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**FINITE ELEMENT MODELLING OF SHEAR CONNECTORS IN  
COMPOSITE STEEL BEAMS**

**M.Sc. THESIS**

**IN**

**CIVIL ENGINEERING**

**BY**

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**January 2022**



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COMPOSITE STEEL BEAMS**

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**Dawod Neamah HUSSIEN**

## **ABSTRACT**

### **FINITE ELEMENT MODELLING OF SHEAR CONNECTORS IN COMPOSITE STEEL BEAMS**

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**M.Sc. in Civil Engineering**

**Supervisor: Assoc. Prof. Dr. Talha EKMEKYAPAR**

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**72 pages**

This thesis discusses of the overall performance to behave the shear stud in the composite steel beam The work has been modeled by using ANSYS APDL program. Under of the influence of lateral horizontal pressure. The structure analyzed is the composite beam slab, beam section (254 X 254 X 73 kg/m) with slab (1600mm length 1200mm width and 150mm high) and 6 headed studs 19mm diameter with 100mm high Featuring a single row of pointed studs spaced at 150mm intervals. First the stud is placed 200mm from the end of the slabs on both sides. Headed studs and the value of the limited load are the most relevant dimensions for the aims of this study. One parameter was changed the change was in load value. The resulting composite steel was analyzed for each change in a parameter. The results were compared to those from the experimental, which revealed a possible alternate analysis that included the selected changes. It has also been studied the Von-mises stresses and Stress Intensity; it is found through structural analysis that there are stresses in area of the studs resistance to horizontal slips caused by lateral pressure loading. Four composite steel were evaluated at each parameter and would chick with other the factors. For this aim a software utilizing Parametric analysis using ANSYS. Language of Design (APDL) is constructed to examine the behavior of the structure.

**Keywords:** Composite Steel Beam, Finite Element, ANSYS, Shear Studs, Stress, Von-Mises

## ÖZET

### KOMPOZİT ÇELİK KİRİŞLERDE KESME BAĞLANTI ELEMANLARININ SONLU ELEMAN MODELLEMESİ

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Bu tez, kompozit çelik kirişte kesme saplamasının davranışına ilişkin genel performansı tartışmaktadır. Çalışma, ANSYS APDL programı kullanılarak modellenmiştir. Yanal yatay basıncın etkisi altında. İncelenen yapı, kompozit kiriş döşeme, kiriş kesiti (254 X 254 X 73 kg/m) döşemeli (1600mm uzunluk, 1200mm genişlik ve 150mm yükseklik) ve tek sıra başlıklı 100mm yüksekliğinde 19mm çapında 6 başlı dikmedir. 150mm mesafelerde saptamalar. İlk saptama, levhaların ucundan 200 mm uzağa yerleştirilmiştir. Başlıklı saptamalar ve sınırlı yükün değeri, bu çalışmanın amaçlarıyla en ilgili boyutlardır. Bir parametre değiştirildi, değişiklik yük değerindeydi. Elde edilen kompozit çelik, bir parametredeki her değişiklik için analiz edildi. Sonuçlar, seçilen değişiklikleri içeren olası bir alternatif analiz ortaya çıkaran deneyden elde edilenlerle karşılaştırıldı. Ayrıca Von-mises gerilmeleri ve Gerilme Yoğunluğu da incelenmiş, yapısal analizler sonucunda, yatay kaymalara karşı yanal basınç yüklemesinin neden olduğu saptamaların alanında gerilmeler olduğu bulunmuştur. Her parametrede dört kompozit çelik değerlendirildi ve diğer faktörlerle cıvıv olacaktı. Bu amaçla ANSYS kullanarak Parametrik analiz kullanan bir yazılım. Tasarım Dili (APDL), yapının davranışını incelemek için oluşturulmuştur.

**Anahtar Kelimeler:** Kompozit Çelik Kiriş, Sonlu Elemanlar, ANSYS, Kesme Saptamaları, Gerilme, Von-Mises

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I want to dedicate this achievement to my longing and belonging homeland Iraq,

To the my most precious thing I have in life most cherished 'Father and Mother',

To my life-long companion wife,

To my brothers who are my support in this life,

To all friends who have been there along the way,

I'm here to dedicate you this simple achievement.

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## **CHAPTER I**

### **INTRODUCTION**

When it comes to building construction, steel structures have a significant market share. They are often utilized in combination with precast concrete floors of various types. Precast concrete floors are expected to be used in 50 percent of multi-story steel frames by 2020, and the percentage is expected to be significantly higher in several building of the sectors, such as the hotels, residential the buildings, and parking garages, according to the International Precast Concrete Association. As an alternative to traditional "down stand beam" construction, precast slabs may be used in a "up stand beam" configuration (slab on top of beams) as well as a "up stand slab" configuration. It is possible to obtain wide spans between supporting beams by using precast units in both instances. The pre-cast units offer a level soffit and lengthy spans between supporting the beams by using pre-cast units in both cases. (Markham 2016)

Flatness is maintained across the whole floor area. Because of mechanical action the shear connectors, longitudinal the shear force is transmitted through the steel flange of the concrete slabs contact in steel concrete composite beams. The ability the shear connections to transmit these longitudinal the shear forces is governed by their strength, as well as the resistance of concrete slab to the longitudinal cracking produced by of the high concentration of shear forces. However, a majority of the research on composite construction has been concentrated on more traditional reinforced concrete and metal deck construction, with little information available on the shear capacity of precast hollow-core slabs with pointed studs. (Queiroz, Vellasco, and Nethercot 2007)

The composite action increases structural of efficiency by the combining structural components into a single composite-section. Construction of composite beam designs is less expensive since it requires less material, allows for deeper floor depths to be kept to a minimum, and is quicker to complete. Furthermore, when compared to non-

composite alternatives, this technology is well known for the stiffness and strength improvements that may be achieved. It is essential to consider the degree of connection and interaction that exists between of the steel section and concrete slab when developing the structural behavior and design of composite beams. In engineering, a "shear connection" is a connection between two components that is capable of withstanding all stresses applied to them. This is probably the most common occurrence; nevertheless, the widespread usage of beams in building construction over the past two decades has led in more instances when the interconnection is unable to resist the full force of the forces applied to it partial shear connection. In this case, the connection may be break in shear before any of the other components reaches their respective failure states. When the connection between the components is considered to be eternally stiff, the situation is referred to as full interaction in the context of composite beams at their serviceability limit. However, although this is often assumed in design, it is theoretically unattainable, and situations where the stiffness of the link is restricted (partial contact) must be addressed. Depending on the circumstances, the connection itself may flex, producing relative movement along the steel concrete contact and increased the shear deformation throughout the beam.

Since the mid-nineteenth century, composite steel concrete systems have been used in a variety of applications. Mechanical interactions between concrete components and steel sections are represented by connections, dents or bumps that are created either by friction or adhesion between the two materials. Typically, composite beams are constructed from a steel section (typically "I" shaped), which is situated in the majority of the tensioned zone, and a concrete slab, which is located in the majority of the compressed zone. They are metal devices that allow mechanical binding to be accomplished. Significant functions of shear connections include enabling slab/beam new the material joint operations, limiting longitudinal the slip and of the vertical displacements of interface components, and taking shear loads. Integrating steel and concrete in this way makes it possible to reap advantages of both the materials functioning in concert. Thus, from the viewpoint of material strength, it is possible to utilize steel sections to support tension loads while concrete is used to support compressive pressures. In addition to greater structural stiffness and reduced structural sections, this combination also results in a lighter foundation design, better material performance, and cheaper construction costs.

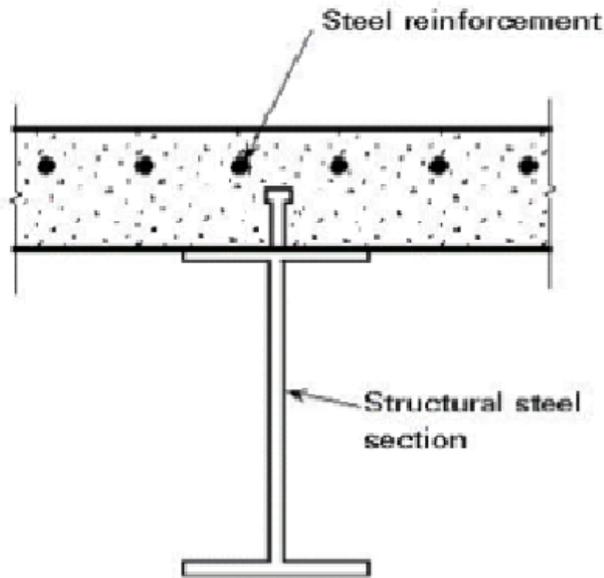
## 1.1 Composite Beam with Shear Connector

Composite structures, which are made up of the concrete slabs and rolled steel-sections, are often used as structure components in (bridges and high rise buildings), among other things. Shear connectors are used to join the concrete of slab and steel segment together, resulting in a composite action.

An example of a composite beam is one that is constructed by placing the concrete of slab on top of a steel or concrete and connecting the two with shear connectors. Composite beams are used in bridges and high-rise structures and are often composed of concrete. Slab and beam the constructions are often used in the building of bridge and other structures.

This contact is made possible by the use of a shear connection, which is welded to the top of the flanges of the steel-beam. The slip between the beam and the concrete of slab may be minimized by utilizing an appropriate connection between the two elements of the construction. Consequently, the steel beam and slab combine to form a "composite beam," which is similar to a monolithic T-beam in appearance and function. While concrete is more resistant to buckling when compressed than when tensioned, steel is more susceptible to this phenomenon when compresses. Our ability to use their individual advantages is increased as a consequence of their combined activity. (Anju and Smitha 2016).

The composite beam often displays partial composite behavior as a consequence of slip deformation occurring at the interface of the beam. By virtue of the pre-stressing effect, external axial loads are applied to composite structures that have been pre-stressed, and the axial effect that is generated changes the interfacial slip behavior of the composite beams. An example of a composite beam is shown in Fig. 1.1, which is composed of the concrete slab, steel I section, and shear connections of the stud type.



**Figure 1.1** The composite of structure with the shear stud connector (Anju and Smitha 2016)

## 1.2 Advantages of Composite Beam by Using Precast Concrete

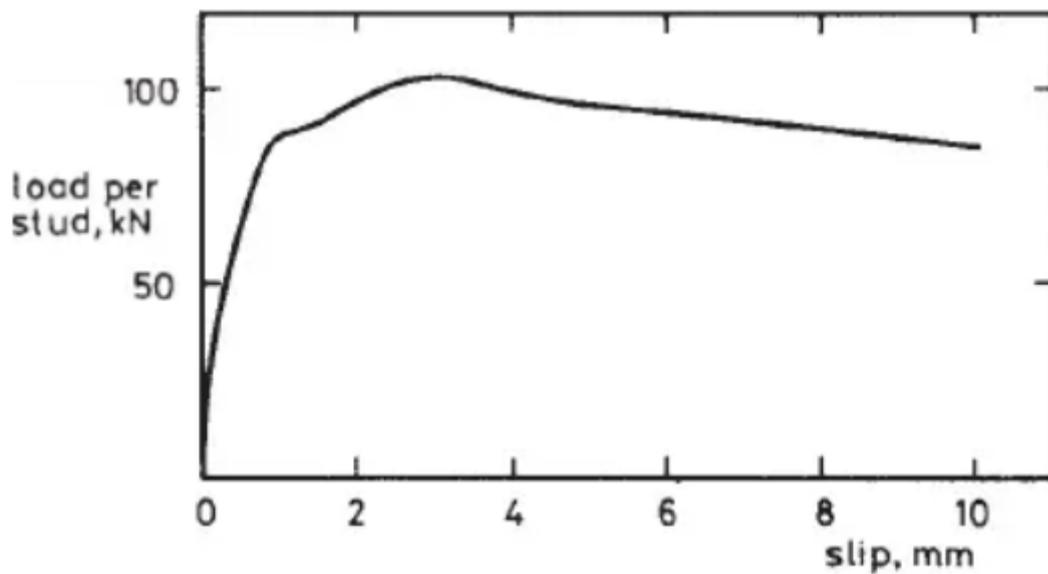
Because they are both manufactured rather than assembled on site, there is a synergy between the usage of the concrete modules and steel structure. Also share factory production quality control as well as precision and dependability. (Stephen James Hicks and Lawson 2003) Some of the benefits of utilizing the components in composite application include the following:

- When comparing composite applications to non-composite applications, it is possible to decrease the weight and depth of the steel parts. Consequently, the cost of booth steel was decreased, as was the overall height of the structure as a consequence.
- The number of secondary the beams able to reduced when compared of standard composite beam, where secondary beams spacing are dictated by the spanning capabilities the composite deck slabs. This results in the use of less steelwork and, consequently, a faster steelwork erection time than with standard composite beams.
- Pre-cast concrete materials and steel beam of sizes are available in range of shapes and dimensions.
- It is necessary to build a level soffit between two different down-stand the beams (which can be aligned with the walls).

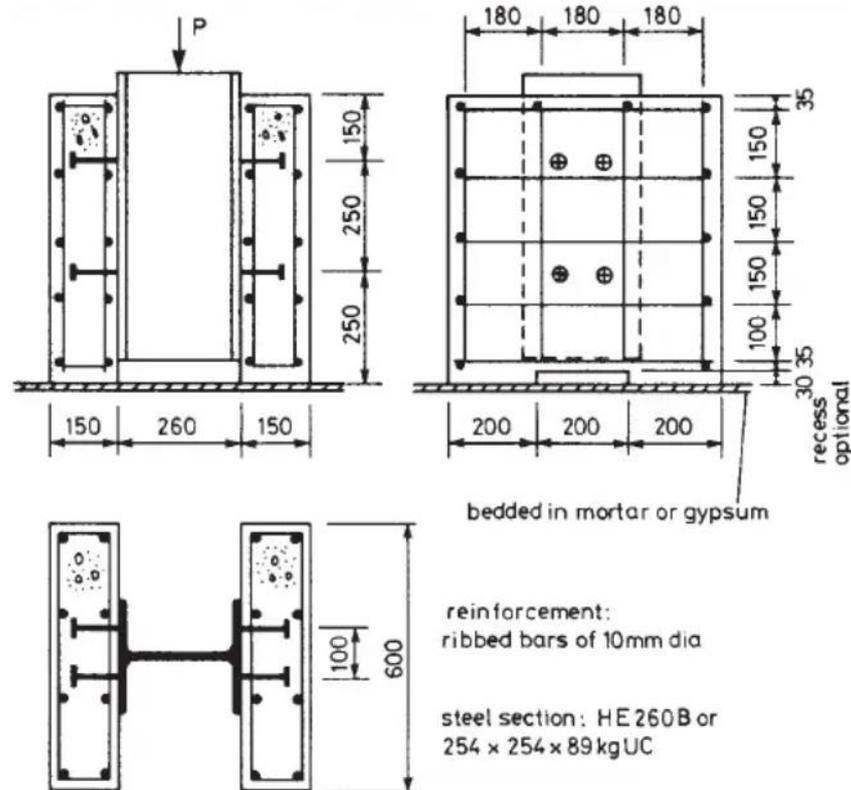
- It is possible to have shear connections shop-welded before they are delivered to the work site (i.e., fewer site operations).

### 1.3 Properties of the Shear Studs Connectors

Relationship between of the shear force the transmitted ( $P$ ), and of slip at interface ( $S$ ), is most essential characteristic of a shear connection when it comes to designing it properly. In an ideal world, this load slip curve would be found via tests on the composite beams but in practice the simpler specimen is needed to do this task. In order to get a better understanding the connections, several different types of (push-out) and (push) experiments have been conducted. Flanges on short length of steel I section connect two tiny concrete the slabs together to form a larger structure. Figure 1.3 depicts the specifics of the typical push-test according to EN1994-1-1 specifications.



**Figure 1.2** Typical slip load curve with D, 19 mm, studs in the composite slab.  
(EN1994-1-1 specifications)



**Figure 1.3** Standard push test according to EN1994-1-1 specifications.

They are placed on the bottom platen the compression test machine or the frame and upper end of steel section is loaded with a slab on top of them. The average slip between a steel a member and two the slabs is a measured at a number of locations and average the slip is plotted against the load applied to the connection at each location. Figure (4) shows the typical slip load curve derived from the composite slab test, (Mottram and Johnson 1989) which may be seen in the background. In practice, designers often select shear connections for which the design strengths have already been established, since performing adequate testing to determine the design strengths for a new kind of connector is time-consuming and prohibitively expensive. A thorough specification of the test is required due to the fact that the load slip relationship is affected by a variety of factors, including temperature, and that reliable results must be obtained.

- The number of connections in a specimen used for testing.
- This term refers to the mean longitudinal tension in concrete that is present around the connectors.

- Construction of stud connections and placement and strength of slab reinforcement in close proximity to the connectors are all important considerations.
- The thickness of the concrete that surrounds the connections' perimeter.
- Because each slab's base has the potential to move laterally, the connections will be subjected to uplift pressures as a consequence of the shifting.
- Form a bond at the steel concrete intersection.
- Concrete slab's compressive strength is measured.
- The degree to which the concrete around the base of each connection has been compacted

It is provided with the information in figure 1 that the criteria for items 1 to 6 have been established. 2. The amount of reinforcement needed, as well as the size of the slab, exceed the requirements of the British standard test, which has remained almost unchanged since its introduction in 1965. When using the Eurocode test, the findings are less affected by slab splitting, allowing for more accurate predictions of connection behavior in beams. (Roger Paul Johnson and Anderson 2004) A range of concrete strengths must be tested since the strength of the concrete has an effect on how it fails as well as how much force it takes to get it to fail.

#### **1.4 Welding of Shear Connectors**

Due to the high electrical power required, larger diameter stud shear connections (22mm or 25mm) are often only welded in factory. However, smaller diameter stud shear connections (14mm or 19mm) are possible to be welded on the job site. Nowadays, the majority of shear connections are welded together in a factory.

They must be tall enough to protrude above the planks or the hollow core unit's reinforcement, enabling for composite the action with the in-situ concrete to be seen. There should be sufficient the space around studs for appropriate concrete installation since the distance between the ends of the precast units has an effect on their shear resistance. The studs may be adjusted by up to 10 mm in either direction relative to steel-beam from the location indicated on drawings or stated in specification, depending on the application.

In order to do on site welding, a generator is used in combination with the local control unit. In order to allow the welding gun between concrete units, a minimum gap of 65 mm between the concrete units is required. When welding on the site the top flange of beam should be unpainted and free of moisture, dirt, and mill scale to ensure proper welded. Manufacturing should take place in-house, particularly if the beam will be galvanized or painted before being transported to the work site. Despite the fact that the top of flange the beam must be completely free of all the coatings before of the shear connections may be welding, it isn't necessary to remove galvanized or painted coating from of the shear studs' connectors.

## **1.5 Methods of Shear Connection**

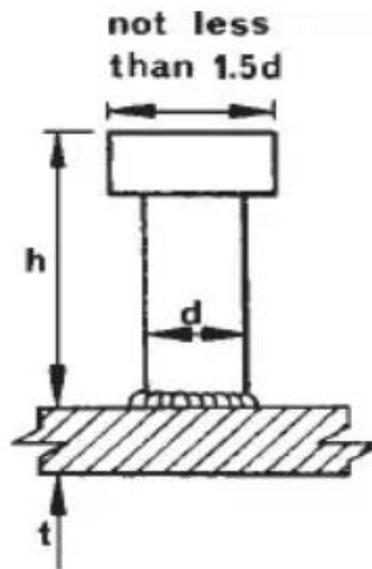
### **1.5.1 Shear connections for profiled of the steel sheeting**

It is often using as permanent the formwork for the construction of floor the slabs, which are well known to as composite slabs because of the way they are constructed. Given the impracticality of welding shear connections to materials less than 1mm thick, shear connections are provided by the pressed or rolled dimples that extend into concrete or by giving the steel profile reentrant form that prevents steel profile from being detached from concrete. (Roger P Johnson 2018)

### **1.5.2 Shear connectors**

The stud is the generality widely used type of connection on the market today (Fig. 1.5). Although lengthier studs are sometimes utilized, most of these studs are between 13 and 25mm in diameter and 65 to 150mm in length. For example, studs with the minimum ultimate tensile the strength of  $450\text{N/mm}^2$ , and minimum elongation of 15 percent are required. They have the advantages of being fast to weld, interfering with minimal reinforcing in concrete slab and being equally strong and the stiff in the shear in all the directions normal to a stud's axis. They are also available in many sizes and shapes.

studs are affected by two factors that determine their diameter: The first is the welding techniques, which become more complex and expensive as the diameter reaches 20mm, and the second is the thickness, which is denoted by the letter  $t$  in the formula.



