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Civil Engineering

IMPROVING AND MODELLING THE FLEXURAL ANALYSIS OF INDETERMINATE REINFORCED CONCRETE BEAMS

Zahraa ALSNGAR

Master's Thesis

Supervisor

Prof. Dr. Tuncer ÇELİK

Istanbul, 2022

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The thesis titled "IMPROVING AND MODELLING THE FLEXURAL ANALYSIS OF INDETERMINATE REINFORCED CONCRETE BEAMS" prepared by ZAHRAA ALSNGAR and submitted on 07/12/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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ABSTRACT

IMPROVING AND MODELLING THE FLEXURAL ANALYSIS OF INDETERMINATE REINFORCED CONCRETE BEAMS

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The modeling of the indeterminate beams analysis under concentrated and uniform loading was the aim of the study. The study defined the geometrical and loading conditions for each case then built its analysis pathway by using the method of slope deflection. The analysis steps including the fixed end moments and the other parameters like the length of beam spans and the magnitude of loading and the cases of joint. the study links all these parameters into equation then derived effective equations based on the relationships and the degree of impact between each parameter and the moment at the second joint which used to be the initial identifies internal moment that ca ease the reach to the other internal moment and the shear forces as well as the joint reactions. The study made number of correlation and checking stages during the scientific path to make the resultant equation be more effective and applicable. The equation obtained considered for two main cases: the first case was the beam with three spans under concentrated load in which load for each span. The second equation was for the case that three spans indeterminate beam under uniform loading. The value of moment reached were examined for both the calculated and the derived state. The difference was so small indicating the closing of the deriving model to the original steps of calculation. The simulation for the cases was done by using ANSYS program which the geometrical shape and loading condition were drawn then analysed under the finite element technique. the magnitude of the moment reached by ANSYS was so satisfied that derived in which the simulation shows visual images for the internal force variation along the spans including the state of directional deformation, the bending moments, and the shear forces. The shear force and bending moment diagram were explained also by ANSYS program.

Keywords: Reinforced Concrete, Beams, Flexural Analysis

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ABBREVIATIONS

FEM_{AB} : Fixed End Moment At The End A

FE : Finite Element

RC : Reinforced Concrete

LIST OF SYMBOLS

θ_A	:	The Slope At Point A
Δ	:	The Displacemnet Of Deformation
H	:	Height of beam
L	:	Length of beam
P	:	Concentrated loading
W	:	Uniform Load
Mbc	:	Moment on member bc

1. INTRODUCTION

1.1 INTRODUCTION

Statically determined structures have the advantage of not acquiring applied stresses as a result of changes in temperature, for example. It's also prevent the development of undesirable forces in the presence of differential settlements [1]. Statically determinate constructions are especially common in bridges, owing to the fact that heat fluctuations can cause significant stresses in the structure. Furthermore, the three-hinged arch is frequently utilized as the supporting structure for various bridges, which is a superbly constructed statically determinate construction that not only prevents undesirable stresses but also eliminates a lot of bending forces [2]. Because of the extra steps necessary to solve the reactions, indeterminate beams can be difficult. Remember that indeterminate structures have what is known as a degree of indeterminacy. Boundary conditions must be introduced in order to solve the structure. As a result, the greater the degree of indeterminacy, the more boundary criteria must be defined. However, before solve an indeterminate beam must first determine whether the element is statically indeterminate. Because beams are one-dimensional constructions, applying the equation to externally statically indeterminate structures is adequate [3].

Any construction should be stable and not shift unnecessarily within imposed loads. It should maintain its place under the applied loads. Indeterminate constructions are a set of connected elements used in building pieces such as beams, trusses, and frames, as well as additional elements not essential to make the structure stable. Fixed Beams: A fixed beam is a beam with both ends firmly fixed so that the slope at the ends remains zero. This type of element is also known as the encase beam [4]. The fixed endings transmit assent to the fixed moments, which contribute to the reactions. Designed signals with faultless end fixing have smaller flexure scenes and relatively small obfuscations than simply evaluated struts with comparable weights. They are therefore stronger and more rigid as a consequence. However, the extreme accuracy necessary in aligning the supports and securing the ends through erection raises the cost. Small subsidence's in either assist or temperature variations might cause enormous stresses. End fixes are generally sensitive to vibrations and changes in joining moments [5].

1.1.1 The Benefits of Indefinite Structures

a. The analysis is more sophisticated in terms of quantity.

b. The strains and deflections are reduced.

c. Greater stability and lower condition of collapse for overload (wind, earthquake, etc.) or poor design [6].

In the case of an indeterminate structure, Support responses and internal forces that may be evaluated in statically determinate constructions can be evaluated using simply the equations of equilibrium. However, studying statically indeterminate structures necessitates the use of additional equations based on the state of geometry of deformation in which the structure is deformed. The framework additional equations are generated by compatibility linkages, which assure the continuation of displacements inside the structure [7]. The remaining equations are built using member constitutive equations, i.e., relationships between stresses and strains and the integration of those equations above the cross section. The design of an indeterminate structure is carried out iteratively, with the (relative) sizes of the structural components initially assumed and used to resolve the structure. The member sizes are changed to suit the governing design principles based on the computed findings (displacements and internal member forces) [8]. The iteration process is repeated until the member sizes based on an analysis's conclusions are close to those considered for that analysis. Another consequence of statically indeterminate statically indeterminate constructions is that the relative variation in which of the member sizes effects the magnitudes in which the member will experience in the future [9]. Despite the problems associated with statically indeterminate structures, the vast majority of structures in the state of construction today are statically indeterminate[10].

1.2 BEAM TENSILE STRESSES

When external loads are applied to a beam, it must be limited in order to maintain non-dynamic equilibrium. Criteria are defined at isolated points along the girder, and the type of restriction is specified by the point is actually boundary. The line of control condition determines whether the component is fixed (unmovable) or allowed to move in all ways[11]. A this double beam is concerned with the cross (axial direction), the y-direction (circumferential direction), as well as rotation. For just a point to have a limitation, the criterion must prove that at least another path is fixed again for juncture[12].

Stress is the action of a force or moment on a structural element. Tensile stress is produced when a force pulls on a member (tension); compressive stress is produced when a load pushes on a member (compression). Tensile tensions stretch a member, while compressive stresses squeeze it. The internal moment causes bending [13]. Because moment can be broken down into a couple, the internal moment can be thought of as a compression force (C) and a tensile force (T). Compression force results in compressive applied stresses, and tensile load results in tensile stresses. As a result, bending force is a combination of compressive and tensile stresses that cause internal moments. Because the stress over a beam segment fluctuates from compression to tension, there is a point where force equals zero. This is known as the "neutral axis." The neutral axis of a homogeneous beam travels via its centroid [14].

1.3 PROBLEM STATEMENT

The analysis of indeterminate structure member include the difficulty of assigning the right magnitudes of fixed end moments and reaction forces in the supporting zone of the members. The designers take these reactions to find the behavior of stresses in the span of the member. The high gap in predicted these stresses with the accurate amounts can be happen in design errors leading to unsuitable constructing and strengthen of the member. The variety of loading and the supporting conditions lead to different state of stresses formation in tension and compression action.

1.4 CONTRIBUTION

The prediction of more precise moments and stresses along the indeterminate concrete members was the pathway of the study for easing the design output. The study tried to build effective analysis with statistical analysis technique to cover the identifying of the internal stresses inside these types of members. The achievement of the study outline can reflect more controlling to the design choices in the way of assigning the right geometrical properties and the amount of reinforcement and any other parameters that effect the final strength capacity of the member.

1.5 OBJECTIVE

a. Analysis the cases of indeterminate reinforced concrete beams that taken by the study with assigning of the parameters that effect the analysis procedure like the cross section dimensions, the compressive strength of the concrete, and the reinforcement properties. The analysis implemented by using slope deflection method.

b. Evaluating the stresses that formed in the concrete body along the beam span then analyzing the strength capacity by using ultimate stress design method

c. Applying of statistical analysis by using of ANSYS program then using the result in the way of modeling the cases of indeterminate beams with various conditions of loading

d. Checking of the model that derived by matching the strength capacity with the calculated bending moments

e. Explain the results in graphs and discus them

2. LITERATURE REVIEW

2.1 OVERVIEW

Since they are stiffer and stronger, nonlinear static constructions are more frequently used than statistically determinate constructions and are generally less expensive[15]. As during maximum going to connect moment, a static element bearing a primarily based load at mid-span, for example, has a center deflection equal to that of a quickly beam with the same time frame and bearing this very same load. As a result, a smaller beam segment is required in the results found scenario, resulting in content savings [16]. Nevertheless, there are disadvantages to using this type of beam because of the trying to settle of a help in a fixed beam generates bending stresses in relation to the those generated by loads, that is a major concern in prone areas to subsidence. This other drawback of nonlinear static constructions is that their analysis necessitates the computation of deformations, which necessitates the use of cross-sectional dimensions from the start[17]. The design of similar structures becomes a question of trial and error, whereas the forces in the components of a statically determinate structure are independent of member size. Failure of, say, a member with a statically indeterminate shape, on the other hand, would not necessarily be disastrous because alternate load pathways would be accessible, at least temporarily. However, the breakdown of a member in a statically determinate truss, for instance, would almost surely result in a quick collapse [18]. The decision between statically determinate and statically indeterminate structures is heavily influenced by the reason for which the construction is required [19]. Figure 1 explained the appearance of fixed ends beam with the reactions that formed on its supports. Figure 2 showed the difference in deformation curve for the simply and fixed ends beams. As its appeared clearly the defection curve indicates usually less value of peak settling in fixed beam as compared to simply supported one and that can be pointed as advantage to the fixed end beam structure [20].

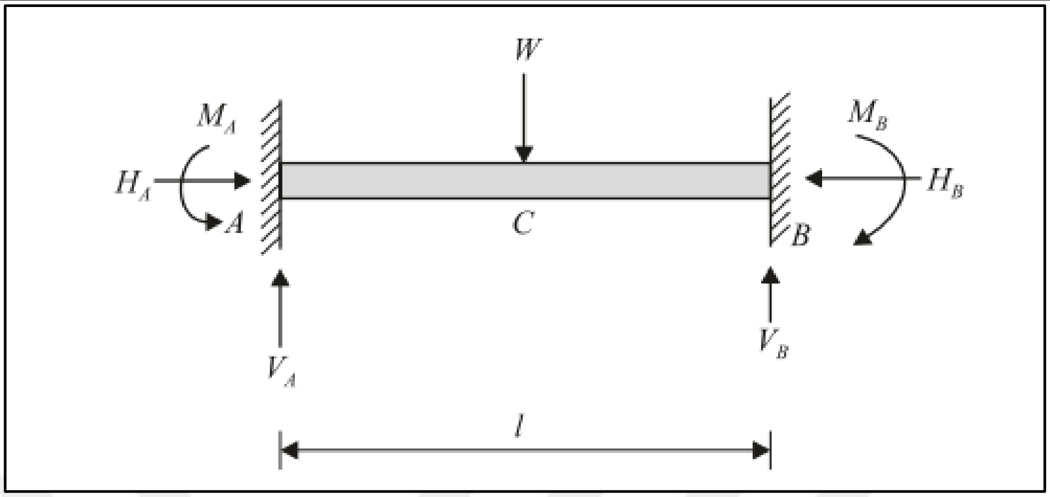


Figure 2.1: Reaction Behavior In Fixed Ends Beam [21]

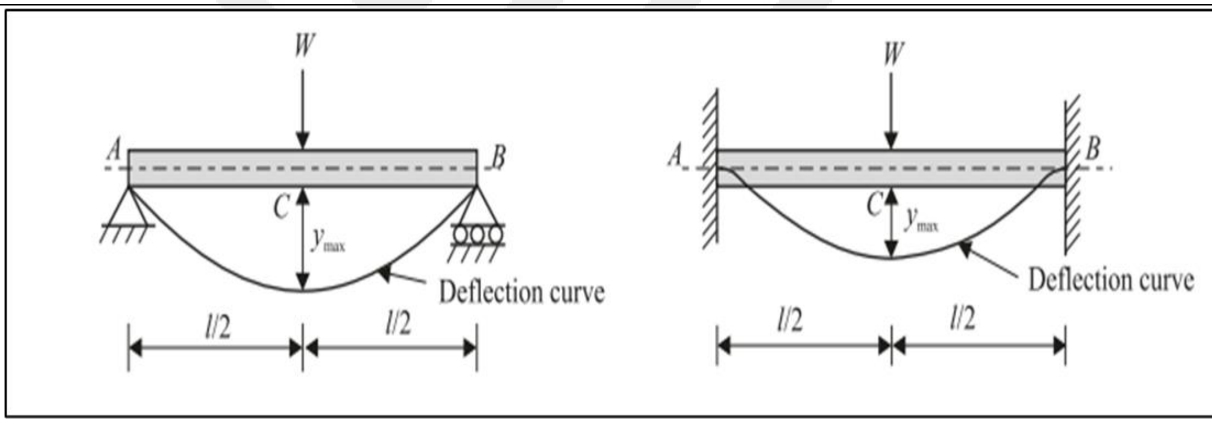


Figure 2.2: The Difference In Deflection Curve For Simply Supported And Fixed Ends Beams [21]

2.2 STEEL IN INDETERMINATE STRUCTURE

Individual parts of a steel or timber structure are manufactured or cut separately and linked together via rivets, bolts, welds, or nails. Unless the joints are specifically engineered for stiffness, they are also flexible when it comes to shifting moments of magnitude from one member to another [22]. With contrast, in reinforced concrete constructions, as much concrete as possible is laid in a single operation. Reinforcing steel is not terminated at the ends of a member, but rather extends through joints into neighboring members. Special care is required at building joints to attach the new concrete to the old by carefully cleaning the latter, extending the reinforcement across the joint, and using other measures [23]. Reinforced concrete constructions are almost always composed of monolithic, or continuous, units. A load supplied to a single point induces deformation and force in all other areas [24]. Even in pre - cast concrete buildings, which are similar to steel construction in that individual members are brought to the job site and joined in the field, connections are frequently designed to provide for the transfer of moment action as well as shear and along axis load, resulting in the least partial continuity [25]. A continuous beam with simple spans, such as those found in many types of steel buildings, only the loaded member might distort, while all other members of the structure remained straight [26]. However, with continuity from one member to the next inside the support sites, as in a structural concrete, the distortion caused by a loading one in a single state span is thought to spread to other spans, although the magnitude of deflection decreases with increasing distance from the packed member. Curvature, and hence bending moment, are present in all areas of the six-span structure as a result of loading span [8]. Similarly, for the rigid-jointed frame, the deformation generated by a load on the single member extends to all beams and columns, however, as previously stated, the influence reduces with increasing distance from the load. Even though no transverse stress is present, all sections are subject to bending moment [27]. If lateral loads, such as wind or seismic action, occur on a frame, it collapses. In this case, too, all elements of the shape distort, even though the forces apply solely on the left side: the quantity of distortion is shown to be close to adequate for all pertaining to members, independent of their distance from the points of loading, as opposed to the state of vertical loading. A member will experience deformations and associated joining moment even in the absence of a direct state imposed transverse load. In statically determinate constructions, such as simple-span beams, the deflected shape and moments and shears are determined solely by the kind and magnitude of the loads [28]. Figure 3 showed the system of continuous beams.

