 m deformations curves. The load – deformation curves from FE analysis 3D FE Model correspond well with the data recording from literature for the shear wall, as shown in Figure 4.9. The relationship of load – deformation is similar for both experimental, after which the deformations curves from FE analysis 3D FE Model become less than the deformations curves from experimental.

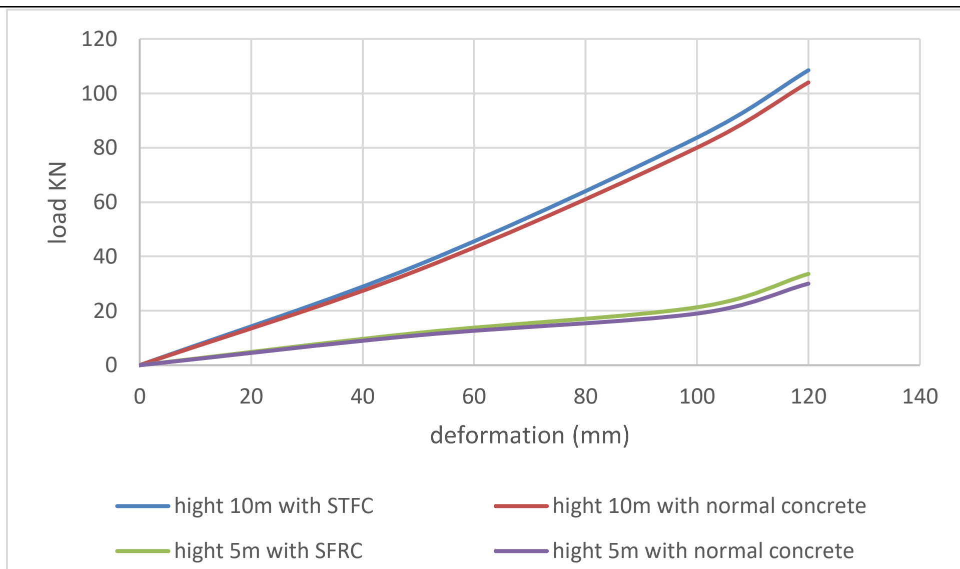


**Figure 4.9:** Numerical Results of Load Effect on Shear Wall Heights

### 4.3.2 Comparison between Load Deformation for Central of Shear Wall

The evenly distributed represents a load applied to the shear wall from the wall (represent foundation). To get and receive data for deformation variation with step applied load, the load is applied. a different thorough comparison between maximum deformations in two situations is provided in Figure 4.10.

