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GEOMETRIC DESIGN AND ANALYSIS OF SPACE FRAMED STRUCTURES FOR LOAD TRANSMISSION IN JOINT - TO CHECK THE STABILITY AND THE SAFETY OF JOINT

Mays Hasan Hadi ALGBURI

Master's Thesis

Supervisor

Prof. Dr. Tuncer ÇELİK

Istanbul, 2023

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

Mays Hasan Hadi ALGBURI

Signature

DEDICATION

With love and sincerity, I dedicate this thesis:

To my beloved father, who worked tirelessly to provide for our family and gave me unwavering support throughout my academic journey. Your sacrifices and unwavering dedication to our family have been a constant source of inspiration for me. To my dear mother, who has been my rock and my confidante. Your love, encouragement, and guidance have played a significant role in shaping the person I am today. To my amazing brothers, who have always been my best friends and have supported me through thick and thin. Your unwavering faith in me has been a source of strength and comfort. To my cherished friends, who have walked with me through this journey and provided a shoulder to lean on when needed. Your love, laughter, and encouragement have made this journey a memorable one. And finally, to my exceptional supervisor, whose guidance, mentorship, and expertise have been instrumental in shaping this thesis. Your invaluable support, insightful feedback, and unwavering commitment to my success have made all the difference. Thank you for believing in me and for helping me achieve my academic goals.

ABSTRACT

GEOMETRIC DESIGN AND ANALYSIS OF SPACE FRAMED STRUCTURES FOR LOAD TRANSMISSION IN JOINT - TO CHECK THE STABILITY AND THE SAFETY OF JOINT

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A space frames or space structure is a stiff, lightweight, truss-like structure that is created from interlocking struts in a design in architecture. To span enormous expanses with minimal interior support, space frames could be employed. For both long and short span constructions, space frame structures have become increasingly commonplace. Using ETABS V19 and American Standards, this study modeled and analyzed the space frame structure. It measured 25 by 25 meters. Standard ASTM A36 and A36 grade steel sections were ASIC-14 HSS3X0.250 and HSS 2.5X0.188. The built-in load combination was specified by American Standards.

The proposed structure was analyzed using 18 load combinations derived from ETAB. The proposed structure's maximum deflection was 5.01mm under the load combination UDStlD2. The load combination UDStlS2 resulted in the maximum deflection of 7.26 mm. On the basis of an analysis of the shear force and bending moment envelopes for the proposed structure in terms of section strength, the major load combinations were calculated. The highest shear force and bending moment values obtained for HSS 3 X 0.250 were both 0.1920KN, whereas for HSS 2.5 X 0.188, the highest shear force value was -0.03650KN and the bending moment value was -0.0296KN. The obtained results for shear force and bending

moment for both sections show that the both HSS section are internally stronger to resist the bending stress in terms of strength with different load combinations.
The obtained P-M ratios values lies between 0.5 to 0.70 at the mid- sections and 0.0 to 0.5 at side-sections. shows that the side sections of the proposed model are not economical. It indicates that the side section should be replaced with the smaller sections for economic structure.
Keywords: Geometric Design, Space Framed Structures, Load Transmission.

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LIST OF ABBREVIATIONS

SIDL : Super Imposed Dead Load

ELX : Earthquake load x-direction

CAD : Computer Aided Design

1. INTRODCUTION

Over the past half-century, there has been a worldwide increase in interest in structural steel constructions. Architects and engineers' primary focus has always been on developing innovative structural forms that allow for big open spaces. It's becoming increasingly common for space frames to be the ideal solution for projects that need to be built quickly, light, and cheaply. Roofs, flooring, outside walls, c 1999 by CRC Publishing LLC and canopies have all been utilized on both long- and short-span enclosures. Around the world, a wide range of unique projects have been conceptualized and built using various combinations *(American Institute of Steel Construction (AISC))*. There are a number of critical aspects that contribute to the fast evolution of the space frame. Humans have long sought such vast indoor areas for their activities. Therefore, sports events, cultural performances and public assemblies can all be held under the same roof. There was also a growing desire for a big area with minimal interference with internal supports because of the demands of modern production and operational efficiency. Because the internal space may be used for a variety of ways, the space frame is excellent for these kinds of applications *(American Institute of Steel Construction (AISC))*. For projects with complex geometries, the use of space-frames has expanded in recent years due to the increasing desire for free-form architecture. Because of this, their construction process has become more complicated, as changes in curvature produce non-uniform space frames.

Member lengths and joint angles are consequently distinct geometrical features of their elements. As a result of this level of customization, the time and cost of building will increase. It is the joints that have the most significant impact, accounting for 30 to 50 percent of the entire fabrication cost and up to 50 percent of the materials required for construction. The geometry of space frame constructions has been optimized for joint cost using a variety of ways. The cost goal used by (*Asadpoure & al*) is a smooth et differentiable one, taking into account the member mass. In spite of this, the cost of production and building does not rise linearly with the weight of the material. To demonstrate that heavier yet modular constructions can be more expense if fabrication and installation costs are accounted, (*Havelia)* employed a cost-driven topology with sizing optimization. Optimizing both the cost and size of two-dimensional truss constructions at the same time is the goal of *Ranalli and his colleagues*. In addition to a list of possible local connections and inputs.

1.1 DEFINITION OF THE SPACE FRAME

The definition of the term "space frame" has been described in a variety of ways in structural engineering literature, some of which are contradictory. Essentially, a three-dimensional framework is what the term "space frame" means taken in its broadest sense. The term "space frame" can also refer to a certain sort of three-dimensional structure action. Structural designers and technicians sometimes appear to fail in conveying what they truly want to express with it through this medium. As a result, the phrase "space frame" as used in this section should be defined here. The International Association has a Working Group on Geo Spatial Steel Structures.

A space frame is a three-dimensional structure system made up of linear pieces arranged in such a way that forces can be conveyed. Component elements in some circumstances are two-dimensional. A flat and curved ground is the most common type of a space frame on the macro level.

1.2 BASIC CONCEPTS

Either a flat or a beveled edge can be used to construct the space frame. A single-layer grid is the earliest type of space frame structure. The single - layered grid is created by adding interim grids and rigid connections to the joist & girder framing system. Grid construction is characterized by its ability to distribute the load in an omnidirectional manner rather than the linear transmission of the weight in a conventional framing system. For broad spans, the bend stiffness can be improved most effectively by using a double layer structure, since such loads are mostly transferred through bending. In contrast to the grid system, the curved surface space frame's load transmission mechanism is fundamentally different. The following example best describes the idea of a space frame*(Brazil, Aine. (2000))*.

1.3 RESEARCH OBJECTIVES

It is the goal of this thesis to investigate and propose design guidelines for the design and analysis of the whole space framed, and how unique space frameworks are more helpful than others based on their geometric and their structural strength,

a. A safe and cost-effective design can be achieved by developing links between stepwise regression analysis and complete height analysis.

b. In order to analyze the effect or role that design in structural design

c. It's important to address serviceability issues such as truss deflection, member deflection, and proper camber.

d. Determine the most cost-effective arrangement of members to accommodate the desired heights, spans, and loads.

e. To observe how planning has a part in the structure of the frame and the design of geometric shapes.

f. Analyze the force levels across columns using the simplest possible external column setup.

g. To see how geometric design and study of space are affected by construction or construction.

1.3.1 Scope of Work

Space trusses & space frames are described in detail in this thesis as previously stated. Stable constructions can be achieved with trusses, but not with space frames since space frames need bending rigid connections between parts. Assumed to really be pin-jointed (i.e. not bending stiff), a tubular space truss is shown in Fig. 1.1. The truss members' (in this instance triangular) arrangement provides stability to the space truss. Figure 1.2, on the other hand, depicts a space frame in which the connections must be bending rigid in order for the space frame to be stabilized *(Brazil, Aine. (2000))*

Structures in this thesis are unique in that they break down into nodes and members. Because of this, buildings can be tailored to fit a variety of designs, from the simplest flat and stepped structures to the most complex double-curved ones. Uniform member lengths and node kinds were a primary target at the outset of the development process, but now cladding techniques are more important. This is particularly relevant to the design of glass structures, but it isn't limited to that. As a result, the structural surfaces are designed to have as many homogeneous facets as possible. This progress was made possible thanks to a set of software tools, which we'll go over in more detail below *(Brazil, Aine. (2000))*

With regards to connecting technologies, there have been similar advancements To connect tubes to nodes at unpredictable angles, a spherical connector (ball) was utilized in the beginning (fig.1.1). For multi-bolt connections, cylindrical and even block nodes must be used when tubes shift to rectangular hollow portions. The tubular structure in fig. 1.2 illustrates the use of cast or fused nodes for larger structures. For single screw connections not covered under building requirements, special attention is paid to the development of a design concept.

Figure 1.1: Church in Errata (Source Google).

1.3.2 The Architectural Context

In our current architectural context, the advancement of space stations is characterized by a made up of a wide range of special of special "free forms," as shown in fig. 1.3. Form does not necessarily follow function in these structures, which runs counter to the basic tenet of the so-called "modern" functional architecture that dominated our city scopes for the majority of the 20th century. Form follows function *(Cheong-Siat-Moy, Francois. (1997))*.

Figure 1.2: Some Free Forms in the Current Architectural Context and its Architects (Source Google).

1.3.3 Classification and Application of Space Structures

A structure's load-carrying ability is determined by which of the following: compression, tension, or bending, and/or the combination of these three. As shown in Fig.1.4, structural systems are divided into four groups based on how they transport load: compression above; tension below; combined compression, tension, and bending on the left and right sides of the figure *(Choi, C. -K; Chung H)*.

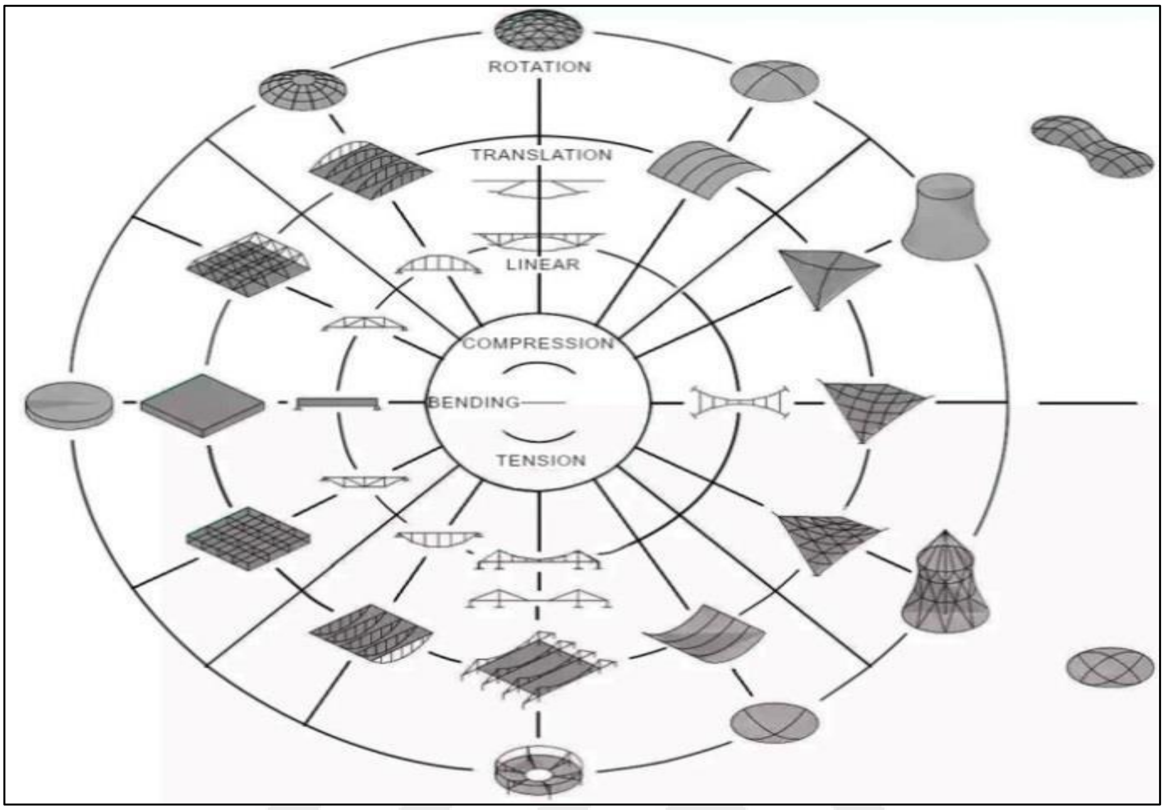


Figure 1.3: Classification of Structures (Source Google).

Figure 1.4: Mitsubishi Electric Hall (Source Google).

Figure 1.5: Testing Hall in Nigeria (Source Google).

Figure 1.6: Olympic Stadium Berlin (Source Google**).**

Figure 1.7: Station Roof in Spandau, Arch. Gmp, Eng. Sbp(Source Google).