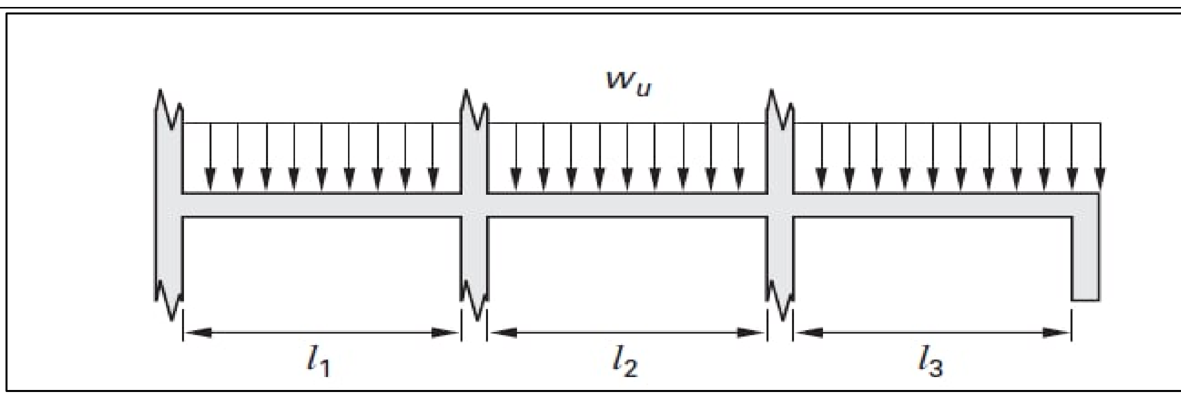


Figure 2.3: Statically Indeterminate Beams System [29]

2.3 CONSIDERATION OF RESOLVING INDETERMINATE STRUCTURE

The load technique of resolving, also known as the method of consistent deformation, is a method of determining the unknowns in statically indeterminate structures by employing equilibrium equations and compatibility requirements. The unknowns are the redundant forces in this strategy [15]. A redundant force might be an external assistance reaction force or an internal member force that, if removed from the structure, will not create instability. This method requires generating a set of compatibility equations based on the number of redundant forces in the structure and solving these formulae simultaneously to determine which of the duplicate force magnitudes is greater. Once the redundant forces are identified, the structure becomes definite and may be completely examined utilizing the states of equilibrium [30]. By considering the propped cantilever beam as an example of the method of consistent deformation. The beam has four unknown response activities, making it indeterminate to the start degree. This indicates that there is one response load that may be eliminated without endangering the structure's stability. The primary construction is the structure that remains once the superfluous reaction is removed [31]. The equilibrium requirement must always be met by a main construction. A comprehensive examination of the future construction will reveal that there are two capable redundancy reactions and two possible major structures. Using the vertical reaction for support B and the reactive moments at support A as the redundant reactions, the primary structures that remain are in a condition of equilibrium. After selecting the superfluous forces and constructing the major structures, the following step is to formulate the compatibility equations for any of the cases by superimposing some sets of partial solving which satisfy the balancing requirements [32].

2.4 METHODS OF FLEXIBILITY AND STIFFNESS

The statically indeterminacy of member is defined a requirement, that member must be steady and statistically determinate, which is not always the case. The circumstance, which limited the number of representatives to the amount of joints, lacked supportive leadership, which could be statically obvious or vague [33]. The tightness or dispersion technique seems to be similar to the non-rigidity method, with the main difference because the unknowns are the deformations at specific locations in the structure. In overall, the procedure necessitates the division of a structure into a number of pieces, of which each has a known capacity relationship. The balance equations are then actually written as gestures of the displacing just at element intersections and managed to solve for the required displacements[34]. Both the flexibility and stiffness methods produce a significant number of simultaneous formulae in the case of practical constructions with a high degree of statically indeterminacy, which are easily solved using computer-based techniques. In any case, the flexibility methods require the construction to be reduced to a statically defined state through the use of inserting releases, a step that takes some judgment on the part of the analyst [35]. The torsional stiffness method, in contrast side, does not necessitate such a decision and thus lends well to instant computation. Even though the adaptability and rigidity processes are typically computer-based in practice, they are critical towards the 'palms' analysis methods[36]. Prior to actually delving into all those stick shift approaches, it is necessary to examine the indeterminacy of constructions more closely, because knowing the degree of uncertainty of a structure is required before determining the required number of updates in the series of non. It is necessary to determine the number of constraints that need to be applied in order to produce a structure that is motion define in the stiffness technique in a reasonable amount of time[31].

2.5 DEGREE OF STATICALLY INDETERMINACY

A nearly acceptable outcome would be obtained if the single support remained fixed and the other support was removed entirely. Furthermore, removing an angled, vertical, or lateral member from the truss causes the truss to become statically determinate. This method of releasing a structure may result in deformations that would otherwise not be present[37]. Those deflections can be calculated by assessing the released details of the design structure; the coercing system needed to eradicate them then is obtained, implying that a suitability of dispersion condition is used. This method is referred to as the versatility or load method, but it was used in the propped telescoping solution [38]. An indeterminate truss case had been showed in Figure 4.

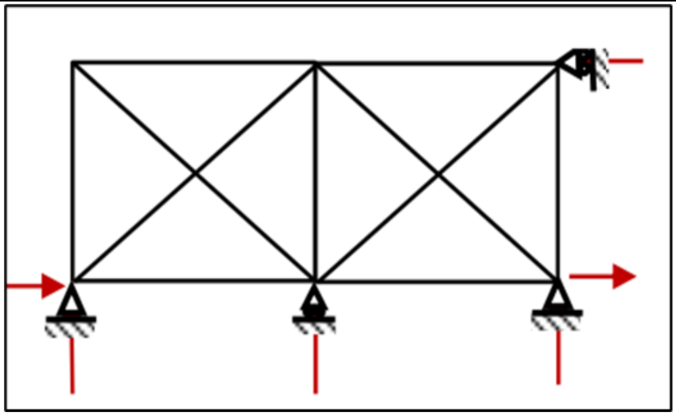


Figure 2.4: Indeterminate Case Of Trusses [38]

Because the regime is two-dimensional, the frame carries loads, concentrated and uniform in its own plane. For a three side frame, there exist three possible equations of statically equilibrium for a two-dimensional system, hence the frame is externally statically indeterminate to the third degree. Taking a section through one of the pieces does not improve the situation since, while reducing one of the sets of reactive forces, this technique introduces three internal stress resultants. However, if three of the assist reactions were recognized or, alternatively, if the three internal stress resultants were known, the other three unknowns would be identified using the equations of statically equilibrium and the solution would be completed [39]. The additional diagonal in the simple truss causes the truss to become internally highly insoluble to the first degree; however, the assist responses are statically determinate. In the research of statically indeterminate constructions, and over one basic method is used. By using releases, the structure is lowered to an analysis to determine state in a single step, i.e. by reducing an adequate rank of unknown factors to allow the help reactions and/or internal pressure take the time to be noticed from a statically balance consideration[40]. When the designer provides bigger quantity support and/or member to structure than required for non-dynamic stability, it creates structure indeterminate. By providing this excess member it guarantees stability and same manner increase stiffness in which of the member or structure. Such of in case in which of truss that supply additional diagonal members to ensure stability [41].

2.6 CURRENT WORK

The study used the strategy of analyzing the conditions of indeterminate reinforced concrete members by taking in considering of the effective parameters that influenced the overall internal strength after applying of analytical method to identify the behavior of bending moment along the beam span under various loading conditions. The study used the case of fixed ends beam and built its evaluation data by using slope deflection method. The modeling was main part inside the study in which the controlling the magnitudes of the effective parameters for better design was implemented. The simulation was done for the cases by ANSYS workbench program. The three and two dimensional figures used to support the outline of the study.

2.7 LITERATURE SURVEY

(I. Jong & J. Rencis, 2007) The study adopted a new approach that applies a combination of four modeling formulas in evaluating statically non-specific responses at struts, as well as slopes and beam misdirection. Form formulas are developed in algebraic form using singularity functions. They are stated in terms of (a) bending stiffness of the beam; (b) Slopes and deflections as well as shear forces and bending moments of both ends of the beam; and (c) forces applied to the girder. The following load classes are used: load concentration and moment; (ii) Uniform distribution moment; and (3) linearly varying distributed pressure. As a result, these modeling formulas are applicable to the vast majority of troubles encountered in the teaching and learning of mechanics of materials, as well as in practice. As an important feature, this modern technology allows a person to process the reactions at the struts, even if they are not at the ends of the beam, as concentrated forces or moments, indicating the boundary conditions of the places where the struts are imposed using the same form formulas. This function allows one to estimate statically independent interactions of beam supports, as well as slopes and deflections at each position. The beam should be separated into sections for analysis only when there is a break in the slope or bending stiffness. Several examples are given to illustrate this (new method) [31].

(A. Rojas, 2013) The study presented a method for evaluating beams taking into account the permanent shear deformation, which is an extension of the tilt and skew approach, which is used to solve all kinds of continuous beams. The approach takes into account shear deformation and flexion. The common method merely considers bending deformation and ignores shear deformation; this is how structural analysis of statically undefined beams is frequently developed. It also compares the summarized method with the traditional method, and the method differences between both methods are greater, especially in the short length segments, as can be seen in the results tables in any of the problems investigated, there are no values higher than in any aspect of safety in the common method. As a consequence, the standard practice of not considering shear deformations explicitly between their abutments is not a recommended solution[7].

(N. Luo & Z. Luo, 2021) the study was an investigation into the effect of spatial variation on building condition assessment. Using a stochastic finite element approach, the differential settlement between the four bases of a continuous element is analyzed probabilistically considering the different soil phases in the space variance. The force technique is used to solve the internal forces of the beam resulting from the leveling in terms of the transverse shear strength and joining moment. This probabilistic methodology is used to systematically estimate the oscillation of the shear force and the joining moment within a statically indeterminate beam caused by the spatial variability of the soil. This study emphasizes the need to properly consider the influence of regionally diverse specific soil conditions on building case design and encourages integrated structural and geotechnical design [42]

(H. Shi & Y. Kim, 2014) This study describes an analytical modeling approach for analyzing the stiffness of a two-fixed-end element. Beam modeling is a risky step in the design and analysis of beam structures and systems. In this research, using of the Screw Theory to create a symbol modeling of a stiffness matrix in relation to the location of the pressures action and the condition of geometry of the beam. The model is used to discuss the link between the force action site and the deformation. The analytical model is validated using a Finite Element (FE) model with an error of less than 1%. Following tasks such as design optimization and sensitivity analysis are made easier by the proposed model method. The symbolic formulas can serve as guides for designers while performing beam structural analysis [43]

(A. shishegaran, et al., 2020) The study showed that the main concerns in construction engineering are in increasing the bendability of the reinforced concrete (RC) body parts. The purpose of this research is to create a moving stress system (TSS) on longitudinal reinforcing bars that will increase the joining ability of RC tires. The investigation is divided into two parts: practical tests and nonlinear FE analysis. The load deflection and faulting pattern curves for conventional stationary tires and TSS were determined by experiments. FE models were optimized to simulate stationary tires. The acquired load skew results and observed path cracks from FE analysis and empirical tests are compared to assess the validity of nonlinear FE models. The force dispersal on normal bars and TSS bars was studied using the validated FE models mentioned above. The load bearing capacity and ductility of TSS fixed beams are 29.39 percent and 23.69 percent, respectively, than those of normal fixed beams. Although there are many slit gaps in the middle of the extension of the TSS fixed beam, crack expansion occurs in the conventional fixed beam. In the repaired TSS framework, the crack that was coming out was changed. It is suggested to use the TSS fixed beam in RC form instead of the standard RC beam to improve the performance of the RC frame[44].

(J. Malesza, 2013) the study showed that the assumption for determining which of the given bending moments on the basis of the determination technique in the examined indeterminate static scheme, the assumed matching criterion for theoretical and empirical deviations served as the basis for determining an unknown internal force; Bending moment at the mounting joint. The bending activity of this moment decides to let go of the band moments along any element. A section of linear decreasing bending moments showing the proportional response of the building for calculations of the action of the forces presented at 20% of the total loading range. All loading methods can be divided into stages to increase the internal forces. The term “analysis results” refers to the process of redistribution of internal forces that occurs between the bridge section and the adjacent sections of the shaft in the frame beam. The development of stiffness in space changing along the length of the element emphasizes severe cracking in the cross-sections of the adjacent joint as well as along the middle part of the frame beam. Good agreement is achieved where the experimentally obtained theoretical deviations confirm the method of bending WI Murashov of reinforced concrete structure as well as the validity of the summary determination for determining the strategy of internal forces in the indeterminate fixed beam regime[45].

(M. Orobia, 2017) The study showed that structures can be created to obtain standards, guidelines or durability to avoid the effects of gradual collapse by studying the structural interaction. In the case of a statically defined truss structure, if a single core member or panel assembled connection in one of the main truss is broken, the truss will collapse along its entire length. A degree of static indeterminacy has been added in the structural system to protect against gradual collapse.

Graphical statistics, an engineering method used to examine the shape of a specific structure and force interaction, has not been used to statically define structures. The truss can be checked graphically using graphic statistics by creating precious shapes, gauges and strength charts. Visual statistics analysis results in a single state diagram, the force polygon, which clearly shows the total loading paths within the structure. The strength polygon also depicts all of the internal forces are at work within the truss. As a result, this research will employ graphical statistical data as a tool for determining the overall load - carrying path of quasi truss structures, as well as highlighting the redistribution of powers in a redundant framework subject to harm or participant removal. A comparative analysis based on structural complexity is also presented in the paper. Both iterative damage and parametric analysis were used to investigate statistically defined truss systems with a variety of structures. These assessments consider both the positively associated of the damaged truss building projects and the overall ability of the truss's capacity to redistribute load through other channels[46]

(Z. Xu, et al., 2017) the study proved that the beam-supported beams, cantilever beams, fixed end, and movable joint in the support are continuous, and so on. Techniques of aggregation, analysis and measurement are proposed, as well as comparative software development. The mechanical analysis and parametric design of the package were accomplished using SINOVATION, VS2005, and ADK to generate the element design software. The derivation efficiency and reliability of the element design are improved. The development methods and practices used in this study can be used as a reference for future CAD system development [47].

(P. Mateˇckováa & L. Lausová, 2016) Fire risk resistance, as an inherent aspect of structural design, is evaluated through testing or calculations. The study focuses on statically indeterminate structures when thermal expansion is limited and large internal forces are present in the structure, which leads to potential annealing and subsequent redistribution of internal force magnitudes. Various methods of firing strength testing are presented in this file, along with a brief description of more than one experiment focused on the above verification of the behavior of a stable unspecified steel shape exposed to high temperatures, which was performed for VSB-TU Ostrava [48].

(M. Mansour, et al., 2020) The study showed that deep continuous reinforced concrete beams with fixed and articulated support conditions are frequently seen in construction, little research has been done on their performance. This could partly be due to the challenging nature of ensuring consistent assistance in pilot testing of such members. However, performing numerical analysis in conjunction with empirical research has been a popular method for generating a reliable model in the numerical case as an alternative to destructive experiments. The purpose of the file is to numerically investigate the effect of different support conditions on the performance of two-span continuous reinforced concrete girders. A computer model was created from three experimentally tested beams, together with two external rollers and supporting conditions for the internal hinges. A good comparison is obtained with the help of adjusting fewer factors in the numerical method, including element, network size, and element constitutive relationships. As an alternative to destructive tests, updated numerical modeling was used to perform parametric analysis to further evaluate the effect of different groups of support cases in the action of two-span continuous steel and concrete deep beams. This research underscores the dangerously dangerous ramifications of support cases in the act of such deep firmness [18].

3. METHODOLOGY

3.1 ANALYSIS TECHNIQUE

The slope-deflection method was basically developed to analyze the statically indeterminate two dimensional beams and frames. However, this method has been used later by many researchers to analyze other cases of structures. Yoshida [10] used the slope-deflection method to analyze the statically indeterminate space frames. The slope-deflection equations with the torsional equation of the member section were used for dealing with the three-dimensional frames. Backer et al. [11] adopted an analytical method to analyze the orthotropic plated bridge decks. The internal forces in the bridge deck section were calculated by applying the slope-deflection equations. Dario [12] studied the stability analysis of Timoshenko beam-column connections in the structures. A set of slope-deflection equations was developed for the beam-columns with symmetrical semi-rigid connections, by considering a combination of the shear, moment, and second-order axial deformation effects. Riahi et al. [13] investigated the determination of buckling load for the tapered columns by using the slope-deflection method. Based on the varying moment of inertia for the non-prismatic columns, slope-deflection equations were developed to compute the critical buckling loads for such columns [49]. For analysis the cases of indeterminate reinforced beam, number of cases were taken as the analytical procedures was applied [50]. The analytical procedure was made based on the variation of the conditions of beam support and also variation of the shape of loading. The study then built a conceptual system that derived from the analysis of all cases in which the new model can cover the design of the reinforced beam by identifying in ease steps the behavior of internal forces along the beam span. The cases were arranged and the examination procedures for the slope deflection method on the support conditions and the loading were made as the following study parts. Figure 3.1 showed the typical deformation of beam member [7].