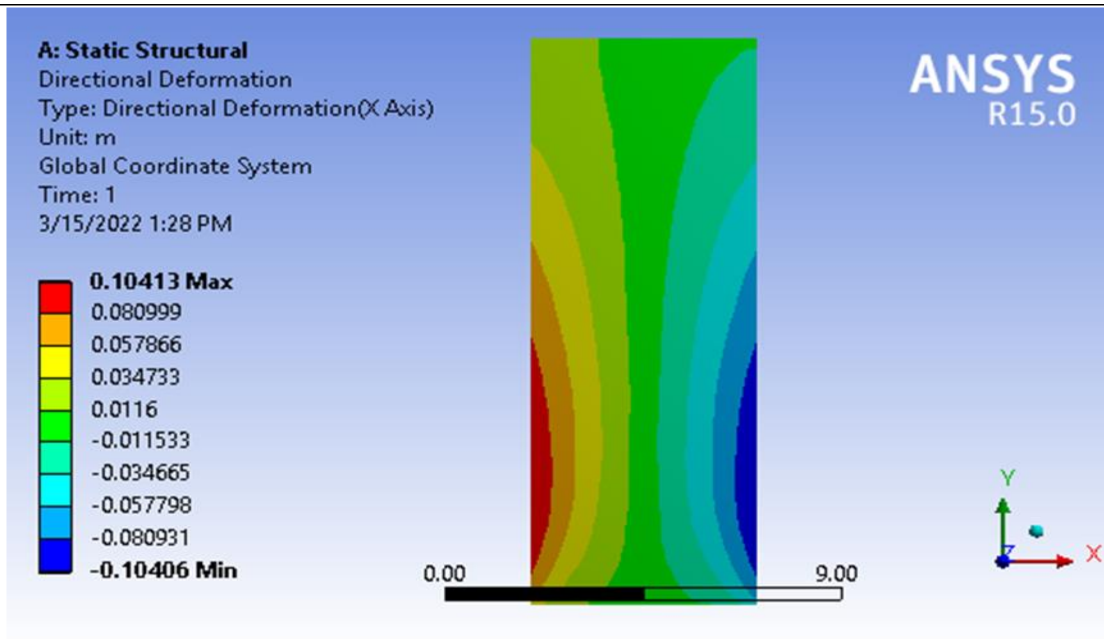


**Figure 4.10:** Eccentric Deformation of 10 m Height

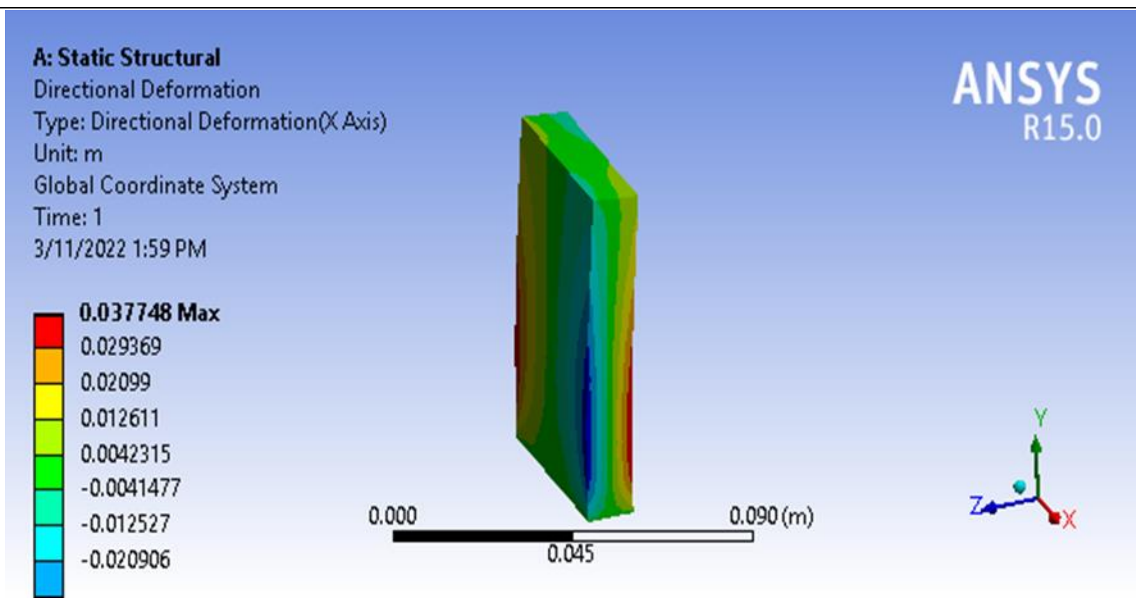


**Figure 4.11:** Eccentric Deformation of 5 m Height

The maximum deformation was observed at mid-span of shear wall at the center of the bottom face, which is on the lower side from the shear wall members. The centerline deformation from numerical model were compared with the experimental data are shown in Figure 4.12 separate detailed comparison between maximum deformations in two cases. Additional results generated by the FE are presented, and also observed that the difference between the maximum deformation results of lab test and FE numerical models ranging from about 10 mm and it is a good to a great extent.