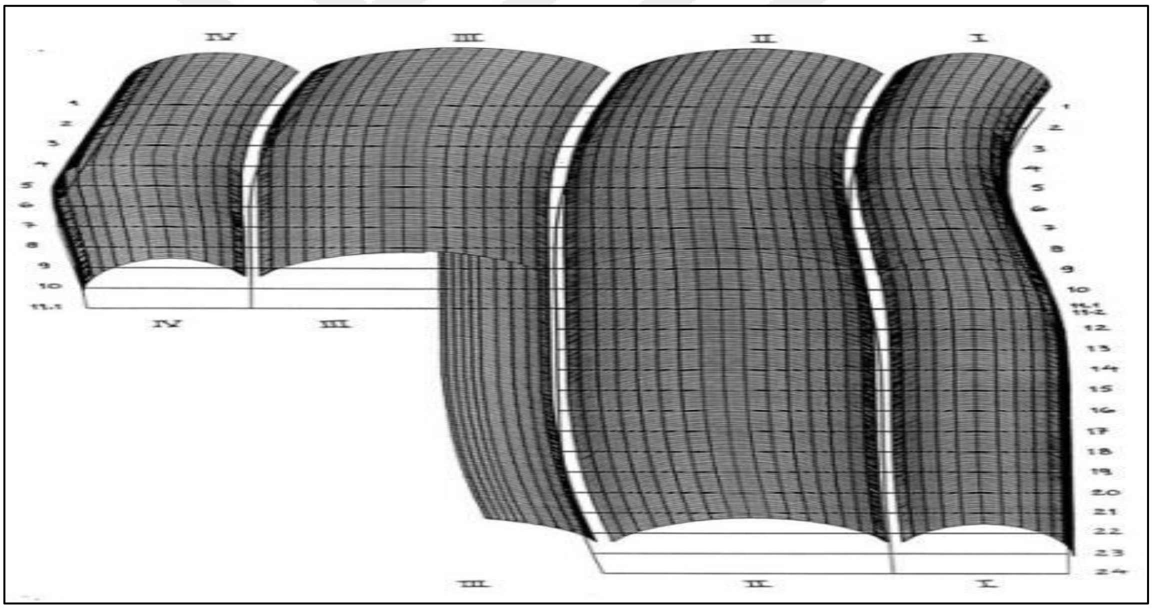


Figure 1.8: Compressed Plane View (Source Google).

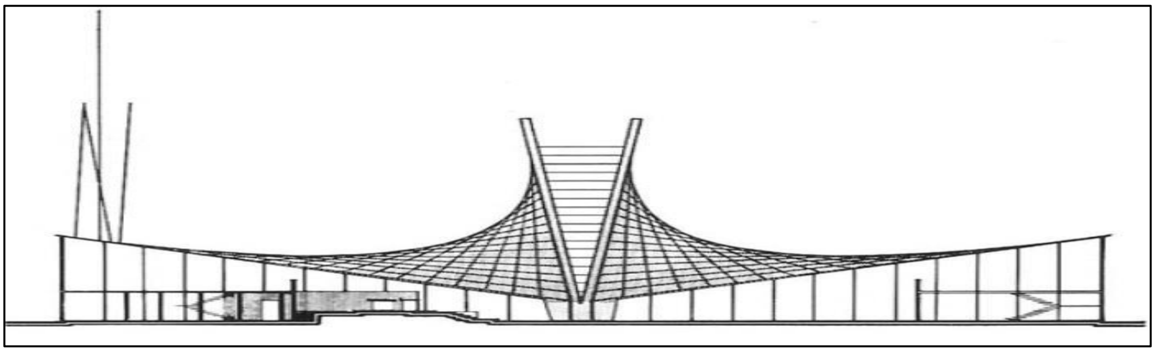


Figure 1.9: Initial Design (Source Google).

Figure 1.10: Church San Orebro in Nuevo Leon/Mexico, Designed by Felix Candela(Source Google).

In an unexpected turn of events, the writers connected with Felix Candela to work on a stadium roof for such Islamic University of Riyadh with a free span of roughly 150 m. TYPSA in Madrid enlisted the help of Candela, who offered a hyper framework for the roof, not surprisingly (fig. 1.16). A single layer reticulated structure model was what he expected from his expertise with thin shell structures. Due to the fact that a decent single layer truss construction could not support a broad span hyper shell, this put us in a tough position. Finally, Candela decided to go with a thin, double-layered space truss that provided the necessary stability while weighing far less than a 4-cm-thick concrete shell would.

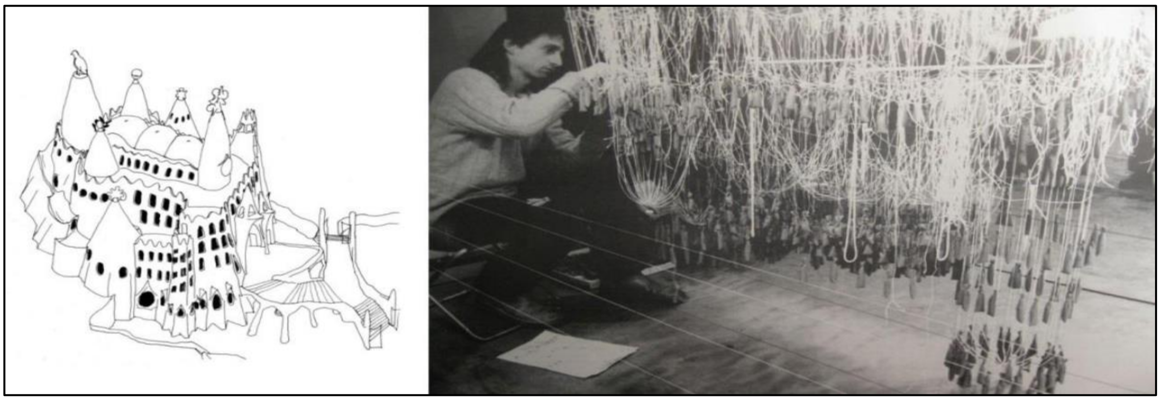


Figure 1.11: Church of Colonia Guell in Barcelona (Source Google).

A number of numerical methods are now available to help tackle form finding difficulties, such as the force concentration method and the dynamic relaxing method.

Table 1.1: Difference Between Plain Frame and Space Frame.

Plain frame	**Space frame**
In Plain frame structure elements are distinguished by their unique Ranks which are determined not just by the size of their cross-section but also by the significance of function given to them.	In space frame there are no any load transfer pattern, as well as all elements responds to the function of resisting the roof load in keeping with structure 3D Geometry of structure
In plain frames, the only direction in which force operates through the axis of the members that are either in tension or compression	In space frames forces, the forces also operate parallel to the axis of member they are attached to, in addition to acting transversely
Every Member is subject to the influence of two forces that are equivalent to one another and have their line of action passing through the center of the member. In other words, each member of it consists of two force members.	One or more frame’s member is subjected to more than two forces (multiple forces members)
Planar structures are simpler to figure out while also being more efficient because of their weight.	Space Frames are constructed with or without an extremely high level of precision in order to fit in a limited design.

1.4 ORGANIZING AND STRUCTURING OF THE THESIS

The following are brief descriptions of each of the six chapters that make up the thesis.

Chapter 1 introduction: The introduction of the thesis lays out the challenges to be solved, the methods to be used to obtain the necessary data, and the overall goals of the study.

Chapter 2 literature review Second, a review of the relevant literature is presented, with a particular emphasis on past research that has been undertaken at the national and global levels. In the methodology section, we detail the procedures we used to collect our data and analyses our samples for contaminants.

Chapter 3. Methodology in this chapter different testing method were explained and how the results varies with respect to previous researches. Also how we conduct the tests are also explained in this chapter. Modeling of space structure were done on this chapter

Chapter 4. Evaluation in this chapter the main focus was on how the sample was selected and how the test result becomes more accurate if some of the measures were taken. Selection of sample is also important part before testing, so all these details are discussed. Assigning of loads combination and analysis result were shown in this chapter.

Chapter 5 Conclusion and future recommendations finally, we draw some final findings and make some recommendations based on what we learned from the model and the conversation. Recommendations have been made based on the results and the discussion of geometry and design of space framed structures will be in that chapter.

2. LITERATURE REVIEW

This section examines the current theories and practices around the space frame structure system via the lens of published material culled from a wide range of Indian and international journals, publications, and conferences. The characteristics and behavior of long-span space frame structures have been the focus of extensive research. A prediction of the space frame structural system's behavior is provided once its behavior is reviewed in the literature.

The buckled truss bar of a space truss in a major shopping market chain in Adana, Turkey, has been studied by Vatansever C. (2019). The study building was developed in accordance with the Turkish Seismic Code for Earthquake Zone 2. The author found that flexural buckling occurred at some bar even in the absence of external loads such as snow or rain. A survey revealed that increased soil consolidation was to blame for the differential settlement of the foundation, which caused the buckled truss bar. This paper's focus is on the buckling of space truss bars brought on by improper grounding. Using vertical coordinates, a photogrammetric survey was conducted to determine the extent of roof settlement. Moreover, the author analysed the buckled distribution pattern of space truss bars caused by differential settlement. It is possible to perform a non-linear analysis of a space roof truss by developing an analytical model in SAP2000v19. Results indicate that tubular truss bars with a higher slenderness ratio, as measured by ANSI/AISC 360-16, are more vulnerable to flexural buckling. According to the authors, soil consolidation over time causes foundation settlement. Buckling of space truss bars is another common result of foundation settling, which can also cause other structural damage.

In 2019, Basil. B. et al. proposed a method for analyzing and designing a space truss using the software package STADD. Pro. STADD-Pro is a versatile programmer for analyzing and designing many kinds of structures, as it is compatible with 90 different design codes for materials as varied as concrete, steel, aluminum, and timber. The space frames are huge, clear-spanning buildings. Certain assumptions are made during analysis and design, such as the fact that structural parts are considered to be pin jointed and that load should be applied axially atjoints only. The three primary types of space truss elements are simple, compound, and complex. A triangular pyramidal shape links the individual components. The author uses a space roof truss as an example to illustrate the stability and predictability of space trusses. Further, the author elaborates on how to figure the dead, live, and wind loads acting on a space roof truss. IS875(Part1, 2, 3, 5): Loading calculations are performed using the 1987- Code of practice for design load (other than earthquake) for buildings and structures. The author finds from his research that there are several advantages to using space structures, including the fact that they are lightweight, have increased rigidity, and are well-suited for large spans. The STADD Pro programmer analyses the structure for bending moment, shear force, and general deflection behavior. In order to ensure the structural integrity of a building, this programmer also specifies the appropriate section for a specific loading.

p. Composite space truss structures made from 3D lattice beam and structural glass have been studied by Lorenzo. G. D. et al. (2018) for the purpose of safeguarding historic and cultural landmarks. The author provides an in-depth procedure for designing 3D-lattice beams. A major archaeological site is enclosed in the current research using steel lattice beams and a structural glass slab. This brittle collapse mechanism is purposefully built into the structural glass slab. The exceptional strength and resistance to corrosion of these three-dimensional lattice beams are just two of their notable features. The beam is simple to produce and needs little upkeep. Castillo cold-formed rectangular hollow section (RHS) and S355J2W steel 3D lattice beams are utilized in accordance with European Standards (EN) 10219-1 and EN 10219-2. In addition to offering a design technique, we performed a numerical study with the commercial FEM code Pro_ Sap and a custom-written programmer. In order to model the composite space truss, ABAQUS was used. Additional prototype lattice beams are created to study structural failure in the lab. It is the author's opinion that the proposed design criteria are strong and will not be compromised by the collapse mechanism. There is room for experimental and analytical exploration, and the lattice beam can be put to various uses after it is dismantled.

q. In 2018, Fu. F., and Parke, G. A. R., used both implicit and explicit techniques to evaluate the progressive collapse resistance of a double-layer grid space structure. Examining the double-layer space structure's behavior structurally is the primary focus of this study. The author discussed two types of assessment techniques, the implicit method and the explicit way. In ABAQUS, we created a three-dimensional finite element model of a double-layer grid space structure, and in SAP2000, we used iterative elastic analysis to construct the structure. The author begins by examining the model using the ABAQUS implicit solver. The collapse phenomenon of the structure, should some structural members be eliminated, can be analyses with the help of the implicit technique. American design codes DOD and

GSA provide an alternate route technique (APM) that bolsters the findings of the investigation. It was determined through examination that the failure of the support is more vulnerable than the collapse of the central parts of the structure. The global failure mechanism of the structure is being analyses via the lens of support failure, which is the subject of ongoing research. The second author conducted the experimental verification. Using a case study, the author additionally elucidates the explicit approach. Author finds that the implicit method is a well-defined and straightforward approach to analyzing the collapse mechanism of structural elements, whereas the explicit method describes the collapse mechanism of the entire system. The gradual collapse of members along the line between the failed support and two other opposite supports has also been observed after the failure of a single support. As a result, it emphasizes the significance of appropriately reinforcing all of the structure's supports and members linking to the supports to forestall the latter's gradual collapse.

P. Composite space trusses' stiffness and energy absorption capacity have been investigated by Sageetha (2017). Space truss employs a three-dimensional system to transfer loads. The author analyses the behavior analytically by changing variables such slab thickness, concrete strength, and composite space truss module size. For the non-linear analysis, we used ABAQUS. EI-(1998) sheikh's and Mezzina et al(2001) .'s published experimental results formed the basis for the analytical investigation (1975). In his research, the author considered slabs of varying thicknesses (50 mm, 80 mm, 100 mm, and 125 mm), concrete of varying strengths (M 25, M 30, and M 35), and module dimensions (800 mm * 800 mm, 1000 mm * 1000 mm, and 1333.3 mm * 1333.3 mm). The author's research led him to the conclusion that the slab's energy-absorbing capability rose in direct proportion to its thickness. We also notice that the ductility factor will remain unchanged. However, neither the slab thickness nor the concrete grade employed in the construction affect the ductility of the building. Additionally, the composite structure is observed to have superior rigidity over the non-composite structure.

Parametric research on long span industrial steel structures has been conducted by Patel B. and Jamani A. (2017). It's important to balance cost-effectiveness and precision in the design of industrial steel truss buildings. Long span industrial truss are planned around the steel's weight as a governing factor in the industrial region. The 125x45-meter long steel industrial structure is designed in this article to withstand lateral loads caused by wind and earthquakes.

The finite element programmer STAAD PRO is utilized for this analysis. In order to provide a thorough comparison, we take into account a number of different factors, including but not limited to horizontal forces, axial forces, deflection, stress, and lateral displacement. The purpose of this research is to perform a comparison study between the different structural systems utilized in long-span roof industrial steel buildings in terms of both cost and stability. The writer took into account the Potentially Explosive Bomb (PEB) Structure, I-Section Rafter, Simple Truss, and Space frame. After analyzing the relative weight of several building types, the author found that the space frame and truss member were the lightest options. The I-section rafter construction is heavier and thus more expensive, but it has the lowest deflection of any steel structure. Hence Compared to other types of buildings, the space frame and truss members are more cost-effective.