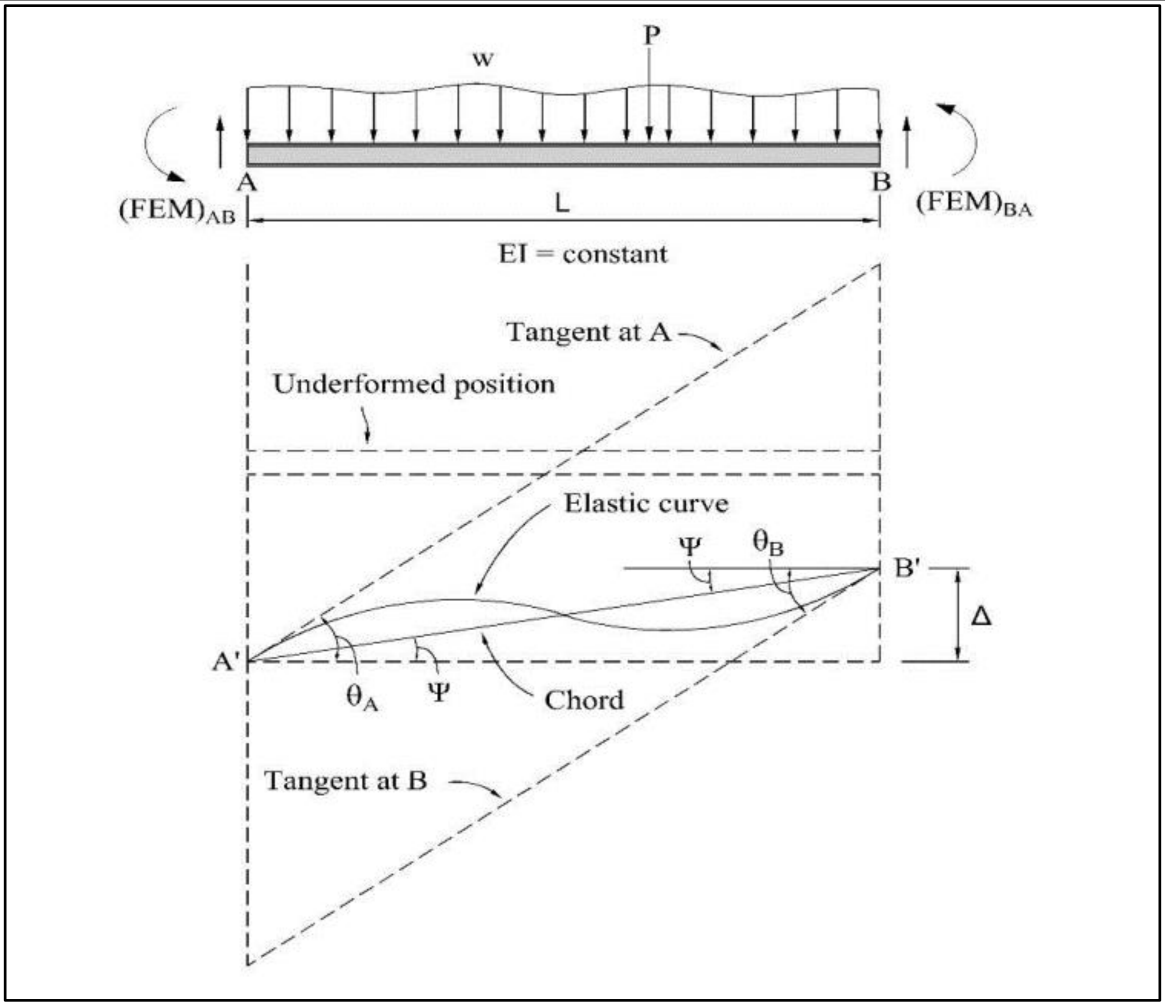


Figure 3.1:Typical Deformation Of Beam Member

The main equation for the slope deflection method is:

$$M_{AB} = 2\frac{EI}{L}\left(2\,\theta_A + \theta_B - \frac{3\Delta}{L}\right) + FEM_{AB} \quad (3.1)$$

$$M_{BA} = 2\frac{EI}{L}\left(2\,\theta_B + \theta_A - \frac{3\Delta}{L}\right) + FEM_{BA} \quad (3.2)$$

Where:

θ_A = the slope at point A

The Δ = the displacemnet of deformation

FEM_{AB} = fixed end moment at the end A

3.2 ANALYSIS CASES

3.2.1 RC Beam with Simply Supports

For the case of RC beam with simply support or other beam for fixed support which is under the influence of concentrated loads in different places of the structural member as explained in the figures:

3.2.1.1 Concentrated loading

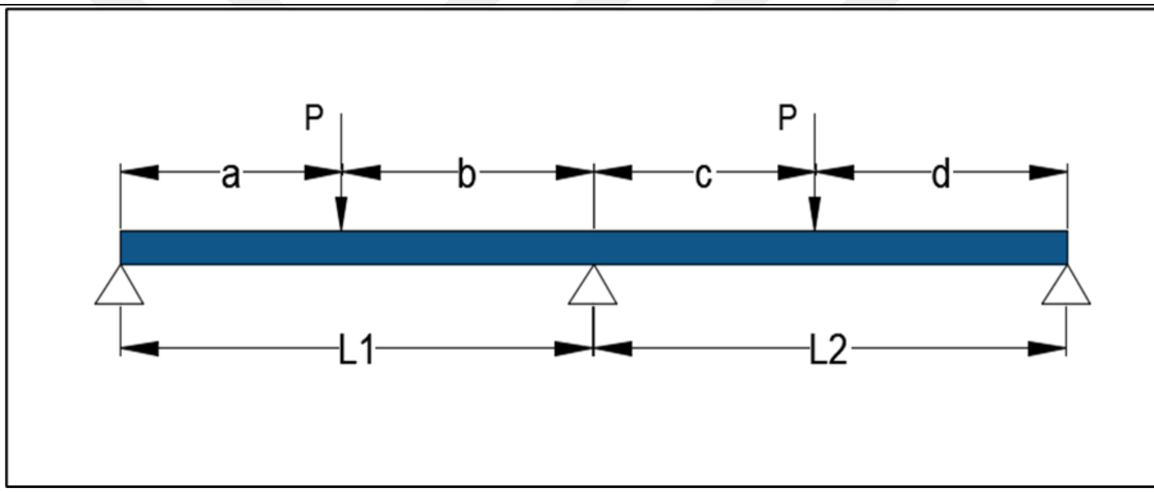


Figure 3.2: RC Beam Under Two Concentrated Loads

The fixed end moment for such case is:

$$FEM_{AB} = \frac{P\,b^2 a}{L1^2} \tag{3.3}$$

$$FEM_{BA} = \frac{P\,a^2 b}{L1^2} \tag{3.4}$$

By assigning a= L-b:

$$FEM_{AB} = \frac{P\,b^2(L1-b)}{L1^2} \tag{3.5}$$

$$FEM_{BA} = \frac{P\,(L1-b)^2 b}{L1^2} \tag{3.6}$$

For n number of the force P on the member, the fixed end moment then included all the forces and the distances of these forces, in other word:

$$M_{AB} = 2\frac{EI}{L}\left(2\,\theta_A + \ \theta_B - \frac{3\Delta}{L}\right) + FEM_{AB} \tag{3.7}$$

By assigning the conditions:

$$M_{AB} = 2\frac{EI}{L1}\ (2\,\theta_A + \theta_B\ ) + FEM_{AB} \tag{3.8}$$

$$0\ = \frac{2\,EI}{L1}\ (\ 2\,\theta_A + \theta_B\ ) +\ FEM_{AB} \tag{3.9}$$

$$2\,\theta_A + \theta_B\ =\ \frac{-L1}{2\,EI}\ FEM_{AB} \tag{3.10}$$

$$M_{CB} = 2\frac{EI}{L2}\ (2\,\theta_C + \theta_B\ ) - FEM_{CB} \tag{3.11}$$

$$0 = 2\frac{EI}{L2}\ (2\,\theta_C + \theta_B\ ) - FEM_{CB} \tag{3.12}$$

$$2\,\theta_C + \theta_B\ = \frac{L2}{2\,EI}\ \ FEM_{CB} \tag{3.13}$$

$$M_{BA} +\ M_{BC}\ \ =\ 2\frac{EI}{L1}\ (2\,\theta_B + \theta_A\ ) - FEM_{BA} +\ 2\frac{EI}{L2}\ (2\,\theta_B + \theta_c\ ) + FEM_{BC} \tag{3.14}$$

$$0\ =\ 2\frac{EI}{L1}\ (2\,\theta_B + \theta_A\ ) - FEM_{BA} +\ 2\frac{EI}{L2}\ (2\,\theta_B + \theta_c\ ) + FEM_{BC} \tag{3.15}$$

$$0\ =\ \left(4\frac{EI}{L1}\ \theta_B + 4\frac{EI}{L2}\ \theta_B + 2\frac{EI}{L1}\ \theta_A + 2\frac{EI}{L2}\ \theta_c\ \right) - FEM_{BA} + FEM_{BC} \tag{3.16}$$

$$0\ =\ \left(4\frac{EI}{L1}\ \theta_B + 4\frac{EI}{L2}\ \theta_B + 2\frac{EI}{L1}\left(\frac{-L1}{4\,EI}\ FEM_{AB} - \frac{\theta_B}{2}\right) + 2\frac{EI}{L2}\ \ (\frac{L2}{4\,EI}\ \ FEM_{CB} - \frac{\theta_B}{2}\right) \\ - FEM_{BA} + FEM_{BC} \tag{3.17}$$

$$0\ =\ \left(4\frac{EI}{L1}\ \theta_B + 4\frac{EI}{L2}\ \theta_B + \left(\frac{-1}{2}\ FEM_{AB} - \frac{EI\,\theta_B}{L1}\right) +\ \ (\frac{1}{2}\ \ FEM_{CB} - \frac{EI\,\theta_B}{L2}\right) - FEM_{BA}\ \ + FEM_{BC} \tag{3.18}$$

$$\theta_B = \frac{\frac{1}{2}\,FEM_{AB} - \frac{1}{2}\,FEM_{CB} + FEM_{BA} - FEM_{BC}}{4\frac{EI}{L1} + 4\frac{EI}{L2} - \frac{EI}{L1} - \frac{EI}{L2}} \tag{3.19}$$

$$\theta_B = \frac{\frac{-1}{2}\,FEM_{AB} + \frac{1}{2}\,FEM_{CB} - FEM_{BA} + FEM_{BC}}{3\frac{EI}{L1} + 3\frac{EI}{L2}} \tag{3.20}$$

$$\theta_A = \frac{-L1}{4\,EI}\,FEM_{AB} - \frac{\theta_B}{2} \tag{3.21}$$

$$\theta_C = \frac{L2}{4\,EI}\,FEM_{CB} - \frac{\theta_B}{2} \tag{3.22}$$

For the beam with four joints:

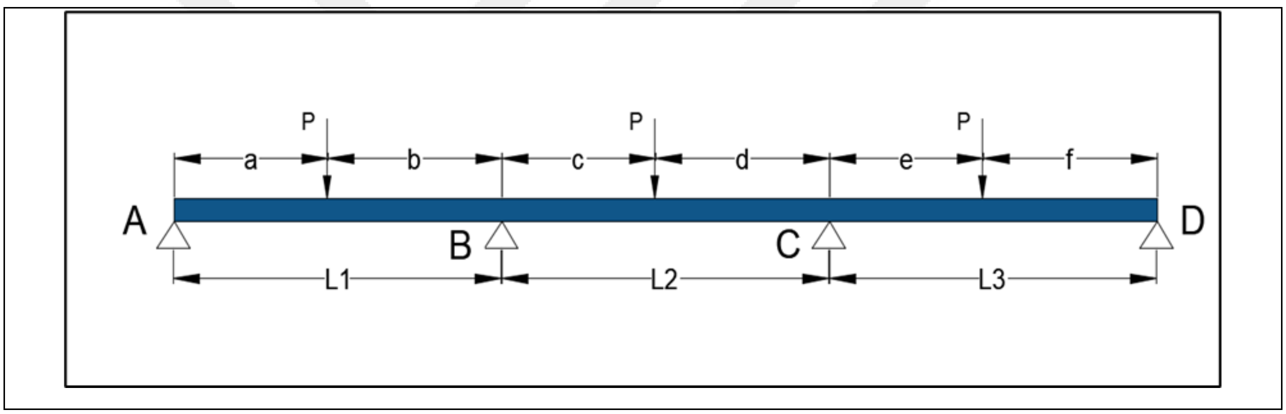


Figure 3.3: RC Beam Under Triple Concentrated Loads (Simply Supports)

$$0 = \frac{2\,EI}{L1}\,(\,2\,\theta_A + \theta_B\,) + FEM_{AB} \tag{3.23}$$

$$\frac{2\,EI}{L1}\,(\,2\,\theta_A + \theta_B\,) = -\,FEM_{AB} \tag{3.24}$$

$$M_{BA} + M_{BC} = 2\frac{EI}{L1}\,(2\,\theta_B + \theta_A\,) - FEM_{BA} + 2\frac{EI}{L2}\,(2\,\theta_B + \theta_c\,) + FEM_{BC} \tag{3.25}$$

$$\left(4\frac{EI}{L1}\,\theta_B + 4\frac{EI}{L2}\,\theta_B + 2\frac{EI}{L1}\,\theta_A + 2\frac{EI}{L2}\,\theta_c\right) = FEM_{BA} - FEM_{BC} \tag{3.26}$$

$$M_{CB} + M_{CD} = 2\frac{EI}{L2}\,(2\,\theta_C + \theta_B\,) - FEM_{CB} + 2\frac{EI}{L3}\,(2\,\theta_C + \theta_D\,) + FEM_{CD} \tag{3.27}$$

$$0 = 2\frac{EI}{L2}\,(2\,\theta_C + \theta_B\,) - FEM_{CB} + 2\frac{EI}{L3}\,(2\,\theta_C + \theta_D\,) + FEM_{CD} \tag{3.28}$$

$$2\frac{EI}{L2}\,(2\,\theta_C + \theta_B) + 2\frac{EI}{L3}\,(2\,\theta_C + \theta_D) = FEM_{CB} - FEM_{CD} \qquad (3.29)$$

$$M_{DC} = 2\frac{EI}{L3}\,(2\,\theta_D + \theta_C) - FEM_{DC} \qquad (3.30)$$

$$2\frac{EI}{L3}\,(2\,\theta_D + \theta_C) = FEM_{DC} \qquad (3.31)$$

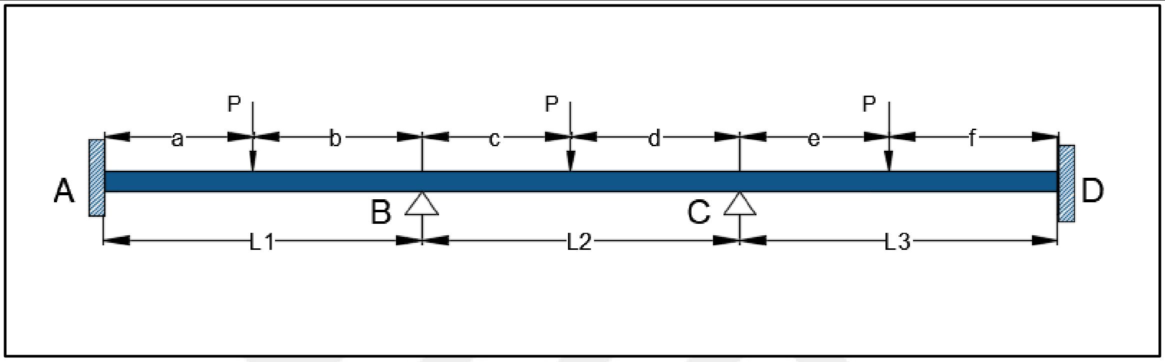


Figure 3.4: RC Beam Under Triple Concentrated Loads (fixed supports)