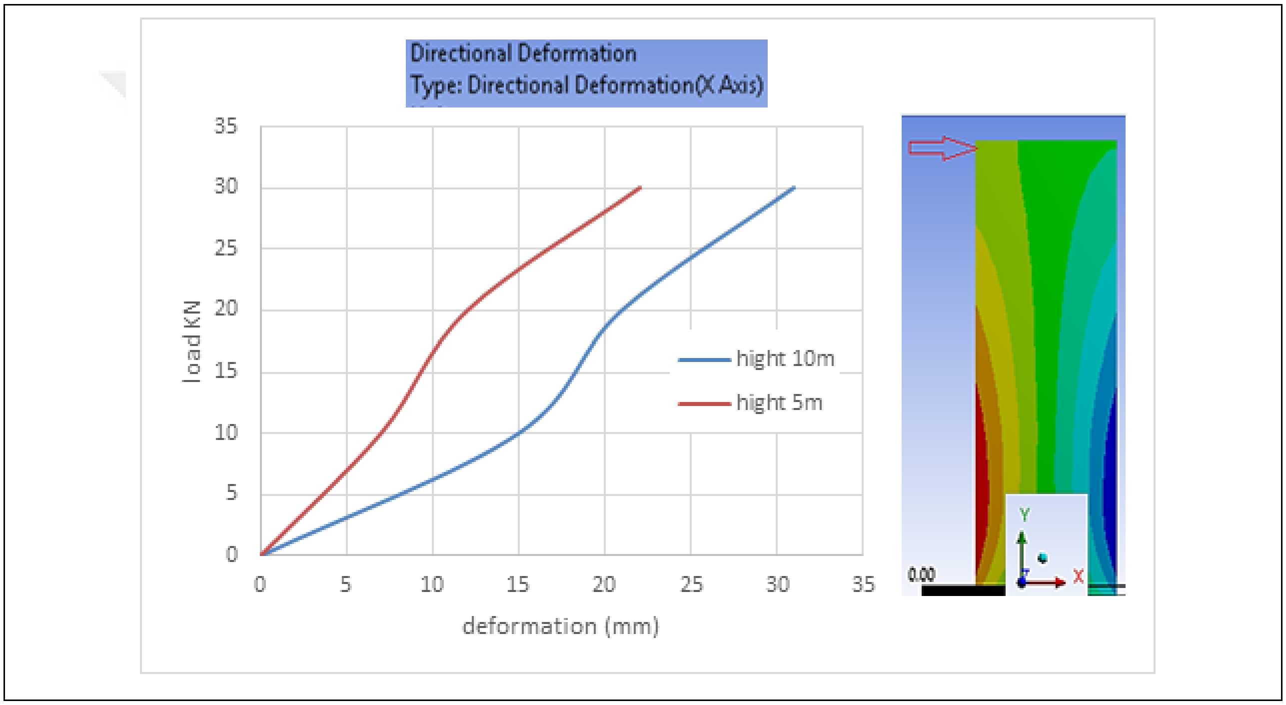


**Figure 4.12:** Numerical Results of Load Effect on Central Shear Wall Heights

The load – deformation curves for varying as shown in Figures 4.13 and 4.14. The results obtained from the lab test for the concrete shear wall matches extremely well with FE Models, and the Behavior of the numerical models in load – deformation curves was also observed. This is due to several elements at the forefront of precision at the simulation work and a suitable decision for the right density of meshing distribution. It is similar to the disposition of classic concrete reinforced shear wall and steel fibre reinforced shear wall shear walls. For both examples, the load – deformation curves are comparable, however the deformations curves from the FE model are bigger than the deformations curves from the experimental.