Analysis and design of a space frame shuttle court, verified through experimentation, have been the subject of research by Sugavnan. R. and Srinivasan. G. (2016). Additionally, the author evaluates the similarities and differences between PEB and steel space truss. STADD Pro software is used for the analytical evaluation of the shuttle court. The primary objective of this study is to lessen compression chord buckling and boost space structure performance. Steel truss and node connections were designed according to the standards set out by the Steel-code of Practice IS 800-2007. IS: 456-2000, the code of practice for plain and reinforced concrete, was used in the design of the columns and footings. Static loads of 1 KN, 4 KN, 8 KN, and 16 KN are applied to the space truss in an experimental setup. Analysis shows that the nodes along the bottom chord edge perform symmetrically and exhibit equal deflection and strain values. Ultimately, the author finds that in PEB the use of steel in volume is less expensive than the use of steel in the form of space trusses. Deflecting outcomes are not consistent. As opposed to software analysis, the value of experimental deflection is higher. It also finds that, compared to mild steel roof trusses, space trusses are less expensive over long spans.

2.1 STRUCTURAL DESIGN OPTIMIZATION IN DESIGN DEVELOPMENT PHASES

From the first brainstorming through the finalized construction, structural design optimization can be employed at every stage. Conceptualization, preliminary design, and implementation are the three stages of mechanical structure design established in this study.

2.1.1 Conceptual Design

Decisions of a more nuanced nature, such as those pertaining to concept, material, and topology, are met in this stage of structural design. Discrete design variables necessitate the employment of optimization techniques that can accommodate them. At this stage, crucial choices are made that, if reversed, will require massive work and expense. Because of the time and effort required for modeling and simulation, structural-mechanical investigations involving advanced finite-element analysis are often avoided.

2.1.2 Preliminary Design

At this stage, the structure's dimensions are determined by a process of size and shape optimization. While often applied to abstract models, finite-element analysis is used here. In some cases, accurate material models for particular alloys just do not exist yet. Below, we'll address this lingering doubt.

2.2 FINAL DESIGN

Finalizing the design's finer points occurs at the conclusion of the development phase. Details such as welds, radio, and acceptable tolerances are examined and established prior to production of the construction. While many degrees of freedom can be fixed to reduce the dimensionality of the design problem, high-resolution models still require more analysis work.

Dong. S. et al. conducted an analysis of several different types of Chinese long-span space structures (2012). Thanks to modern engineering, these space stations are constructed from lightweight yet incredibly sturdy materials. This analysis classifies space architecture into three periods: the ancient, the mediaeval, and the modern. In addition to delving into their theoretical origins, theoretical guises, and distinguishing characteristics, the writers of this paper also investigate how they are put to use in China. Structures in modern space can be rigid, flexible, or a combination of the two. There are five primary types of modern rigid space structures: composite space trusses, open web latticed shells, partial double-layer lattice shells, tree-type space frame structures, and polyhedron space frame structures. Flexible space architecture, also known as supported membrane structures or air-supported membrane structures, has been increasingly popular in recent decades. Cable-stayed grids, cable truss structures, composite domes and single-layer lattice shells, truss strings, pre-stressed grids, beam strings, prestressed segmental steel, and tensairity buildings are the ten types of stiff and flexible space structures. There are, fundamentally, three types of people, as the author sees it. Rigid elements include things like beams, plates, and bars, whereas flexible ones include things like membranes and cables. China has made significant progress in creating space bridges, and is currently the world leader in this field. In addition, the country's long-span constructions became known on a global scale. The author also emphasizes the need for more study and innovation in the technology utilized to construct structures in space.

Steel and composite space structures have been studied by Lakshmikandhan K. N. and Senthil R. et al., who have taken into account a variety of factors (2010). The layout of the space is reminiscent of a grid with two layers. I a concrete topping slab and (ii) different support configurations were used as study variables. Iii) a carefully monitored study on a sizable spatial grid. The purpose of this study was to compare the effect of a concrete slab on the top of a composite and non-composite space truss structure. An analysis was performed using STADD Pro and ANSYS. Experimental study demonstrates that the top components of the composite truss outperform those of a non-composite space truss at transferring compressive forces and do not buckle under these loads. The supporting mechanism at the midpoint cuts down on steel consumption by twenty percent, which is a nice bonus.

Madi U. R. (1986) has analyses the double-layer space frame grids by means of a conceptual example. The grid's depth, module, layout, and support configuration are the primary factors considered in this study. Four possible grid layouts and seven possible infrastructural choices are considered. It was hypothesized that in a diagonal on diagonal arrangement, the forces on the top, bottom, and bracing members would be distributed uniformly. When the supports were relocated to the grid's interior, the author also noticed a dramatic decrease in member forces. You may conclude that it is economically preferable to increase the depth of your grid to its limit. This study also sheds light on how the functionality and complexity of the grid are impacted by changes to these properties.

has examined the double-layer space frame grids using a theoretical illustration. The depth, modules, layout, and support configuration of the grid are the main variables taken into account in this study. Seven different options for infrastructure and four different grid layouts are taken into consideration. The forces acting on the top, bottom, and bracing elements in a diagonal-on-diagonal configuration were predicted to be distributed evenly. The author also noted a sharp decline in member forces when the supports were moved to the core of the grid. You can decide that raising the depth of your grid to its maximum value is economically advantageous. This research

The process of designing and optimizing space structures that are statically secure and materially efficient, and are formed out of linked beams. (Caigui jian at el 2017) proposed a systematic computational framework for the construction of space structures that takes into account classical stability as well as the approximating of standard areas, boundaries orientation, and geometrical smoothness. In order to solve this difficult issue, by using a nonlinear continuous optimization technique to maximize both the placements of the nodes and the connection between them. The beam cross sections is then formulated as a mixed-integer programming problem with a nonlinear optimization method and quadratic constraints. All of that is done using the xed nodes and connectivity. Tackling this issue by using an innovative and workable alternate direction strategy that is based on the linear programming relaxation. Many different comparisons and instances are used to prove that the algorithms and the computational framework are capable of doing their jobs effectively and efficiently. The result demonstrates the L-framework, which, via efficient use of material, generates space structures that are in static equilibrium. Using a nonlinear optimization algorithm that is based on continuous variables, we maximize both the placements of the nodes and the connection between them. Incorporate furthermore the useful consideration of the constructional complexities involved, in which there are a restricted number of beam kinds.

A large deformation static analysis of three-dimensional space-frame structures is the primary focus of the work that is being done at the moment. In order to conduct an elastic analysis of frame structures using the finite element technique in the post-buckling range, it is necessary to solve extensive nonlinear equation systems. Combining the Newton-Raphson approach (also known as the NR method) as the iteration strategy with the arc-length method (also known as the Risk and Crisfield method) inside each increment is the most satisfying way to solve issues of this kind. The rotational displacement of a joint has been kept up to date via the use of the joint orientation matrix that was proposed by Oran. This was done for big joint rotations. (J.L meek & S. loganathan 1989) investigates the focuses on a "imperfect" method for tracing the secondary routes of three-dimensional frame structures. As specific examples, a two-hinged deep arch and a shallow geodesic dome were used for the research. Eigenvectors are computed at bifurcation points in order to coerce the structure onto the secondary route by causing a little disturbance in either the load or the geometry. This may be accomplished by introducing a slight perturbation.

(Ami.A and B.A 2014) carried comparing the seismic performance of RC frame constructions of G+15 story that comprise of rectangle shaped column to corresponding square shaped column. The total plan size of the structure is 31.5 meters by 13.5 meters, and it has panels that are 4.5 meters by 4.5 meters in both directions. It is assumed that each beam will measure 300 millimeters by 600 millimeters, and the height of each floor's columns will be three meters. The columns that are rectangular in form are all orientated in the same way in the model that was just shown, with the longer side parallel to the global Y direction and the shorter side parallel to the global X direction. In the design process, the M25 grade of concrete and the Fe 415 grade of steel are both taken into consideration. Analyses of pushover are carried out with the help of the commercially available programmer ETABS, and the behavior of RC frames is investigated. The fluctuation in material consumption necessary to maintain the building in the immediate occupancy stage is another component that is investigated by the models that are now in use. In addition to this, a contrast between a conventional RC frame and an instantaneous occupancy level RC frame is carried out for both kinds of shaped columns. For each of the models, the amount of concrete and steel required to construct it, in addition to the total cost of the structure, are computed. also includes a comparison of all of the models in terms of the amount of materials and the cost of the structure. It has been determined that the performance of columns with a square cross section is superior than that of columns with a rectangular cross section.

(Haolong at el 2017) deve;ops a novel transfer matrix approach called the thin-walled beam transfer matrix method (TBTMM) is developed for the static analysis of thin-walled space frame structures with arbitrary closed single-cell sections. Also enhances the benefits of the conventional transfer matrix method (TMM). Focusing on the Vlasov's beam theory and the Kollbrunner-Hajdin assumption, this method takes into account the bimoment B and the rate of twist of the beam, x(). Additionally, the bending and twisting can be calculated separately when combined with the characteristic of Maillart's shear Centre. First, the transfer matrix of a single beam is obtained through the Laplace transform and the inverse Laplace transform. Next, the coupling equations of the entire structure are obtained with respect to the coordinate transformation matrices and the joint coupling matrices. This method is described in more detail below. In order to demonstrate the validity of the developed method, a few numerical examples are presented and contrasted with the outcomes of the general TMM and the finite element method (both B-FEM and S-FEM).

The second-order plastic hinge analysis of three-dimensional frame constructions (J.Y at el 1999). The beam–column formulation takes into account the elastic coupling effects that occur between axial, flexural, and torsional displacements. This formulation is based on the use of stability interpolation functions for the transverse displacements. By modeling each physical part as a separate element, the computer software that was built may be put to use to provide precise predictions about the elastic flexural buckling load that columns and frames would experience. It is also possible to utilise it to forecast the elastic buckling stresses that are associated with axial-torsional and lateral-torsional instabilities, both of which are critical for predicting the nonlinear behavior of space frame structures. The influence of members bending and beginning out-of-straightness are also taken into consideration in order to portray the nonlinear spatial behavior of structures while using fewer components per member. The concentrated plastic hinge modeling technique is used to simulate the nonlinear behavior of materials. It is okay for there to be a plastic hinge between the two ends of the member. To show the robustness, accuracy, and effectiveness of the proposed analytical technique and computer programmer, numerical examples are given that include both geometric and material nonlinearities.

Beam components with unrepresentative stiff joints are used to create a three-story aluminum space frame building in the model. (J.E at el 2000) conducting five model-updating experiments, each of which uses a unique combination of updating parameters. It has been shown that each one of them produces superior forecasts, even when the frame arrangement is altered. It is believed that the parameter configuration that, on average, yields the greatest results will also give a physical enhancement to the modeling of the joints.

2.3 SUMMARY OF LITERATURE

Researchers found that spatial structures are superior to conventional ones for covering huge areas with no impediments in the middle. All of the weight is distributed in the same way, making the structure stronger and more rigid.

Space frame construction has a strong aesthetic appeal because it is lightweight and can be shaped into many forms.

The efficiency of the construction is improved through the employment of several approaches, such as composite space frame structures, over-strengthened top chord members, and the use of heavier sections.

When it comes to lowering compression loads on the top chord elements, composite space trusses outperform its non-composite counterparts. Top chord members' buckling failure can be averted by lowering compression forces. The composite space truss system improves the building's functionality.

Researchers discovered that in order to cover large areas without obstacles in the middle, spatial structures are preferable than conventional ones. The structure is strengthened and made more rigid since the weight is evenly distributed.

Because space frame construction is lightweight and can take many different forms, it has a high aesthetic appeal.

The use of numerous strategies, including composite space frame constructions, over-strengthened top chord elements, and the use of heavier sections, improves the efficiency of the construction.

Composite space trusses outperform their non-composite equivalents in reducing compression stresses on the upper chord members. By reducing compression forces, the buckling failure of top chord components can be avoided. The building's utility is increased by the composite space truss system.

3. METHODOLOGY

3.1 INTRODUCTION OF METHODOLOGY

The primary objective of this chapter is to explain the methods, employed to achieve the objectives, set out in this study. Initially, an introductory precise explanation and background of the techniques is presented. The steps followed for the achievement of objective on a techniques and methods has also been present in very figurative methods.

3.2 STRUCTURAL MODELING DESIGN AND ANALYSIS SOFTWARE

The design and analysis of space structure, because of its three dimensional and complex architectural structure is difficult. Because design procedure is recurrent in nature and based on trial and analysis, it demands extensive calculation repetition, which is extremely laborious. So, it takes a lot of time for conventional designer that solely follow hand written calculation skills to design and analyze. Modern technological advancement has gravely improved the efficiency in the design and analysis of the structure. As the capacity of the modern technology increase, to handle and process the data, so the efficiency and ease of analysis and design of difficult structures increase. Modern technology provides multiple digital products that are specially programmed, to handle the work of modeling design and analysis of the structures. These digital products day by day improve the interaction of designer and the program by introducing the unique and attractive features that increase the efficiency of the designer. The most popular digital products are ETABS, STADpro, and SAFE etc. In this study we will use the ETABS software to care out our objectives.

3.2.1 Etabs

Extended Three-Dimensional Analysis of Building System is the abbreviation that stands for ETABS. It is a piece of engineering software that specialises in the investigation and planning of multi-story buildings. All aspects of modelling, including modeling tools and templates, code-based load prescriptions, analysis methods and solution strategies, coordinate with the grid-like geometry that is characteristic of this class of construction. ETABS is capable of doing evaluations of fundamental as well as complex technologies, under either static or dynamic situations. It is possible to connect modal and directintegration time-history studies with P-Delta and Large Displacement effects linear static Earth quake analysis to produce a more complex evaluation of seismic performance. Material nonlinearity can be captured using nonlinear linkages and focused PMM or fibre hinges, depending on whether the behaviour is monotonic or hysteretic. Applications of any complexity can be implemented with ease because to features that are both intuitive and integrated. In addition to linear dynamic analysis (response spectrum), wind study of the structure was also performed. Because it is compatible with a number of different platforms for design and documentation, ETABS is a coordinated and productive tool that can be used for projects that range from straightforward 2D frames to complex contemporary high-rises.