The magnitude of the displacement and the slope of deformation at the fixed joint equal zero so that:

$$0 = 2\frac{EI}{L1}\,(2\,\theta_B) - FEM_{BA} + 2\frac{EI}{L2}\,(2\,\theta_B + \theta_c) + FEM_{BC} \qquad (3.31)$$

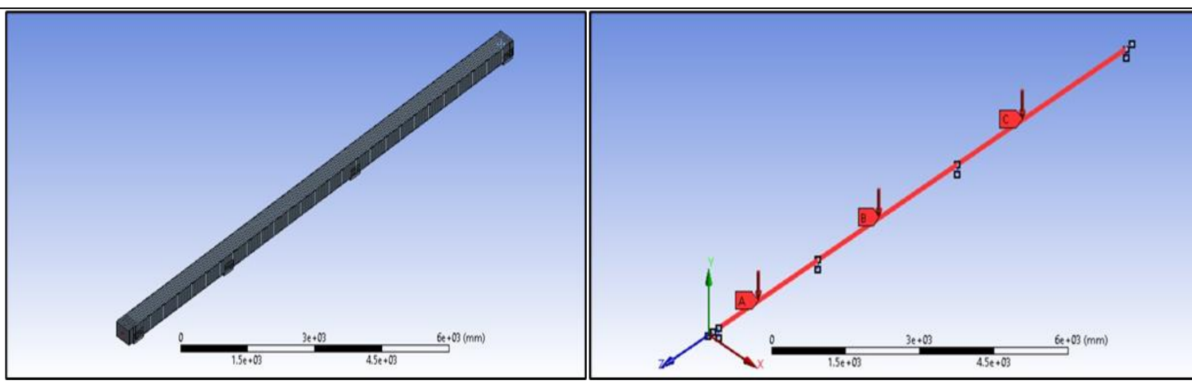
$$0 = 2\frac{EI}{L2}\,(2\,\theta_C + \theta_B) - FEM_{CB} + 2\frac{EI}{L3}\,(2\,\theta_C) + FEM_{CD} \qquad (3.32)$$

3.3 ANSYS WORK

For evaluating the formation of bending moments along the beam span, simulations of the cases of beam with simply and fixed joint under concentrated loading and under uniform loading were evaluated and explained images. The initial data of the beam were as following table:

Table 3.1: Initial Conditions In ANSYS Analysis

Property	Magnitude
Height of beam	300 mm
L1	3 m
L2	4 m
L3	5 m
Concentrated loading	10 kN
a	1 m
b	2 m
c	1 m
d	3 m
e	1 m
f	4 m
Uniform loading	40 kN/m



(a) (b)

Figure 3.5: a. Applying Of Mesh For Four-Joints Beam **b**. Set of The Uniform Loadings on The Beam

4. RESULT

4.1 CALCULATION STRATEGY

The parameters that effect the internal moment in the indeterminate beam at the middle joint showed various impacts on the overall values of this moment. The identification of the moments at the middle joint(s) can lead easily to find the other static data like the reactions at the joints. For first step with an indeterminate beam with single middle support, the magnitude of the internal moment variation by the changing of related parameters were explained in the following tables and figures.

Table 4.1:The Variation Of The Internal Moment In The Joint B By The Increasing Of The Concentrated Load P

P (kN)	MBC (kN.m)
10	3.75
20	7.5
30	11.25
40	15
50	18.75
60	22.5
70	26.25
80	30
90	33.75
100	37.5

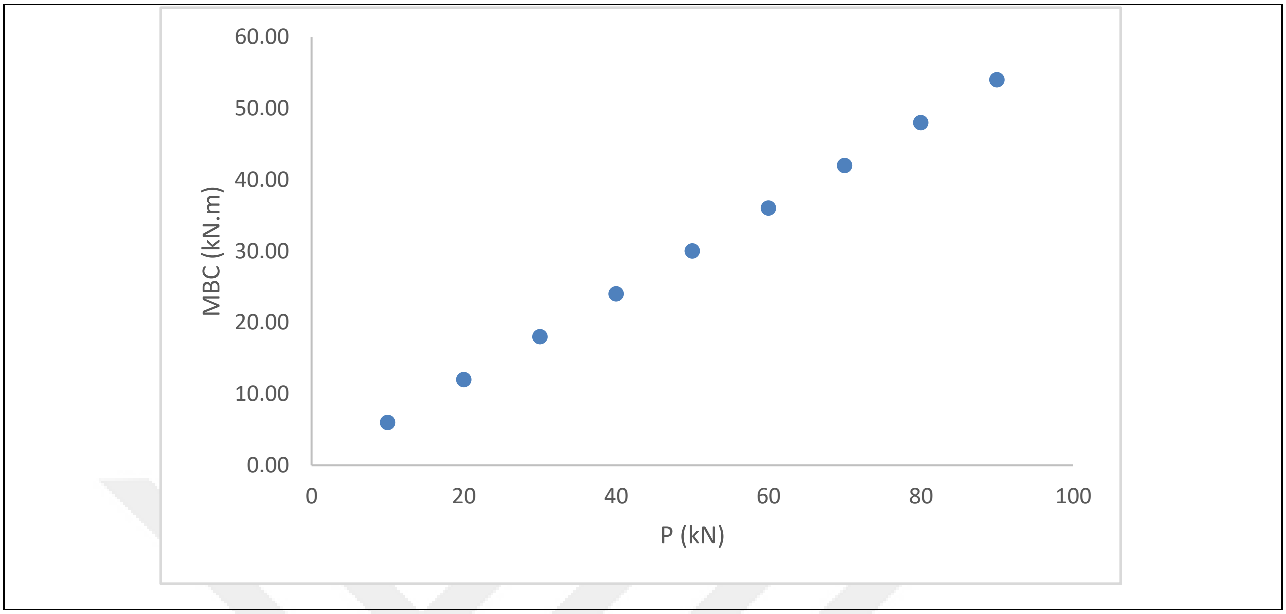


Figure 4.1: The Variation Of MBC Moment When (L1=5 m and L2==5 m)

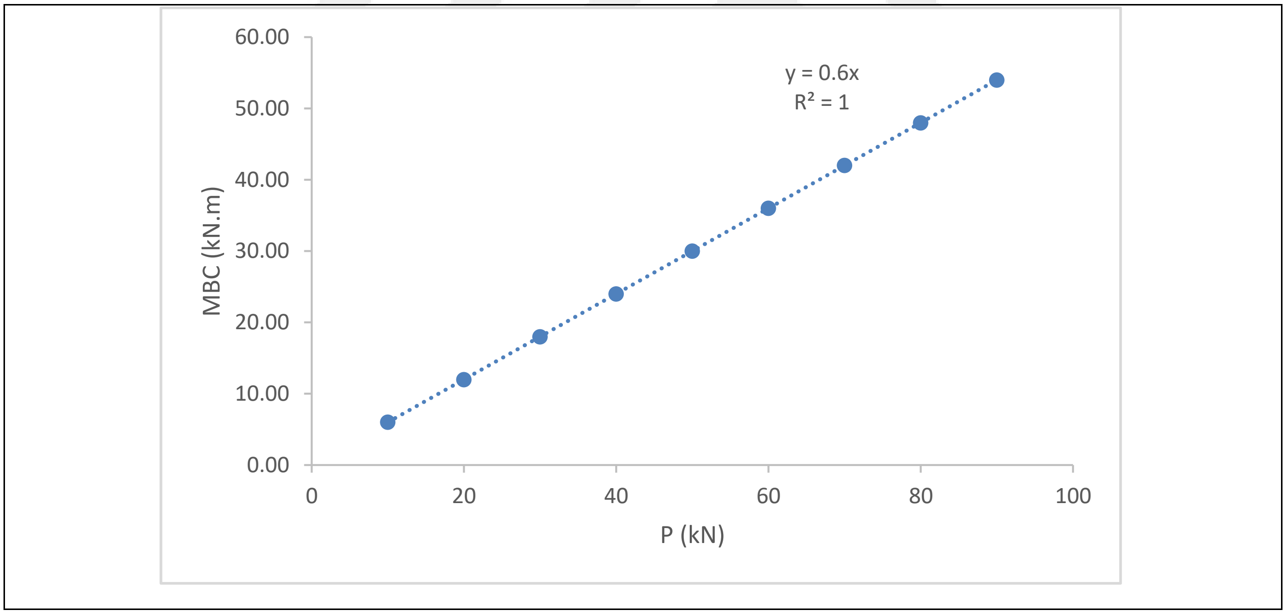


Figure 4.2: Linear Fitting For The Variation Of Mbc Moment When (L1=5 m and L2==5 m)

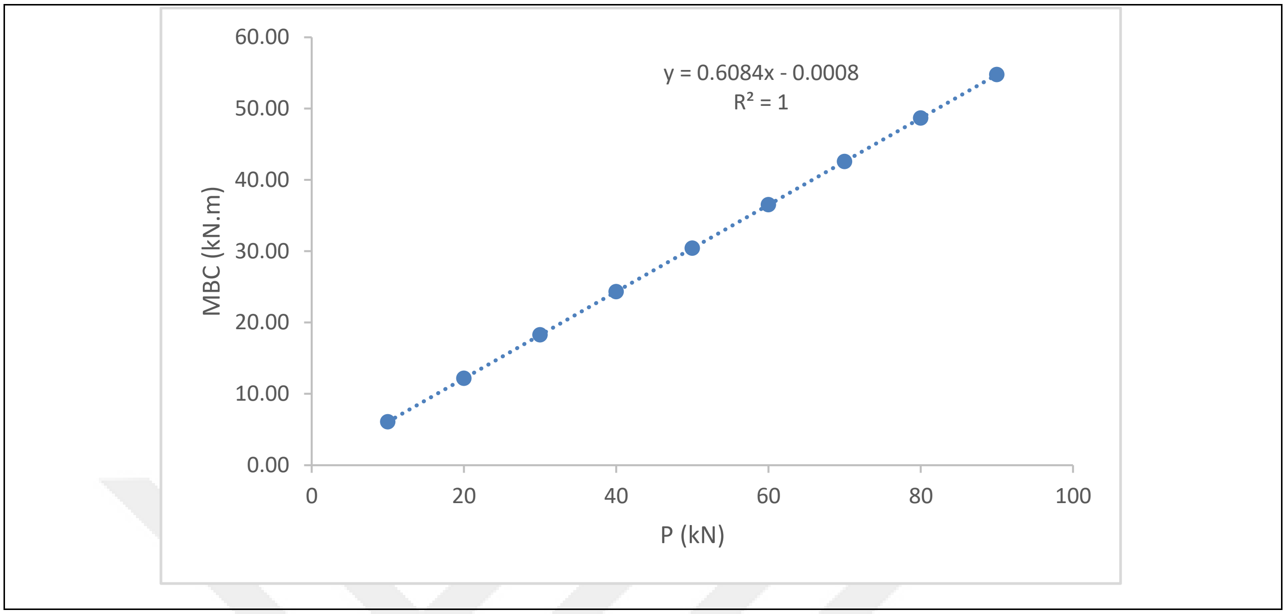


Figure 4.3: Linear Fitting For The Variation Of Mbc Moment When (L1=4 m and L2==5 m)

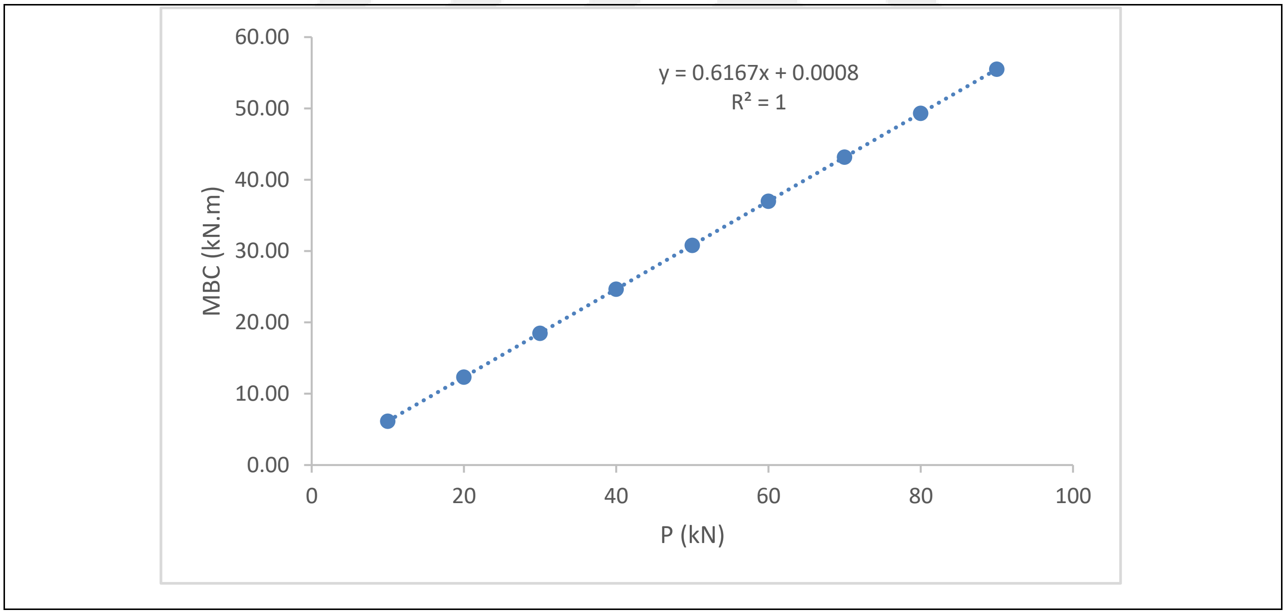


Figure 4.4: Linear Fitting For The Variation of MBC Moment When (L1=3 m and L2==5 m)

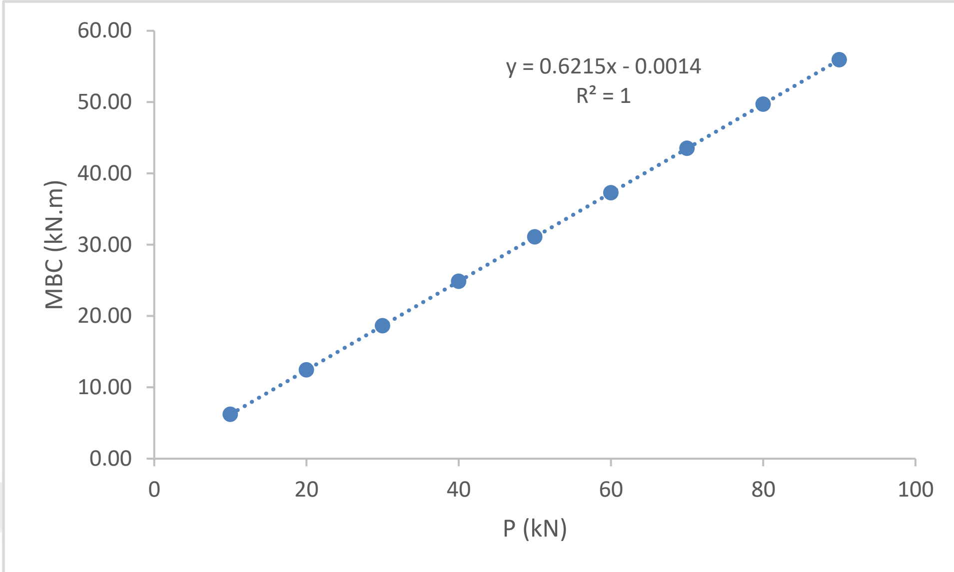


Figure 4.5: Linear Fitting For The Variation of MBC Moment When (L1=2 m and L2==5 m)