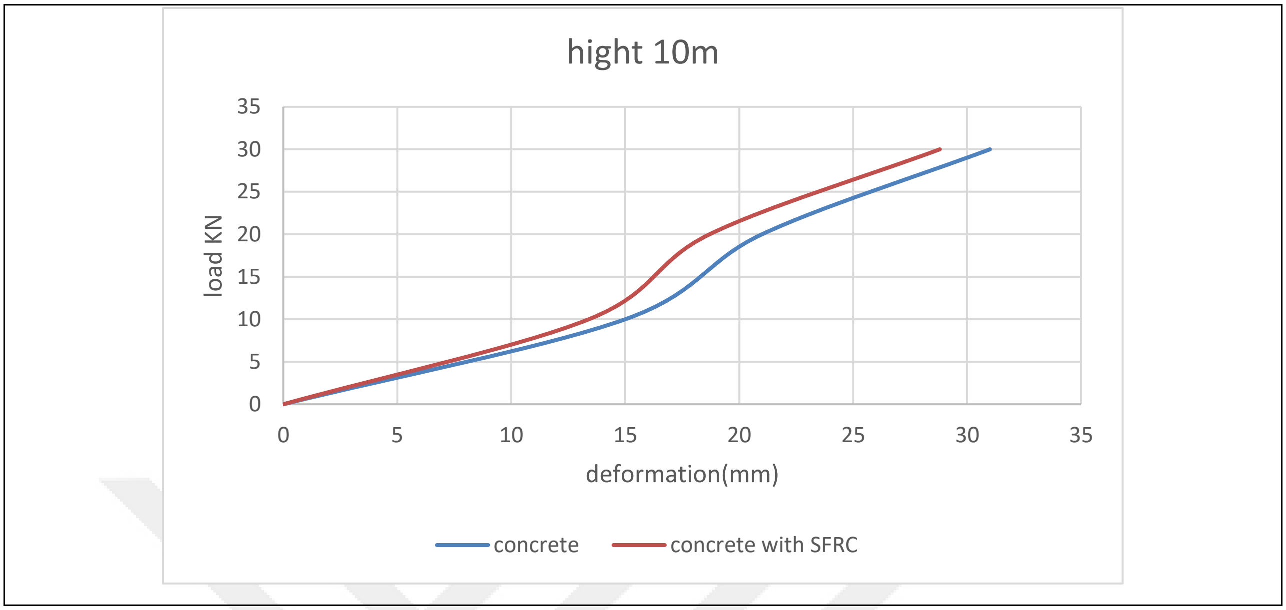


**Figure 4.13:** Comparison Results of Load Effect on Shear Wall Heights (10m)

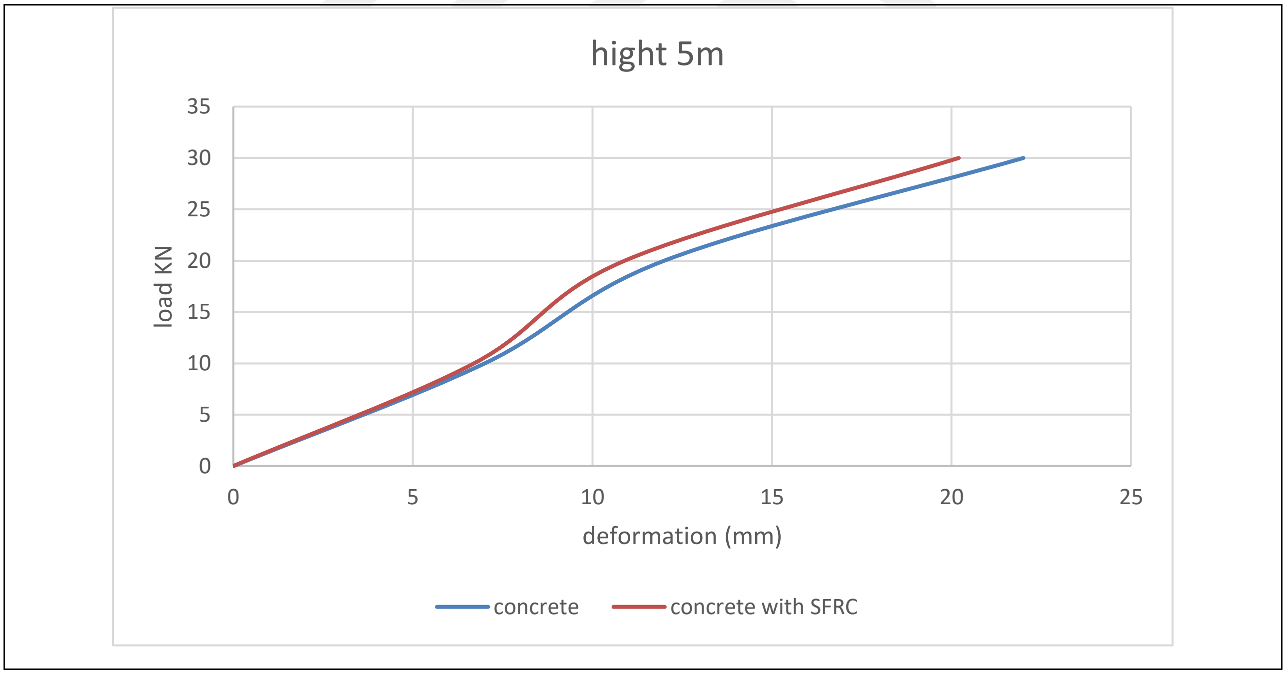


**Figure 4.14:** Comparison Results of Load Effect on Shear Wall Heights (5m)

# 5. CONCLUSION AND RECOMMENDATION

This chapter summarises the research methodology's accomplishments as well as efforts to fill research gaps. Using ANSYS software, this work presents a sequence of operations and conditions for processing a reinforced concrete shear wall case study. As the results indicate, the observed maximum horizontal load sustained by the wells tested exceeded, by a significant margin, the lower the values of horizontal load corresponding to either flexural capacity or shear strength. The evaluation of the differences between a concrete shear wall and a steel-reinforced shear wall is the study's essential contribution. The purpose of this thesis is to determine the deformation behavior of a shear wall when different loads are applied to it and it is exposed to varied subgrade modulus effects. The following concerns may be deduced from the current work:

a) The FE analytical tests carried out for the two cases studied indicate that the load-deformation response and the ultimate load's Behaviour in concrete shear walls are in agreement.

b) The optimum enchainment is obtained when the steel fibre added to the shear wall concrete with high load effect

c) The optimum enchainment obtained in booth short length and long shear wall length with the same enhancement behavior of adding the steel fibre.

d) The deformation values produced for all of the models were analyzed and found to be within the permitted limits. It was discovered that in the model with shear wall given as the outer walls, and the deformation is of importance in terms of structural stability and strength a. When comparing the findings, it can be observed that the lateral deformation values for the low-height structure with shear walls as the outside walls are lower than for the other models.