3.2.2 Procedure

The design of any structure begins from reading of the architectural details and the building standards that the structure will follow. In this study we are working on a mechanical workshop, having dimension of 25x25m. The space frame was chosen as option to build a roof for the workshop. The roof is a space truss that is our prime requirement to work. The roof is supported by all side of masonry wall. The building standards that we will follow for execution of design work of the space frame are following:

a. Steel section – AISC-14

b. Steel Design Code – AS 360-16

c. Dead and Live Load - ASCE 7-02

The dead load = 1.25KN and live load = 1.5 KN

After the determination of the design requirement and standards we head to our ETABS software the modeling the structure. The modeling of the structure follows design and analysis of the structure.

The design and analysis work is simultaneous work that support one and other. In design we provide sections that have capacity to hold the internal effects due to external loads. The analysis is procedure to determine the internal and external load effect, so the design carries out accordingly.

3.2.3 Modeling

The implication of the software starts from the modeling of the structure. Modeling of the structure is actually process of making a digital copy of the structure to be built. It requires the dimension of structure, its individual component. The common parameter in the modeling is the width, length and height of the structure. We also provide inside partitions, the number of stories commonly when building multi story building, and in steel space structure the end and final points of the members. In ETABS the modeling procedure is done by using the built-in features of defining gird spacing, story height and number, assigning member such as beam, column, and shear wall. Using these features we prepare the model of structure. The modeling in ETABS differs from the modeling in especially 3D modeling software, because we model the entire structural element in the ETABS and avoid the decorative or non-structural features. It is for a reason to focus on the structural behaviors of the structural member that support and transmit the load.

3.2.4 Design and Analysis

The design procedure starts from the selection of the preliminary sections. The preliminary sections are chosen based on the thumb rule provide by the building standards and experience. The preliminary section properties are assigned to the respective members. The final design comes after multiple trial assessment. Trials are based on the assignment of different section properties to respective member in order to improve economy without any violating any of the building standard such as serviceability, deflection etc.

In ETABS design procedure starts after the analysis of the space frame. The analysis is process of application of formulas and methodologies that result the effect of external loading in term of Bending moment, axial forces, torsion and shear. These parameters are calculated by the software during the analysis of the structure. Then design procedure is start by software after analysis the external load effects and the software calculate the internal capacity of each member and the results are compared to determine the adequacy of each member. The section that fits all the criteria such as economy, serviceability, ease in construction and local availability etc is selected.

3.3 GUIDE TO MODELING, DESIGN AND ANALYSIS

Step 1: Open ETABS from any of the source such as desktop, window Search Bar and program installation location.

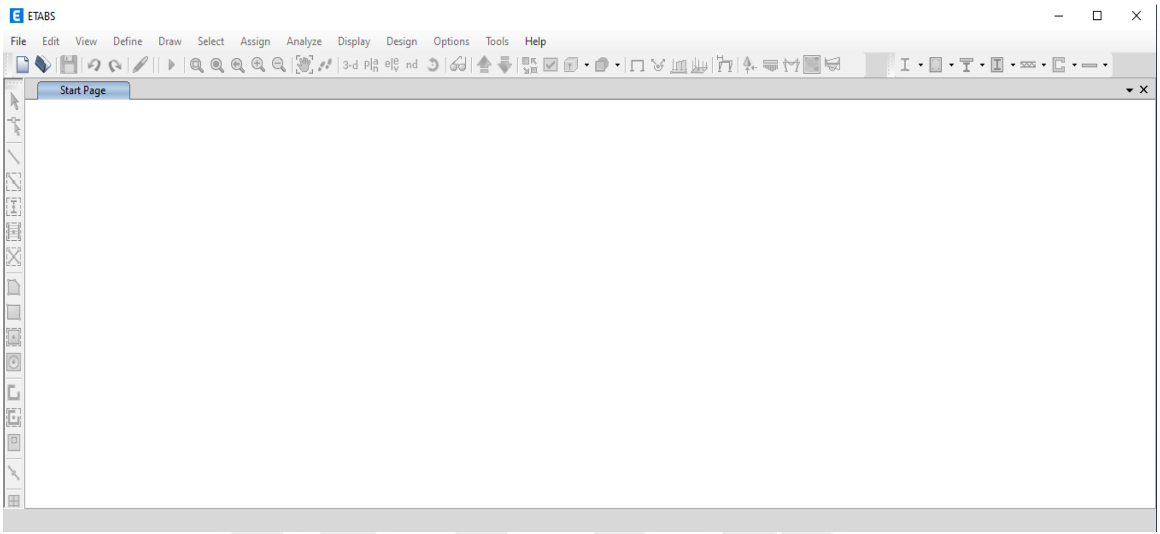


Figure 3.1: Guide to Modeling, Design and Analysis – Step: 1 (ETABS).

Step 2: Click New file or press Crtl+N for open new file to work on new project. Choose the building standards by check on the ‘Built-in setting with’ then first select the unis Metric SI, second select steel section ASIC-14, third select the design code ASIC360-16, the concrete design code is not in need but for built in option select latest ACI 318-14

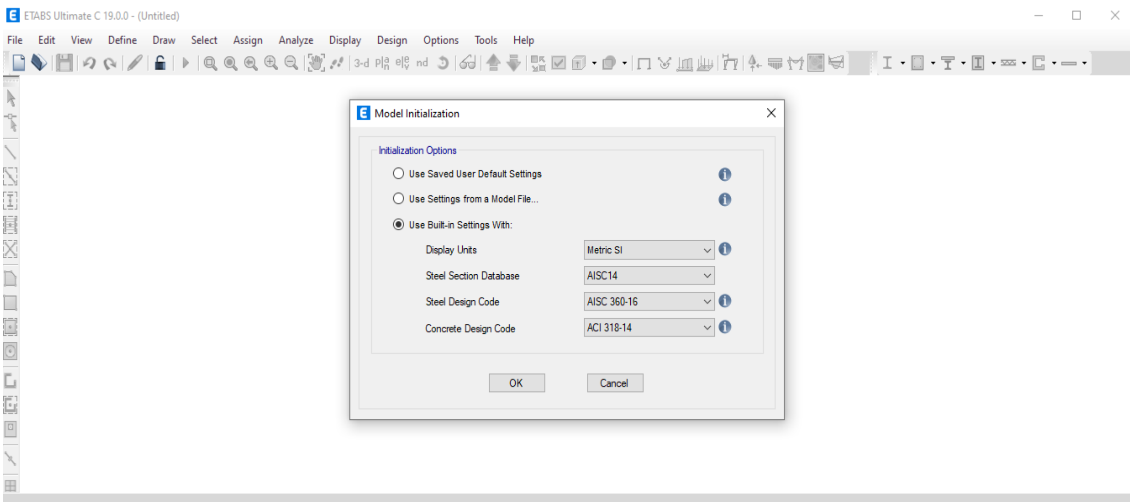


Figure 3.2: Guide to Modeling, Design and Analysis – Step: 2 (ETABS).

Step 3: (a) Draw the grid and spacing, check on the custom grid spacing click on edit grid data.

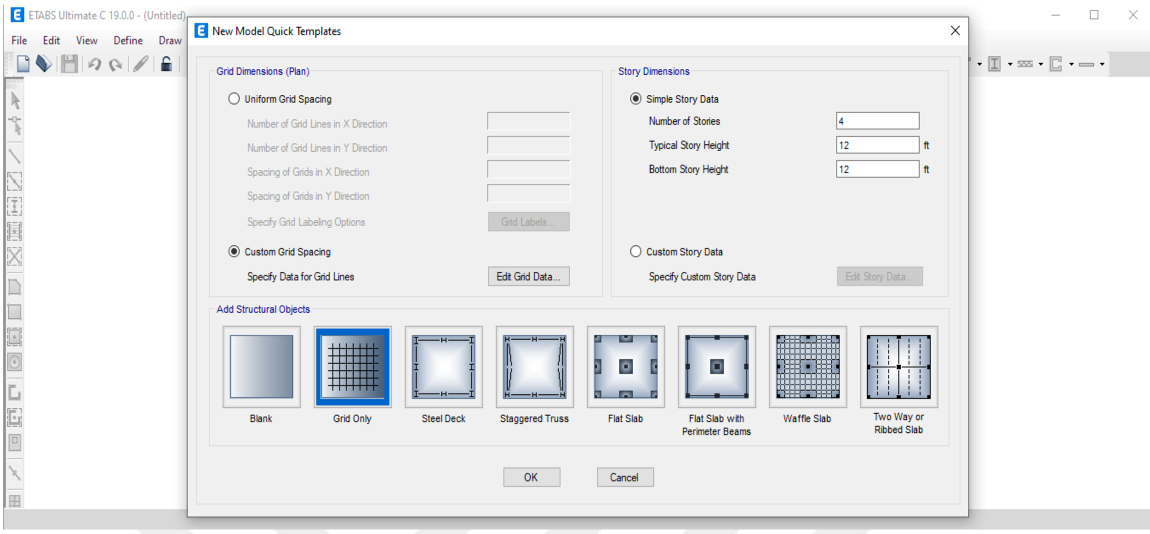


Figure 3.3: Step 3 (a) Guide to Modeling, Design and Analysis – Step: 3 (b) (ETABS).

Step: 3 (b) check on display grid at spacing, now define the X grid data and Y grid data that represent the one unit of 1x1m in detail for double layer space frame and the overall dimension space frame. Also set the bubble size at 1250mm

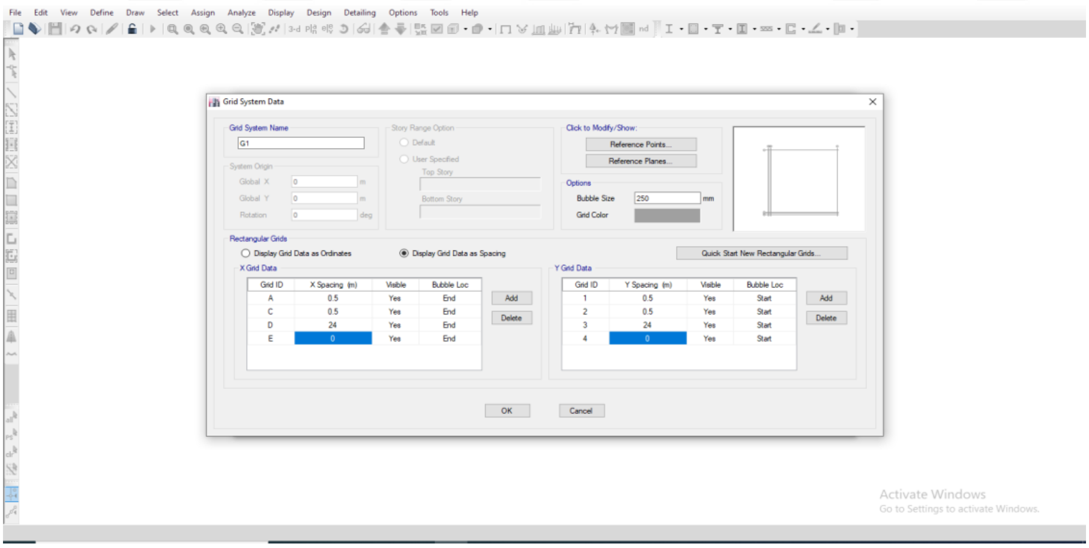


Figure 3.4: Guide to Modeling, Design and Analysis – Step: 3 (b) (ETABS).

Step: 3 (c) Define the story data the one story is required for 25x25m of double layer space frame also specify the number of story which is 1, typical story height 1m also bottom story height as 1m.

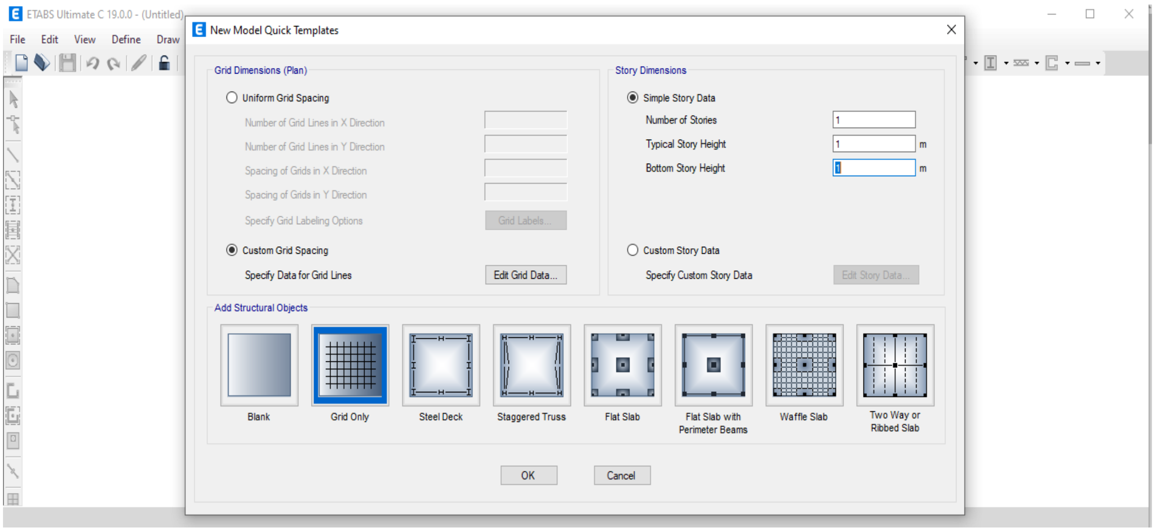


Figure 3.5: Guide to Modeling, Design and Analysis – Step: 3 (c) (ETABS).