Table 4.2: The Variation Of The Linear Equation Factors In The Joint B By The Changing Of The Concentrated load L1

L1 (m)	L2 (m)	Factor
2	5	0.6215
3	5	0.616
4	5	0.6084
5	5	0.6

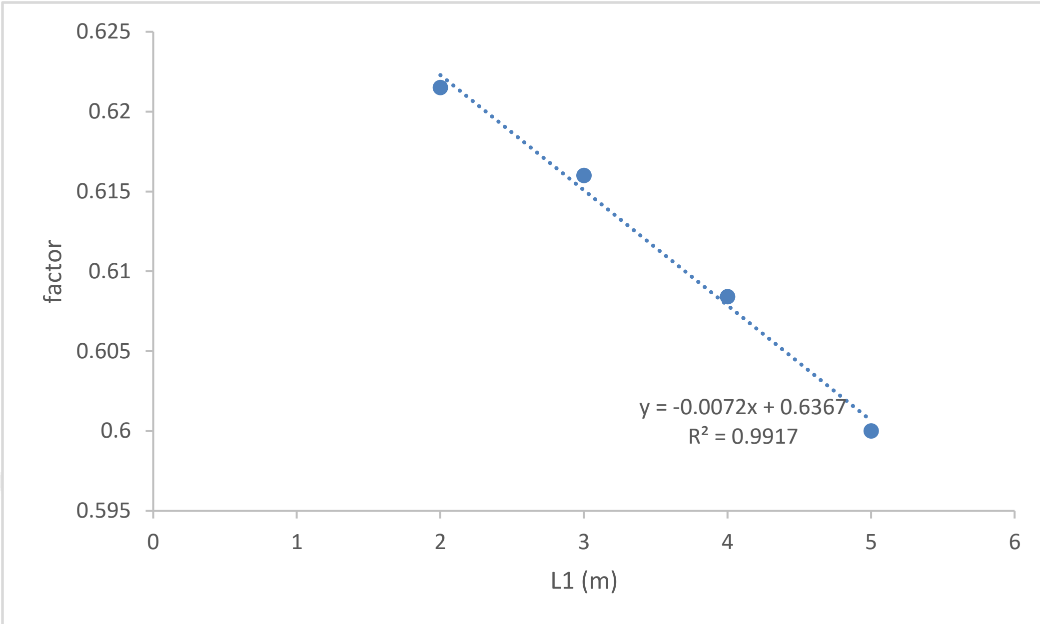


Figure 4.6: Linear Fitting For The Equation Factor Moment and L1

From this linear equation, the magnitude of the equation for identifying the MBC moment can be written as:

$$\mathrm{MBC} = -0.0072\ \mathrm{L1}\ \mathrm{P} + 0.6366\,P \tag{4.1}$$

The equation cannot be adopted until a correlation applied for the other parameters that impact the value of MBC. For checking the value of other parameters, the following procedures were used to updating the equation:

Table 4.3: The Effect of L2 On The Internal Moment In The Joint B Under Concentrated Loads

p	L1	L2	MBC calculated	MBC derived	Difference (kN.m)
10	2	2	3.75	6.222	-2.47
20	2.5	2.5	9.00	12.372	-3.37
30	3	3	15.00	18.45	-3.45
40	3.5	3.5	21.43	24.456	-3.03
50	4	4	328.12	30.39	-2.27
60	4.5	4.5	35.00	36.252	-1.25
70	5	5	42.00	42.042	-0.04
80	5.5	5.5	49.09	47.76	1.33
90	6	6	56.25	53.406	2.84
100	6.5	6.5	63.46	58.98	4.48

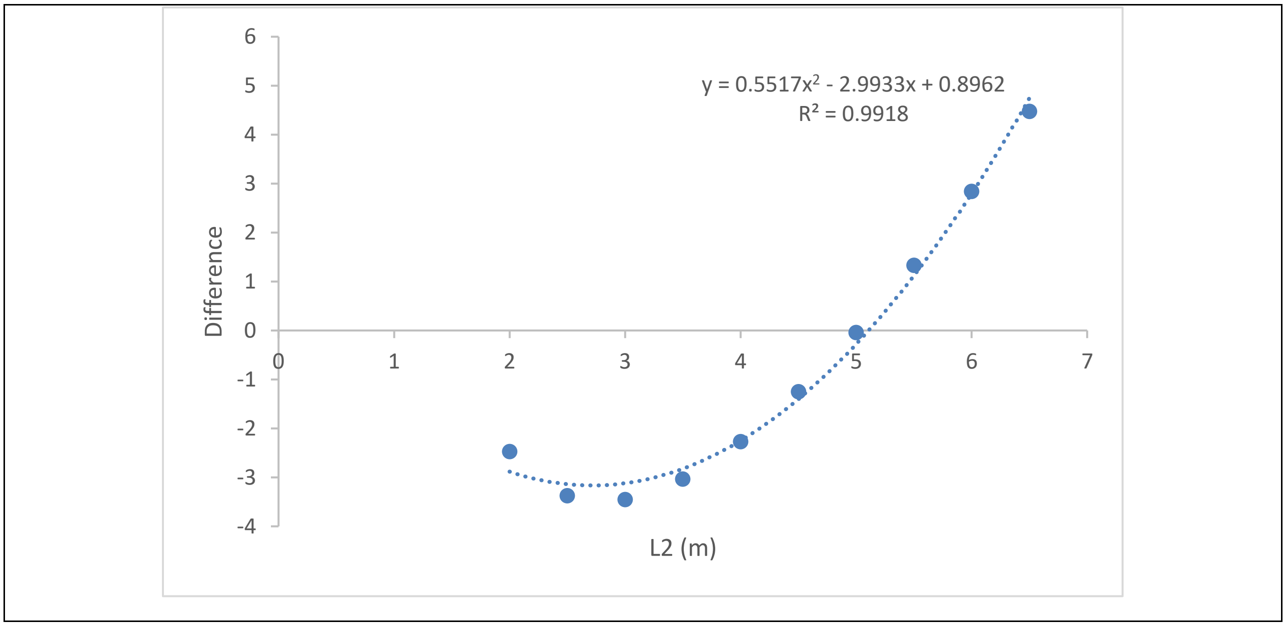


Figure 4.7: Polynomial Fitting For The Variation Of Difference And L2

The updated equation became:

$$\text{MBC} = -0.0072\,L1\;P + 0.6366\,P + 0.55 * L2^2 - 3\,L1 + 0.9 \tag{4.2}$$

Table 4.4: The Difference Of The Internal Moment In The Joint B By The Derived And Calculated Steps

P (kN)	L1 (m)	L2 (m)	MBC calculated	MBC derived	The Difference
10	2	2	3.75	3.32	0.43
20	2.5	2.5	9.00	9.21	-0.21
30	3	3	15.00	15.3	-0.30
40	3.5	3.5	21.43	21.6	-0.16
50	4	4	28.12	28.1	0.03
60	4.5	4.5	35.00	34.8	0.21
70	5	5	42.00	41.7	0.31
80	5.5	5.5	49.09	48.8	0.29
90	6	6	56.25	56.1	0.14
100	6.5	6.5	63.46	63.6	-0.16

Table 4.5: The Effect Of A On The Internal Moment In The Joint B Under Concentrated Loads

p	L1	L2	a (m)	MBC calculated	MBC derived	Difference (kN.m)
10	2	2	1	3.75	3.322	0.43
20	2.5	2.5	1.2	9.36	9.2095	0.15
30	3	3	1.4	16.80	15.3	1.50
40	3.5	3.5	1.6	26.06	21.5935	4.47
50	4	4	1.8	37.12	28.09	9.03
60	4.5	4.5	2	50.00	34.7895	15.21
70	5	5	2.2	64.68	41.692	22.99
80	5.5	5.5	2.4	81.16	48.7975	32.36
90	6	6	2.6	99.45	56.106	43.34
100	6.5	6.5	2.8	105.33	60.33	45

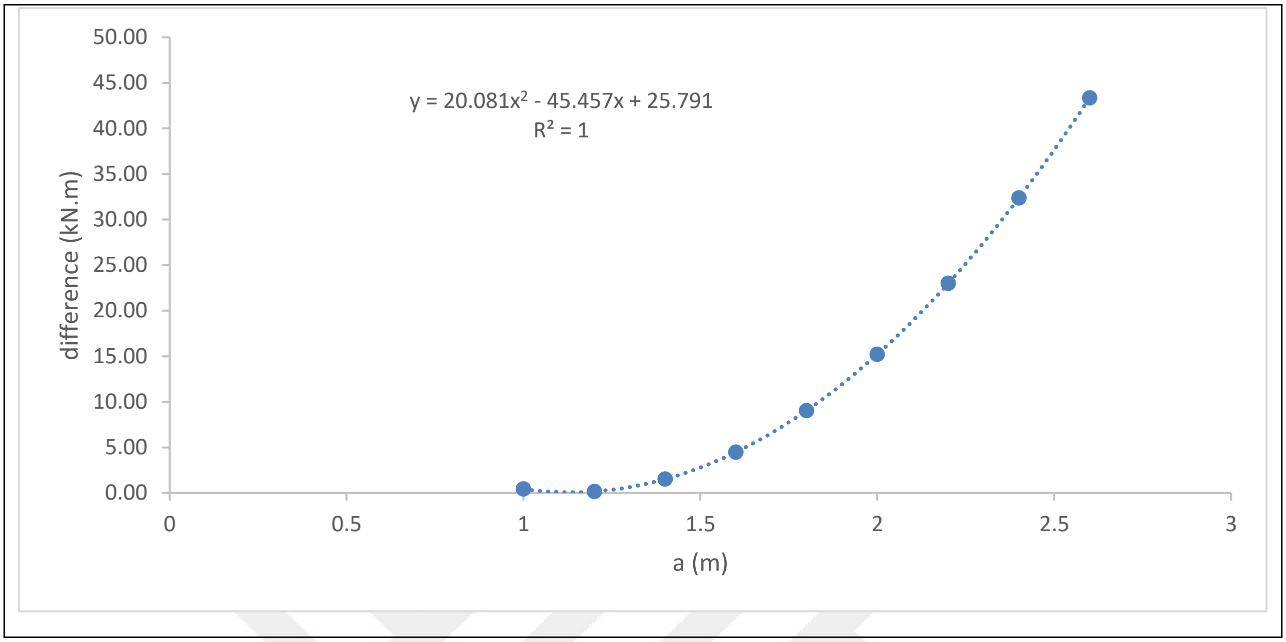


Figure 4.8: Correlation Fitting For The Differences In Value Of Mbc Moment From Conventional Calculation And Derived Equation With A

The updated equation became:

$$\mathrm{MBC} = \ -0.0072\, L1\ \ P + \ 0.6366\, P + 0.55 * L^2 - 3\, L1 + 0.9 + 20.08 * a^2 - 45.45\, a + 25.8 \tag{4.3}$$

Table 4.6: The Difference Of The Internal Moment In The Joint B By The Derived And Calculated Steps Based on a, L1 and L2 variation

p	L1	L2	a (m)	MBC calculated	MBC derived	Difference (kN.m)
10	2	2	1	3.75	3.752	0.00
20	2.5	2.5	1.2	9.38	9.3847	-0.02
30	3	3	1.4	16.88	16.8268	-0.03
40	3.5	3.5	1.6	26.25	26.0783	-0.02
50	4	4	1.8	37.50	37.1392	-0.02
60	4.5	4.5	2	50.62	50.0095	-0.01
70	5	5	2.2	65.62	64.6892	-0.01
80	5.5	5.5	2.4	82.50	81.1783	-0.02
90	6	6	2.6	101.25	99.4768	-0.03
100	6.5	6.5	2.8	119.3	119.335	-0.035

Table 4.7: The Internal Moment In The Joint B By The Derived And Calculated Steps Based On Variation Of L3 For Three Spans Beam

Derived MBC (kN.m)	Calculated (kN.m) L3=3.5 m	C-D L3=3.5	Calculated L3=4 m	C-D L3=4	Calculated L3=5 m	C-D L3=5	Calculated L3=6 m	C-D L3=6
3.752	2.55	-1.2	2.45	-1.31	2.28	-1.47	2.15	-1.6
9.3847	6.85	-2.54	6.59	-2.79	6.17	-3.21	5.85	-3.54
16.8268	12.9	-3.89	12.5	-4.34	11.7	-5.08	11.2	-5.67
26.0783	20.8	-5.23	20.2	-5.89	19.1	-7.02	18.1	-7.94
37.1392	30.6	-6.55	29.7	-7.44	28.1	-9	26.8	-10.3
50.0095	42.2	-7.83	41	-8.96	39	-11	37.3	-12.7
64.6892	55.6	-9.09	54.2	-10.4	51.7	-12.9	49.6	-15.1
81.1783	70.8	-10.3	69.3	-11.9	66.3	-14.9	63.7	-17.5
99.4768	87.9	-11.6	86.1	-13.4	82.7	-16.8	79.6	-19.9

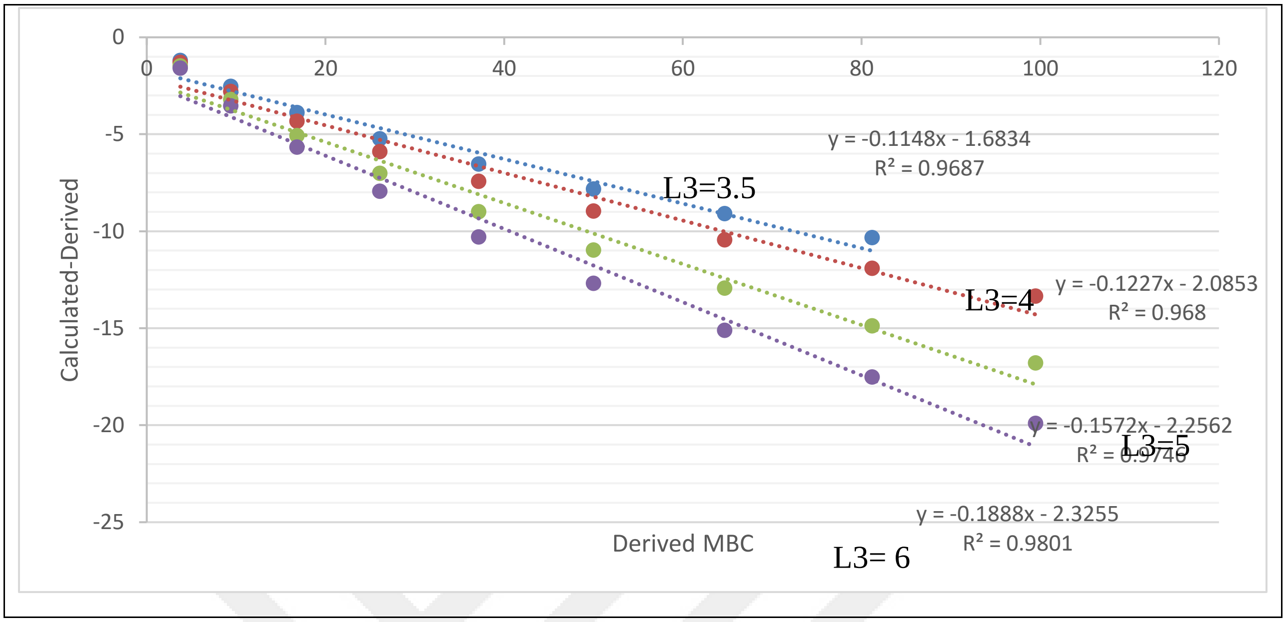


Figure 4.9: Correlation Fitting For The Value Of Mbc Moment From Conventional Calculation And Derived Equation By The Impact of L3

Factor 1 represented the parameter of x while factor 2 represented the other number in the liner eq.