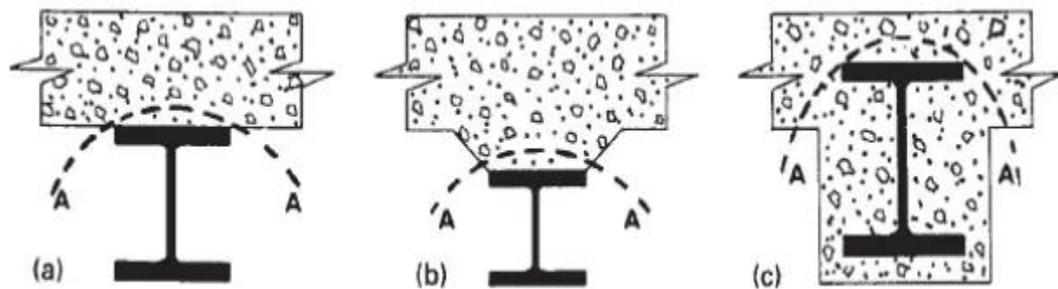
**Figure 1.4** Headed stud shear connector. (Roger P Johnson 2018)

### 1.5.3 Bond

The bulk of concrete reinforcement was made up of smooth mild steel-bars until widespread use of deformed bars gained popularity. Bond or adhesion at a concrete-steel contact was believed to be responsible for the transmission of the shear stress from steel to the concrete. Because of the resemblance to reinforced concrete, shear connections are not needed when the steel component of the composite part is enclosed by reinforcement concrete, such as in an encased beam (Fig. 1.8 (c)) or an encased stanchion (Fig. 1.8 (d)). Because of the parallelism with reinforced concrete, shear connections are not needed. This has been shown in testing on encased stanchions and filled tubes where bond stresses are usually low, as well as in tests on encased beams in the elastic range. To account for uncontrolled effects like concrete shrinkage, poor adhesion to the steel surfaces at the bottom, and stresses induced by temperature variations, it's critical to maintain bond stress low in the design.

The majority of composite beams shown in Fig. 1.8 have cross sections of type (a) or (b). When such beams are subjected to low-load tests, it is discovered that the majority of longitudinal shear is transmitted by the bond at the interface, but that the bond fails at high pressures and cannot be restored. As a consequence, in design calculations, bond strength is considered to be zero and, in the research, the connection is intentionally destroyed by greasing a steel flange before the concrete is poured. In uncased beams the more feasible kind of the shear connection is a dowel welding

to top flange of steel section and then surrounded by in-situ the concrete when a floor or the deck slab is constructed.



**Figure 1.5** Typical Cross Sections for Composite Beams. (Roger P Johnson 2018)

### 1.6 Finite Element Models (FE)

It's potential to utilize finite element (FE) simulations in combination with experimental study to evaluate the behavior of the shear connections in a composite the beams with a profiled sheeting if the findings of simulations are properly verified against those of the experiments. There are complex interactions between the concrete slabs, profiled sheeting's, wire mesh's, shear studs, and steel beam that must be taken into consideration. It has been challenging to accurately model the behavior of headed the shear studs in the composite beam with profiled sheeting in the computer simulation. In all previous numerical analyses, the premise has been established that the concrete slabs and profiled sheeting's nodes, will maintain their connection throughout the study, ignoring the effect of the concrete slab separation from the profiled sheeting, which in direct conflict with the results of the push test experiment. Delamination of steel-deck from a concrete of slab is a common occurrence after a failure. (El-lobody 2002)

In order to do this, the basic idea is to make use of ANSYS, a computer tool that employs Finite Element Method (FEM). A partial the shear stud connection will reduce the overall stiffness and strength of the structural system, while perhaps improving its ductility at the same time. Non the laboratory, tests are well-known for taking a long time and spending a lot of money, as well as for being infeasible in certain circumstances. Recently, however, the (FEM), has developed as the strong and useful a tool for study the broad variety of the engineering problems, particularly those involving structural analysis. With the use of a comprehensive (FEM), it is possible to

substantially decrease a number the trials. In every structural of a system, however, the experimental phase is essential to a full understanding of the system. When investigating a specific structural phenomenon, experimental and numerical/theoretical investigations must be conducted in tandem, with the understanding that the numerical models should be based on accurate tests findings and vice versa. Numerical techniques have previously been used to the study of behavior the composite beam in the past. Although most of these models are a based on two dimensional analytical of models, they are unable to simulate additional the complex aspects of behavior that required for three-dimensional study, such as the full of distribution the stresses and strains across an entire section of the structural components, (steel beams and concrete slabs), crack evolution and local deformation within of concrete slabs. The shear connections were also considered to be evenly distributed throughout a composite component in the model presented by, which was further supported by experimental evidence. For each load step, El-Lobody and Lam built a three-dimensional (FE) model using the ANSYS software tool, in which they identified the mode of the failure the beams by doing manual of check on the compressive of concrete stress and studs forces. Despite this, the suggested model for the composite beams with solid slab, was verified using just two beams, which was a significant improvement. This research was entirely focused with the presentation and validation of the models that were used; however, these models were never used to investigate the impact of certain structural features or other elements of system behavior in more detail. Papers on (FE), analyses of the composite systems have just lately beginning to incorporate research parametric, which is a very new development (e.g., investigation into behavior the individual of shear connectors). The component portions of finite element models must be accurately represented, suitable elements must be used, and acceptable solution methods must be used so as to get reliable the results up to and including failure. Because composite beam shows significant Non-linear effects it's essential that interaction of different component, as well as the interface behavior, be well understood before further development can begin. Once the model has been thoroughly tested and verified, it may be utilized to the investigate specific aspects the behavior in additional detail. Example: It allows researchers to investigate the relationship between response sensitivity and changes in key component factors such as material quality and shear stud design. As a consequence, various spacings may be employed in different areas of the beam, allowing for the

investigation of partial interaction effects in each zone. It is the goal of the present study to simulate composite beam with full and the partial of shear connections used the ANSYS computer simulation software. Three dimensional models represent all of the main structural variables as well as their related nonlinearities and nonlinearities (steel beams, concrete slabs and shear the connectors). It's verified using test data and the numerical data from literature to show that the model is capable of dealing with simply supported system with I beams and solids flat slab, among another things. (Patil and Shaikh 2013).



## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Previous the research on behavior of headed shear stud connectors in the composite beam with or without profiled steel sheeting is critically reviewed in this chapter, which also contains numerical and experimental investigations on behavior of headed shear stud connectors in composite beam with or without profiled steel sheeting (composite beams). A goal of this the literature review is to draw attention to knowledge gap in steel structures by presenting the most recent contributions of research on composite beams.

#### **2.2 Previous Studies Survey**

Shear connections are using to connect the solid concrete slab to the steel beam in the oldest kind of composite beams application. When headed studs were first introduced onto the market, channel connections were extensively utilized in the construction of bridges and buildings. It was (Ollgaard, Slutter, and Fisher 2010) who were the first to the evaluate of shear capacity the headed stud. To do this, 48 'small scale' pushout specimens with the solid concrete slab were cast and tested, and the results were published. When designing the studs, it was important to consider their diameters (16 and 19 mm) as well as the quantity of studs per slab. The aggregates used in normal weight concrete and light weight concrete are two different kinds. Significant concrete features include the strength the concrete and its density. Modulus of the elasticity and split of concrete are also important. Concrete strength, density, modulus of elasticity, and split the tensile strength are all factors to consider. As a result of implanting the headed studs in light-weight concrete, test results of revealed a significant reduction in shear connection resistance from (15to25 percent), leading to the conclusion that shear stud of capacity was primarily controlled by the modulus of elasticity and concrete's compressive strength. In addition, it was

discovered that cross sectional size of the studs was a function of shear the strength in testing. The following experimental equation for estimating the shear of capacity the headed studs implanted in solid concrete slab was established as a result of this research for structural design purposes.

As ribbed steel decks are used in the composite beam, it has been discovered that the shear ability of headed studs is reduced when compared to when they are embedded in the solid slabs. The reduction factor techniques, were used to show the relationship between the shear connection resistance in solid slabs and that in the composite steel deck, respectively (Robinson1967) developed this technique, which states that shear of capacity the stud with ribbed steel decking a determined by the rib deck geometry, which is the ratio of average rib width of the rib height, However (Fisher 1970) was the first to develop a relative correlation based on the results of tests conducted on composite beams with ribbed steel decking.

If profiled steel decking is utilized in the primary composite beams, it would be placed parallel to the steel beams in the primary composite beams. Thus, headed the studs would-be subjected to pure of shear in the same way as they would be exposed to shear in solid slabs, and vice versa. As a result, the presence of decking prevents the headed studs from reaching their maximum shear strength, resulting in a reduction in shear connector of resistance. This is because, in a case of the composite beam with parallel decking, the mesh reinforcement is the located close to head of the studs where it's less effective. The mesh reinforcing, on the other hand. The beam is positioned near to the root of studs, where its efficacy in restricting splitting failure of the concrete slab is realized, as is the case with the composite beam with a solid's slabs. As a result, the development of a relative formula to estimate of shear the capacity of a stud in the parallel steel decking was a logical extension of research. According to, (Grant, Fisher, and Slutter 1977) the empirical reduction factor established for stud connections with parallel decking was also shown to be relevant to these connectors.

The composite construction utilizing steel beam and pre-cast HCU slabs, there was only a limited quantity of published information available. Studies on composite of construction utilizing steel beam and pre-cast concrete slab have been found and they will be discussed in more depth later in this section. (Moy and Tayler 1996) A total of 27 push-off experiments were conducted in 32 for determine of the shear strength the

headed studs in solid precast concrete boards. A long-term shuttering system for the in-place concrete was provided by the prefabricated panels. A 65mm depth and 50mm bearing breadth were provided by the precast boards on the steel beam flange. There are 533mm of length on the item. a 92kg steel beam measuring 210mm in depth and 210mm in width was used, with two studs soldered to each flange, was used to support the structure. In this case, the diameter the headed of stud was 19 mm, and the length employed varied from 95 to 120 mm. In-situ of concrete was used to the fill in remaining 150mm of slab's height. This specimen, which was developed by Moy & Tayler, with its specifics. In this study, typical load slip curve for the 19 mm stud was developed, and it was discovered that when the volume of in-situ concrete decreases, strength of connection decreases. In situ concrete should be at least 100mm broad on the flange, according to the advice of the engineers. Another suggestion was that two the layers of reinforcing be put in a slab to prevent the concrete from breaking.

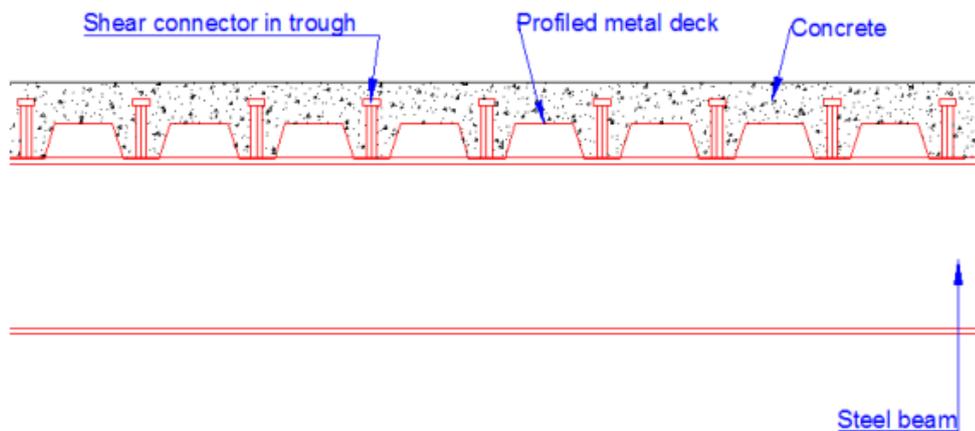
Standard push-test method is intended for use with the composite beam and pre-cast hollow-core slab to the determine of shear capacity the headed shear connections. (Lam 2007) In order to validate a testing method and show that new the test is consistent with results indicated in existing code of the practice, push tests on headed studs in solid RC slabs were performed first. Having developed a standard method for evaluating the capabilities of headed the stud connectors in pre-cast hollow-core slab, it is now possible to perform push tests on the headed stud in hollow-core slab. Load–slip characteristic curves for 72 full-scale push tests were produced, and the results were analyzed. As a result of the results, 100mm long the headed studs with of the square end hollow-core slab outperformed 125 mm long headed studs with of the tapered end slabs. It's recommended that top of the headed stud for tapered-end slabs be at least 35 mm above the chamfered-end of hollow-core slab in order to prevent early slab collapse. An in-situ gap width of 80mm is suggested for the hollow-core slab with square ends. Transverse reinforcing has greatest impact on shear capacity and slip ductility.

It is recommended that transverse reinforcement be constructed of high tensile bars with a diameter of 16 mm in order to keep the slip ductility down to 6 mm when the maximum load is applied. Design equation for ultimate of the shear capacity that have been proposed are in good agreement with experimental data, and they may be used to

estimate of the shear capacity the hollow-core slab with headed shear connections made of precast hollow-core slab.

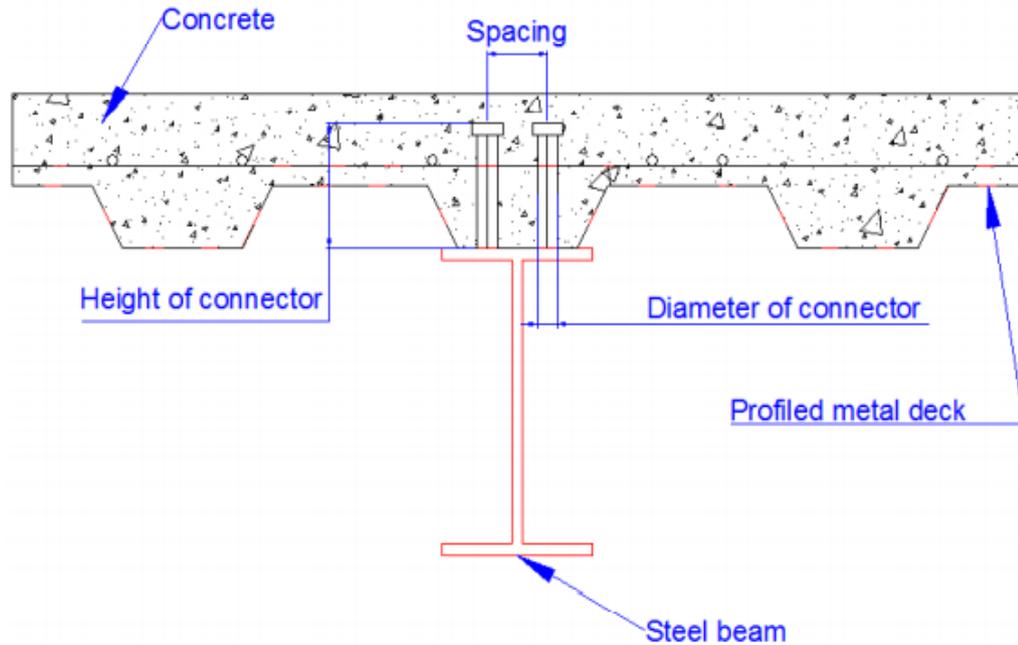
The composite of construction with of profiled metal decking is additional cost effective in a terms of labor costs and the construction time because it reduces of amount the concrete needed for concrete slab and reduces the self-weight of a concrete slab. As consequence, in building sector the composite beams are now constructed using profile of metal decking. There is relatively new idea in the construction industry, and it is used as permanent concrete formwork in a variety of applications. Once the concrete slab has been allowed to cure, this increases the tensile strength of the slab. In accordance with the requirements of the construction, profiled metal decking may be placing each parallel or perpendicular to steel beams, as shown in Fig. 2.1 and 2.2. In order to attached the profiled metal decking to steel beams, shear connectors used. Steel beam is then welded to steel flange via a profiled metal decking.

When the concrete and steel are used together they perform much best than when used alone. Composite steel concrete the construction is both of efficient and cost effective since each material is used to its full potential.



**Figure 2.1** The Composite Beams with the Profiled of Metal Deck. (Hegger and Goralski 2006)

Concrete is capable of withstanding compression, while steel is capable of withstanding tension. (Hegger and Goralski 2006) Using welded shear connections, they are able to accomplish their composite action by transmitting longitudinal of shear forces at interface of the steel beam and a composite concrete slab.



**Figure 2.2** The Composite beams with a profiled of metal the decking. (Hegger and Goralski 2006)

Using the push test and composite beam testing methods (Ollgaard, Slutter, and Fisher 2010) carried out a comprehensive experimental investigation of the behavior of the welded of shear connections in composite structure, investigated behavior welding shear connections in of solid the concrete slab in their research. (Grant, Fisher, and Slutter 1977) on the other hand, utilized profiled metal deck in this thorough research studies and updated Fisher's (1970) equation by include the heigh of shear connection in their calculations. According to Hawkins and Mitchell (1984), push-tests were used the investigate to influence a reverse and monotonic load on behavior of weld shear the connections in the composite structures, and they discovered there reverse loading had a 17percent lower of shear capacity than monotonic the loading in composite structures. To investigate the shear of resistance the welded shear connections in the composite structures under of monotonic stress, (Jayas and Hosain 1988) utilized the like profiled metal of decking high as in their push-tests, which they repeated with different profiled metal decking heights. After some further study, the equation provided by a previous author was revised, and two of new equations based on density factor and different deck a heights were suggested.

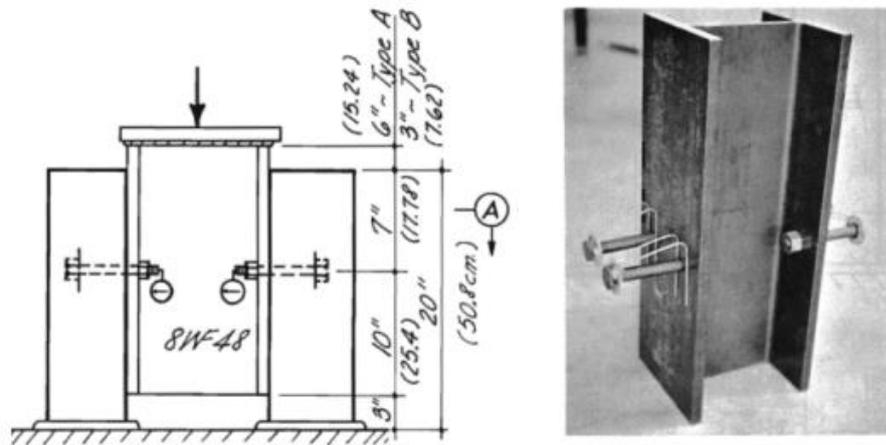
In (S. Hicks 2009) performed the comparison of the results of the push test with the full-size beam test. Six push out experiments and two full scale composite beam the tests were carried out using composite of concrete slabs and profiled metal of decking,

and results were published in the journal *Composites*. The load slip performance assessed in the push-tests was found to be much lower than the results obtained from the beam tests. A review published in 2010 (Pallarés and Hajjar 2010) reviewed research conducted on welding of shear connections used the push-test method over the last few decades. Currently, the bulk of research on the welded shear connection is carried out using (FE) analysis, which is becoming more popular (FEA). When (El-Lobody and Lam 2002) conducted an investigation of the behavior of the welded shear connection in the solid of concrete slab with a different connectors heights and the concrete strength, they utilized a finite element model to do so. It was (Ellobody and Young 2006) who developed the finite element model for composite beam profiled metal decking.

A 3D (FEM), for composite structures was developed by (Qureshi and Lam 2012) and used to study a post failure behavior the welding shear connections in the trapezoidal-deck. The (FE), results were compared to the results of experimental push tests in the trapezoidal deck. In this study, it was discovered that the concrete strength has a significant effect on shear connection performance, with greatest stresses in the concrete occurring toward a bottom half of connector result in the concrete collapse surrounding a connector. As weight increases the steel deck has a tendency to separate, from concrete and eventually become deformed as loading approaches point of collapse.

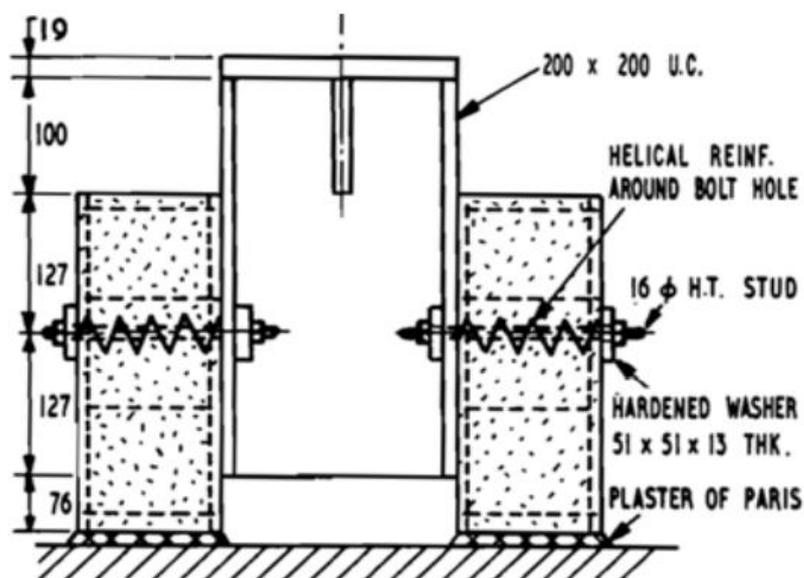
According to literature, demountable shear connections have been the subject of very little investigation. In the (1960s, 1970s, and 1980s), (Dallam 1968), (Marshall, Nelson, and Banerjee 1971), were among the first to explore the use of bolted shear connections, as did Marshall (Dedic and Klaiber 1984), and (Hawkins 1987). As previously indicated, high strength-friction grip bolts in the solid of concrete slab were investigated using the push out method as well as full scale composite beams test as part of the previously mentioned research endeavors. The post-installation method was often used to put these bolts into the concrete slab after it had been cast, and this was a common practice. It takes more time to complete the post-installation process, on the other side. Using the push test method shown in Fig. 2.3, Dallam examined the behavior of high strength grip bolt ASTM A325 and A449 in the composite structures with three different diameters, (12.7mm, 15.9mm, and

19.9mm) and a height (102mm). The formwork for a bolt placement was not immediately noticeable. At serviceability limit stage, there was no evidence of sliding, and of ultimate the shear strength was almost double, that of weld studs, indicating that the design was successful.