Step: 3) d) Check on custom story data then click on Edit story data.

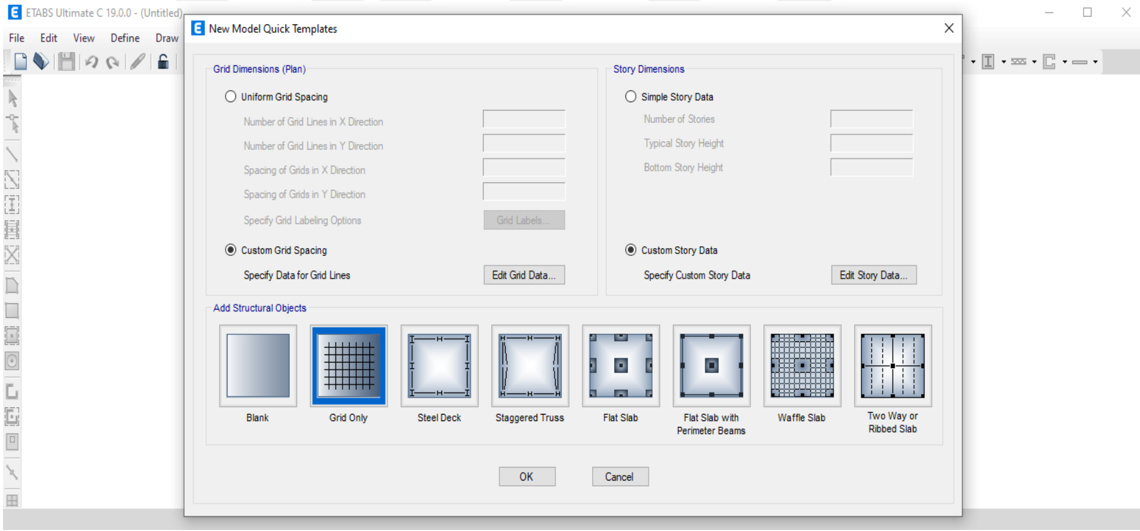


Figure 3.6: Guide to Modeling, Design and Analysis – Step: 3 (d) (ETABS).

Step : 3 (e) edit the name of story level from story 1 to top of space frame shows height of 1m and base at 0m then click on ok.

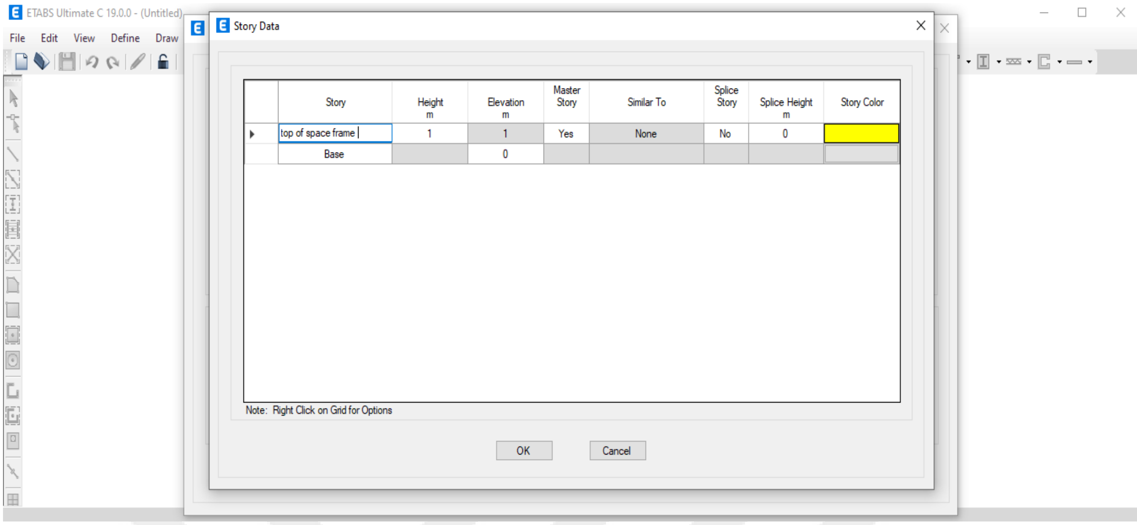


Figure 3.7: Guide to Modeling, Design and Analysis – Step: 3 (e) (ETABS).

Step: 4 (a) Two window, one shown 2D plane view and second showing 3D view appears on the screen. The first step after the program open is the defining of material property.

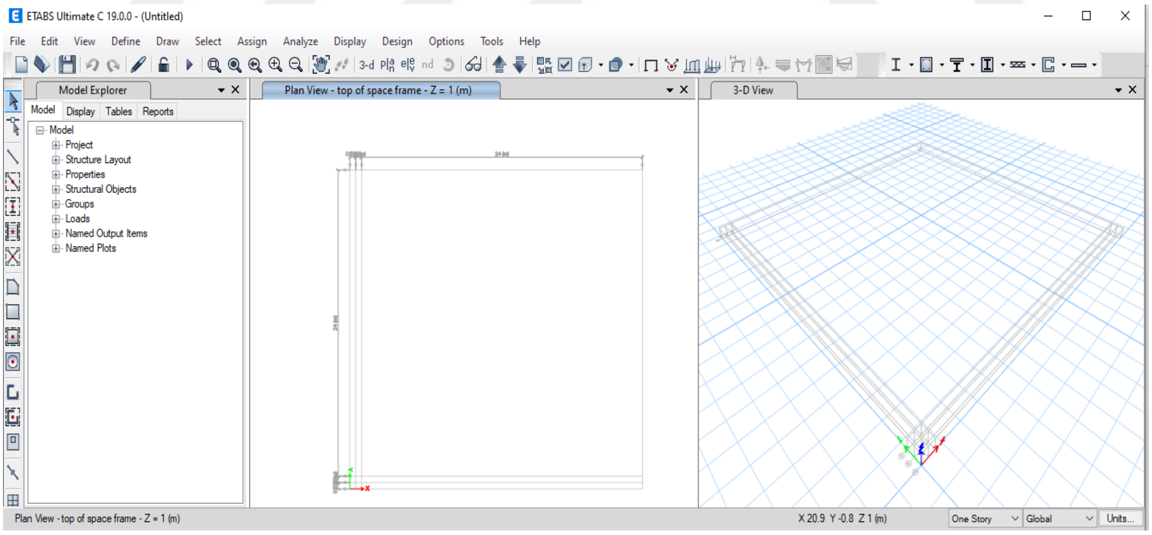


Figure 3.8: Guide to Modeling, Design and Analysis – Step: 4 (a) (ETABS).

Step: 4 (b) the material property were as per American standard so click on add new material

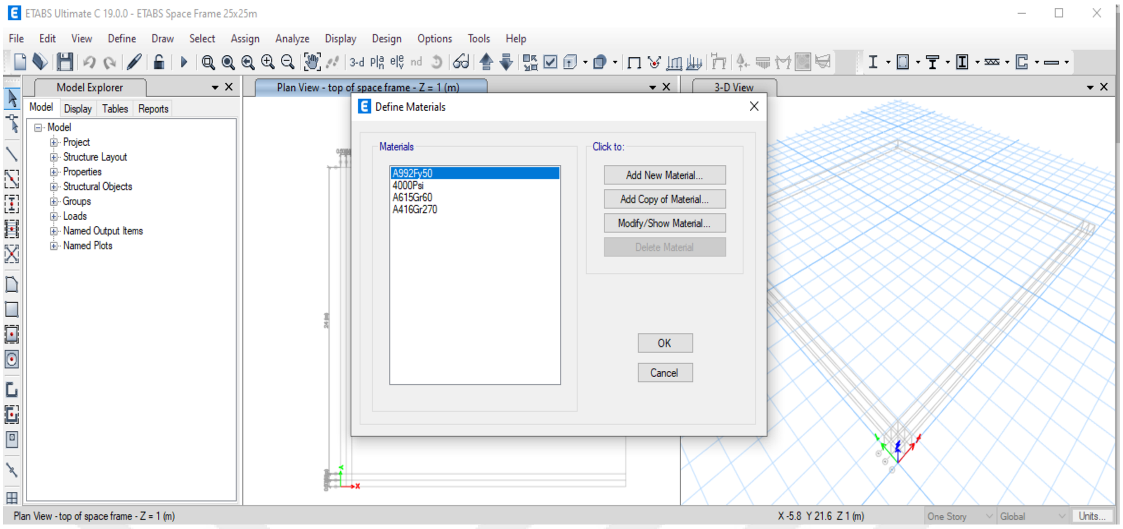


Figure 3.9: Guide to Modeling, Design and Analysis – Step: 4 (b) (ETABS).

Step: 4 (c) Add new material property option were appearing the select the region as united states, material type Steel, Standard ASTM A36 and grade of steel is A36.

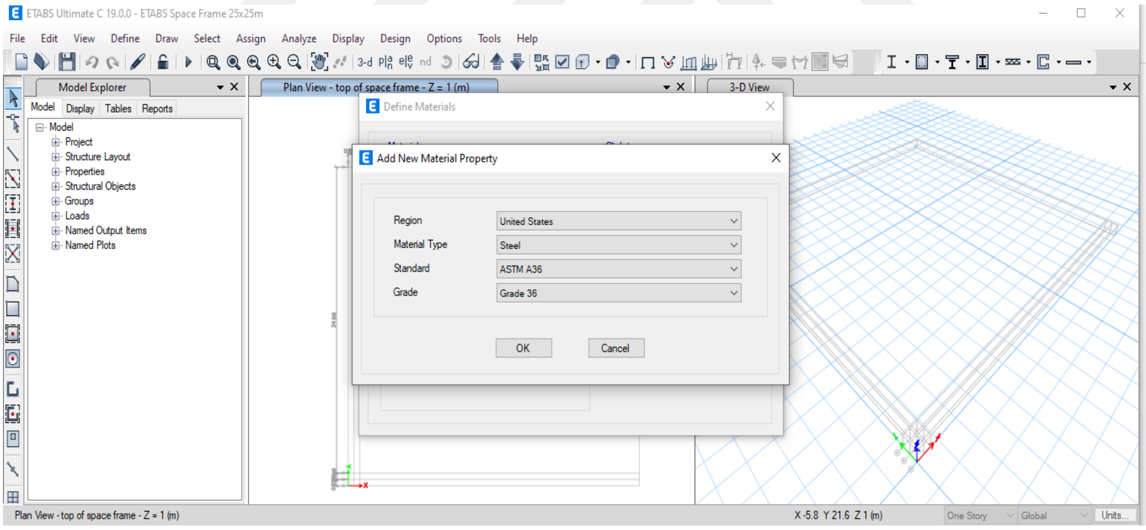


Figure 3.10: Guide to Modeling, Design and Analysis – Step: 4 (c) (ETABS).

Step: 4 (d) Material property Data were appear give material name Steel A36 the click on ok

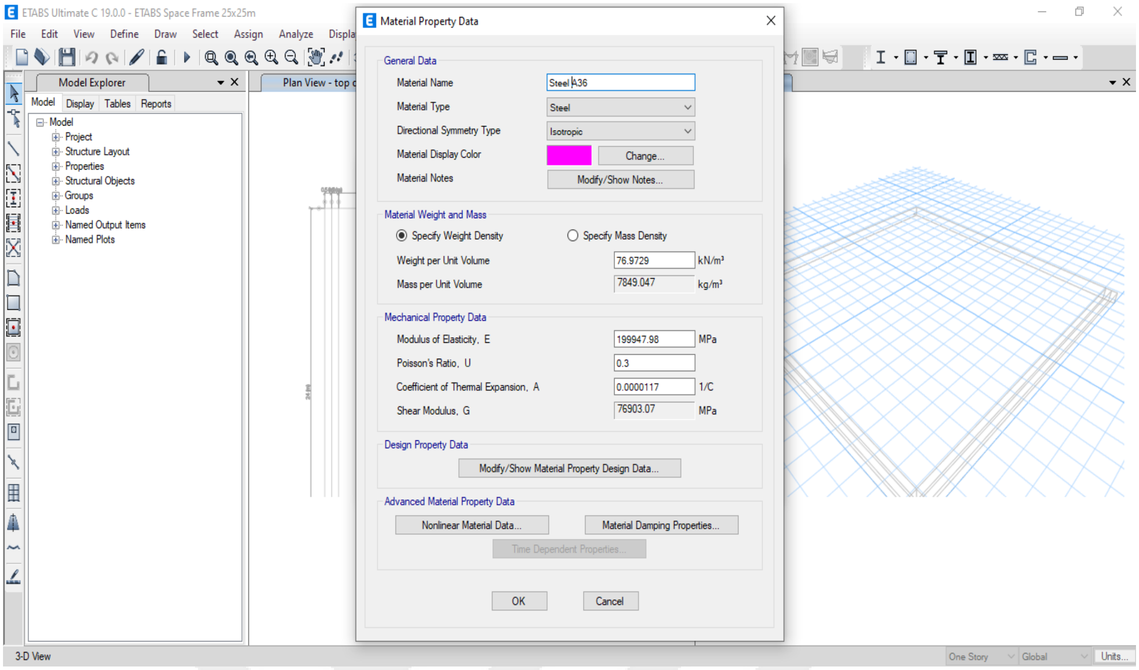


Figure 3.11: Guide to Modeling, Design and Analysis – Step: 4 (d) (ETABS).

Step: 5 (a) Define the section property for space frame section define tab then select section property then click on frame sections.