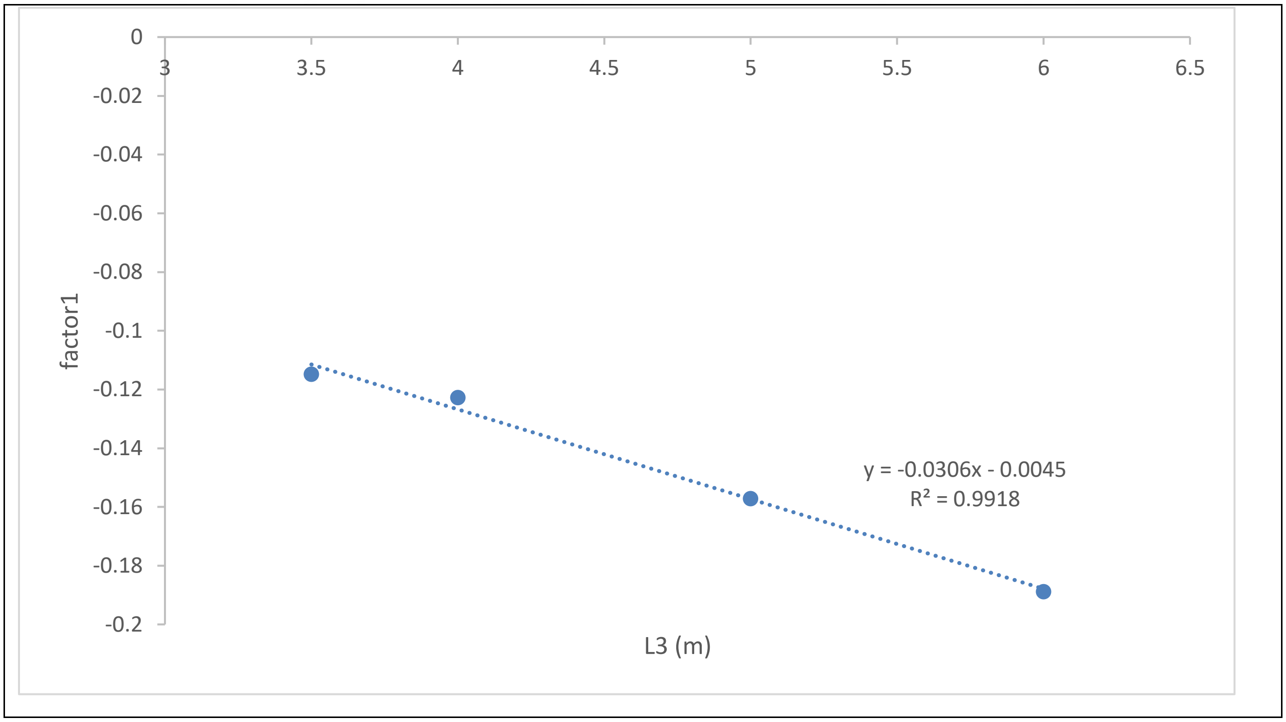


Figure 4.10: Linear Fitting For L3 And The Factor1 Of Correlation

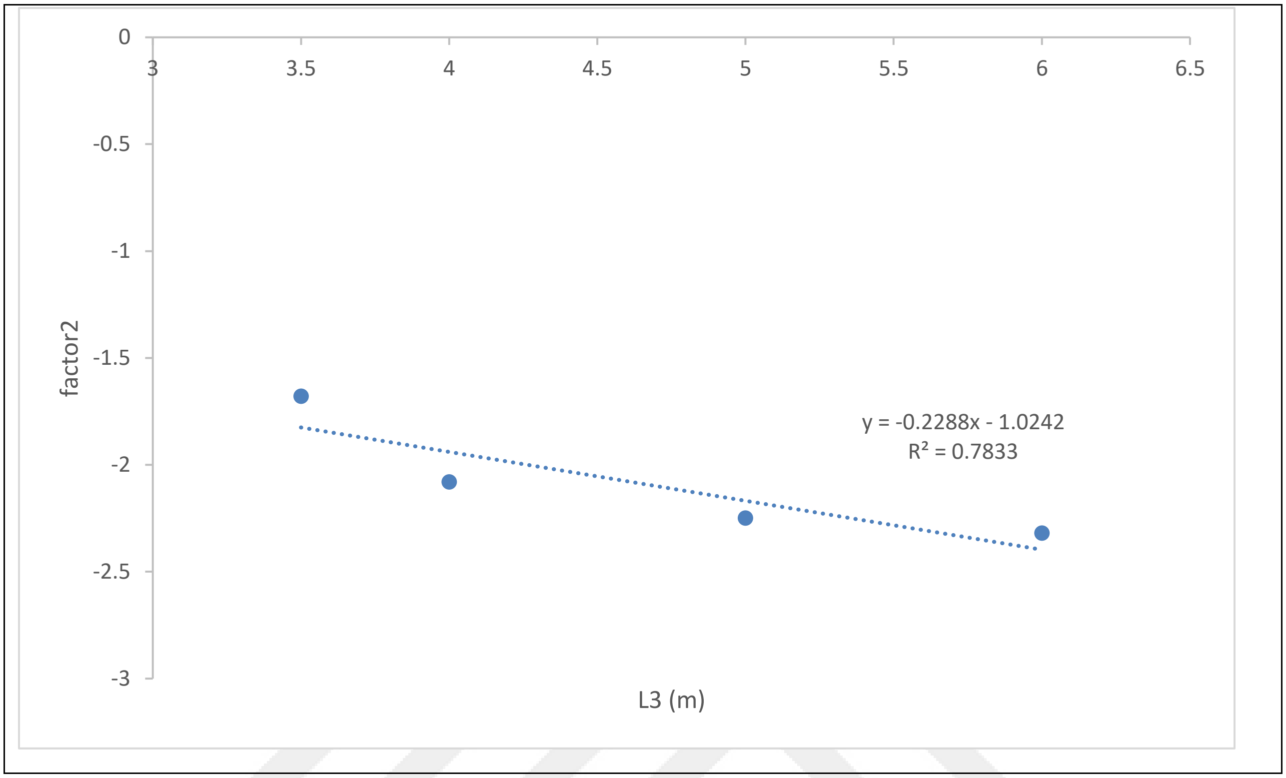


Figure 4.11: Linear Fitting For L3 And The Factor2 Of Correlation

By taking the effect of the third span on the MBC moment, the equation became:

$C - D = (-0.0306\, L3\ -\ 0.0045) * D - 0.228 * L3 - 1.02$

$C = (-0.0306\, L3\ -\ 0.0045) * D + D - 0.228 * L3 - 1.02$

$$C = (-0.0306\, L3 + 0.995) * D - 0.228 * L3 - 1.02$$

$\mathrm{MBC} = \ (-0.0306\, L3 + 0.995)\,(-0.0072\, L1\ \ P +\ 0.6366\, P + 0.55 * L2^2 - 3\, L2 + 20.08 * a^2 - 45.45\, a + 25.8\,) - 0.228 * L3 - 1.02$

(4.6)

Table 4.8: Checking The Difference Of The Internal Moment In The Joint B By The Derived And Calculated Steps Based On Variation Of L1, L2, L3, And A For Three Spans Beam

L1 (m)	L2 (m)	L3 (m)	a (m)	P (kN)	Derived MBC (kN.m)	Calculated (kN.m)	Difference
2	2	2	1	10	2.03	3.00	0.97
2.5	2.5	2.5	1.2	20	7.03	7.49	0.46
3	3	3	1.4	30	13.49	13.44	-0.05
3.5	3.5	3.5	1.6	40	21.34	20.85	-0.49
4	4	4	1.8	50	30.48	29.70	-0.78
4.5	4.5	4.5	2	60	40.83	40.00	-0.83
5	5	5	2.2	70	52.31	51.74	-0.56
5.5	5.5	5.5	2.4	80	64.84	64.93	0.09
6	6	6	2.6	90	78.33	79.56	1.23

4.2 SIMULATION OUTPUT

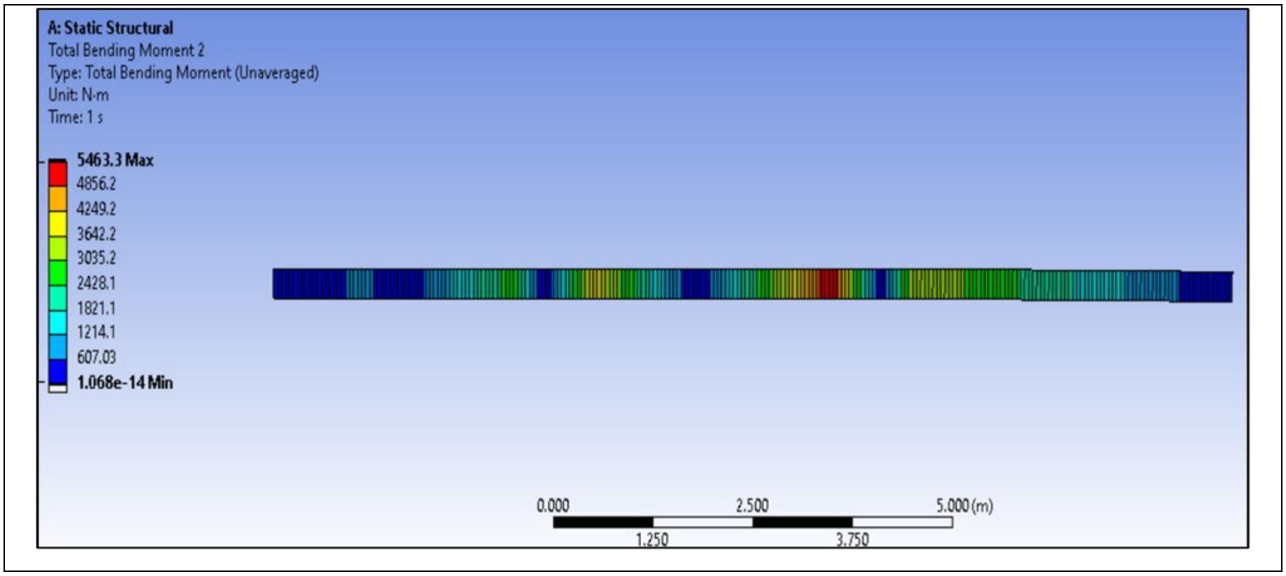


Figure 4.12: Bending Moment Along The Beam Under Concentrated Triple Loadings (ANSYS

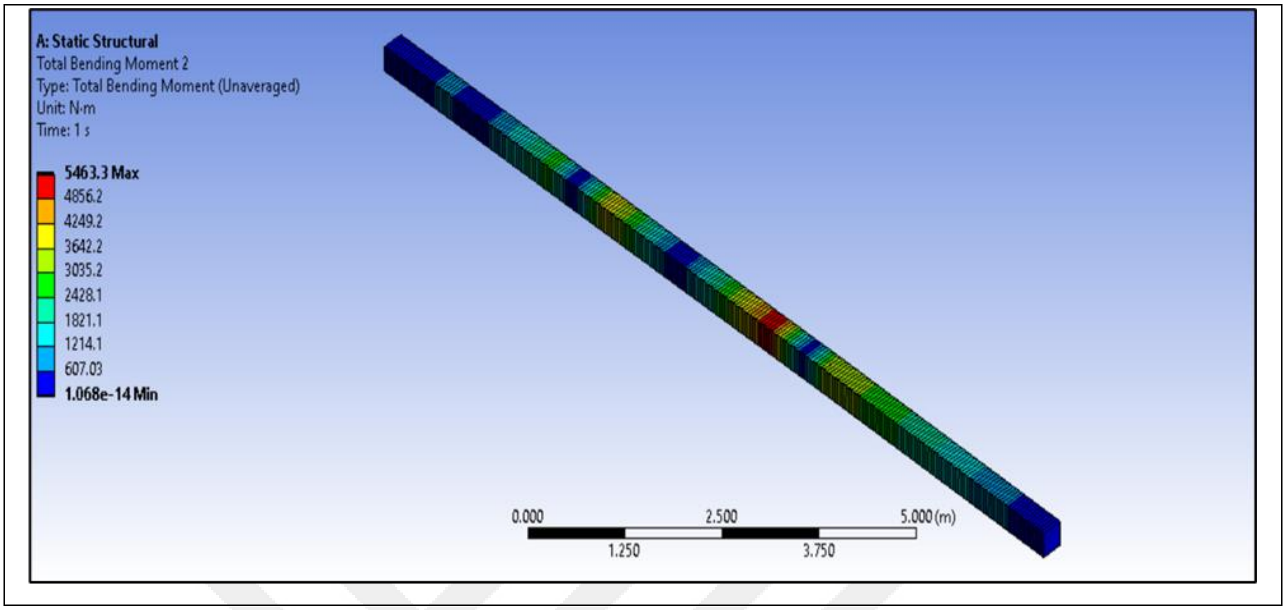


Figure 4.13: Bending Moment Along The Beam Under Concentrated Triple Loadings (3D ANSYS)

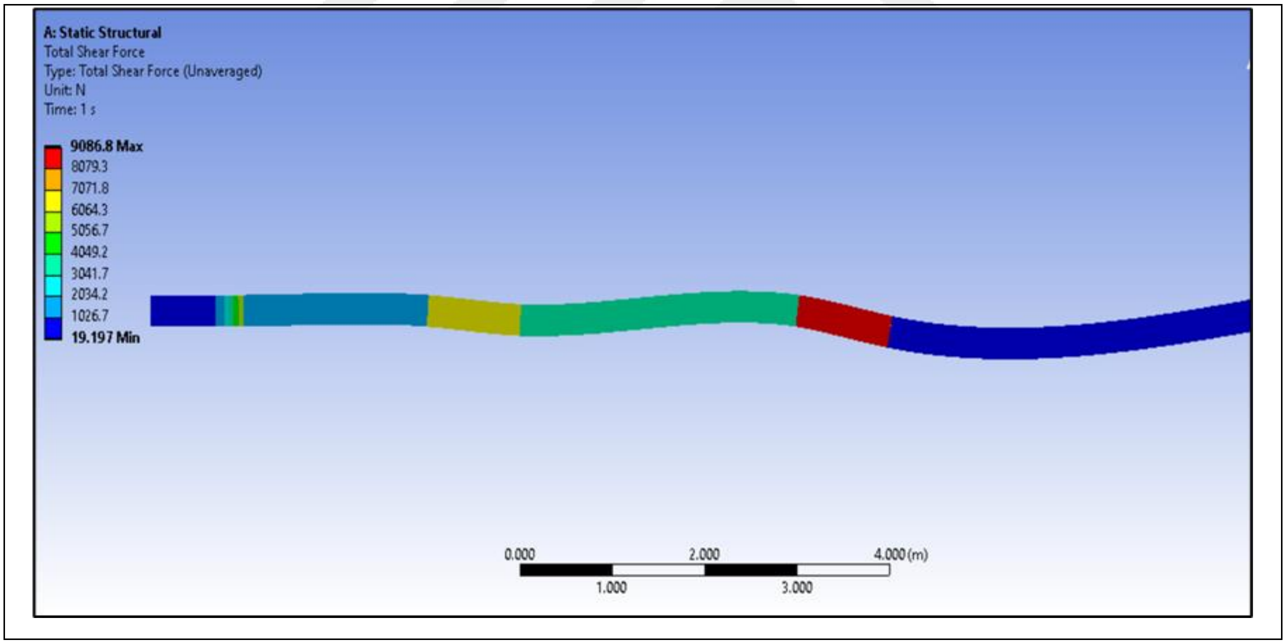


Figure 4.14: Shear Force Along The Beam Length Under Concentrated Triple Loadings (ANSYS)