e) In an effort to push the frontiers of high-end structural applications, the usage of Steel Fiber Reinforced Concrete (SFRC) has gotten a huge boost in recent years. In general, concrete is characterized by brittle failure, which limits its application. This can be overcome by incorporating a small amount of short randomly distributed fibers (steel, glass, synthetic, and natural), which can be used to remedy concrete weaknesses such as low ductility, high shrinkage cracking, and low durability, among others. SFRC possesses outstanding tensile and flexural strength, as well as impact resistance, fatigue resistance, ductility, and fracture bridging properties. As a result, it has been used in a variety of building areas across the world. Steel fiber reinforced concrete (SFRC) is a heterogeneous structural material made up of traditional concrete parts supplemented with steel fibers for tensile strength. These fibers are discrete, discontinuous structures that are randomly dispersed and directed (nominally uniformly) throughout the concrete matrix. Depending on the application, SFRC can be used alone or in conjunction with traditional reinforcing bars. Because of the fiber reinforcing mechanisms supplied by fibers crossing the fracture surfaces, SFRCs have a higher post-cracking tensile residual strength. The quantity of fibers successfully spanning a fracture, their angle of orientation, and the bonding strength qualities of the type of fibers utilized all impact post peak tensile behavior.

## 5.1 FUTURE WORKS

In the ongoing research, the researcher recommendations are:

a) A new investigation for concrete material need for exposing the booth types on high temperature based on different shear wall design conditions.

b) To investigate the failure shape due to using steel fibers in the shear walls based on different load conditions.

c) Improving the mechanical properties and shear strength of shear wall by adding polypropline to the concrete.

d) Improving the mechanical properties and shear strength of shear wall by compbining polypropline with steel fibers to the concrete.

# REFERENCES


[1] Z. Deng, C. Xu, Q. Hu, J. Zeng, and P. Xiang, "Investigation on the Structural Behavior of Shear Walls with Steel Truss Coupling Beams under Seismic Loading," *Adv. Mater. Sci. Eng.*, vol. 2018, 2018, doi: 10.1155/2018/5602348.

[2] M. K. Rahman, M. H. Baluch, M. K. Said, and M. A. Shazali, "Flexural and Shear Strength of Prestressed Precast Hollow-Core Slabs," *Arab. J. Sci. Eng.*, vol. 37, no. 2, pp. 443–455, 2012, doi: 10.1007/s13369-012-0175-8.