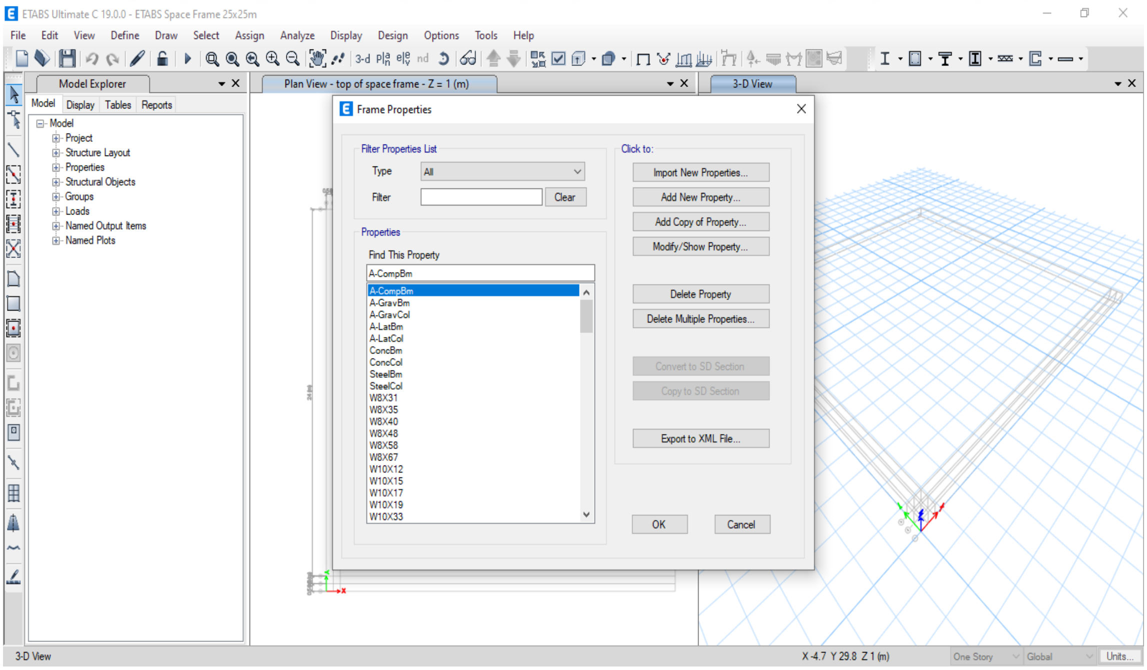


Figure 3.12: Guide to Modeling, Design and Analysis – Step: 5 (a) (ETABS).

Step: 5 (b) then click on import new property

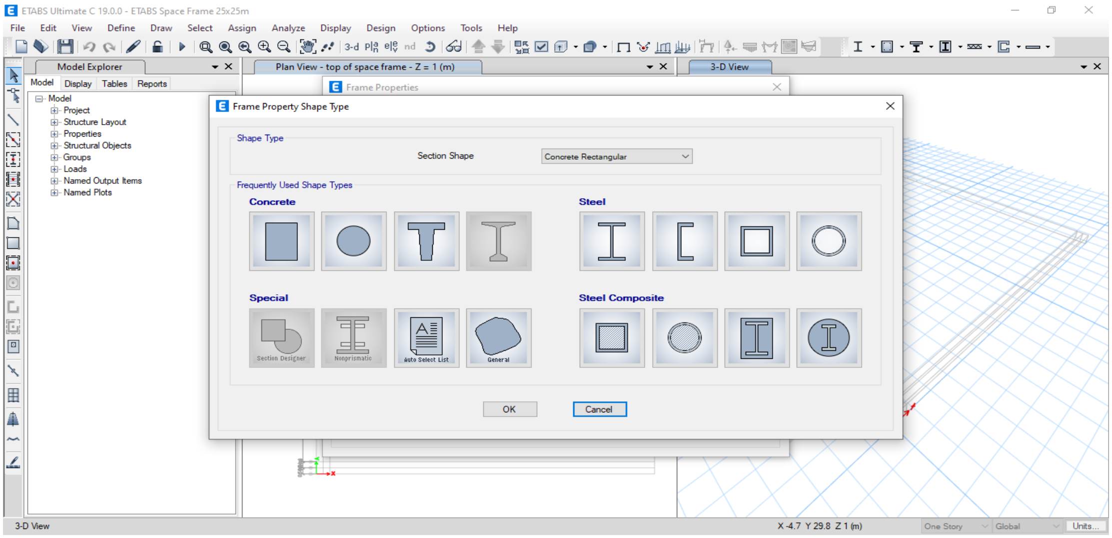


Figure 3.13: Guide to Modeling, Design and Analysis – Step: 5 (a) (ETABS).

Step: 5 (c) Select Pipe section then Default material for selection option select Steel A36.

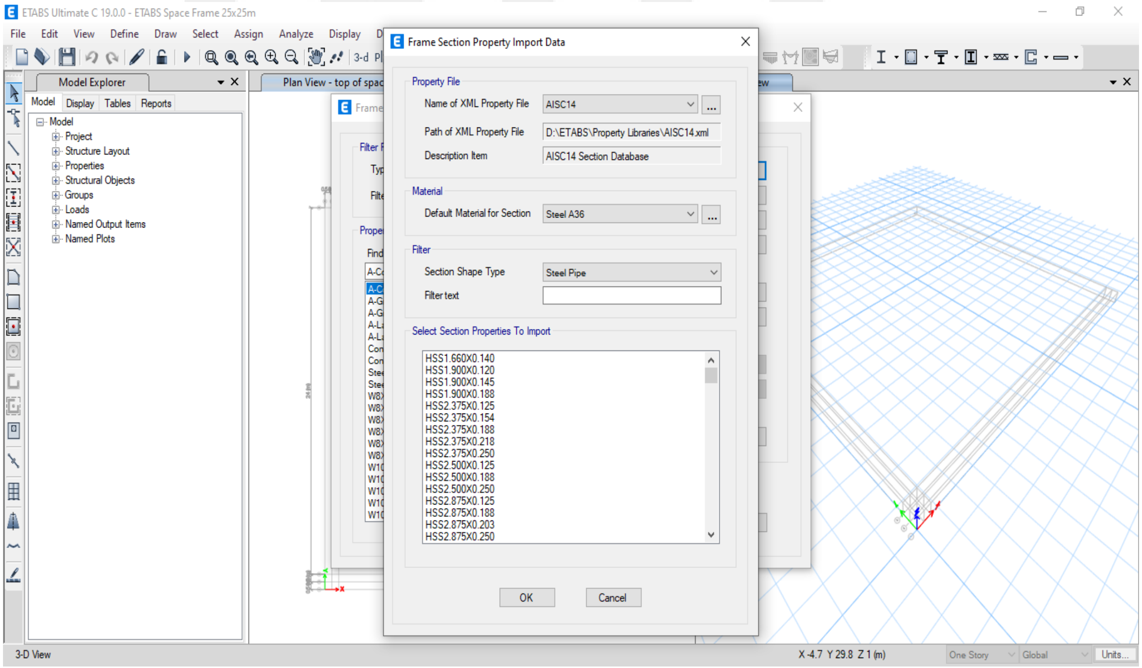


Figure 3.14: Guide to Modeling, Design and Analysis – Step: 5 (c) (ETABS).

Step: 5 (d) select the HSS 2.5 x 0.188 and HSS 3 x 0.250 section property to import list

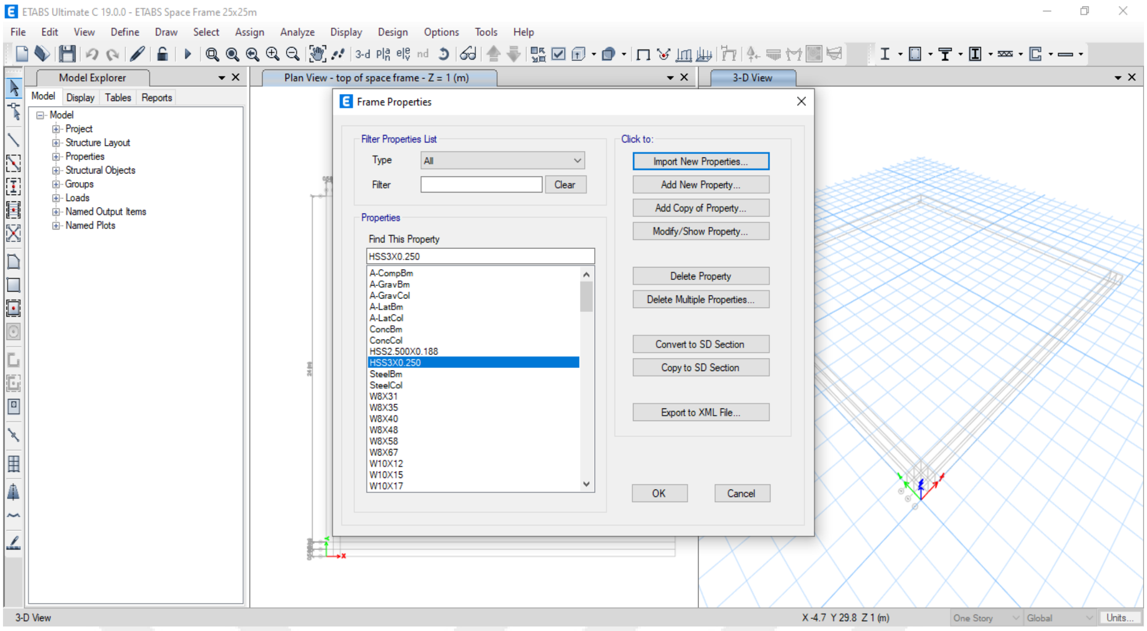


Figure 3.15: Guide to Modeling, Design and Analysis – Step: 5 (d) (ETABS).

Step: 6 (a) Draw the structure of space first click on plan view and go at first gird then click on plan view go at base of structure the select draw beam bar, select property none.

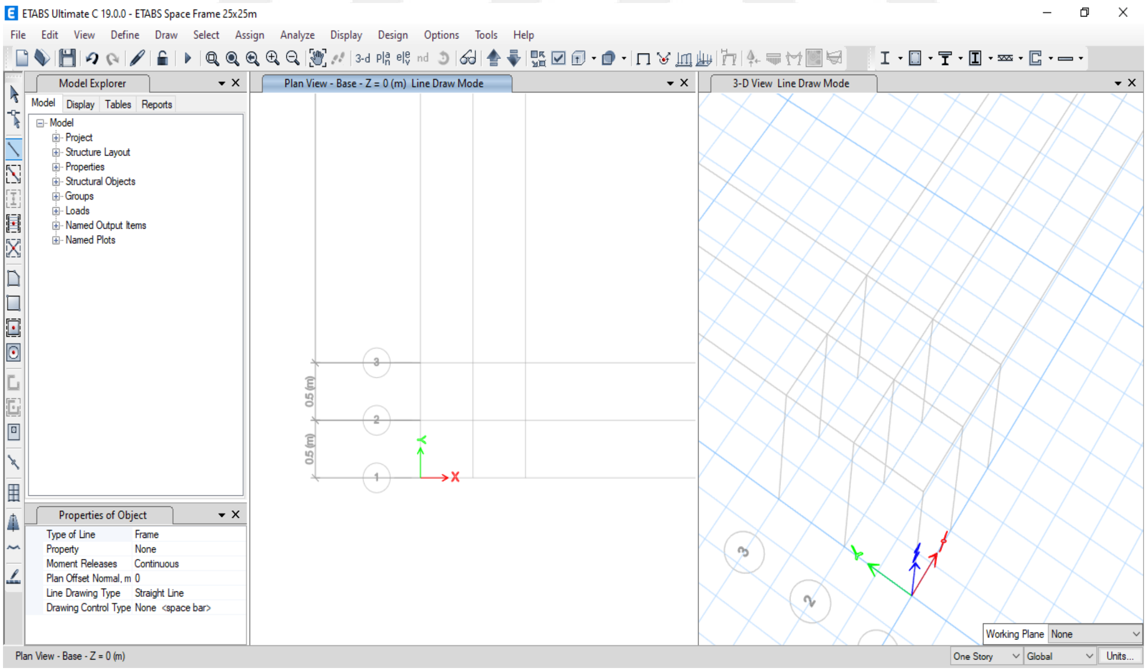


Figure 3.16: Guide to Modeling, Design and Analysis – Step: 6 (a) (ETABS).

Step: 6 (b) Draw the base of one space frame, by using arrow and right click drag form one to other point

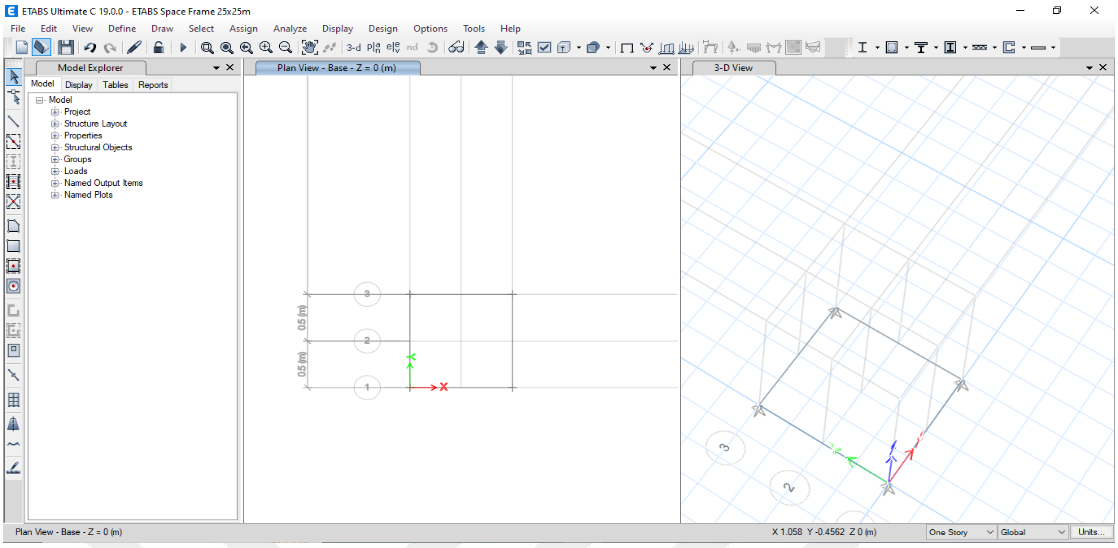


Figure 3.17: Guide to Modeling, Design and Analysis – Step: 6 (b) (ETABS).