**Figure 2.3** Friction the grip of bolt push-out the tests. (Dallam 1968)

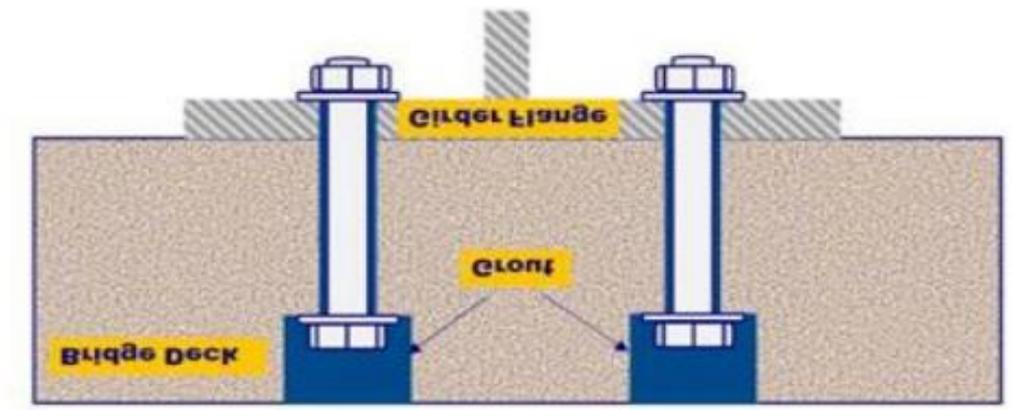
Because of unusual technique of casted the concrete of slab and holding the bolts, it is possible that this approach had an effect on ultimate the shear of resistance and the slip-capacity of structure. utilized push test illustrated in Figure 2.4, as well as a full scale the composite beams technique based on solid of concrete the slabs, to investigate the stability of composite beams.



**Figure 2.4** Push test technique. (Dallam 1968)



embedded nuts, and shear and tensile stresses were employed to evaluate anchor bolts with diameters ranging from 19 to 25 mm, respectively.

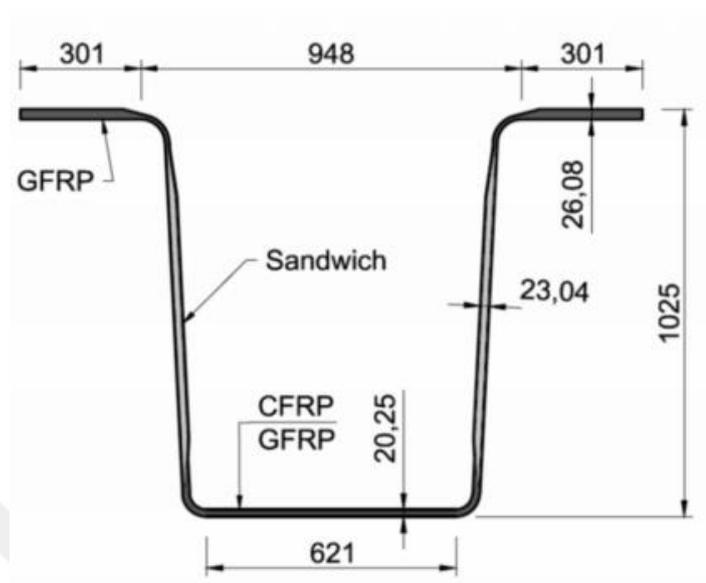


**Figure 2.6** High-tension of friction the grip of bolt in the composite beams.  
(Hawkins 1987)

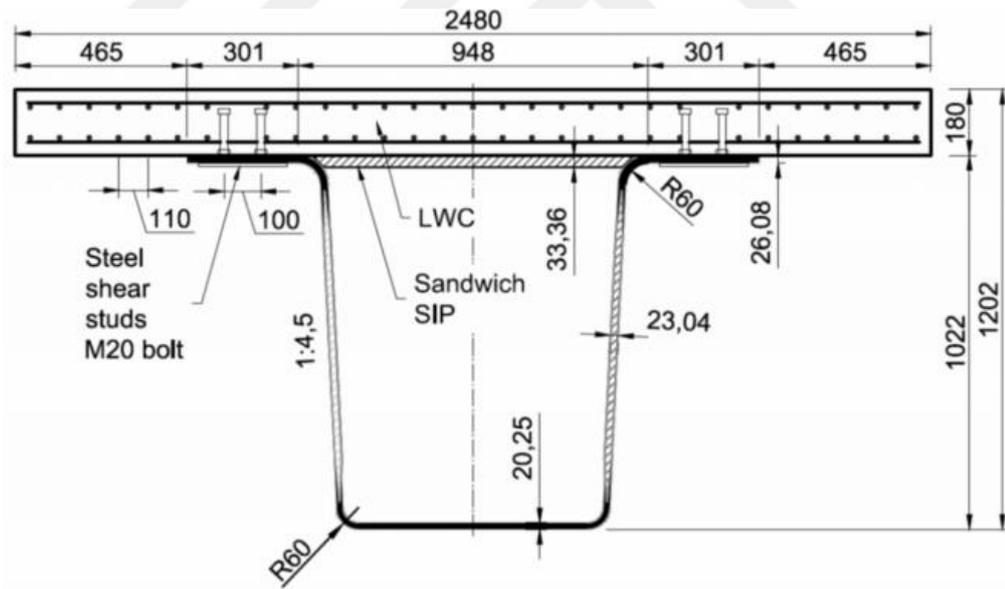
It was not very clear how to properly place the bolts, on the other hand. When compared to welded studs, anchor bolts may achieve a shear resistance of up to 80% without the need of a nut inserted in the bolt. Shear stiffness, on the other hand, accounted for just 15% of the total. (Kwon, Engelhardt, and Klingner 2010) utilized a post-installation method to the strengthen existing non composite bridges, as shown Figure 2.6, and the results were promising. This project was the continuation of research, which formed the basis for this project. In accordance with ASTM, A325 requirements, friction of grip the bolts with an inserted nut were put through their paces under of static and fatigue stress conditions. The demount ability of the composite beam, on the other hand, was not taken into consideration in this research. In accordance with studies, using A325, and A449, bolts to post-install bolted shear connections to convert a non-composite structure to a composite structure is a viable method of accomplishing this transformation.

The innovative hybrid, (FRP) the concrete of bridge girder (Siwowski et al. 2017) is planned to be use in a construction of the first Polish the road of bridge constructed of (FRP) composites. Hybrid of girder is made out of a fiber reinforced plastic composite beam with an open a trapezoidal cross-section and of a concrete slab (Figure 2.7). There is a 1025-millimeter depth to the FRP composite beam, a top width of 1550 millimeters, and a bottom width of 621 millimeters. Both of the beam's upper flanges

are 301 mm wide, and two slightly inclined webs link them to the bottom plate at their intersections.



a) fiber reinforcing polymer (FRP) beam,

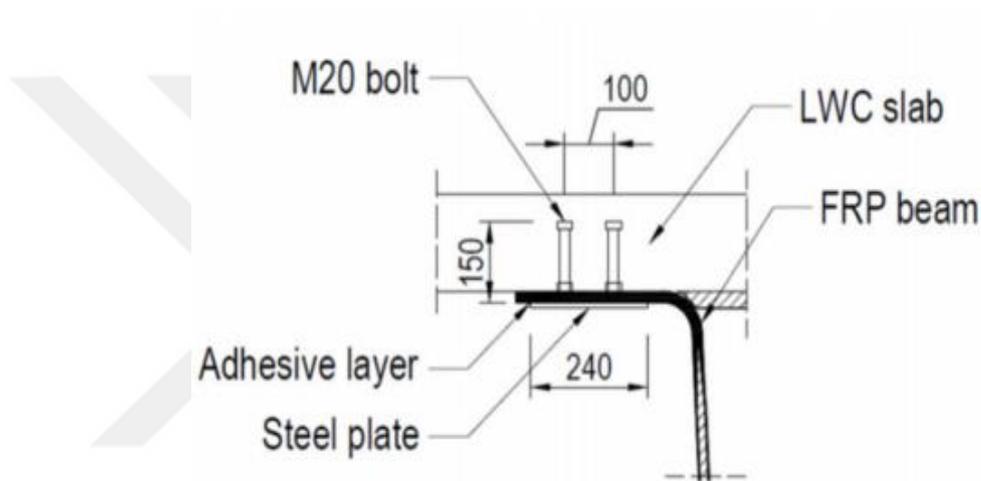


b) hybrid (FRP), light weight concrete (LWC), girder (unit: mm)

**Figure 2.7** The bridge of girder cross section. (Siwowski et al. 2017)

A component laminates have thicknesses of about (25mm, 22mm, and 19mm) for the top the flanges, webs, and the bottom plate, respectively, while a overall thickness is around (25mm). Although the top the flanges and webs are constructed the solid and

the sandwich (GFRP) laminates the bottom of plate, is built of a hybrid glass carbon fiber reinforced polymer solid the structure, (Siwowski and Rajchel 2019) the bottom plate is not. The stay in place (SIP), formwork is supported on two top flanges in order to ease the casting of the concrete of slab. The (SIP) formwork is constructed of a (33.4mm) thick the sandwich a plate with web that are identical in size. On the basis of the type aggregate, the (180mm) thick slab was constructed of (35/38) class LWC concrete with a density percent of 1968 kg/m<sup>3</sup>. Two steel beams were used to strengthen the slab both longitudinally and the transversally. grids made of a (12mm) ribbed (GFRP) rebars spaced every (120mm) in each direction.



a)



b)

**Figure 2.8** Idea and the elements novel of shear the connections system. (Siwowski et al. 2017)

In order to attach the LWC slab to the (FRP) beam, the researchers developed new shear connectors consisting of (M20 class 4.8) bolts that were welded to the rectangular steel plate, (Figure 2.8). Single connection was made up of eight bolts that were welded together in two rows to a steel plate that measured (240mm\*660 mm) in plan and was (10mm) thick. Epoxy glue was used to attach the connections to the bottom surface of the beam top flanges on both sides. The shear connection method that has been designed combines two conventional means that are often used for a slab to beam connections in the hybrid (FRP) concrete girders: studs and adhesive. (Patil and Shaikh 2013) Stud is a conventional means that are utilized for the slab to beam connections in the hybrid (FRP) concrete girders. For studs, standard (M20) bolts are used in conjunction with the appropriate nuts and washers. Several bolts are welded to the steel plate in one or two rows with transverse and longitudinal spacing that is determined by the design of the bolts and plate (Figure 2.8). The connection is deep galvanized in order to provide superior corrosion protection as compared to FRP composite. It is necessary to drill holes in the laminate in order to attach the connection to the beam's top flange, and the number of holes, their arrangement, and diameter must all match to the stud design pattern. Following that, the adhesive layer is applied to the appropriate locations starting from the bottom of the girder's top flange, and the connection is connected to the laminate using a bonding process. The final step is to attach a steel washer and two nuts to each bolt. The first nut is tightened with the predetermined tension to ensure good bonding, while the latter is put on the top of the bolt to form an internally threaded stud and to enhance the tear out capacity of the connection (Figure 2.8). When compared to conventional studs in the steel concrete composite systems and the bolts in (FRP) concrete hybrid systems, the new connecting method is more durable and reliable. Typically, in the steel concrete composite systems, the headed stud is attached to the top flange of steel girders by welding. Shear connections are typically attached to the top flange of (FRP) structure using a predetermined torque in (FRP) concrete hybrid systems. When welded headed bolts with the preset torque are used in conjunction with adhesive in the connection, a reasonably high shear capacity is guaranteed, and slippage at the interface is expected to be significantly reduced. Aside from that, epoxy applied around the laminate holes and at the interface protects the cut-out areas from environmental assaults, and a stress release is also generated inside the laminate around the hole.

### **2.3 Finite Element FE Analysis of the Shear Connectors**

When it comes to civil building projects, composite constructions are becoming more popular. Composite beam in particular is structure made up of two the materials a steel section that is primarily used in tension region and a concrete section that is using primarily in a compression cross sectional area both of which are connected by the metal devices known as the shear connectors. Steel-concrete composite beams are particularly common. In addition to allowing for joint behavior the beams and slabs, these connectors also serve to limit longitudinal slippage and lifting at elements the interface as well as take of shear stresses. This article provides (3D), numerical models of steel the concrete composite beams for the purpose of simulating their structural behavior, with particular focus on the contact between beam and slab. The (FEM) was used to conduct of simulations, which were carried out the using the ANSYS code version 14.0. (Patil and Shaikh 2013). The acquired findings were the compared with those given by of Standards experimental work or those available in literature and the results of this comparison showed that the numerical method used is a viable instrument for evaluating the performance of steel concrete composite beams.

The vertical displacements at mid span as a comparison of the results obtained with increasing the applied load. They are based on the first stage of simulation, and are consistent with the value acquired experimentally, and quantitatively reported before and in the study. Take note to that although the computational of model created in included shored of composite beams the work, presented here and the practical testing demonstrated in deal a with non-shored composite beams, respectively, for composite beams operating in the elastic region, the findings obtained from both the experimental and computational models are comparable.

According to the numerical model, there is a 27 percent reduction in vertical displacement at center span of beams when subjected to the limit load compared to the experimental model that was used in the experiment. This indicates that the model created in this study will have a more rigid behavior. Unlike the studied slip, which did not exhibit the same behavior as the analyzed slip During the limit the load, both of experimental and the numerical models showed comparable sliding with the experimental of model showing sliding, that was 20 percent lower than that of the numerical model. As a result, it is possible.

By joining concrete of the slabs and the steels segment together, using shear connectors composite components are produced. (Anju and Smitha 2016) In this article, four different kinds of shear connections were investigated, and best of connector for the certain composite beams, was selected based on its performance under static stress, with the loading and quantity steel in connector serving as of common variable.

In the research, the (FE) was using to analyze of various types the steel shear connections in the composite beams. In this experiment, nodal displacements were applied in increments at a load of 155kN, and the resulting displacements were compared with each other. Following the findings of the finite element FE research, it was discovered that channel type of shear, connection has low displacement than other the types, while the perfobond types connectors has the most displacement the applied loads.

It's becoming more and more common in civil construction projects to utilize composite constructions. Shear connectors are metal devices that link two materials together. (Patil and Shaikh 2013) Steel concrete composite beam, in the particular, are constructions made up of two elements: a steel portion situated mostly in tension region and a concrete portion located primarily in compression cross-sectional area. The primary purposes of these connector is to enable for a joint behavior of beam slab to prevent longitudinal, sliding and lifting at elements interface, and absorb shear stresses as necessary. An focus is placed on the interface between the beam and the slab in this study, which includes (3D) numerical models of steel concrete composite beam, to simulate their structural behavior. Based on Finite Element Method, simulation was performed use the ANSYS code version (14.0). The findings produced were compared to those given by the Standards, experimental the work, or those available in a literature and the results of this comparison showed that the numerical method used is a viable instrument for evaluating the performance of the steel-concrete composite beams.

In the experimental investigations, looked at the behavior of composite beams. A computer model of this issue was developed later using the ABAQUS software package. The impact of change in shear connections, on the other hand, had not yet been investigated in any detail. The authors have taken into account variations in the height, diameter, and form of shear connections in this study. It has been discovered

via calculations that the height of the shear connections has little effect on the deflection of the composite beam.

#### **2.4 Effects the Elevated of Temperatures on Shear Stud Connectors**

After subjecting series of the experimental push-tests to high temperatures, (B Zhao and Aribert 1992) came up with a conclusion, the factors that varied included the compressive strength of the concrete and the structural steel beam., the ultimate shear capacity of concrete is highly dependent on its compressive strength  $f'_c$ , the diameter shear connectors  $d$ , and the size the structural the steel of beams used in structure. Also suggested was a mathematical model for determining how accurate a push test's heat transfer accuracy was being. This is shown by Figure 2.9, which shows that predicted value and the experimental data are in excellent agreement. Note that the authors only utilized solid slabs for experimental tests and didn't investigate impacts of headed stud the shear of connections. The research presented in this thesis extends (B Zhao and Aribert 1992) work by taking into account both solid and profiled slabs, as well as of behavior headed the stud shear connections when subjected to high temperature. In (Bin Zhao and Kruppa 1996) conducted research on behavior the shear connectors and composite beams, when subject to extreme heat. This test was carried out in three different series. Among the tests were 12 push-tests conducted at of room temperature in the order to determine ultimate the shear capacity 4 push-tests conducted with an of increase in the temperature but no load in order to determine of influence the temperature on elongation of due to of the temperature and 31 push-tests conducted at of elevated temperatures with a variety of loading conditions. As a result of the tests, it was possible to determine the temperature-dependent development of shear capacity of various connection types, as well as the force-slip correlations between them. During the third set of tests, evidence was obtained about the failure of the headed stud shear connections as well as the phenomena of local instability of continuous composite beams when exposed to high temperatures. The impact of high temperatures on the behavior of a headed stud shear connection will be investigated in more depth in this thesis. A further study of headed stud shear capability with regard to fire duration exposure will be conducted in this paper.

The reaction of isolated members tested under fire is used to determine the design guidelines for building structures in the majority of international standards now in use.

Similarly to the conventional design approach for ambient temperatures, this method is used in the design of high temperatures. During a fire, the behavior of composite steel concrete beams is strongly influenced by heat transmission via structural elements, the surrounding structures, and the headed shear connections, which are all present. When a composite steel-concrete building is exposed to fire, heat transmission dominates the behavior of the structure. Researchers COOK, G. E., Lawson (1988), (Lamont, Usmani, and Drysdale 2001), (Huang, Burgess, and Plank 2004), and (Huang, Burgess, and Plank 2004). For the most part, these investigations were based on numerical modeling and comparison with experimental tests, which were conducted using the Cardington Test. A primary goal of this thesis is to shed light on design and behavior of the headed stud shear connections for both composite steel concrete beams and steel concrete beams when exposed to high temperature conditions. Sanad et al. (1999) conducted a series of four full-scale multi-storey composite steel-concrete buildings fire tests, each of which was completed in one day. The experimental tests were carried out in a building with a profiled slab as the foundation. The experimental investigations were focused on the heat transmission between a concrete slab and structural steel beams, both of which were tested. The authors also looked at the bending of the composite steel concrete beam in the middle of its span when it was subjected to fire. Emphasized the significance of temperature evolution in influencing the structural response of a structure. They also carried out four British Steel fire tests on Cardington building, which is an eight-story composite steel-concrete structure. The authors discovered that the concrete slab does not reach a temperature that is suitable for the environment. So (Lamont, Usmani, and Drysdale 2001) utilized a finite element heat transfer software called HADAPT to simulate the heat transmission for composite steel-concrete slabs. When exposed to fire, the headed stud shear connections of composite steel-concrete beams did not perform as expected, which was a shortcoming of the article stated above. (Sanad et al. 1999) and (Lamont, Usmani, and Drysdale 2001) also did not call attention to this issue. It was the focus of this thesis to investigate the behavior of the headed studs shear connector, when exposed to flames.