[3] L. Xu *et al.*, "Experimental Investigation on Damage Behavior of Polypropylene Fiber Reinforced Concrete under Compression," *Int. J. Concr. Struct. Mater.*, vol. 12, no. 1, 2018, doi: 10.1186/s40069-018-0302-3.

[4] T. Terzioglu, K. Orakcal, and L. M. Massone, "Cyclic lateral load behavior of squat reinforced concrete walls," *Eng. Struct.*, vol. 160, no. October 2016, pp. 147–160, 2018, doi: 10.1016/j.engstruct.2018.01.024.

[5] G. Eslami and A. Rahai, "Experimental Investigation on the Behavior of Fiber Reinforced Lightweight Concrete Filled Double Steel Plate Shear Wall," no. August, pp. 149–151, 2018, doi: 10.5075/epfl-ICSS12-2018-149-151.

[6] A. Arabzadeh, R. Aghayari, and A. R. Rahai, "Investigation of experimental and analytical shear strength of reinforced concrete deep beams," *Int. J. Civ. Eng.*, vol. 9, no. 3, pp. 207–214, 2011.

[7] A. M. Mahmoud, "Finite element implementation of punching shear behaviors in shear-reinforced flat slabs," *Ain Shams Eng. J.*, vol. 6, no. 3, pp. 735–754, 2015, doi: 10.1016/j.asej.2014.12.015.

[8] Musitefa Adem Yimer, "Seismic Performance of Steel Fiber Reinforced Concrete Beam-Column Joints under the Variation of Column Axial Load," *Int. J. Eng. Res.*, vol. V9, no. 02, pp. 206–224, 2020, doi: 10.17577/ijertv9is020110.

[9] K. Holschemacher, T. Müller, and A. Fischer, "Effect of fibre type on properties of steel fibre reinforced concrete," *Mater. Exp. Maint. Rehabil. - Proc. 10th East Asia-Pacific Conf.*

*Struct. Eng. Constr. EASEC 2010*, no. August, pp. 383–388, 2006.

[10] Z. Li, M. Wu, J. Wu, Y. Cui, and X. Xue, “Steel Fibre Reinforced Concrete Meso-Scale Numerical Analysis,” *Adv. Civ. Eng.*, vol. 2020, no. 2017, 2020, doi: 10.1155/2020/2084646.

[11] F. Altun, T. Haktanir, and K. Ari, “Effects of steel fiber addition on mechanical properties of concrete and RC beams,” *Constr. Build. Mater.*, vol. 21, no. 3, pp. 654–661, 2007, doi: 10.1016/j.conbuildmat.2005.12.006.

[12] M. A. Qissab and M. M. Salman, “Shear strength of non-prismatic steel fiber reinforced concrete beams without stirrups,” *Struct. Eng. Mech.*, vol. 67, no. 4, pp. 347–358, 2018, doi: 10.12989/sem.2018.67.4.347.

[13] C. N. M. Faci, “Shotcrete for Underground Support XI CASE HISTORIES USING SYNTHETIC FIBER REINFORCED,” no. January, 2009.

[14] J. Bothma, “ISI2013-15. Literature Review on Macro Synthetic Fibres in Concrete,” *Univ. Stellenbosch, Inst. Struct. Eng.*, p. 20, 2013.

[15] S. Walls and S. V Venkatesh, “Structural Behaviour of Lateral Load Resisting Systems With Shear Walls,” no. August 2007, pp. 1–8, 2016.

[16] W. Bu, *Punching Shear Retrofit Method Using Shear Bolts for Reinforced Concrete Slabs under Seismic Loading*. 2008.

[17] Y. Singh, S. Singh, and H. Singh, “Effect of Steel Fibers on Strength of Concrete,” *Lect. Notes Mech. Eng.*, no. July, pp. 479–491, 2021, doi: 10.1007/978-981-15-4779-9_32.

[18] J. D. Chaitanya, G. V. S. Abhilash, P. K. Khan, G. Manikanta, and V. Taraka, “Experimental study on Steel Fiber concrete,” *Am. J. Eng. Res.*, vol. 5, no. 5, pp. 100–104, 2016.