Step: 6 (c) Drawing one unit of pyramid like structure, using draw beam tab select joint point and draw up to mid of upper level from every point .

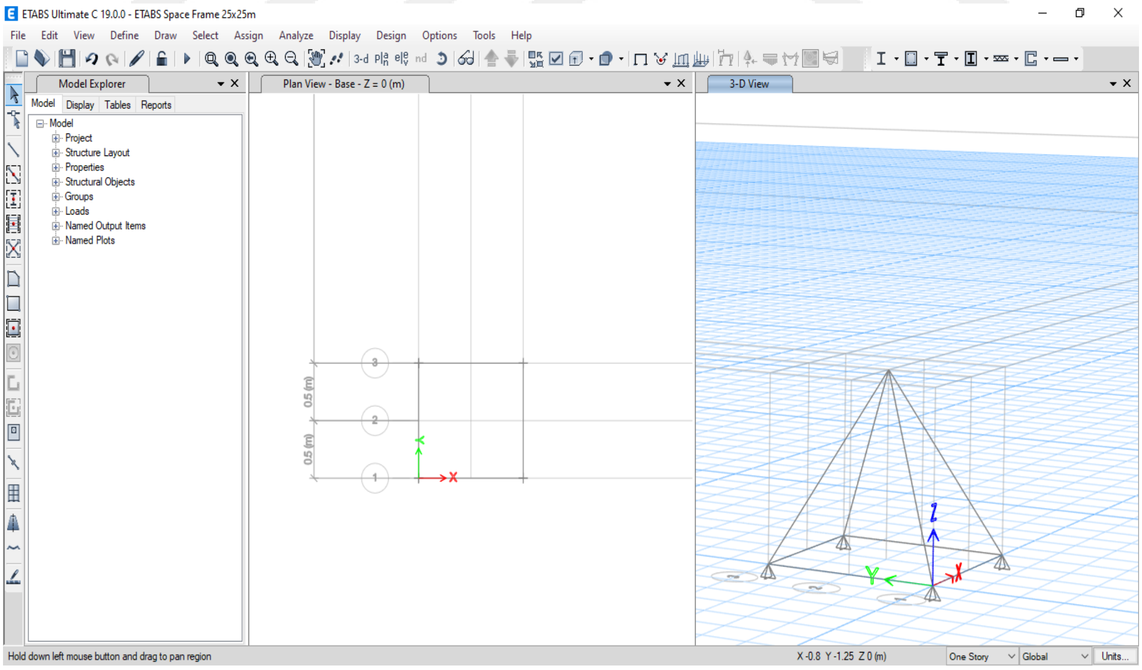


Figure 3.18: Guide to Modeling, Design and Analysis – Step: 6 (C) (ETABS).

Step: 6 (d) for pyramid like structure required more so go at edit click replicate

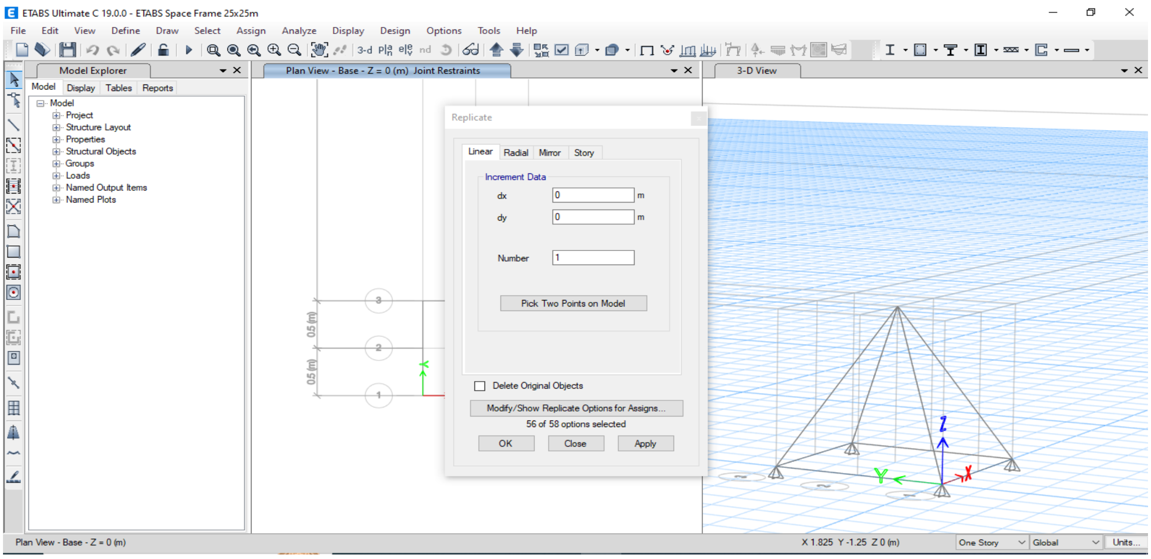


Figure 3.19: Guide to Modeling, Design and Analysis – Step: 6 (d) (ETABS).

Step: 6 (e) now go in x-direction draw in increment of pyramid using replicate.

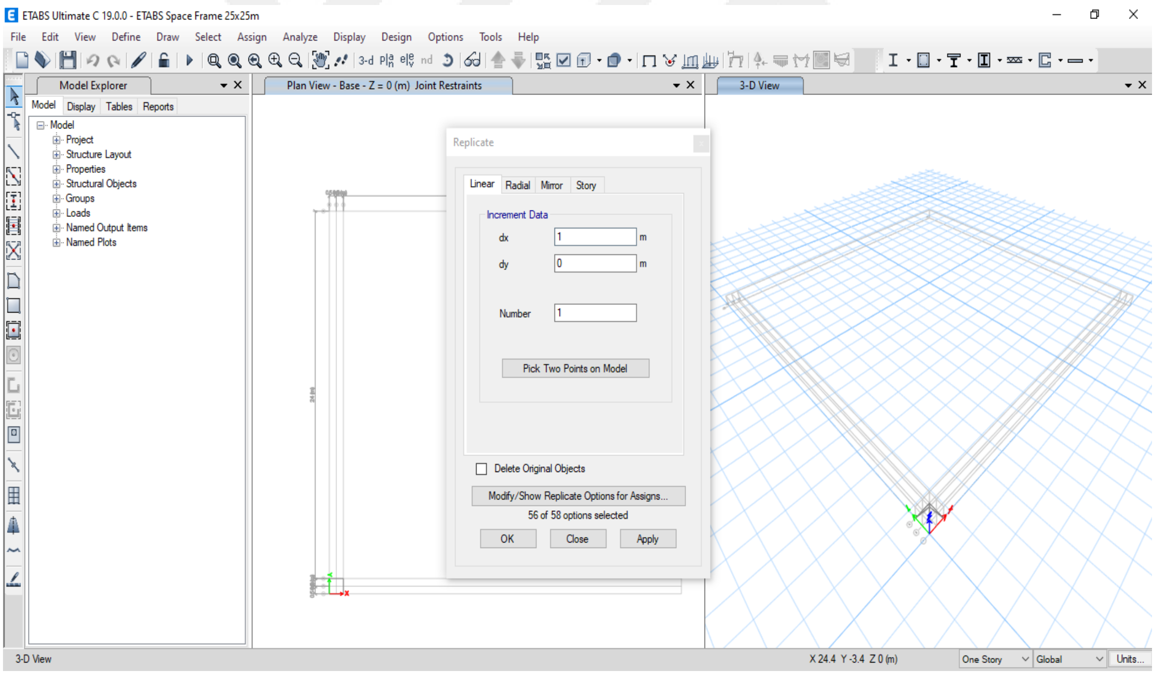


Figure 3.20: Guide to Modeling, Design and Analysis – Step: 6 (e) (ETABS).

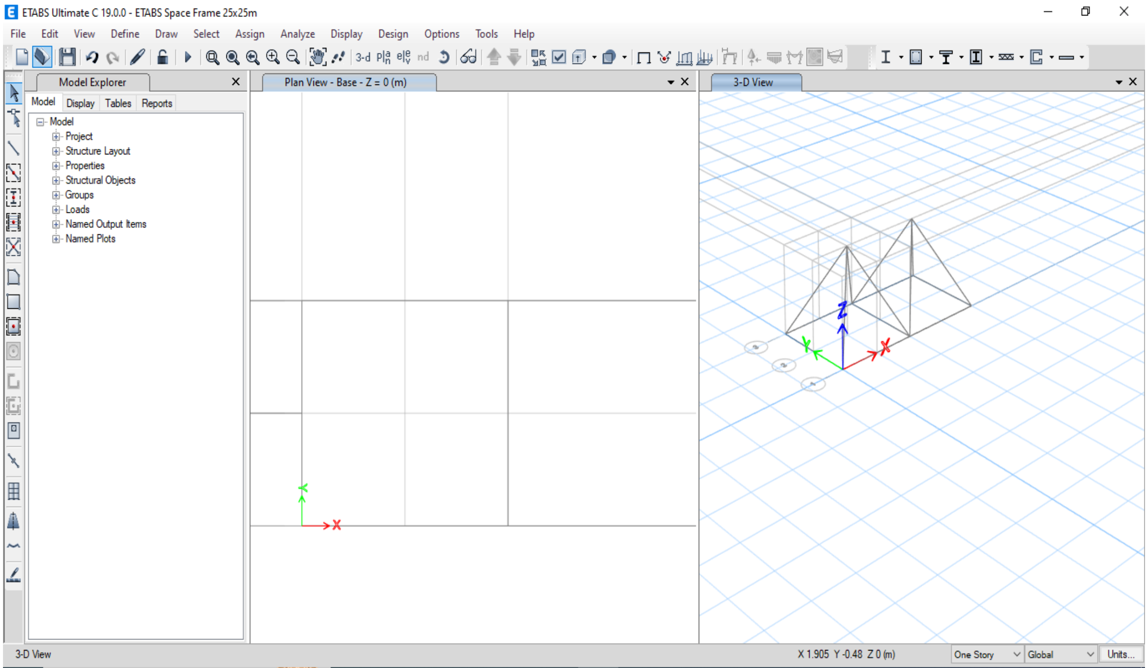


Figure 3.21: Guide to Modeling, Design and Analysis – Step: 6 (e) (ETABS).

Step: 6 (f) Replicate also in Y-direction.

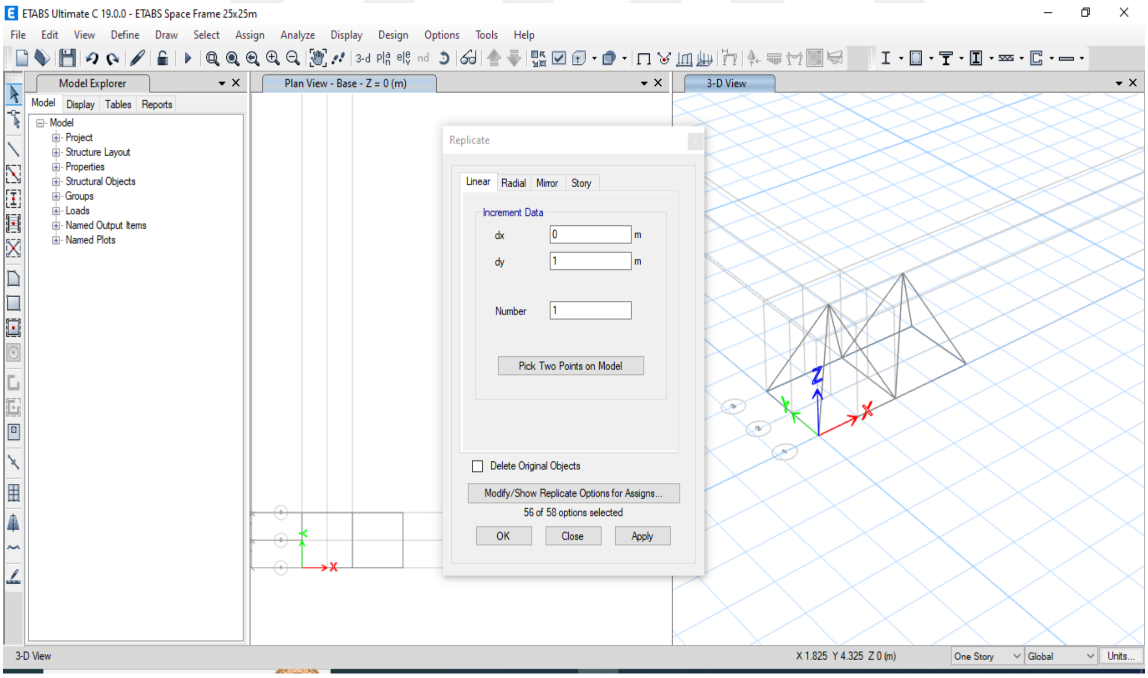


Figure 3.22: Guide to Modeling, Design and Analysis – Step: 6 (f) (ETABS).