## 2.5 Effect of Strain Regime on Shear Connectors

Push-out tests and the composite beams tests are often used to determine the behavior of shear connections in terms of static and fatigue strength as well as load slip relationships. (Carlsson and Hajjar 2000) said that the findings of beam tests are so difficult to analyze since the connections are load by a variety of force and are influenced by residual the stresses and non linearity concrete slabs and steel beam, among other factors. Push out test produced results that were more conservative than those obtained from beam testing in the majority of instances. In large part, this may be attributable to the force distribution that acts on the connections themselves. For example, whereas in push-out tests, the connections are exposed mainly to direct shear, in beams, they must contend with the combined effects of several forces, including axial-force, shear-force, and shear bending the moment. Aside from that, a existence of frictional force at the slab-beam contact may result in a decrease in longitudinal shear force, which may result in some extra strength. According to this is important. (Seracino et al. 2004) The assumption was that this would improve the durability of the shear connections and allow them to last longer than their original intended life span. The authors of (Oehlers and Bradford 1995) pointed out that even while push out tests have acquired widespread recognition as a tool for experimental purposes, the outcomes of these tests may be very inconsistent. Due to the usage of varying sizes, forms, material characteristics, specimen arrangement, number and location of connections, and support constraints, the results were unpredictable and unexpectedly successful. There was even more dispersion in the findings since there were so many various types of failures, such as failures in the stud shank, welds, steel flanges, and profiled sheeting. Additional factors contributing to the collapse included the slab's shear, embedment, and splitting failures, among others. By providing appropriate details, enough cover, and reinforcement, it is possible to prevent these secondary nonductile failure mechanisms. For the resistance and ductility of shear connectors, (40) conducted both beam test and push test with trapezoidal decking in order to determine their properties. A major concern while developing beam specimens was to create the most adverse combination of variables that might occur in current operation. This was done to determine the extent to which shear stud connection resistance was increased when the compared to the push-tests. Furthermore, the author emphasized the high degree of safety that may be achieved via the usage of modern composite

materials, the studies demonstrated that, when compared to the beam tests, the headed stud shear connector's behavior in the push test is stronger and more conservative in strength. According to, (S J Hicks 2007) any brittleness seen in a push test is due to a weakness in the push test specimen itself, rather than a deficiency in the shear connection itself. Because of this, the impacts of strain regimes in the push test were studied in order to get a more representative result, similar to what would be anticipated in beams.

## **2.6 Effect of the different loading Types on the Headed Stud Shear of Connectors**

As reported by (Cook, Eligehausen, and Appl 2007) and (Wisser, Kunz, and Geiss 2000), the need for additional flexibility in the planning and design of the concrete components in the composite steel concrete of the system has result in an increase in the use of the fastening methods. In fastening the system headed stud or bolts are utilized. It is possible to observe two different types of failure processes in headed studs when they are exposed to tensile stresses. The failures of concrete and steel are examples of such. Concrete a failure occurs when embedded depth of headed studs is too shallow. When headed studs are inserted deeper, in a concrete, of the combined failure the modes of concrete and the steel will become apparent. After being subjected to the combination axial and the shear stresses, composite steel-concrete constructions may collapse in a number of ways. In accordance with, (Eligehausen, Mallée, and Silva 2006) there are many types of the failure modes are the divided into five groups. Axial force concrete the failure, shear force of concretes a failure, local cone failure, and steel the failure if the headed stud and pull-out of headed studs are all examples of concrete failure. It is assumed that headed studs and concrete have been subjected to both shear and axial stress in this thesis as a starting point for this investigation. A series of experimental programs was carried out by (Eligehausen, Mallée, and Silva 2006) in order to evaluate the strength and the deformation of capacities headed stud for use in infill wall system applications. A modification the conventional push-out test was a developed in order to make the application of shear and axial tensile stress more convenient and accurate. Several experimental studies were carried out, however only a handful were completed due to financial limitations. During the testing, two the different steel reinforcement of configurations were tested. A reinforcement cage was

utilized in one case to provide adequate confinement for the headed studs, whereas little limiting reinforcement was applied in the other case. The experimental investigations were not compared to the finite element analytic study, which was a flaw in this work and a limitation of the research.

As a result, the experimental data will be compared to the finite element models by the author. Push test failure may occur when headed stud is forced out the concrete during the push-test. In accordance with, (Anderson and Meinheit 2000) pryout failure occurs when of the headed stud is too-short. They also showed that arrangement and the spacing of the headed studs, as well as the shear stress used, had a substantial effect on the outcome of a pryout failure in their experiment. A headed stud with a  $hd/d$  ratio less than 4.5 may have pryout failure, leading in a lower ultimate capacity than would be anticipated under current standards, according to the authors' research. Between 5.4 to 7.4 is the optimal high-definition-to-digital ratio, according to the researchers. To obtain most capacity, out of the headed stud, (Anderson and Meinheit 2000) showed that the studs must be completely embedded in the concrete. The failure of the shear stud shank, in addition to the failure of the pryout, will have an effect on the ultimate capacity of the headed. Shear the stud of shank failure is determined by ultimate tensile strength of stud. Also shown was the inability of headed stud to the achieve it is full potential while using  $1.0A_sF_u$ . In addition to shear stress, the authors recommended that further study be conducted into the consequences of other kinds of loading. Consequently, the headed studs will be utilized in this thesis when exposed to shear and axial tensile stresses in conjunction with each other. Axially tensioned loads are applied to the concrete cone, and (Odenbreit and Fromknecht 2007) hypothesized that hanger strengthening may be necessary to prevent cone failure. The tension force produced by the headed studs in the concrete may be mitigated by the use of concrete hangers as reinforcing bars.

After being subjected to repeated loads on deformable connections in the steel and concrete composite beam, studs may be pushed to undergo reverse shear during unloading. (Li et al. 2011) For the purpose of examining the behavior of the connectors in the structures exposed to the shear, it's necessary to develop the test that precisely replicates the actual behavior the studs under of reverse cyclic stress. For that aim, of direct shear the test is devised and, thoroughly described. It was necessary to conduct

the test in order to examine the behavior of four the specimens, two which were subjected to the monotonically rising stress and the other two to the cyclic of loading. They were found to be very comparable in terms of results when monotonic testing was conducted in comparison to a standard push-out test. A series of blocks of cycles between two different load levels were performed on the specimens during the cyclic testing procedure. It was discovered via these tests that there was a relationship between the form of the load slip curves and how much wear and tear was left after each cycle.

It is possible to derive these conclusions from the results of the proposed experimental test, which is based on an application of a direct shear force directly to the connection.

1- When long the span of composite beams with deformable connections are subjected to repeated a loads, certain connectors may be exposed to the reverse cyclic of shear strain. In these situations, a traditional 'push out' test has a number of restrictions and modeling mistakes that may have impact on the fatigue life estimate. It is possible to remove the bulk of them using the suggested direct the shear of test.

2- The direct of shear test, as described above, was also use for loads that increased monotonically. In fact, the outcomes of this test were very comparable to those obtained via the 'push-out' procedure.

3- Due to the additional attention taken during the testing procedure, significant information on the connection behavior was gathered, resulting in reliable sources for the development of analytical models

4- After a few early cycles, the results the cyclic of test show a rise in slip to that stays practically constant after a few more cycles, which indicates slow damage buildup and no shakedown.

## **2.7 The Shear Capacity of the Headed Studs in Steel Concrete Structures, Analytical Prediction via Soft Computing**

Generally speaking, headed stud is used as shear connector in composite structures a transmit longitudinal shear the force at steel-concrete interface, (e.g. bridge decks). (Abambres and He 2019) Code based formulae are used to estimate shear the capacity of headed stud. An artificial of neural network (ANN) based analytical method of

provided for evaluating shear the capacity of the headed steel studs. Push out test findings from previous published research were collected into a database and used to feed simulations of artificial neural networks (ANNs). For prediction of the headed stud shear force at the failure, steel studs tensile strength and the diameter, together with concrete (cylinder) compressive strength, were found to be important input variables. The highest and mean relative errors produced by the proposed ANN-based analytical model were 3.3 percent and 0.6 percent, respectively, for the whole set of data. Furthermore, it has been shown that neural the network method significantly outperforms current code-based equation, which generate mean error greater than (13) percent for the data in this experiment.

In testing using proposed (ANN) based analytical model, the highest and mean relative error for all 234 push-out test data previously obtained were 3.3 percent and 0.6 percent, respectively. Rather than attempting to understand mechanics the underlying of behavior of the headed stud, the aim of this research was to use precise, reliable artificial neural networks (ANNs) to assess and enhance the accuracy and robustness of existing mechanical models.

## **2.8 Effects of Creep and Shrinkage on Composite Steel-Concrete Beams**

A time-dependent study for the composite steel and concrete beam with the shear connectors incorporating slip between steel and concrete interface, was carried out by, (Marcello Tarantino and Dezi 1992) who demonstrated that the stresses in a concrete are dependent on stiffness of connections system. (Marcello Tarantino and Dezi 1992) used slip between steel and the concrete interface to demonstrate their findings. The shear force per unit length on connections, on the other hand, (Bradford 1989), tends to rise with time as a result of creep and shrinkage, and as a result, stiffness connectors have less effect on deflection. A simplified approach to evaluating creep and shrinkage effects in steel concrete composite beams was developed and validated. The approach was based on the age adjusted effective modulus to model the stress and strain relationship for concrete, and it was discovered that residual stress resulted in a decrease in concrete stiffness. Furthermore, it was shown that creep and shrinkage accounted for the majority of the loss in concrete stiffness under service load conditions. Kwak and colleagues created an analytical model based on a layer technique, which was then utilized by the authors in their research. (Bradford 1989)

studied the behavior of continuous composite beams under long-term and short-term service loads in their research paper from 2000. The research took into account a cracking of concrete slabs in a regions of negative moment. The researchers evaluated full-scale continuous composite beams with evenly distributed stresses in a controlled laboratory setting. When (Bradford 1989) evaluated several beams over a 340-day period, they found that the numerical model was accurate enough. These observations were used to verify the theoretical model's accuracy. According to the authors, the slab with tension cracks under service load contributed less to strength in negative bending, and its stiffness had been significantly reduced. According to (Bradford 1989), the time dependent deflections were caused by the creep and shrinkage of the concrete. In this thesis, further investigation is carried out by looking at the behavior of the headed shear studs connections in composite steel concrete beams when long term analysis is included.

## **2.9 Summary of this chapter**

Several conclusions have been made from the of review of the prior studies provided in the preceding section, which are briefly summarized as follows:

Push-off tests, which constitute the majority of experimental the work, are used to determine the complete load slip curve and failure of load the shear connections, which are both important parameters.

2. In the case of a shear connection between steel and concrete there is no closed form analytical the solution.
3. Until recently, only a small amount of experimental the work has been published on steel prefabricated hollow core slab push off testing, with the majority of the study focusing on steel solid slab push off tests instead.
4. Numerous studies have used the (FE) technique in the numerical modeling of the behavior of shear connectors in push off tests and in composite girders, as well as in the interpretation of the results obtained.
5. We were unable to locate any previous work on modeling the behavior of shear connectors in steel precast hollow core slab push off tests.

model has been found dealing with steel precast hollow core slab girders.

6. In the published research, it has been shown that taking into account the actual load slip characteristic of the shear connection is important and improves the safety of composite girders while they are in service.



## **CHAPTER III**

### **EXPERIMENTAL WORK**

#### **3.1 General**

Rebar was used in the design of the structures, which were made of steel frame and steel structures. During the final decades of the nineteenth century, concrete was put in places where it performs fully independently in carrying any stresses placed on it, and no impact of this variation was seen in the integration of components for both the concrete and steel structures. As a consequence, it started to see significant increases in demand from designers, and ultimately became engaged in the installation of the vast majority of engineering infrastructures. Unlike in the past, composite structures are now used in a variety of fields, including industrial, mechanical, electrical and electronic engineering. Composite structures are no longer only for civil engineering. Heavier structural components in civil engineering include reinforced concrete slabs, steel beams or columns, and shear connectors. Shear connectors are used to resist horizontal shear forces generated between the reinforced concrete slab and the steel beams or columns.

According to common definitions of "composite structure," a composite structure is created when two basic structural components, such as the concrete slab and the steel beams that support it, are connected and resist impact (deflection) as if they were composed of the same material. Composite structures are created when reinforced concrete slabs are connected to steel beams with shear connectors. These composite structures are capable of withstanding a third or more of the applied load in the absence of non composite activity between the reinforced concrete slab and the steel beams, depending on the application. When connecting two or more different materials, one of the most important requirements is the development of a functioning system that makes the two materials homogeneous with one another as if they were derived from the same source,

allowing them to withstand external stresses and slide without breaking. Assuming that the composite structure is intended to operate as a T, shear connections must be constructed to prevent movement in all directions between the reinforced concrete slab and metal beams. The strength of the shear resistance between the concrete slab and the steel beams is used to determine the design of the composite structure. In order to avoid movement between the slab and the steel frame, these shear connections are mainly used.

### **3.2 Finite Element (FE) Approach**

In addition to the analytical techniques available, finite element, FE analysis is considered to be the most powerful, flexible, and suitable numerical tool for addressing a complex continuing problem. In recent years, the approach has developed into a crucial and often needed component of engineering analysis and design purpose. Because of recent advances in computer technology, finite element computer FEP programs are now capable of being utilized in almost every engineering area. Even though there are a variety of analytical techniques available, the finite element approach is often regarded as the most powerful, flexible, and suitable numerical tool for addressing a complex and continuing problem. In recent years, the approach has developed into a crucial and often needed component of engineering analysis and design purpose. Because of recent advances in computer technology, finite element computer FEP programs are now capable of being utilized in almost every engineering area. The finite element method is well suited for representing complex geometries such as those seen in composite structure. In addition, the method is capable of dealing with a wide range of material properties, structural component connections, boundary conditions, and static or dynamically applied stress conditions. Using this technique, it is possible to anticipate with great accuracy the linear and nonlinear structural reactions of such composite structure. (Abbu, Ekmekyapar, and Özakça 2013)

The Finite Element Method, (FEM) has established itself as the de facto standard for predicting and simulating the physical behavior of complex engineering systems. Finite Element Analysis (FEA) tools, which are used by engineers in the corporate world as well as academics in universities and government laboratories, have gained popularity. As a consequence, graduate or undergraduate senior-level engineering programs are available that teach not just the theory of finite element analysis, but also

how to apply it in real-world situations using commercially available finite element analysis software . Finite element analysis, (FEA) is a technique for analyzing a set of data using a computer. FEA, also known as the finite element technique or the finite element method, is a numerical approach for addressing field problems. If there is a field problem, it is necessary to establish the geographical distribution of one or more dependent variables. It is possible to quantitatively characterize a field problem in the laboratory using differential equations or an integral expression. The formulation of finite elements in Finite Element Analysis may be based on any description that is provided. It is possible to think of individual finite elements as little components of a greater structure. The assembly of components is referred to as a finite element structure since the elements are connected together at nodes.

### **3.3 Finite Element Modelling (FEM) Methods**

In addition to its structural analysis capabilities, ANSYS offers the finite element analysis, (FEA) program that is used for the solid modeling. The solid model is composed of significant points such as nodes, lines, regions, and volumes, which are arranged in a hierarchy of increasing complexity. It is necessary to pay close attention to the model before proceeding with the construction of the whole model. It is not possible to delete volumes, regions, or lines from a model after it has been meshed if they are linked to existing meshed components. The aspect ratio and mesh kind of the whole solid model should also be selected based on the size and form of the full solid model. Solid finite elements are available in a variety of shapes and sizes in ANSYS, each having its own specialty. It is necessary to first identify the kind of analysis to be performed, which may vary from structural analysis to thermal analysis to fluid analysis. When you've determined what sort of analysis you want to do, you may choose an element type from a list that includes beam, plate, shell, 2D solid, 3D solid, contact, couple field, Specialty, and explicit dynamics. In both 2D and 3D analysis, each element has its own set of capabilities and is made up of tetrahedral, triangle, brick, 10node, or 20node finite elements, depending on the situation and the kind of analysis.

Simple linear static studies that may give stresses or deformations to more sophisticated modal analyses that identify a description of the vibration characteristics and advanced transient non-linear phenomena that include dynamic effects and

complex behavior are all possible using ANSYS structural mechanics solutions. From designers to expert professionals, ANSYS structural mechanics solutions provide assistance to everyone who works with them. Every product, from single components to very complex assemblies with hundreds of components interacting through contacts or relative motions, as well as a wide variety of material models available, the quality of the elementary library, the robustness of the solution algorithms, and the can be to model every product, from single components to most complex assemblies with hundreds of components interacting through contacts or relative motions are all important features. ANSYS structural mechanics solutions are easy to use, allowing product developers to concentrate on the more important part of the simulation process: understanding the results and determining the impact of design changes on the model. A finite element analysis software package, ANSYS, is available for download (FEA). Using a preprocessing software engine, it generates geometry for use in the game. A solution method is used to load the mesh geometry once it has been loaded. Finally, it delivers the desired results during the post-processing stage.

### **3.3.1 Finite Element Modelling Methods FEMM**

In spite of the fact that three dimensional Finite Element, (FE) modeling is the more time-consuming and complex, it remains the more comprehensive and comprehensive method for static and dynamic evaluations, taking into account all factors that influence structural reaction. However, although the other methods were competent, they were limited in their scope and applicability. Recent advances in computer technology have elevated the approach to the status of a necessary component of engineering analysis and design. Presently, Finite Element, (FE) computer programs are being used in virtually every area of the engineering, including aerospace and automotive.

Create a model using one of three methods available in any finite element software for solid modeling application. It is possible to construct the first way directly (manually); in this technique, we define the location of the nodes as well as which nodes constitute an element. This technique is suitable for basic problems that may be represented by line components (pipes, connections, beams), as well as objects with simple geometry (rectangles), but it is not recommended for complex solid structures such as bridges.

Another approach is to import geometry, which requires generating geometry in a (CAD) system such as Autodesk Inventor and storing it as an import file, for example, an (IGES) file, before importing the geometry. The model may, however, fail to import properly due to problems that may occur during the import. Another method is solid modeling, which involves creating a model using basic primitives (circles, rectangles, blocks, cylinders, polygons, and so on), and then combining those primitives using Boolean operations.

### **3.3.2 Three-Dimensional Finite Element (3D FE) Modelling**

When it comes to levels of research, 3D analysis is often the most difficult to analyze. Similarly to a grid analysis, a three-dimensional (3D) analysis is a finite element modeling method. An alternative to a 2D grid of nodes and line elements is a 3D analysis that depicts the superstructure in three dimensions (flanges, webs, deck, bracing components, and so on) rather than limiting the model to a 2D grid of points. Commercial software may be used to complete any or all of a 3D analysis. The use of 3D modeling software to build a 3D model of a composite steel beam with a reinforced concrete slab and perform a live load analysis using influence horizontal load generating techniques are both possible options.

Despite the fact that the three-dimensional finite element method, FEM is the more time-consuming and involved, it is still the most general and comprehensive technique for static and dynamic analyses, capturing all aspects affecting structural response; the other methods were found to be adequate but limited in scope and applicability; Due to the direct simulation of the composite steel beam with reinforcing concrete slab, a 3D analysis has the advantage of being rigorous and internally consistent across all parts of the structure. For each component of the structure, direct analysis results are given for all of the stiffness parameters that were modeled in the 3D study. The simulation of complicated structural configurations is carried out in full rather than estimating the overall stiffness characteristics using approximated single values.

A three-dimensional (3D) study of a steel beam with a reinforced concrete slab includes separate components for the bottom flange, the three webs (top flange, below flange, and middle web), and the three flanges (top, below, and middle). An alternative approach is to do a grid analysis, which models the whole reinforced concrete slab as

a single line element, with the stiffness of the associated complex framework approximated using simpler calculations or empirical estimates. An analysis that is more accurate as a consequence of this degree of depth and rigor in a three-dimensional model should be possible. A number of additional designers believe that the findings of 3-D analysis are less intuitive and more difficult to perceive and understand than they were before. As a consequence, there is a greater likelihood of making a mistake or misinterpreting the findings of a study.

### **3.4 Description of Collecting Experimental composite steel beam with Reinforcement concrete slab**

It was decided to carry out the horizontal push-test with 19mm dia. headed shear studs in the solid of in-situ concrete slabs, and the test specimen consisted of four (600mm wide 800mm long 150mm depth) concrete solid slabs supported by steel beams (254 X 254 X 73kg/m) in order to achieve the required results. This is the specimen before it is cast in bronze in Figure 3.1. as well as the findings were compared to the most recent rules of practice. This was done to verify that of the results and methods were consistent and representative, so that the test arrangement and procedures can be used to evaluate the shear and slip capacity of a headed shear stud in a composite reinforced concrete (RC) composite. A diagram of the test setup for the solid slab specimen may be seen in the accompanying illustration.

**Table 3.1** The headed of shear studs in slab of the concrete. (Lam 2007)

<b>No. of Test</b>	<b>Concrete compressive strength (N/mm<sup>2</sup>)</b>	<b>dia. Stud (mm)</b>	<b>Max. load (kN)</b>	<b>Slip (mm)</b>
RC1	15.3	19	71.7	3.7
RC2	29.1	19	102.6	6.2
RC3	28.5	19	101.6	6.9
RC4	28.0	19	100.1	6.3



**Figure 3.1** Push test for solid slabs before casting. (Lam 2007)

### **3.5 Description of Numerical composite steel beam with Reinforcement concrete slab Model**

#### **3.5.1 Loading Test for Finite Elements Models**

A known degree of freedom's behavior may be known in certain engineering issues, which is useful in solving them. Examples include the expectation that certain points (nodes) will have the same displacement in a particular direction. To obtain a correct solution with the least amount of computing resources, one may take advantage of this behavior and enforce it. When it is anticipated that a given degree of freedom at multiple nodes will have the same unknown value, these degrees of freedom may be linked together.

It is possible to compel a group of nodes to have the same degree of freedom (DOF) by coupling them together. However, unlike with constraints, the (DOF) value is often computed by the solver rather than being provided by the user. A linked set is a collection of nodes that are all connected in the same direction as the connection between them (i.e, one degree of freedom).