[19] S. C. Paul, G. P. A. G. van Zijl, and B. Šavija, “Effect of fibers on durability of concrete: A practical review,” *Materials (Basel).*, vol. 13, no. 20, pp. 1–26, 2020, doi: 10.3390/ma13204562.

[20] P. Zhang, Q. Li, Y. Chen, Y. Shi, and Y.-F. Ling, “Durability of Steel Fiber-Reinforced

Concrete," *Materials (Basel).*, vol. 12, 2019.

[21] M. Husain, A. S. Eisa, and M. M. Hegazy, "Strengthening of reinforced concrete shear walls with openings using carbon fiber-reinforced polymers," *Int. J. Adv. Struct. Eng.*, vol. 11, no. 2, pp. 129–150, 2019, doi: 10.1007/s40091-019-0216-6.

[22] P. You, S. Song, H. Zhang, L. Zhang, K. Shi, and Y. Wang, "Shear Strength Prediction for SFRC Shear Wall with CFST Columns by Softened Strut and Tie Model," *Adv. Civ. Eng.*, vol. 2020, 2020, doi: 10.1155/2020/8824308.

[23] M. J. Tolou Kian and C. Cruz Noguez, "An experimental study on damage-resistant reinforced concrete shear walls," *6th Int. Struct. Spec. Conf. 2018, Held as Part Can. Soc. Civ. Eng. Annu. Conf. 2018*, pp. 77–86, 2018.

[24] E. Investigation, "Seismic Behavior of Steel-Fiber-Reinforced High-Strength," 2021.

[25] K. F. O. El-Kashif, A. K. Adly, and H. A. Abdalla, "Finite element modeling of RC shear walls strengthened with CFRP subjected to cyclic loading," *Alexandria Eng. J.*, vol. 58, no. 1, pp. 189–205, 2019, doi: 10.1016/j.aej.2019.03.003.

[26] F.-P. Hsiao, J.-C. Wang, and Y.-J. Chiou, "Shear Strengthening Of Reinforced Concrete Framed Shear Walls Using Cfrp Strips," *14th World Conf. Earthq. Eng.*, no. 1987, 2008.

[27] M. Harati, M. Mashayekhi, A. Khansefid, S. Pourzeynali, and A. Bahar, "Sharif University of Technology Nonlinear behavior of RC shear walls : From experiments to the field reports Mojtaba Harati University of Science and Culture Mohammadreza Mashayekhi Sharif University of Technology Ali Khansefid Saeid Pourzeynali Arash Bah," no. February, 2020, doi: 10.13140/RG.2.2.31639.52647.

[28] B. Bessason, "Capacity and Earthquake Response Analysis of RC-Shear Walls," pp. 1–14.

[29] A. A. A. B. U. Altemen, F. H. Arna'ot, A. A. Abbass, and M. Ozakca, "Punching Shear Behavior of Small SFRC Flat Plate," *ICOCEE-Cappadocia2017*, no. May, pp. 891–901, 2017.

[30] K. Soudki, A. K. El-Sayed, and T. Vanzwol, "Strengthening of concrete slab-column

connections using CFRP strips," *J. King Saud Univ. - Eng. Sci.*, vol. 24, no. 1, pp. 25–33, 2012, doi: 10.1016/j.jksues.2011.07.001.

[31] D. S, I. R. Mithanthaya, and S. V. Venkatesh, "Performance Based Analysis of Shear Wall with Flexible Soil Base," *Int. J. Sci. Res. Sci. Eng. Technol.*, vol. 4099, pp. 459–468, 2021, doi: 10.32628/ijsrset2183195.

[32] S. Gupta, S. Akhtar, A. Hussain, M. Tech scholar, and A. Professor, "Effect of Shear Wall Location on Bending Moment and Shear Force of Multistory Building Subjected to Earthquake Loading," *Int. J. Comput. Adv. Eng. Res.*, vol. III-Issue, no. Ii, p. 4, 2016.