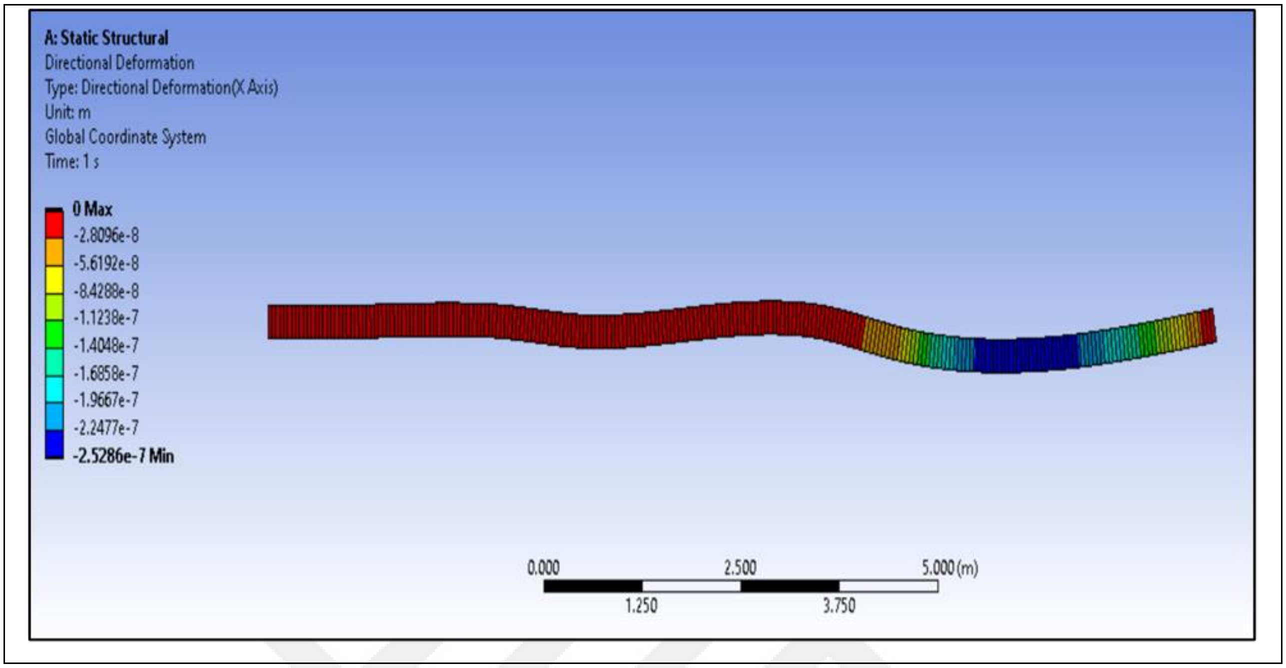


Figure 4.15: Shear Force Along The Beam Length Under Concentrated Triple Loadings (ANSYS)

Case two: indeterminate beams under uniform loading

Table 4.9: The Mbc Moment Based On L1 Changing Under Uniform Loading

W	L1=2	L1=3	L1=4	L1=5	L1=6
2.5	1.3	2.04	3.70	5.97	8.87
5	2.2	4.08	7.39	11.94	17.74
7.5	3.1	6.12	11.09	17.92	26.61
10	4.5	8.16	14.78	23.89	35.48
12.5	5.2	10.20	18.48	29.86	44.35
15	6.2	12.24	22.17	35.83	53.23
17.5	7.1	14.28	25.87	41.81	62.10
20	8.2	16.32	29.57	47.78	70.97
22.5	9.2	18.36	33.26	53.75	79.84

Table 4.9: The Mbc Moment Based On L1 Changing Under Uniform Loading "Table Continued"

W	L1=2	L1=3	L1=4	L1=5	L1=6
25	10.3	20.39	36.96	59.72	88.71
27.5	11.4	22.43	40.65	65.69	97.58
30	12.2	24.47	44.35	71.67	106.45
32.5	13.3	26.51	48.04	77.64	115.32
35	14.1	28.55	51.74	83.61	124.19
37.5	15.2	30.59	55.43	89.58	133.06
40	16.2	32.63	59.13	95.56	141.94
42.5	17.1	34.67	62.83	101.53	150.81
45	18.3	36.71	66.52	107.50	159.68

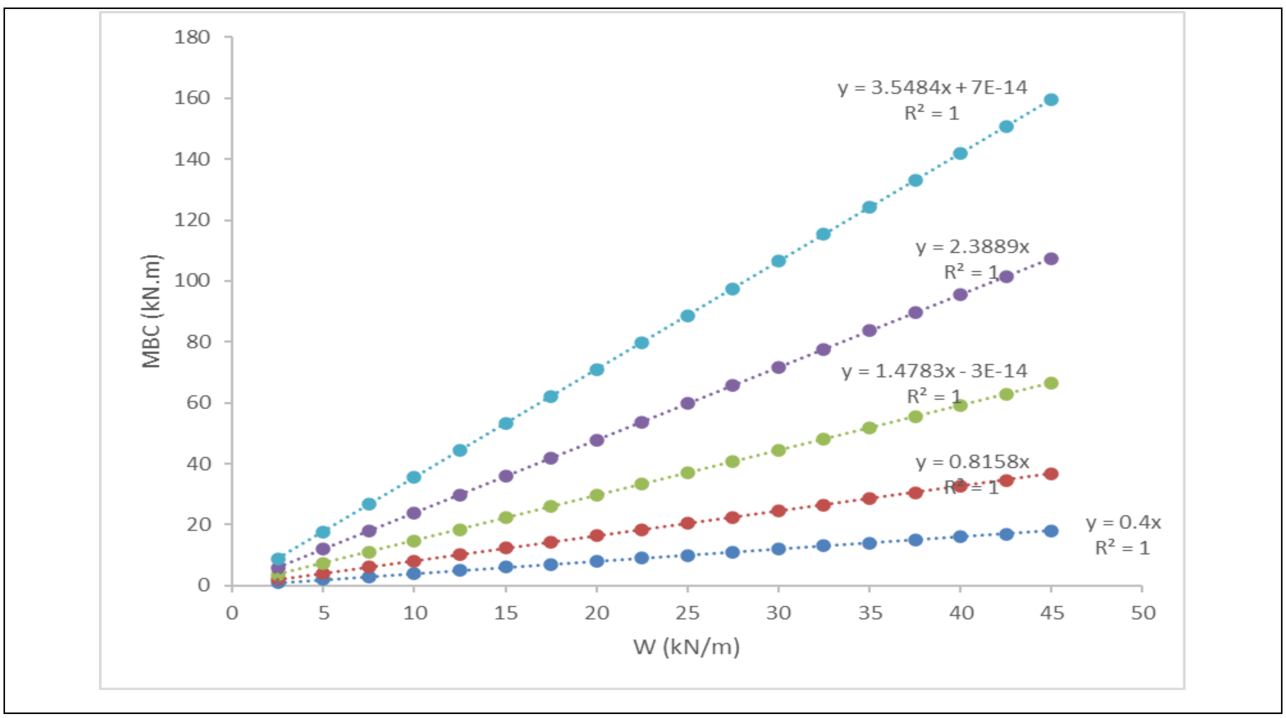


Figure 4.16: Variation Of Mbc Under Various Uniform Loading

Table 4.10: Equation Factor and the L1 Values for Beam Under Uniform Loadings

L1 (m)	Factor
2	0.4
3	0.8158
4	1.4783
5	2.3889
6	3.5484

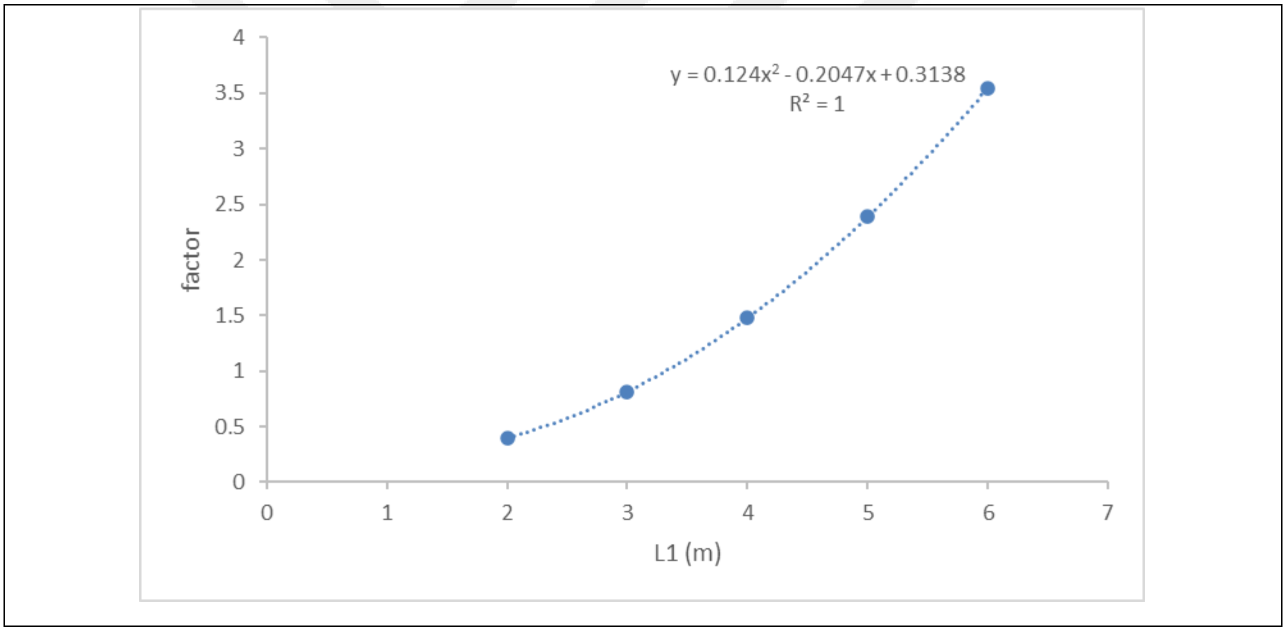


Figure 4.17: Polynomial Fitting For The Impact Of L1 O The Equation Factor

From the figures, the equation derived to:

$$\text{MBC} = \ W(0.124\ L1^2 - 0.204\ L1 + 0.3138\ )$$

Table 4.11: The Difference Between Derived And Calculated Mbc Based On L1 Changing Under Uniform Loading

W	derived MBC	Calculated MBC	Difference
2.5	1.00	1.00	0.00
5	2.89	2.89	-0.01
7.5	6.13	6.12	-0.02
10	11.19	11.16	-0.03
12.5	18.52	18.48	-0.04
15	28.60	28.54	-0.06
17.5	41.89	41.81	-0.09
20	58.86	58.75	-0.11
22.5	79.96	79.84	-0.12
25	88.85	88.71	-0.14
27.5	97.73	97.58	-0.15
30	106.61	106.45	-0.16
32.5	115.50	115.32	-0.18
35	124.38	124.19	-0.19
37.5	133.27	133.06	-0.20
40	142.15	141.94	-0.22
42.5	151.04	150.81	-0.23
45	159.92	159.68	-0.24

Table 4.12: The Difference between Derived And Calculated Mbc Based On L1 And L2 Changing Under Uniform Loading

W	L1	L2	derived MBC	Calculated MBC	Difference
2.5	2	2	1.00	1.00	0
5	2.25	2.25	2.41	2.62	0.21
7.5	2.5	2.5	4.34	4.97	0.63
10	2.75	2.75	6.91	8.15	1.24
12.5	3	3	10.22	12.25	2.03
15	3.25	3.25	14.41	17.37	2.96
17.5	3.5	3.5	19.58	23.62	4.04
20	3.75	3.75	25.85	31.09	5.24
22.5	4	4	33.34	39.89	6.55
25	4.25	4.25	42.16	50.11	7.95
27.5	4.5	4.5	52.44	61.86	9.42
30	4.75	4.75	64.28	75.23	10.95
32.5	5	5	77.80	90.33	12.53
35	5.25	5.25	93.12	107.26	14.14
37.5	5.5	5.5	110.36	126.11	15.75
40	5.75	5.75	129.62	146.99	17.37
42.5	6	6	151.04	170.00	18.96
45	6.25	6.25	174.71	195.24	20.53

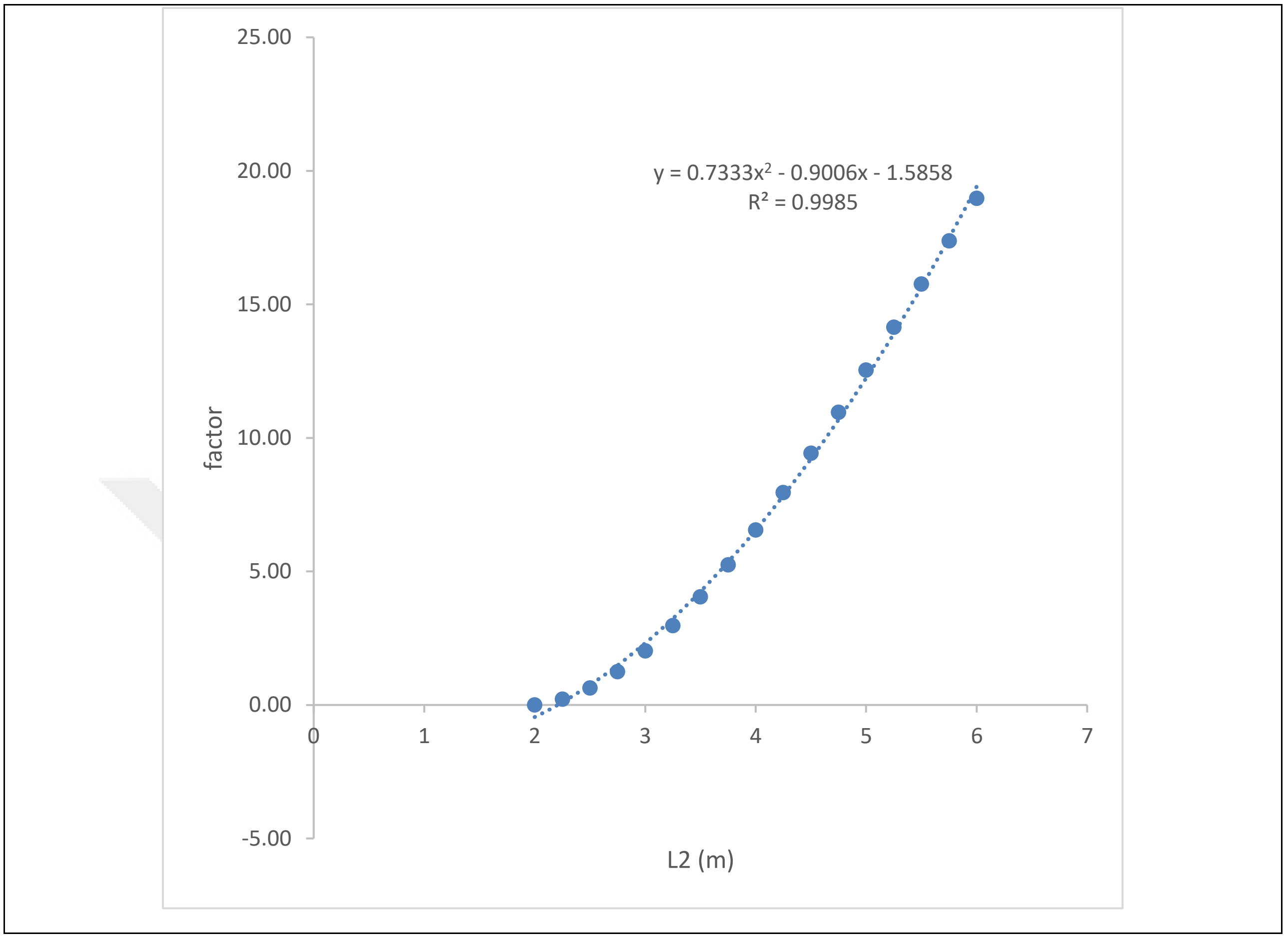


Figure 4.12: Polynomial Fitting For The Impact Of L2 O The Equation Factor

Table 4.13: the difference between derived and calculated MBC based on L1 , L2, and L3 changing under uniform loading