Using the CP instruction, the coupling is accomplished, and the (DOF) is the same for all of the points to be linked. Additionally, CPINTF and CPCYC, both of which are CP commands, are often used in conjunction with command CP. It is used to connect nodes that are at the same place, while it is used to connect nodes that are in a symmetrical model, and it may also be used to connect nodes that are at a certain distance from one another. For the (FEM) of composite steel beam with reinforcing concrete slab, a single point load was applied to each span and a concentrated load was simulated by applying a concentrated load to a total of line nodes that are linked and restricted on the Midspan of each span.

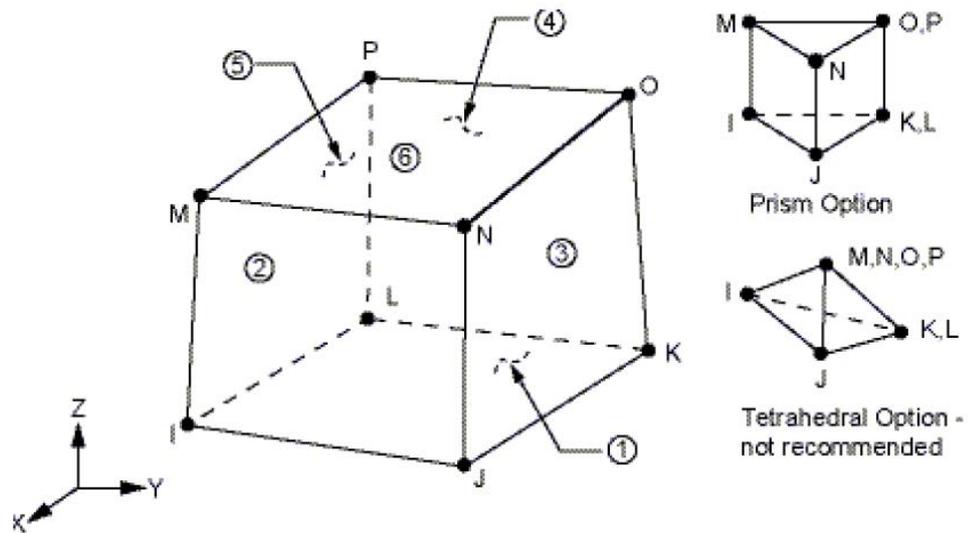
### **3.5.2 Description about the Elements Used in the Model**

Modeling and analysis of beam and solid elements were carried out using the ANSYS finite element software, which is a multi-discipline, general-purpose tool with a large library of, beam and solid elements. In the next section, you will find a short explanation of the components of the model:

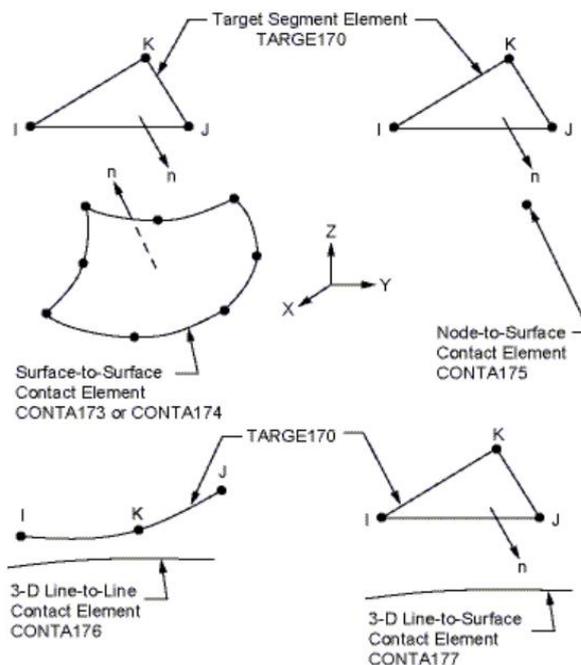
(SOLID 185) It's used for (3D) modeling of solid the structures, and it has the following description: Each of the eight nodes in the graph has three degrees of freedom (DOF): translations in the X,Y and Z, directions of the graph node at each node. Plasticity, hype elasticity, stress stiffening, creep, huge deflection, and high strain capacities are all characteristics of this material. The capacity to simulate deformations of virtually incompressible elastoplastic materials as well as completely incompressible hyper elastic materials is also provided by the mixed formulation capabilities. Detailed geometry node positions and element coordinate system information are the shown in Figure 3.1 for this particular component. "ANSYS Mechanical Manual (2009)."

Target surfaces (TARGE 170) are used to depict a variety of three-dimensional "target" surfaces for the contact elements that are connected with them (CONTA 173, CONTA 174, CONTA 175, CONTA 176, and CONTA 177). They are placed on top of the solid, shell or line components that define border of deformable the body and may come into contact with target surface, as specified by (TARGE170), if the target surface is deformable. An element set of target segment elements (TARGE170) is used to discretize this target surface, which is then coupled with it's corresponding contact

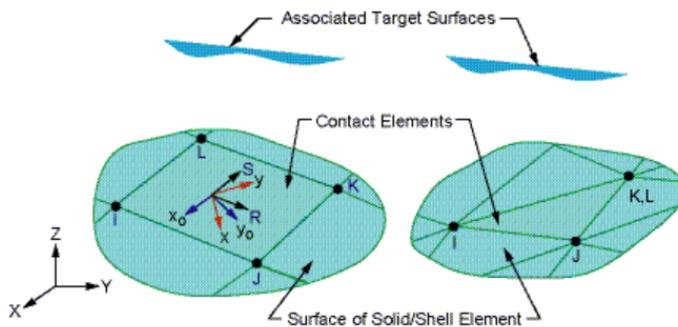
the surface via the use of a common real of constant set. Depending on target segment element, you may apply any kind of displacement translational or rotational, temperature, voltage, or magnetic field. Furthermore, you may impose pressures and moments on the components under consideration. These components can readily represent complicated target forms for stiff target surfaces, which makes them very useful for simulations. These components will be shown on top of the solid, shell or line elements, that define border of deformable the target body in the case of flexible targets.



**Figure 3.2** SOLID185 Geometry. (Ansys 2009)



**Figure 3.3** TARGE170 Geometry. (Ansys 2009)



R = Element x-axis for isotropic friction

$x_0$  = Element axis for orthotropic friction if **ESYS** is not supplied (parallel to global X-axis)

x = Element axis for orthotropic friction if **ESYS** is supplied

**Figure 3.4** CONTACT173 Geometry. (Ansys 2009)

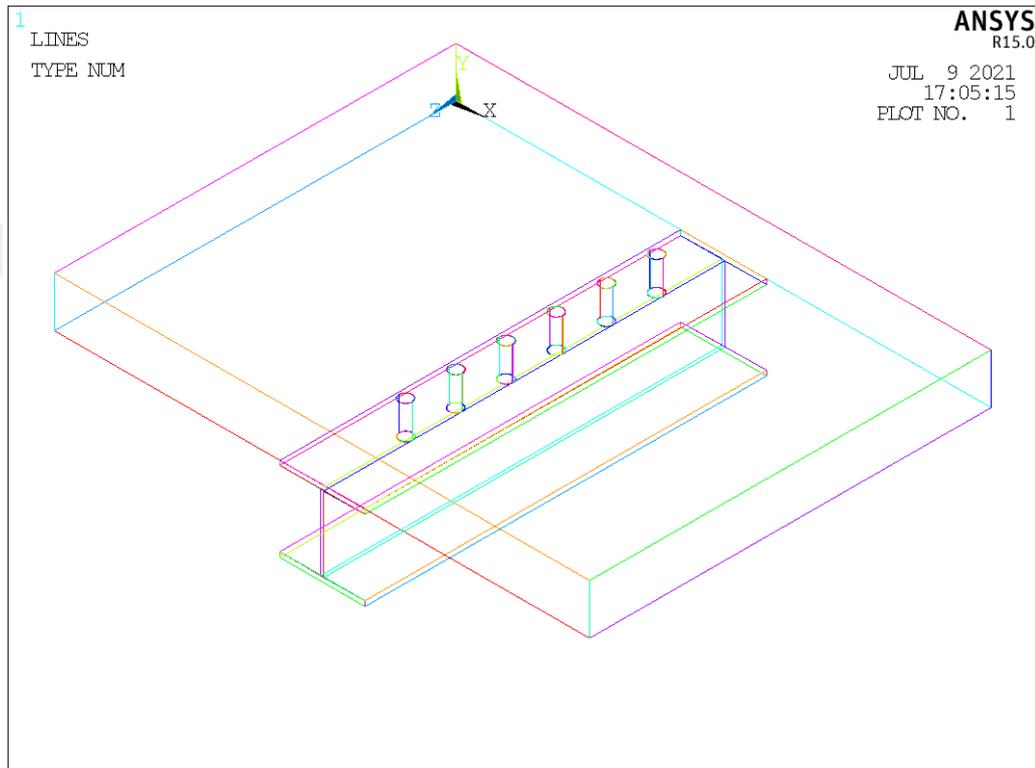
TARGE 170 is a (3-D) target surface that is used to depict contact and sliding between deformable the surface specified by this element and a (3D) target surface (CONTACT 173). 3D structural and linked field contact studies are possible with this element. In 3D solid or shell of elements with no mid side nodes this element is placed on surfaces of these elements (SOLID 65, SOLID 70, SOLID 96, SOLID 185, SOLID 285, SOLSH 190, SHELL 28, SHELL 41, SHELL 131, SHELL157, SHELL181, and MATRIX50). In terms of geometric features, it is the same as the face of the solid or shell element to which it connects (see Figure 3.3: CONTACT173 Geometry). When the element surface penetrates one of the target segment elements (TARGE170) on a designated target surface, contact is formed between the elements. Various types of friction are permitted, including Coriolis force friction, shear stress friction, user-defined friction with the USERFRIC subroutine, and user-defined contact interaction with the USERINTER subroutine. Separation of bound contacts is also possible with this element, which may be used to model interface delamination.

### 3.5.3 FE MODELS

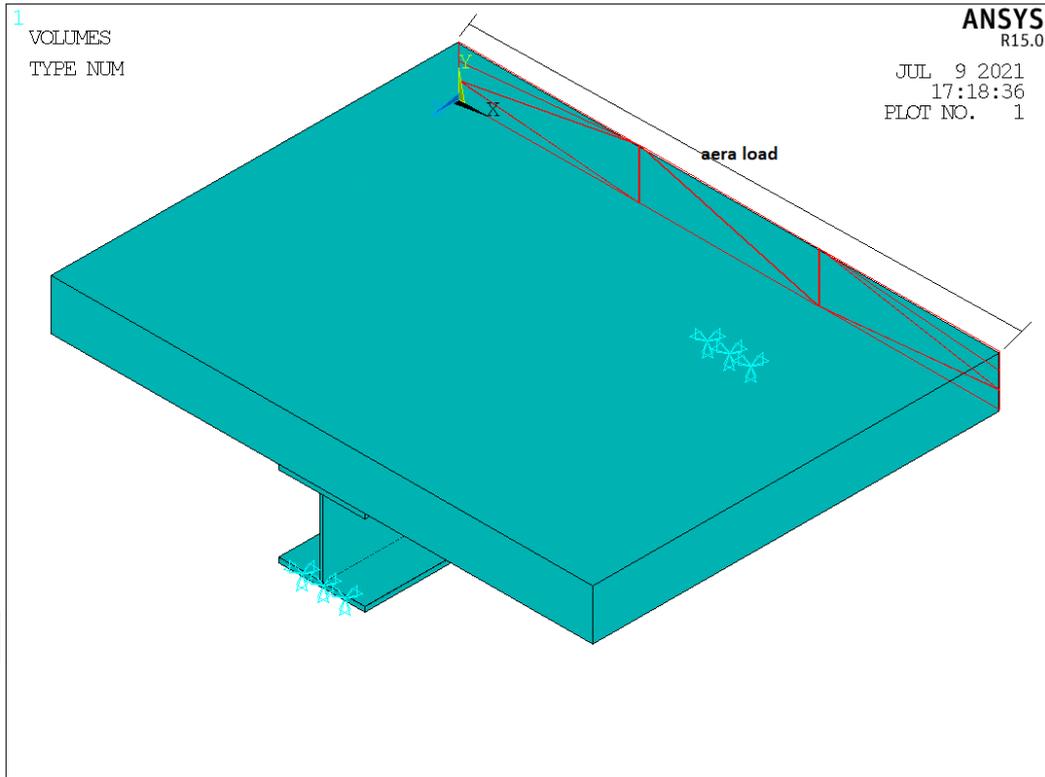
Construction of a composite slab concrete with steel beam consists of three major parts: the concrete of slab, the structural steel beam and the connection stud. Three-dimensional line elements are used to represent these three components. A three-dimensional linear frame element is used to model the composite structure. The models were simulated using ANSYS, a commercial finite element software. Figure 3.5 and figure 3.6 shows the FE model, which was built using solid elements in both the slab

and steel beam sections as well as, link element for the stud connection. The slab is attached to the steel beam by stud connectors.

Solid185 components are utilized in the 3-D modeling of the slab concrete and steel beam in the model. It is necessary to model a stud connector using the TARGE170 element, and the CONTA173 element is required to model a point connection between slab concrete and the stud connector.



**Figure 3.5** FE model by ANSYS program



**Figure 3.6** Area load is applied in FE model

## **CHAPTER III**

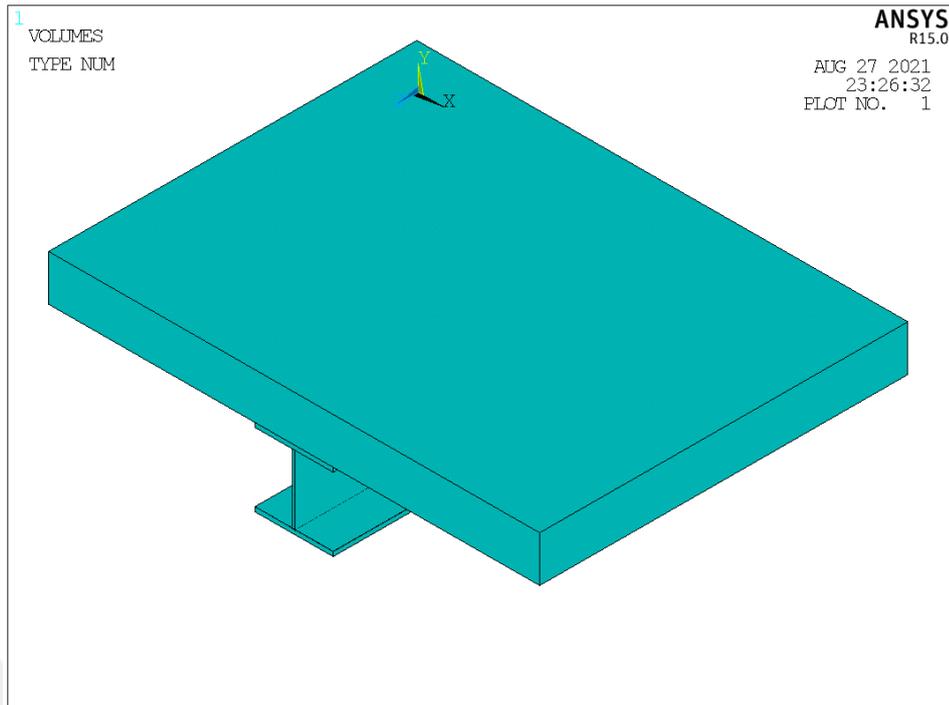
### **RESULTS AND DISCUSSIONS**

#### **4.1 General**

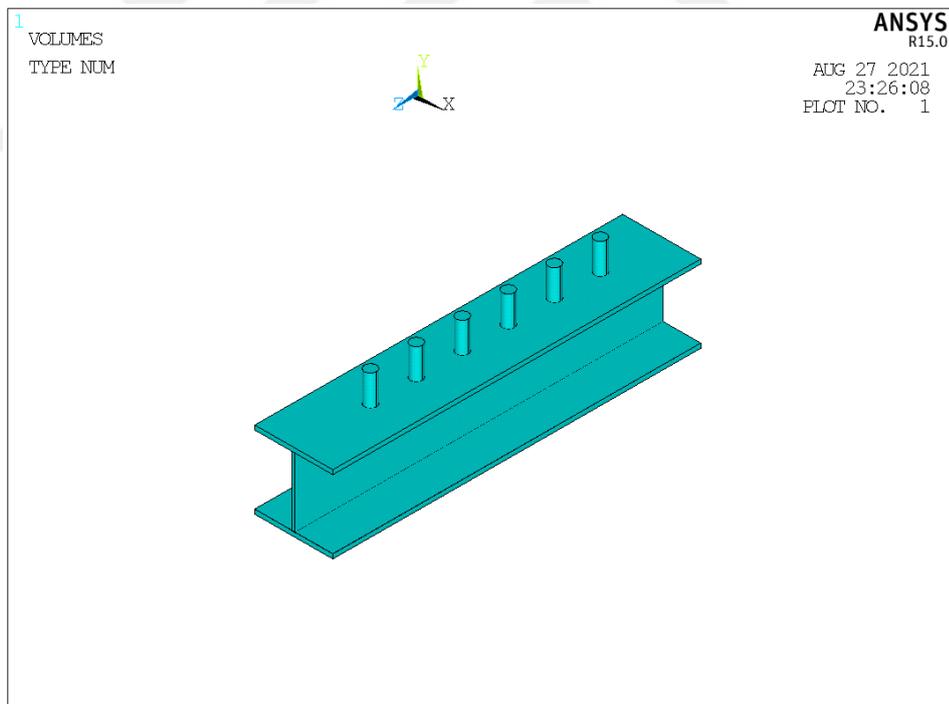
When it comes to civil building projects, composite constructions are becoming more popular. Steel-concrete of the composite beams in particular, are structures made up of two materials a steel section located primarily in a tension cross sectional area and the concrete-section located primarily in the compression cross-sectional area, both of which are connected by metal devices known as shear connectors. Steel concrete composite beams are particularly common. The primary purposes of these connections are as simulations were carried out using the version (15.0-ANSYS), code based on the Finite Element Method, (FEM).

#### **4.2 Standard Model by ANSYS**

By using a ANSYS FE program, composite beam slab models were simulated. Because the materials in the preceding chapter were stressed to their elastic limits. The current research involves a linear analysis of composite models. Because full contact between a slab concrete and beam steel with studs was envisaged, they were joined together. 3D modeling of composite steel beam is done with stud's parts. CONTA173 is used to depict contact and sliding between a deformation surface, while collection of target segment element (TARGE170) discretizes the target the surface, which is linked with its corresponding contact surface through common real the constant set. Figure 4.1 and 4.2 presents FE Standard Model (SM), The slab is installed on the steel beam by means of studs and horizontal pressure applied to measure the slip in the studs.