[33] J. W. Wallace and A. Safdari, "Design of reinforced concrete structural walls," *11th National Conference on Earthquake Engineering 2018, NCEE 2018: Integrating Science, Engineering, and Policy*, vol. 3. pp. 1324–1328, 2018.

[34] K. Wang, W. Zhang, Y. Chen, and Y. Ding, "Seismic analysis and design of composite shear wall with stiffened steel plate and infilled concrete," *Materials (Basel).*, vol. 15, no. 1, 2022, doi: 10.3390/ma15010182.

[35] A. C. I. Committee, *ACI 318-14, Building Code Requirements for Structural Concrete and commentary*. 2014.

[36] M. A. Husain and O. I. Mahmood, "Comparative Study for Different Types of Shear Walls in Buildings Subjected to Earthquake Loading," *J. Eng. Sci.*, vol. 20, no. 2, pp. 358–367, 2017.

[37] A. F. Oan and N. G. Shrive, "Shear of concrete masonry walls," *11th Can. Mason. Symp.*, no. February, pp. 29–38, 2009.

[38] A. Astaneh-Asl, "Steel Plate Shear Walls," *U.S.-Japan Work. Seism. Fract. issues Steel Struct.*, vol. 1, no. February, pp. 1–12, 2000.

[39] M. He, "A Study of Wood Based Shear Walls Sheated with Oversize Oriented Strand Board Panels," pp. i-Xii;1-95, 1997.

[40] N. Eser and I. E. Bal, "an Overview of Modeling of Rc Shear Walls: Advantages and

Limitations,” *3rd Turkish Conf. Earthq. Eng. Seismol.*, pp. 14-16 October, 2015.

[41] J. Tarigan, J. Manggala, and T. Sitorus, “The effect of shear wall location in resisting earthquake,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 309, no. 1, 2018, doi: 10.1088/1757-899X/309/1/012077.

[42] P. Dhiman and A. Prof, “Effect of Different Shear Wall Configurations on Seismic Response of a Moment-Resisting,” vol. 7881, no. May, pp. 139–145, 2014.

[43] U. Islam and U. Abass, “Comparison of Storey Drift , Storey Displacement & Base Shear for Different Structural Systems,” vol. 9, no. 1, pp. 140–146, 2021.

[44] K. Kaur and B. Singh, “Seismic Analysis of Symmetric and Asymmetric Structures with and without Shear wall using Etabs software,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 889, no. 1, 2021, doi: 10.1088/1755-1315/889/1/012043.

[45] B. Di and X. Fu, “Seismic behavior of shear wall-frame systems considering foundation stiffness,” *Int. J. Struct. Stab. Dyn.*, vol. 17, no. 3, 2017, doi: 10.1142/S0219455417500419.

[46] L. M. Al-Shather, A. A. Ali, and H. M. Abed, “The Shear Behavior of Reinforced Concrete I – Beams With Polypropylene Fibers,” *Al-Nahrain J. Eng. Sci.*, vol. 20, no. 5, pp. 1040–1046, 2017.

[47] N. Z. Hassan and H. M. I. A. M. Salman, “Behavior of Fibrous Hollow Reinforced Concrete Beams,” no. June, 2018, doi: 10.14741/ijcet/v.8.6.13.

[48] S. Khosravi and M. M. Heydari, “Design and analysis of gravity dams by Ansys Parametric Design Language,” *Walailak J. Sci. Technol.*, vol. 12, no. 2, pp. 167–180, 2015.

[49] O. C. Zienkiewicz, “The Finite Element Method: Its Basis and Fundamentals,” *Finite Elem. Method its Basis Fundam.*, p. iii, 2013, doi: 10.1016/b978-1-85617-633-0.00020-4.

[50] H. M. Jassim and A. G. Anwar, “Experimental Study of Polypropylene Fiber-Reinforced Concrete,” *Int. J. R&D Eng.*, vol. 4, no. February, pp. 149–161, 2016, [Online]. Available: www.rndpublications.com/journal.

[51] Lefas, I. D., Kotsovos, M. D., & Ambraseys, N. N. (1990). Behavior of reinforced concrete structural walls: strength, deformation characteristics, and failure mechanism. Structural Journal, 87(1), 23-31.