W	L1	L2	L3	derived MBC	Calculated MBC	Factor
2.5	2	2	2	0.55	1.00	0.45
5	2.25	2.25	2.25	2.51	2.53	0.02
7.5	2.5	2.5	2.5	5.09	4.69	-0.40
10	2.75	2.75	2.75	8.39	7.56	-0.83
12.5	3	3	3	12.53	11.25	-1.28
15	3.25	3.25	3.25	17.64	15.84	-1.80
17.5	3.5	3.5	3.5	23.82	21.44	-2.39
20	3.75	3.75	3.75	31.20	28.13	-3.07
22.5	4	4	4	39.88	36.00	-3.88
25	4.25	4.25	4.25	49.99	45.16	-4.84
27.5	4.5	4.5	4.5	61.65	55.69	-5.96
30	4.75	4.75	4.75	74.95	67.69	-7.27
32.5	5	5	5	90.04	81.25	-8.79
35	5.25	5.25	5.25	107.01	96.47	-10.54
37.5	5.5	5.5	5.5	125.99	113.44	-12.56
40	5.75	5.75	5.75	147.10	132.25	-14.85
42.5	6	6	6	170.44	153.00	-17.44
45	6.25	6.25	6.25	196.14	175.78	-20.36

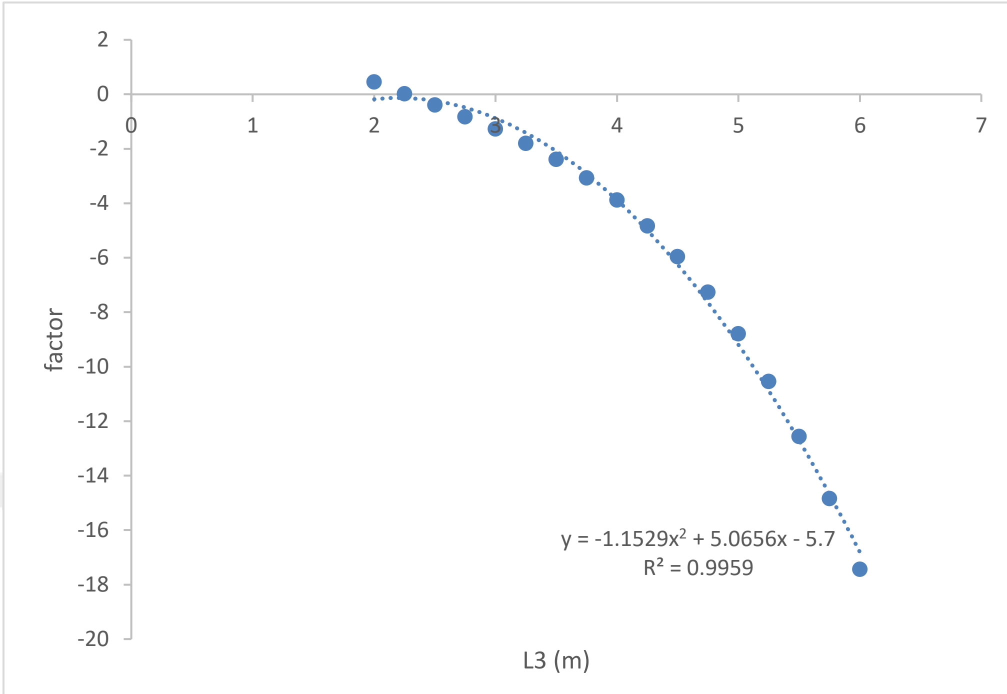


Figure 4.19: Polynomial Fitting For The Impact Of L3 O The Equation Factor

The final equation became:

$$MBC = W(0.124\, L1^2 - 0.204\, L1 + 0.3138) + \beta 1 + \beta 2 \qquad (4.8)$$

$$\beta 1 = 0.733\, L2^2 - 0.9\, L2 - 1.585 \qquad (4.9)$$

$$\beta 2 = -1.153\, L3^2 + 5.06\, L3 - 5.7$$

Table 4.14: Correlation The Difference Between Derived And Calculated Mbc Based On L1 , L2, And L3 Changing Under Uniform Loading

W	L1	L2	L3	derived MBC	Calculated MBC	Factor
2.5	2	2	2	0.36	1.00	0.64
5	2.25	2.25	2.25	2.36	2.53	0.17
7.5	2.5	2.5	2.5	4.83	4.69	-0.14
10	2.75	2.75	2.75	7.88	7.56	-0.32
12.5	3	3	3	11.64	11.25	-0.39
15	3.25	3.25	3.25	16.21	15.84	-0.36
17.5	3.5	3.5	3.5	21.71	21.44	-0.27
20	3.75	3.75	3.75	28.26	28.13	-0.13
22.5	4	4	4	35.98	36.00	0.02
25	4.25	4.25	4.25	44.97	45.16	0.18
27.5	4.5	4.5	4.5	55.37	55.69	0.32
30	4.75	4.75	4.75	67.28	67.69	0.41
32.5	5	5	5	80.81	81.25	0.44
35	5.25	5.25	5.25	96.10	96.47	0.37
37.5	5.5	5.5	5.5	113.25	113.44	0.19
40	5.75	5.75	5.75	132.37	132.25	-0.12
42.5	6	6	6	153.59	153.00	-0.59
45	6.25	6.25	6.25	177.02	175.78	-1.24

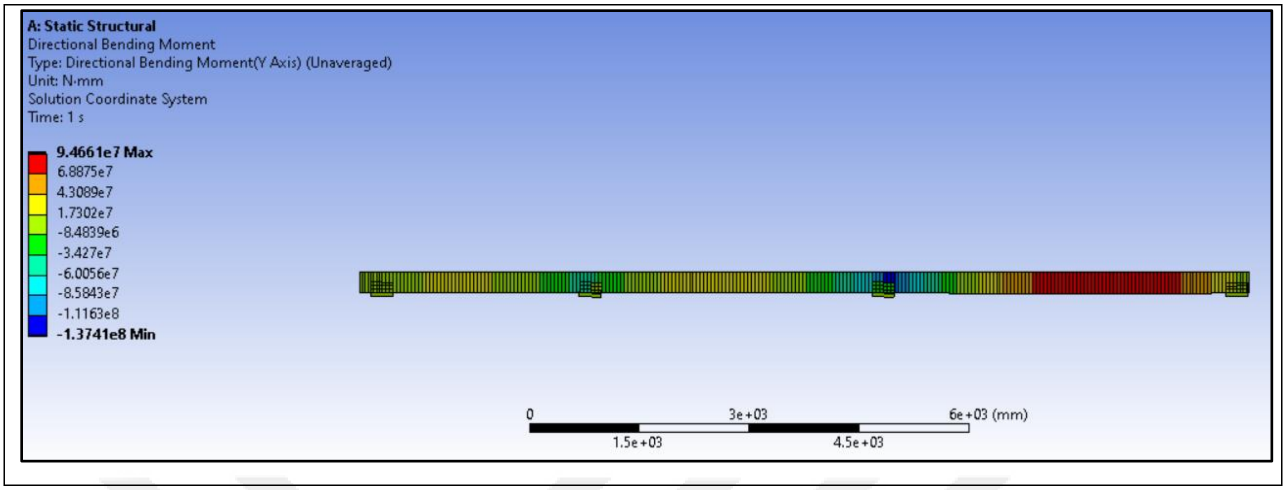


Figure 4.20:Bending Moment Behavior Along The Beam Under Uniform Loading (ANSYS)

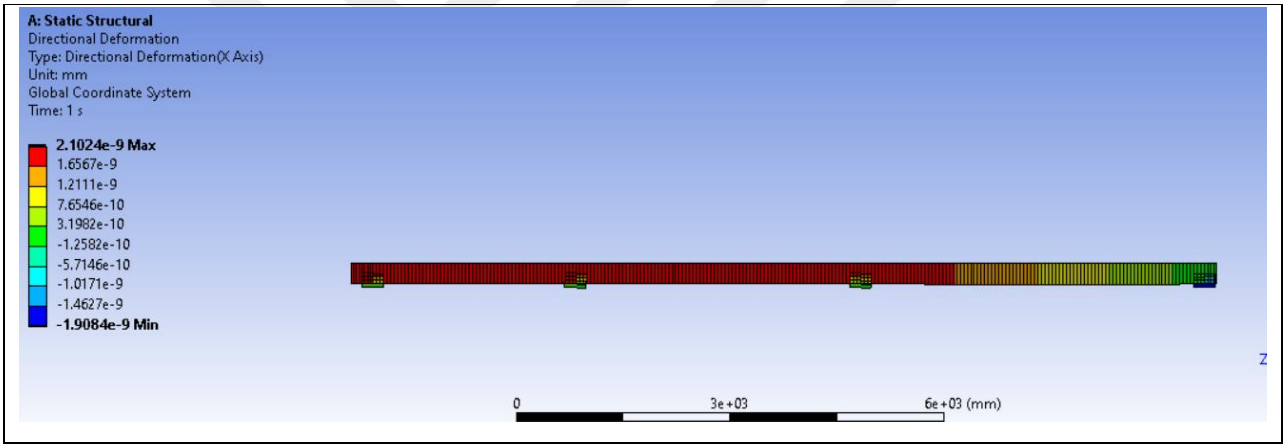


Figure 4.21 :Directional Deformation Behavior Along The Beam Under Uniform Loading (ANSYS)

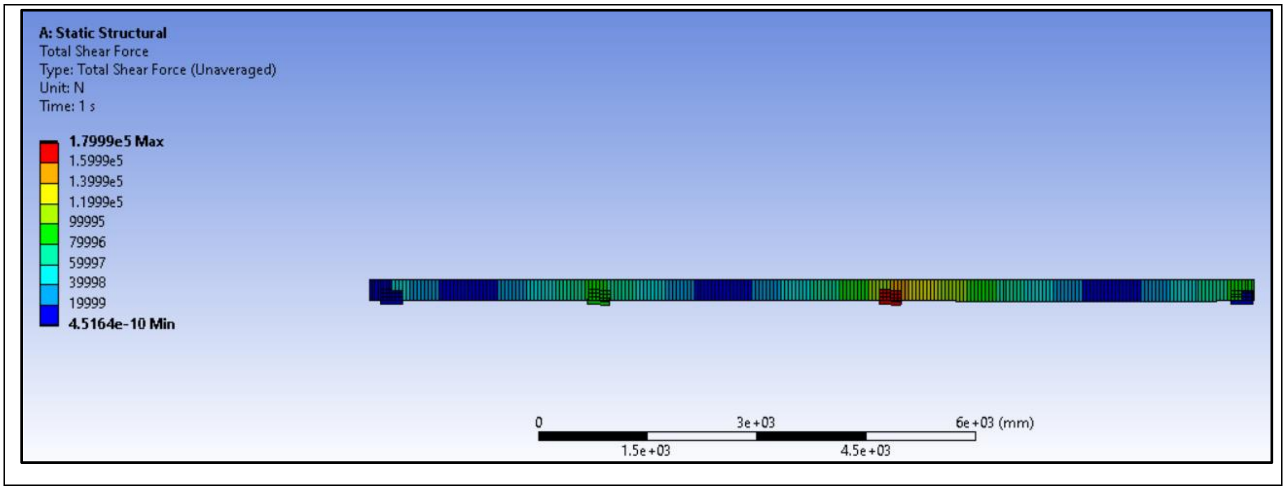


Figure 4.22: Shear Force Behavior Along The Beam Under Uniform Loading (ANSYS)

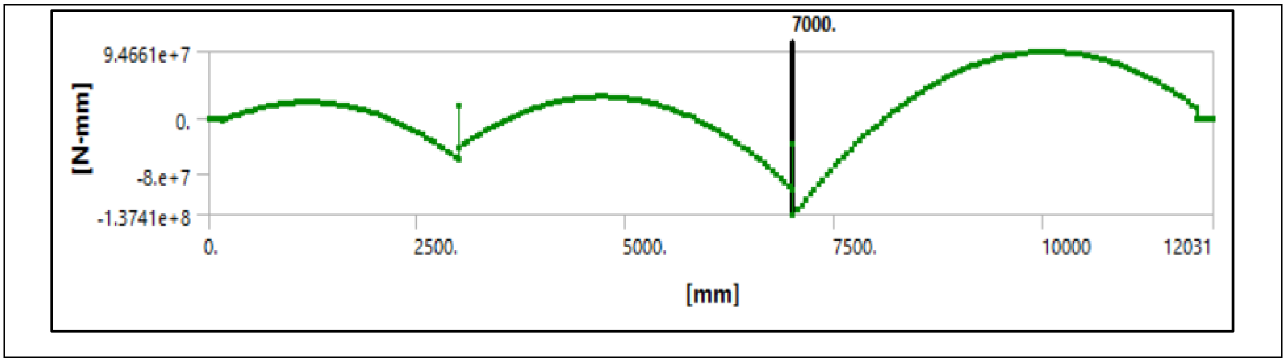


Figure 4.23 : Bending Moment Diagram Along The Beam Under Uniform Loading (ANSYS)

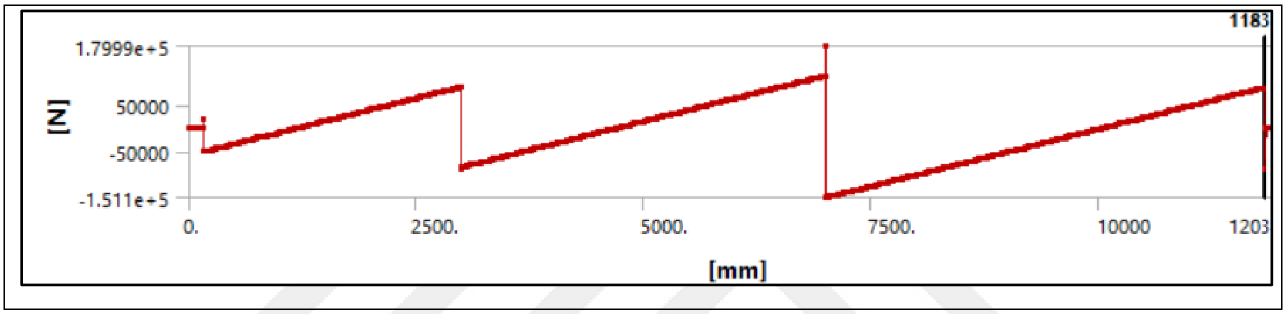


Figure 4.24: Shear Force Diagram Along The Beam Under Uniform Loading (ANSYS)

5. DISCUSSION AND CONCLUSIONS

5.1 CONCLUSIONS

The improvement of indeterminate beam design which has non simple reachable internal stress is important matter for better design of these elements. The study converted the conventional analysis stages for the calculation of the bending moments as first unknown items inside the member into derived equation that correlated in multi stages to achieve better results which the designer can used to find out the behavior of stresses inside the members. the study took the case of three spans indeterminate beams under concentrated loads then under uniform loading. for each case, the study derived equation that included the effect of the three span lengths and the external loading. For the case of concentrated loadings on three spans, the derived equation derived was: $\mathrm{MBC} = (-0.0306\ L3 + 0.995)\ (-0.0072\ L1\ \ P + \ 0.6366\ P + 0.55 * L2^2 - 3\ L2 + 20.08 * a^2 - 45.45\ a + 25.8\ ) - 0.228 * L3 - 1.02$. The case of three spans under uniform loading indicating the derived equation: $MBC = \ W(0.124\ L1^2 - 0.204\ L1 + 0.3138\ ) + \ \beta1 + \beta2$

$$\beta1 = \ 0.733\ L2^2 - 0.9\ L2 - 1.585 \qquad (5.1)$$

$$\beta2 = \ -1.153\ L3^2 + 5.06\ L3\ - 5.7 \qquad (5.2)$$

Where: the factors $\beta1\ and\ \beta2$ reflected the effect of the spans length near the place of joint B. The finding of MBC moment considered the key data in which all the other forces can be obtained. The simulation for the two cases was made using ANSYS program. The images that gained after the finite element analysis under the program showed so close values to that obtained for the MBC moment. The images showed the variation of the directional deformation, the shear forces, and the bending moments along the beam spans.

5.2 FUTURE WORK

The structural analysis of indeterminate members can be obtained by future work in which the design of the required reinforcement and the effective depth of the beam and other geometrical and physical properties can be modeled toward derived applicable equation for support the design output. the future studies can deal with the trusses for evaluating the behavior of compression and tension and also the state of vibration by converting the steps of design under the available analysis technique into models that ease the reach to the internal forces state.

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