**Figure 4.1** Showing the model beam steel with slab concrete



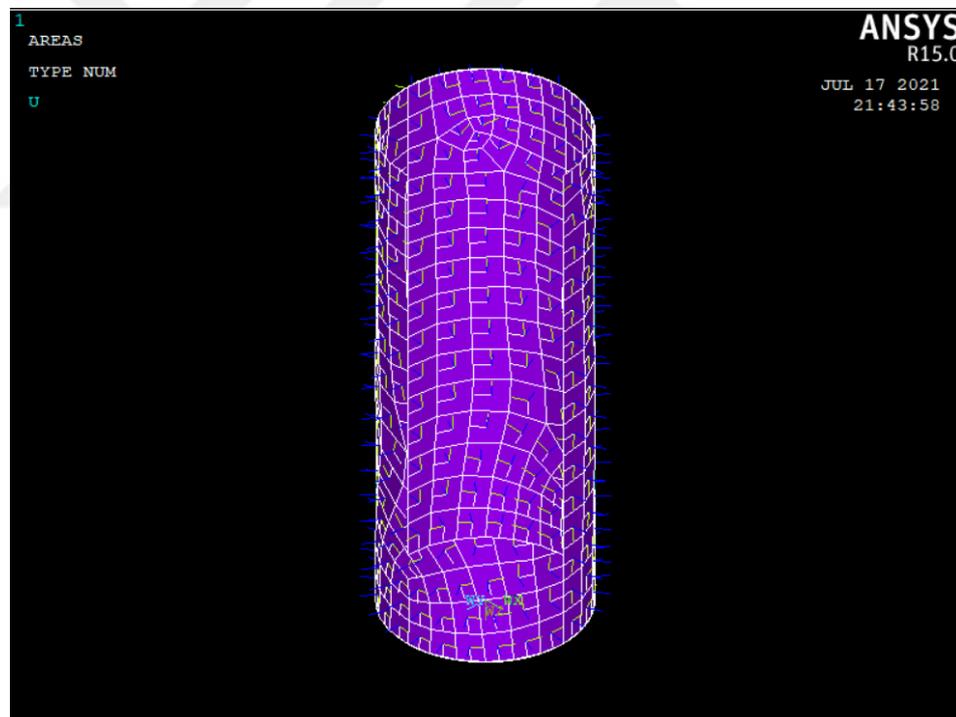
**Figure 4.2** Showing the steel section with studs

### **4.3 FE Configuration of the CONTA and TARGE**

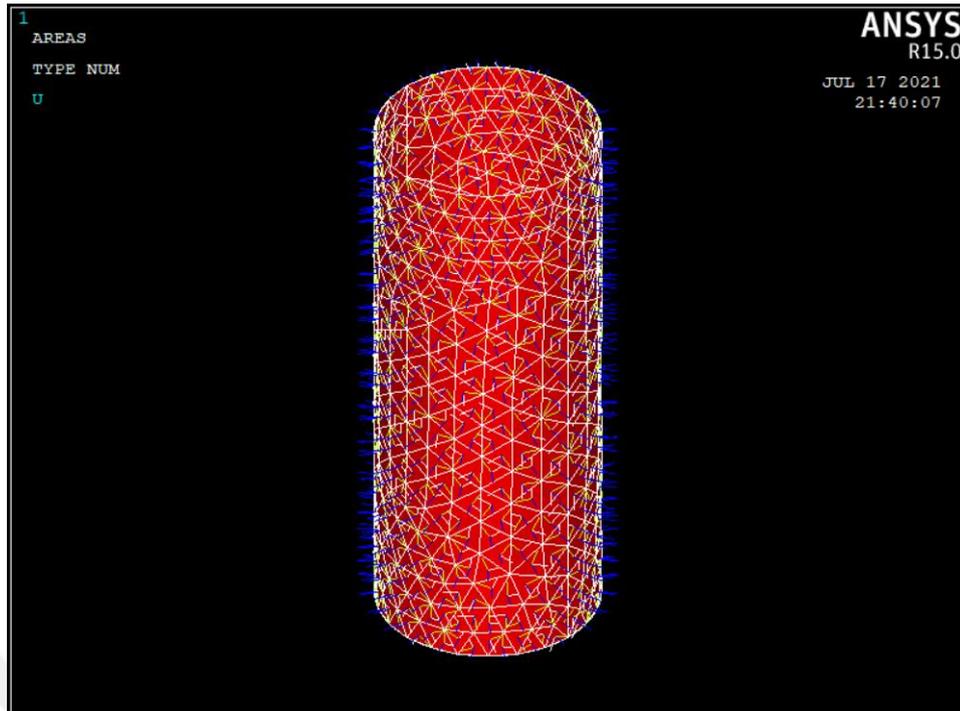
CONTA173 is use to depict contact and a sliding between a deformation surface, specified by this element and three-dimensional "target" surfaces (TARGE170). The

component can be used in three dimensional structural and of coupled field contact studies. This element is found on a surface of 3D solid or shell elements, that do not have any nodes in the middle (has been used SOLID185). It has the same geometrical parameters as the face of the solid or shell element with which it is linked. This element can also be used to mimic interface delamination by separating bound contacts. The CONTA was modeled in the ANSYS on the slab as shown in the fig. 4.1.

A collection of target the segment elements (TARGE170) discretizes the target the surface, which is linked with its corresponding contact the surface through common real constant set, any longitudinal or circular displacement can be imposed on target segment element. Forces and moments can also be applied to target components. These components can readily simulate complicated target forms on stiff target surfaces. These components will overlap the solid, shell, or line elements that characterize the deformable of target body's border in a case of flexible targets.



**Figure 4.3** Showing TARGE170



**Figure 4.4** Showing CONTA173

#### **4.4 Cross Section Parameter Variations**

The structure analyzed is the composite beam slab, beam section (254 X 254 X 73 kg/m) with slab (1600mm X 1200mm) and 6 headed studs 19mm diameter with 100mm high with the single row of studs with headed spaced at 150mm distance. The first stud is 200mm from the end of the slabs. The headed studs and the value of the limited load are the most relevant dimensions for the aims of this study. One parameter was changed the change was in load value. The resulting composite steel was analyzed for each change in a parameter. The results were compared to those from the experimental, which revealed a possible alternate analysis that included the selected changes. In this parametric investigation, the experimental analysis was also examined for a constant slip of studs. The influence of load on slab was ignored in this section, and just the cross-section parameters were studied. Also, keep in mind that in the analysis, we selected a different load for each model that was almost equal to the experimental concentrated load values.

Four composite steels were evaluated at each parameter and would check with other factors. For this aim a software utilizing Parametric analysis using ANSYS. Language of Design (APDL) is constructed to examine the behavior of the structure.

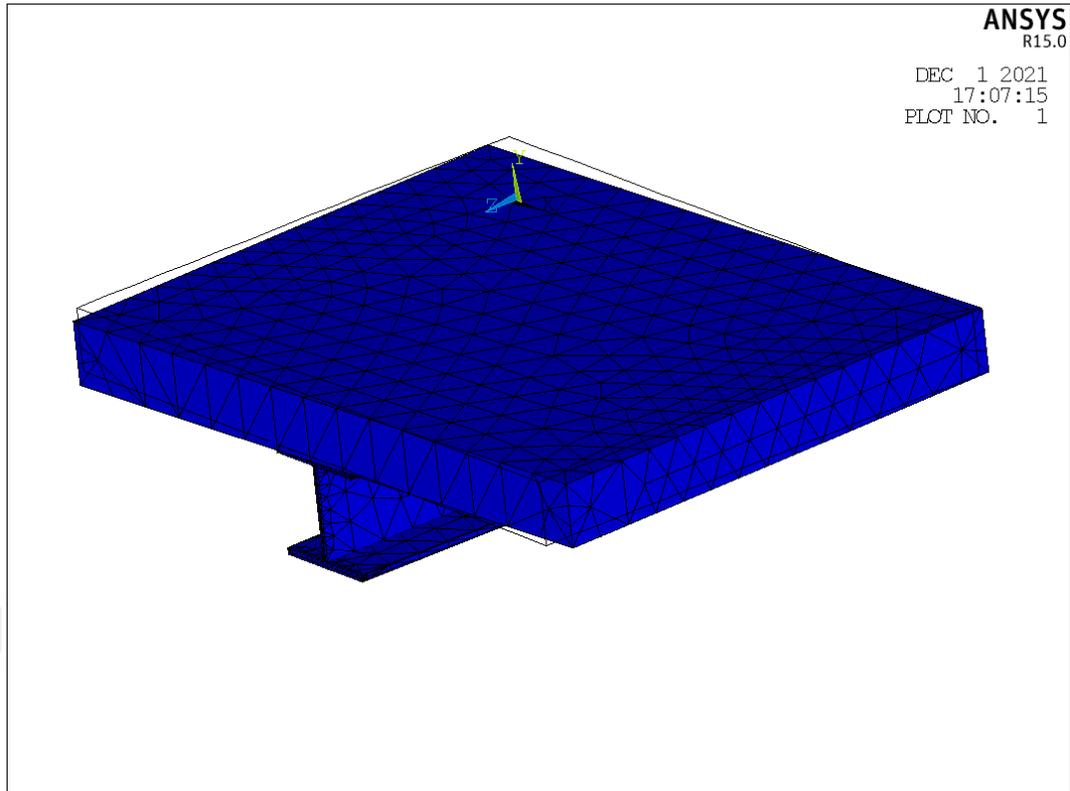
## 4.5 Numerical Simulations Results and Discussions

### 4.5.1 Results for Variations of Cross Section Parameters

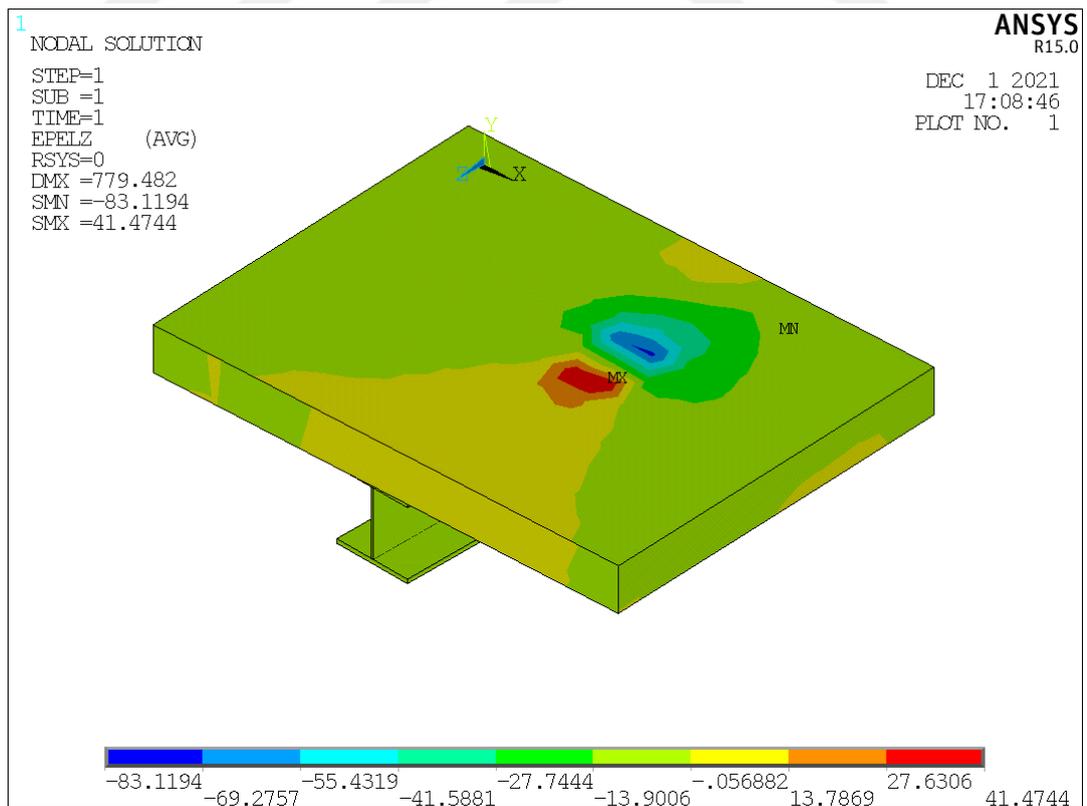
Figure 4.5 shows the deformation and un-deformed of the model as a for the horizontal pressure on this model, table 4.1 and Figures 4.6 to 4.9 show the results of the Finite Element Analysis (FEA) employing RC1, RC2, RC3 and RC4. Along with the results the loading tests, and design values. The design study finds that the stresses and horizontal movement obtained during the loading test are overstated. A composite structures behavior may be determined by using displacements and stresses obtained from finite element models. It's also possible to compare stress profiles with it. The slip studs in RC1 during the experiment was 3.7 mm, while it was 4.14 mm in an analysis done at a load of 71.7 kN for model RC1 by using ANSYS program. As well as the rest of the models as shown in the table.

**Table 4.1** Slip value results for FE models.

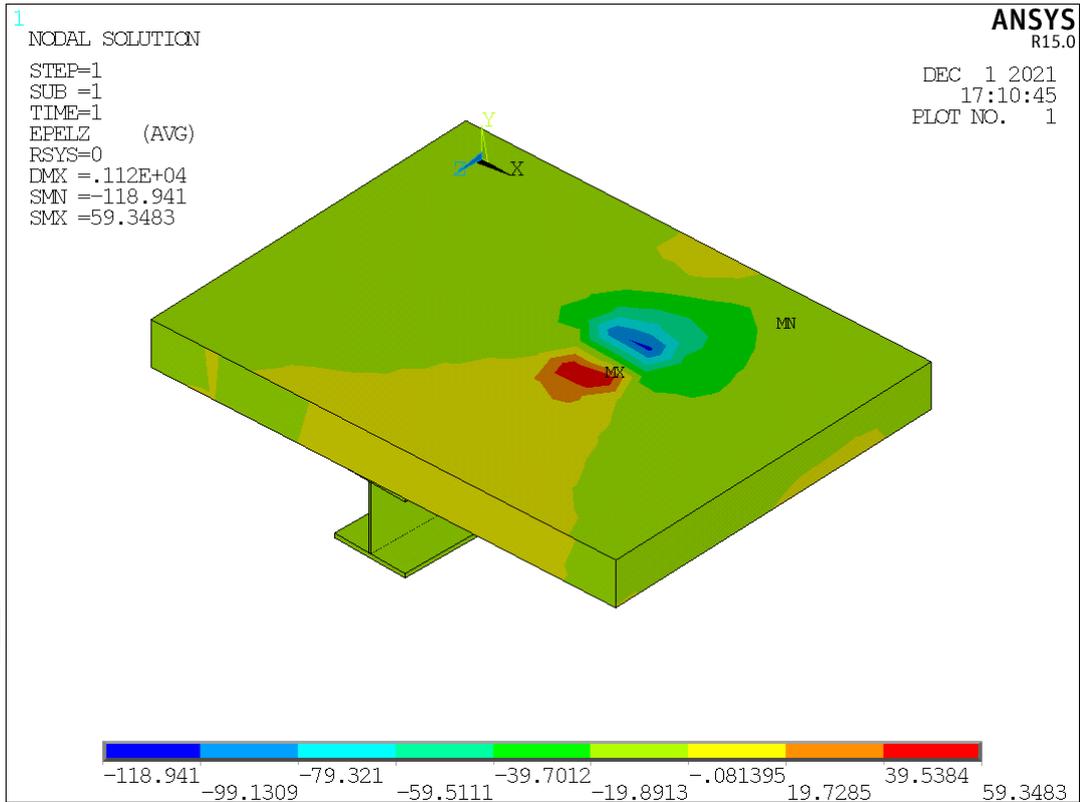
<b>Model Name</b>	<b>Maximum load to stud (kN)</b>	<b>Slip at Maximum load (mm) Experimental</b>	<b>Slip to Maximum load (mm) Simulation by ANSYS</b>
RC1	71.7	3.7	4.14
RC2	102.6	6.3	5.93
RC3	101.6	6.9	5.88
RC4	100.1	6.2	5.79



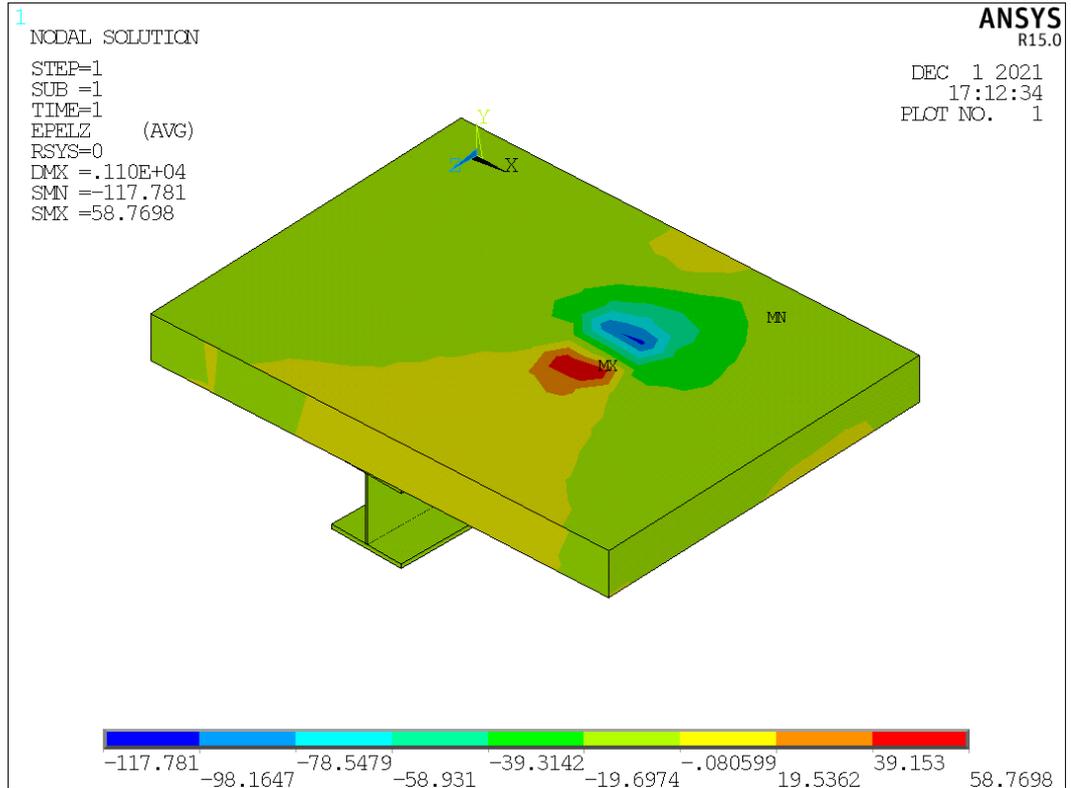
**Figure 4.5** Deformed shape with undeformed model.



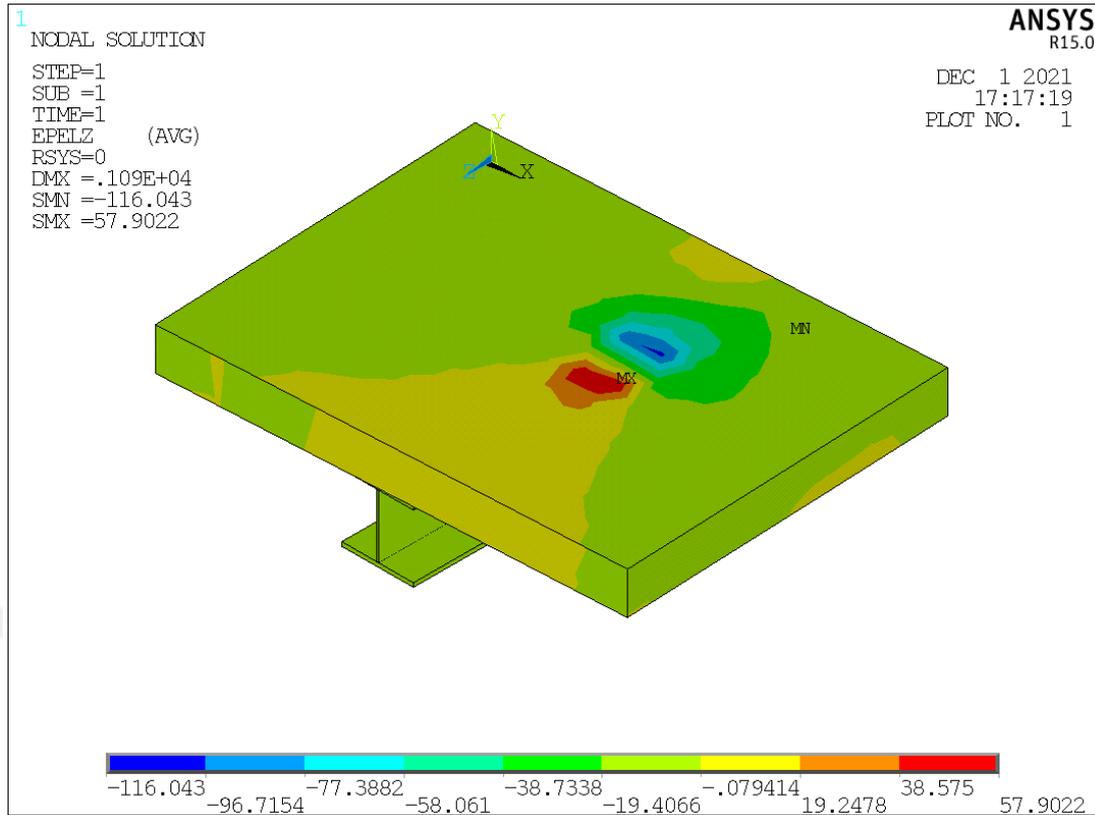
**Figure 4.6** Slip value of numerical model RC1.



**Figure 4.7** Slip value of numerical model RC2.



**Figure 4.8** Slip value of numerical model RC3.



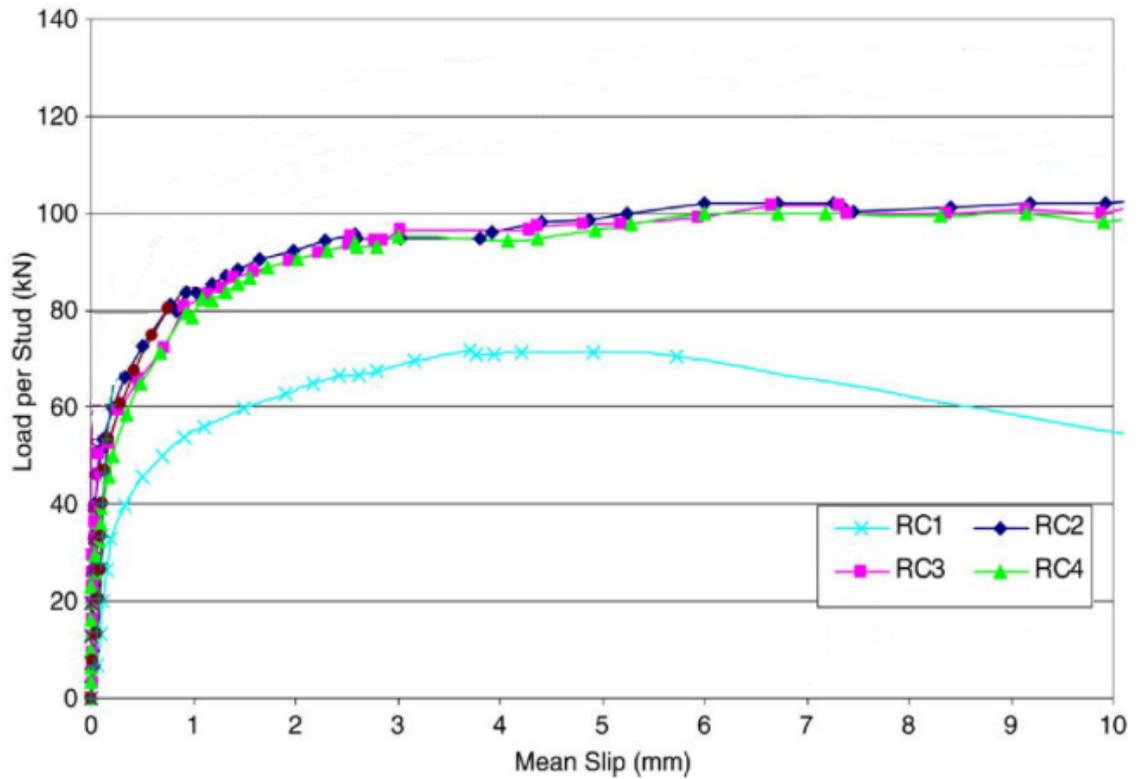
**Figure 4.9** Slip value of numerical model RC4.

**Table 4.2** Slip values with deferent loads.

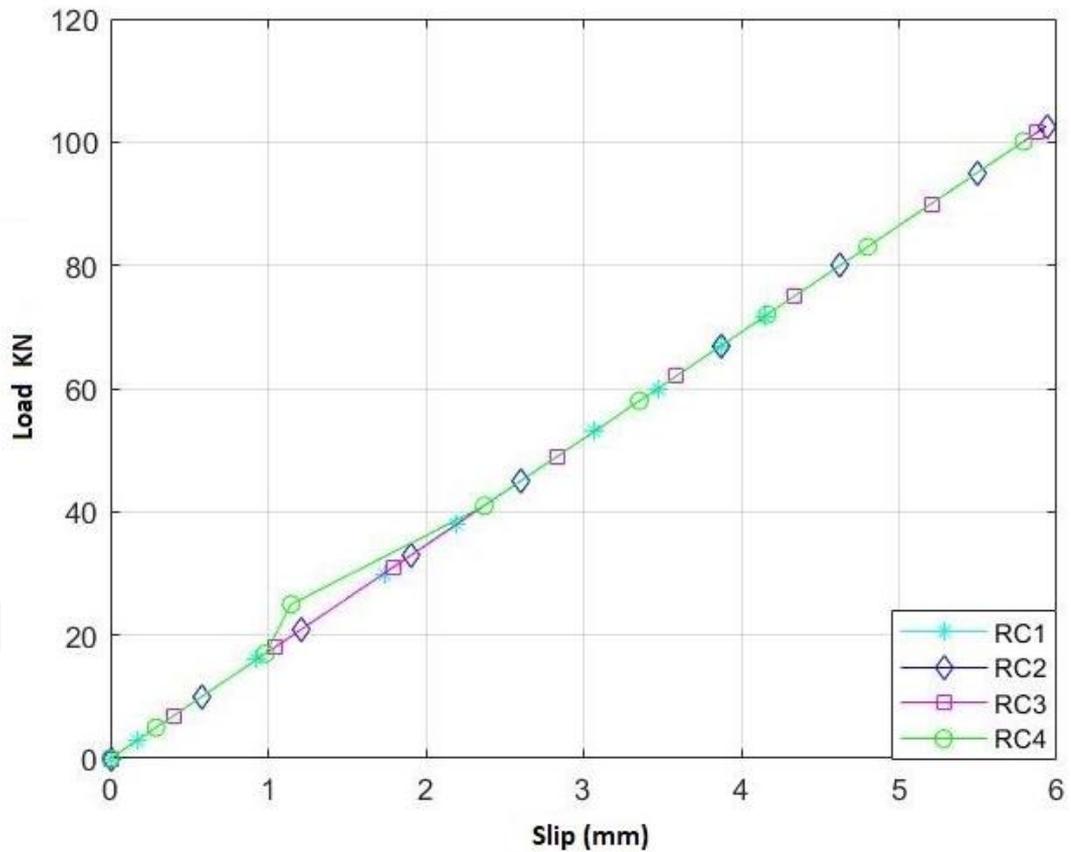
<b>RC1</b>	<b>Load (kN)</b>	0	3	16	30	38	53	60	67	71.7
	<b>Slip (mm)</b>	0	0.173	0.925	1.735	2.19	3.065	3.471	3.875	4.147
<b>RC2</b>	<b>Load (kN)</b>	0	10	21	33	45	67	80	95	102.6
	<b>Slip (mm)</b>	0	0.578	1.214	1.908	2.602	3.875	4.627	5.495	5.934
<b>RC3</b>	<b>Load (kN)</b>	0	7	18	31	49	62	75	90	101.6
	<b>Slip (mm)</b>	0	0.404	1.041	1.793	2.834	3.586	4.338	5.206	5.876
<b>RC4</b>	<b>Load (kN)</b>	0	5	17	25	41	58	72	83	100.1
	<b>Slip (mm)</b>	0	0.29	0.983	1.146	2.371	3.354	4.164	4.801	5.79

Through the curved drawing shown in the figure 4.4 and 4.5, There is a small difference by following the curve between the experimental work and by the ANSYS and the reason for the difference may be some laboratory conditions that led to this

difference, but the results of the slip were somewhat close to the experimental results. It is noticed that the increase in slip has a direct relationship with the applied load, and as shown in the table 4.2 shows the values of slip (mm), at each applied load (kN), where random loading points were selected and slipping was determined.



**Figure 4.10** Showing experimental curve. (Lam 2007)



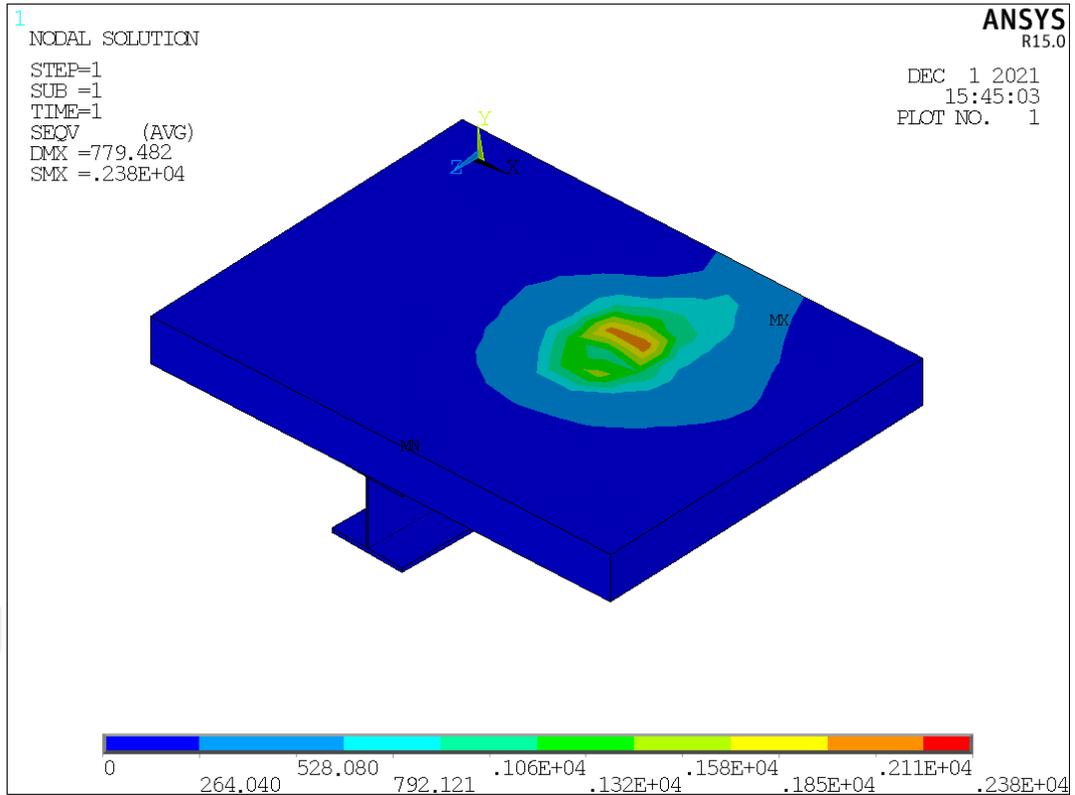
**Figure 4.11** Showing ANSYS curve.

#### 4.5.2 Von Mises Stress

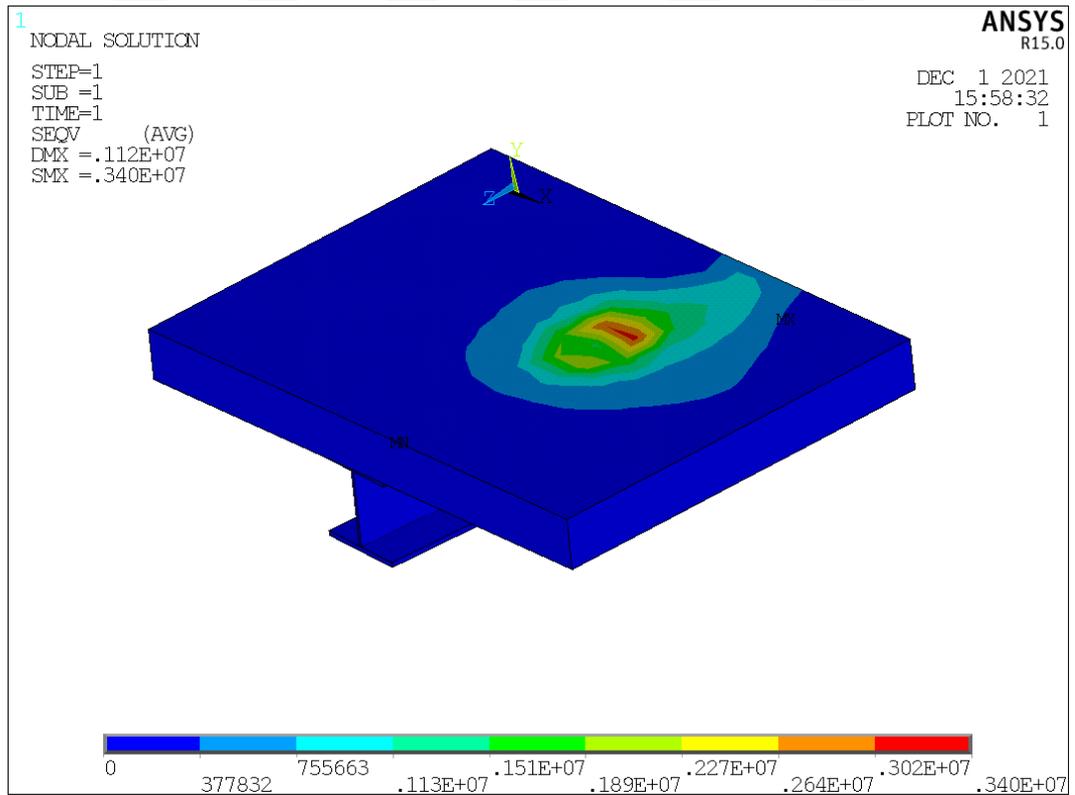
For Von mises stress to has been calculated analytical Finite element analysis of displacement and Von-mises stress in this study in composite structures. The four models component of composite structures with a loading pressure are (71.7 kN, 102.6 kN, 101.6 kN and 100.1 kN) The analysis was done using ANSYS (APDL) programming. The results were shown in Table (4.3) and Figures (4.12 to 4.15).

**Table 4.3** Von Mises Stress.

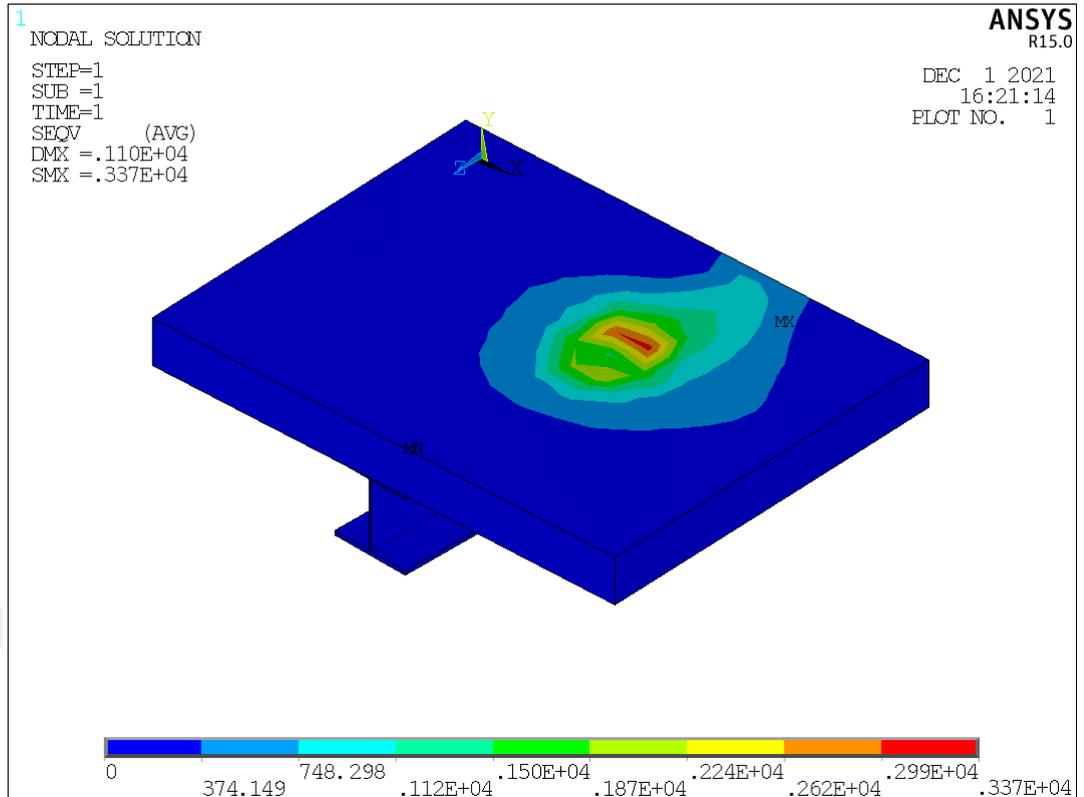
Model Name	Max. load per stud (kN)	Von-Mises Stress by ANSYS N/mm <sup>2</sup>
RC1	71.7	238
RC2	102.6	340
RC3	101.6	337
RC4	100.1	332



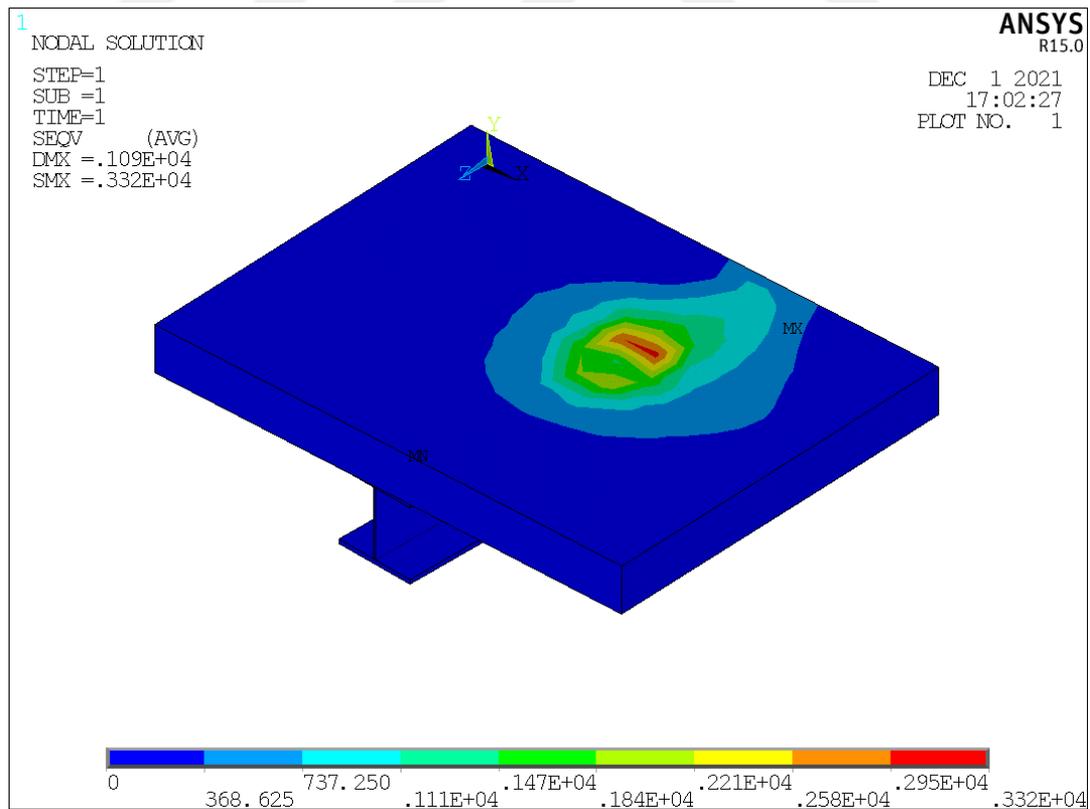
**Figure 4.12** Value of Von Mises Stress model RC1.



**Figure 4.13** Value of Von Mises Stress model RC2.



**Figure 4.14** Value of Von Mises Stress model RC3.

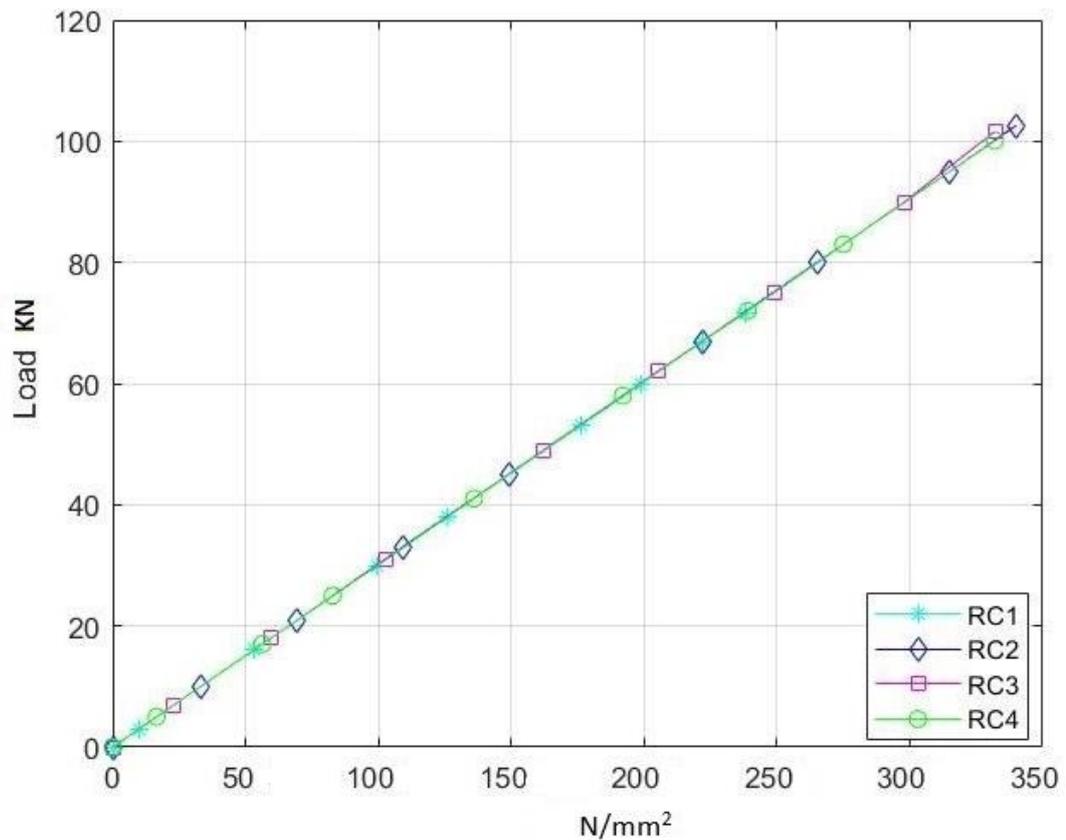


**Figure 4.15** Value of von mises stress model RC4.

Through the curved drawing shown in the figure 4.16 there is high stresses in the studs' areas, it is noticed that the increase in von-mises stress has a direct relationship with the applied load, and as shown in the table 4.4 shows the values of von-mises stress ( $\text{N/mm}^2$ ), at each applied load (kN), where random loading points were selected and von-mises stress was determined.

**Table 4.4** Von mises stress values with deferent loads.

<b>RC1</b>	<b>Load kN</b>	0	3	16	30	38	53	60	67	71.7
	<b>Stress N/mm<sup>2</sup></b>	0	99	530	994	1260	1760	199	222	238
<b>RC2</b>	<b>Load kN</b>	0	10	21	33	45	67	80	95	102.6
	<b>Stress N/mm<sup>2</sup></b>	0	331	696	109	149	222	265	315	340
<b>RC3</b>	<b>Load kN</b>	0	7	18	31	49	62	75	90	101.6
	<b>Stress N/mm<sup>2</sup></b>	0	232	596	103	162	205	249	298	337
<b>RC4</b>	<b>Load kN</b>	0	5	17	25	41	58	72	83	100.1
	<b>Stress N/mm<sup>2</sup></b>	0	165	563	828	136	192	239	275	332



**Figure 4.16** Showing von mises stress.

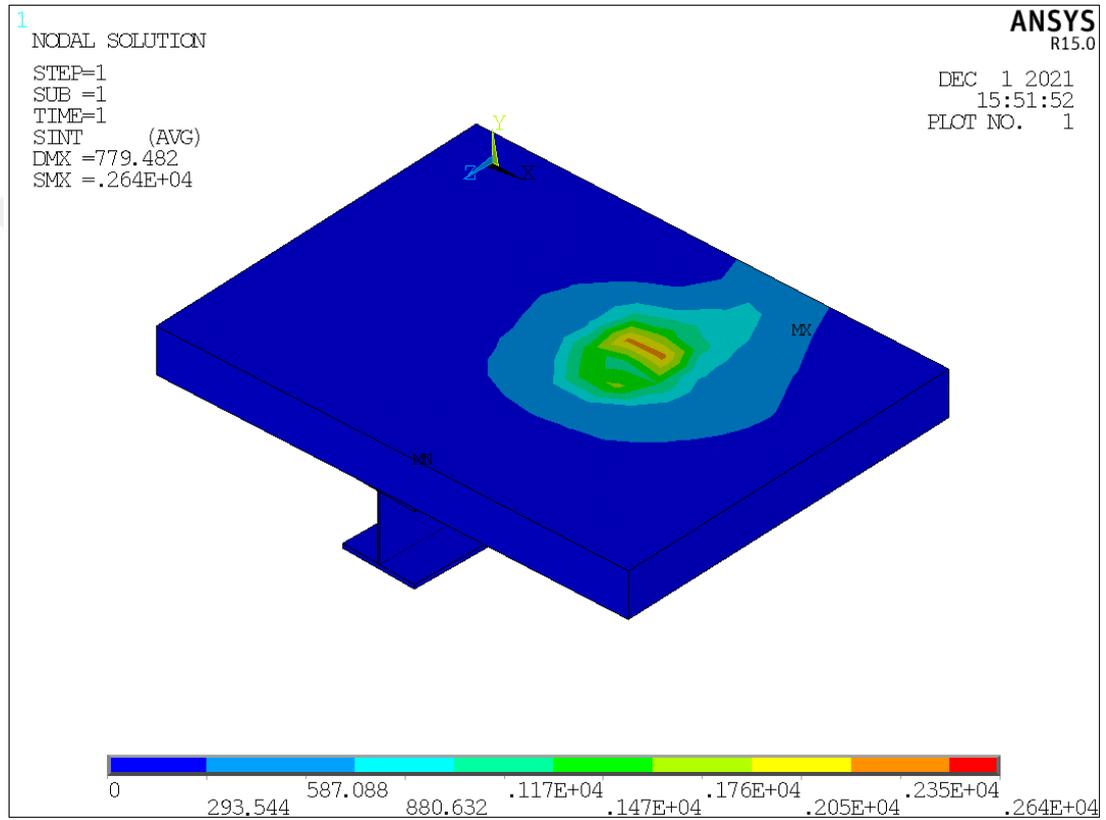
### 4.5.3 Value of Stress Intensity

It's used in the fracture mechanics to anticipate stress condition (or "stress intensity") near tip of the crack or the notch that is produced by a distant load or residual stress. Heterogeneous linear elastic materials are typically considered in this context. It is helpful for giving a failure criteria for brittle materials, and it is an important method in the field of the damage tolerance.

Stress intensity factor able to obtained by finite element analysis with modeling by using ANSYS program. The results by the Finite Element Analysis, (FEA) using RC1, RC2, RC3 and RC4 are shown in Table 4.3 and Figures 4.14 to 4.17 together with the loading test results and design values. It is observed that design analysis tends to overestimate a stress intensity measured in the loading test in zone of studs. Obtaining stresses from the Finite Element Models (FEM), able to utilized in understanding the composite structure behavior. In addition, it is can also be used to the compare of the stress profiles.

**Table 4.5** Value of stress intensity.

Model Name	Max. load per stud (kN)	value of stress intensity by ANSYS N/mm <sup>2</sup>
RC1	71.7	235
RC2	102.6	295
RC3	101.6	291
RC4	100.1	287



**Figure 4.17** Stress intensity model RC1.

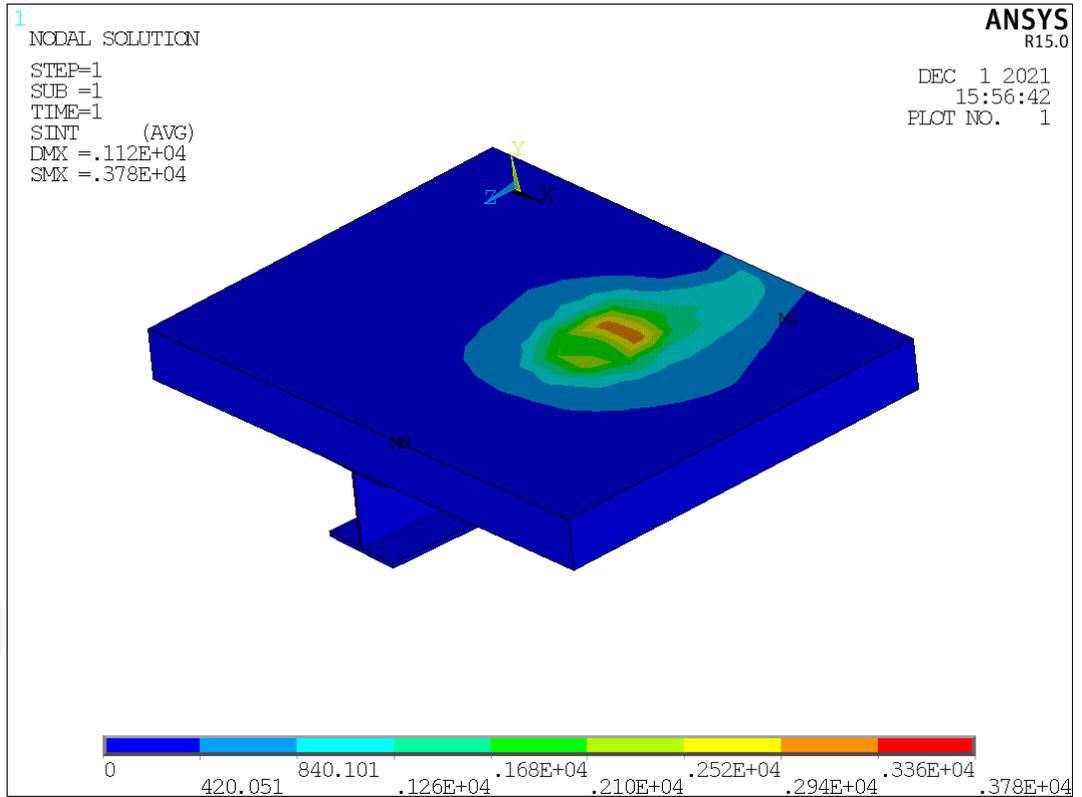


Figure 4.18 Stress intensity model RC2.

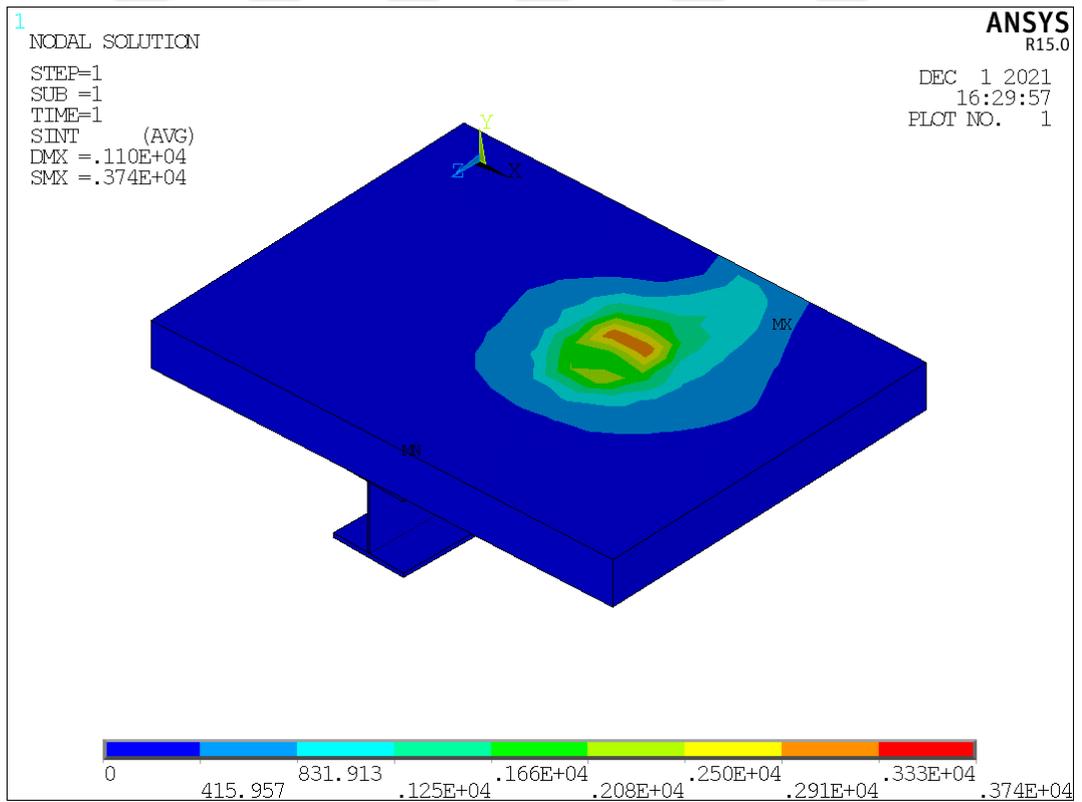
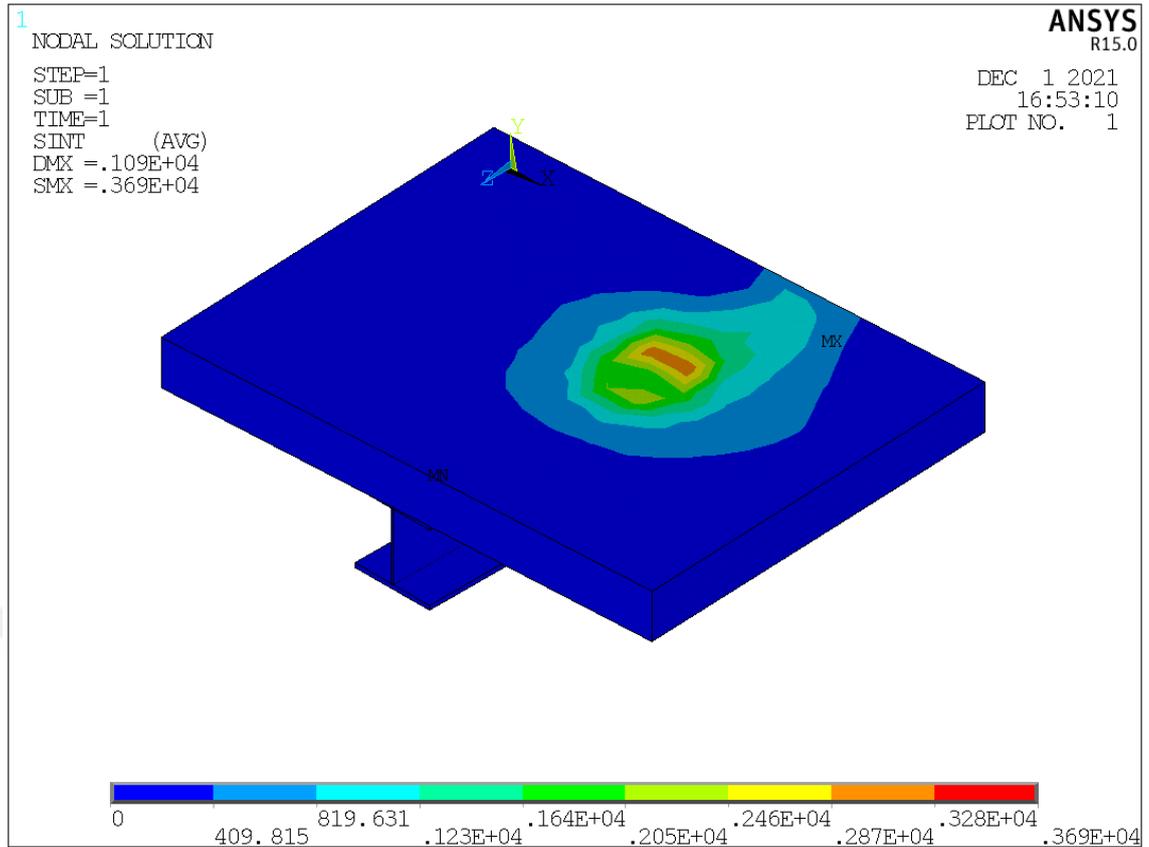


Figure 4.19 Stress intensity model RC3.



**Figure 4. 20** Stress intensity model RC4.

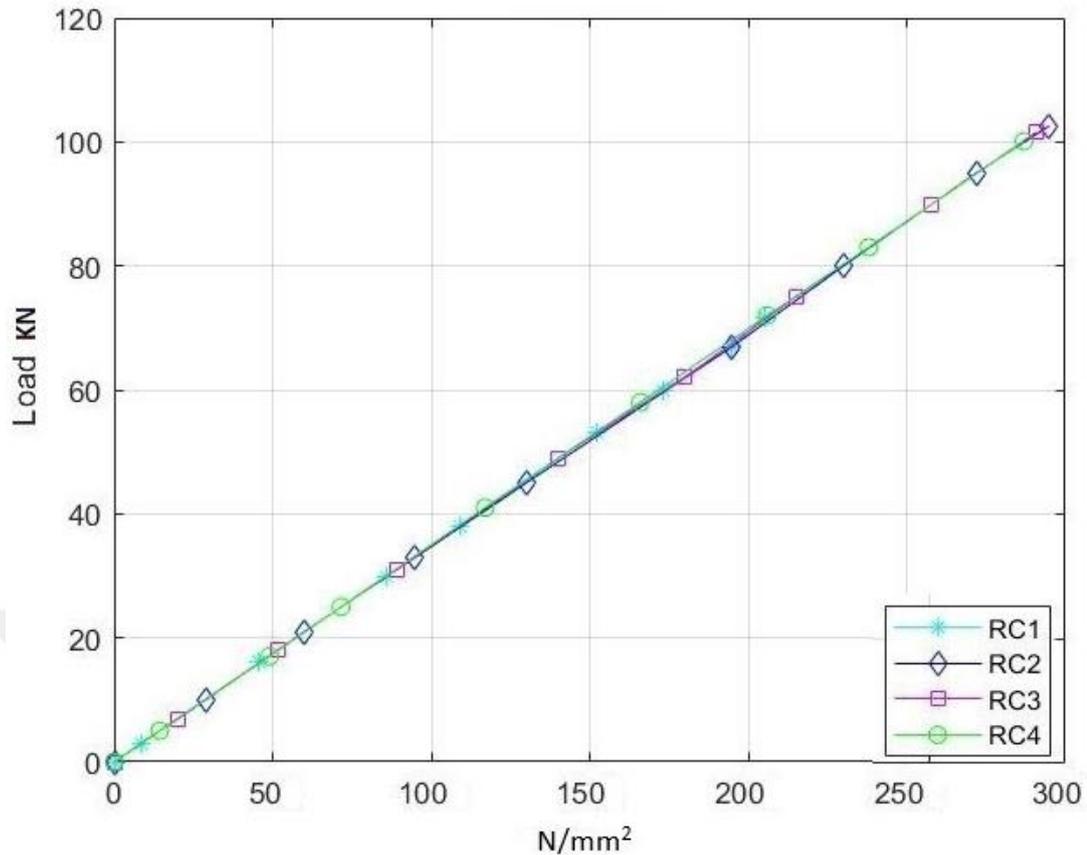
Through a curved drawing shown in the figure 4.21 the is high stresses in the studs areas, it is noticed that the increase in stress intensity has a direct relationship with the applied load, and as shown in the table 4.5 shows the values of stress intensity (N/mm), at each applied load (kN), where random loading points were selected and stress intensity was determined.

**Table 4.6** Showing stress intensity values with deferent loads.

<b>RC1</b>	<b>Load kN</b>	0	3	16	30	38	53	60	67	71.7
	<b>Stress N/mm<sup>2</sup></b>	0	8.5	45	86	109	152	173	195	235

**Table 4.6** Continued.

<b>RC2</b>	<b>Load kN</b>	0	10	21	33	45	67	80	95	102.6
	<b>Stress N/mm<sup>2</sup></b>	0	29	60	95	130	195	230	272	295
<b>RC3</b>	<b>Load kN</b>	0	7	18	31	49	62	75	90	101.6
	<b>Stress N/mm<sup>2</sup></b>	0	20	51	89	140	180	215	258	291
<b>RC4</b>	<b>Load kN</b>	0	5	17	25	41	58	72	83	100.1
	<b>Stress N/mm<sup>2</sup></b>	0	14	49	71	117	166	206	238	287



**Table 4.21** Stress intensity values with deferent loads.

#### 4.6 Summary of This Chapter

A computer program depended on finite element method for simulating the behavior of composite beam slab is used. The composite beam slab are modeled as three-dimensional structures using commercially available software. The parameters considered in the study include flange thickness, web thickness, span length, haunch ratio, concrete depth and web box depth. The aim of this study is to present a detailed description and explanation of the behavior of composite beam slab at several types of models under variety loads. Comparisons are made between stresses obtained for the composite beam slab according to many changes in the variety of the load. Finally, the parametric investigations are performed on the composite beam slab model, to evaluate of effects the several important parameters on behavior the composite beam slab. The results from this study would enable structures engineers to design composite beam slab more reliably and economically.

The results obtained from ANSYS FEM, were compared with the experimental results in the case of slip and found that they are very close to reality and this indicates the correct work of the program.



## **CHAPTER V**

### **CONCLUSION**

#### **5.1 Conclusion**

The composite structures, which are made up of the concrete slabs and rolled steel-sections, are used as structure components in (bridges and high rise buildings), among other things. Shear connectors are used to join the concrete of slab and steel segment together, resulting in a composite action.

The composite action increases structural of efficiency by the combining structural components into a single composite-section. Construction of composite beam designs is less expensive since it requires less material, allows for deeper floor depths to be kept to a minimum, and is quicker to complete.

The ability the shear connections to transmit these longitudinal the shear forces is governed by their strength, as well as the resistance of concrete slab to the longitudinal cracking produced by of the high concentration of shear forces.

It's the purpose of this thesis to understanding a fundamental of Shear of Connectors in the Composite Steel Beam. The results of fundamental behavioral patterns of Composite Steel Beams for loads are presented in the past chapter. The modeling of four types of composite beams has been studied, which have the same model, but differ in loading.

The used of the analytical techniques available, finite element, FE analysis is the considered to be the most powerful, flexible, and suitable numerical tool for addressing a complex continuing problem. Finite element computer FEP programs are now capable of being utilized in almost every engineering area. The finite element method is well suited for representing complex geometries such as those seen in composite structure. In addition, the method is capable of dealing with a wide range of material properties, structural component connections, boundary conditions, and static or dynamically applied stress conditions. Using this technique, it is possible to anticipate

with great accuracy the linear and nonlinear structural reactions of such composite structure.

The structure analyzed is the composite beam slab, beam section (254 X 254 X 73 kg/m) with slab (1600mm length 1200mm width and 150mm high) and 6 headed studs 19mm diameter with 100mm high consisting of a single row of pointed studs spaced 150mm apart. The first stud is 200mm from the end of the slabs. The headed studs and the value of the limited load are the most relevant dimensions for the aims of this study. One parameter was changed the change was in load value. The resulting composite steel was analyzed for each change in a parameter. The results were compared to those from the experimental, which revealed a possible alternate analysis that included the selected changes. The slip results obtained from the ANSYS and after comparing them with the practical results showed very closeness, which indicates the accurate analysis of the elements in the ANSYS. It has also been studied the Von-mises stresses and Stress Intensity; it is found through structural analysis that there are stresses in area of the studs resistance to horizontal slips caused by lateral pressure loading. Using software utilizing Parametric analysis using ANSYS. Language of Design (APDL) is constructed to examine the behavior of the structure.

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