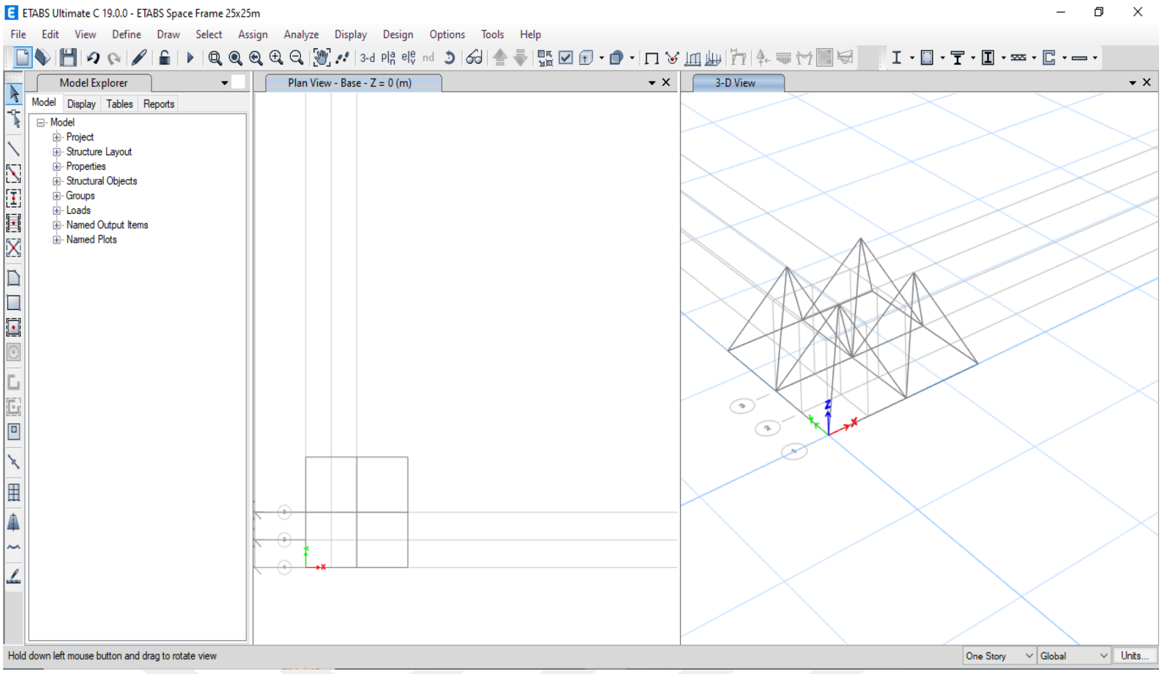


Figure 3.23: Guide to Modeling, Design and Analysis – Step: 6 (f) (ETABS).

Step: 6 (g) now tie the chord of each pyramid like structure.

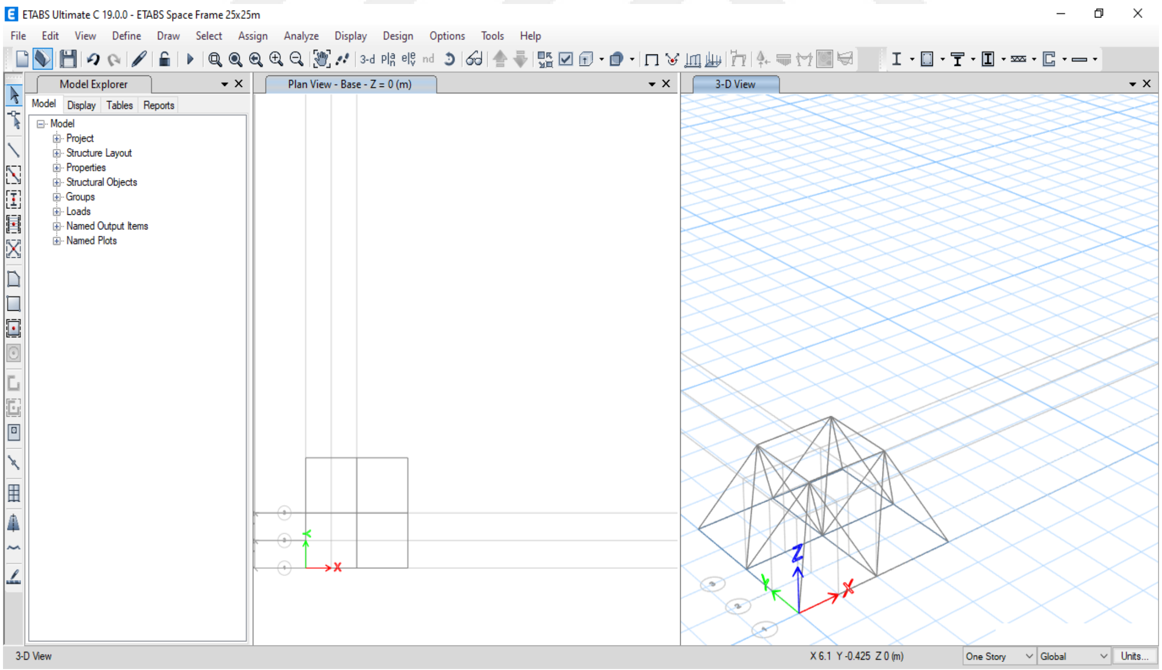


Figure 3.24: Guide to Modeling, Design and Analysis – Step: 6 (g) (ETABS).

Step: 6 (h) The similar space frame should replicate up to next 23 meters in x direction so go at replicate option again select dx is 1 and number up to 23**.**

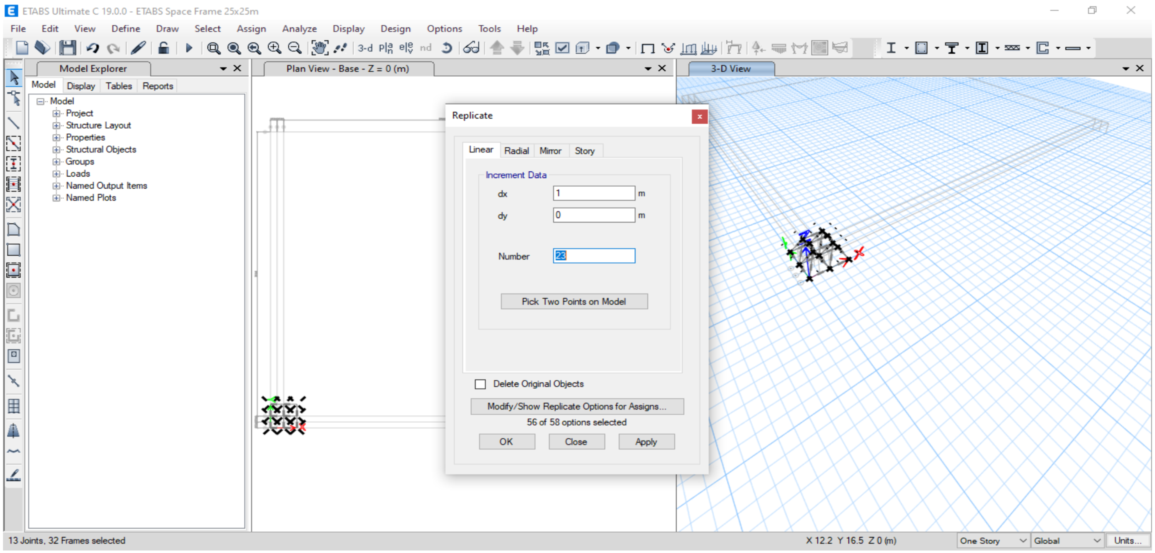


Figure 3.25: Guide to Modeling, Design and Analysis – Step: 6 (h) (ETABS).

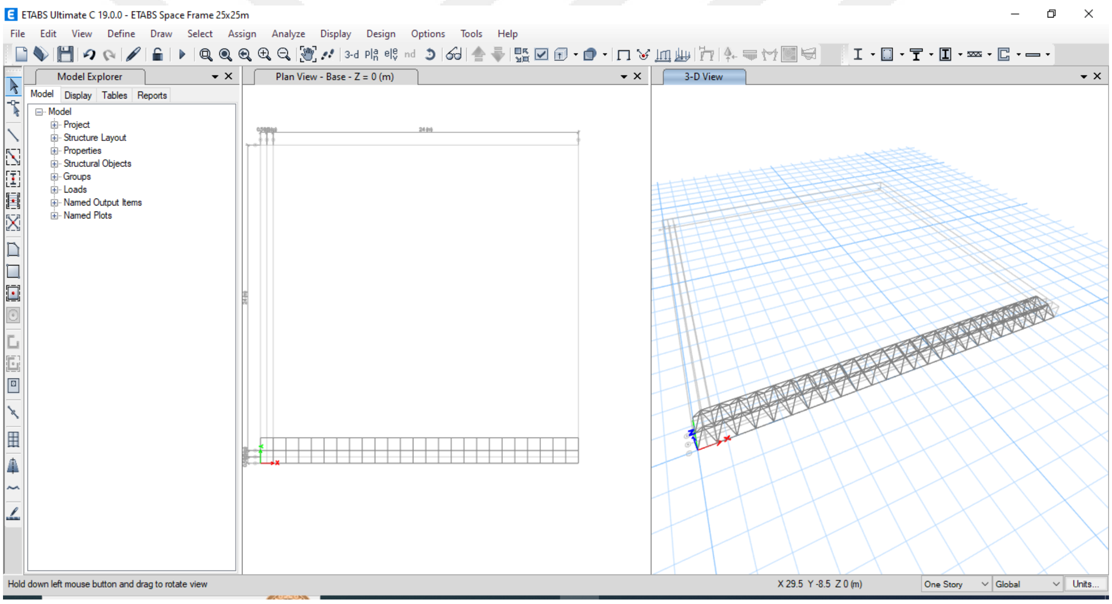


Figure 3.26: Guide to Modeling, Design and Analysis – Step: 6 (h) (ETABS).

Step: 6 (i) now repilcate at y-direction for whole structure model, select whole model then go at replicate optin dy = 1 and number = 23.

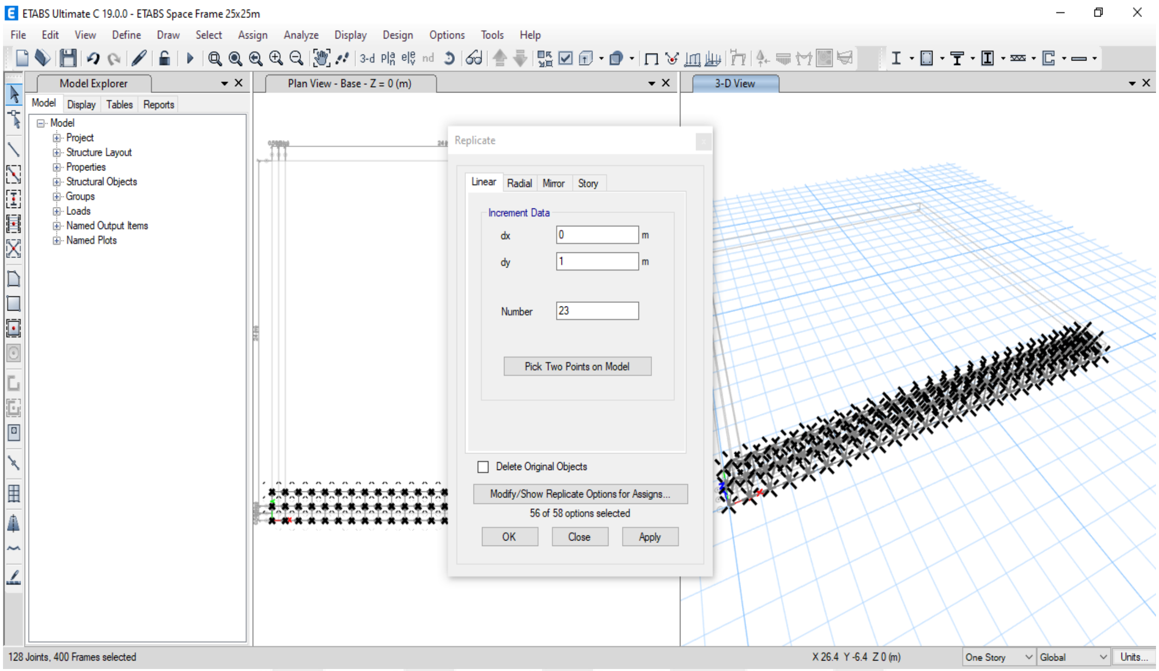


Figure 3.27: Guide to Modeling, Design and Analysis – Step: 6 (i) (ETABS).

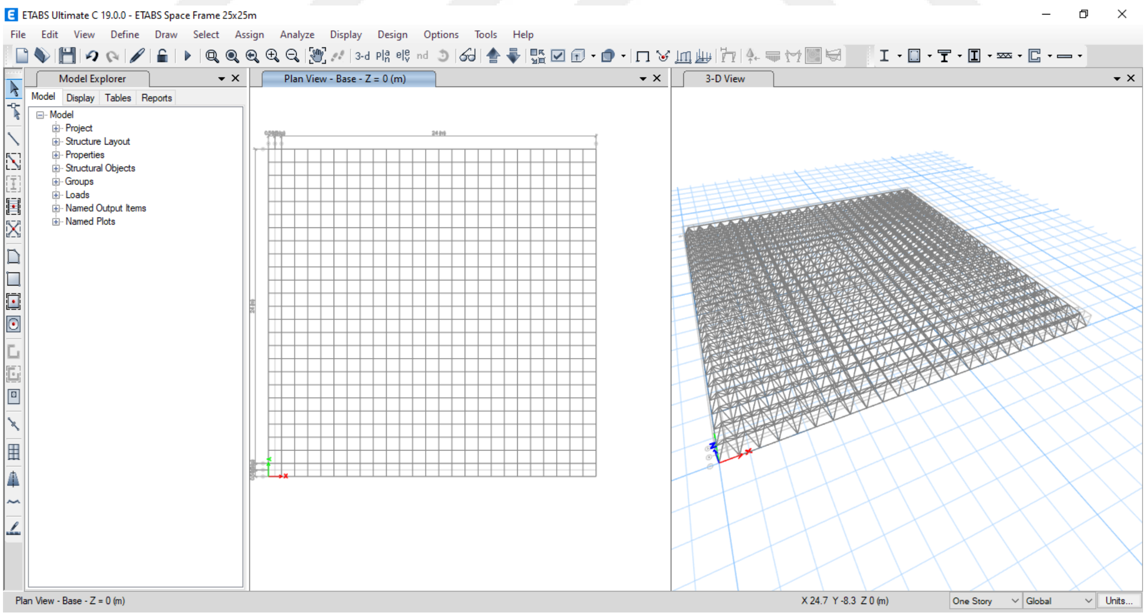


Figure 3.28: Guide to Modeling, Design and Analysis – Step: 6 (i) (ETABS).

Step: 7 (a) now assign the section property to the space frame model which was developed in early.

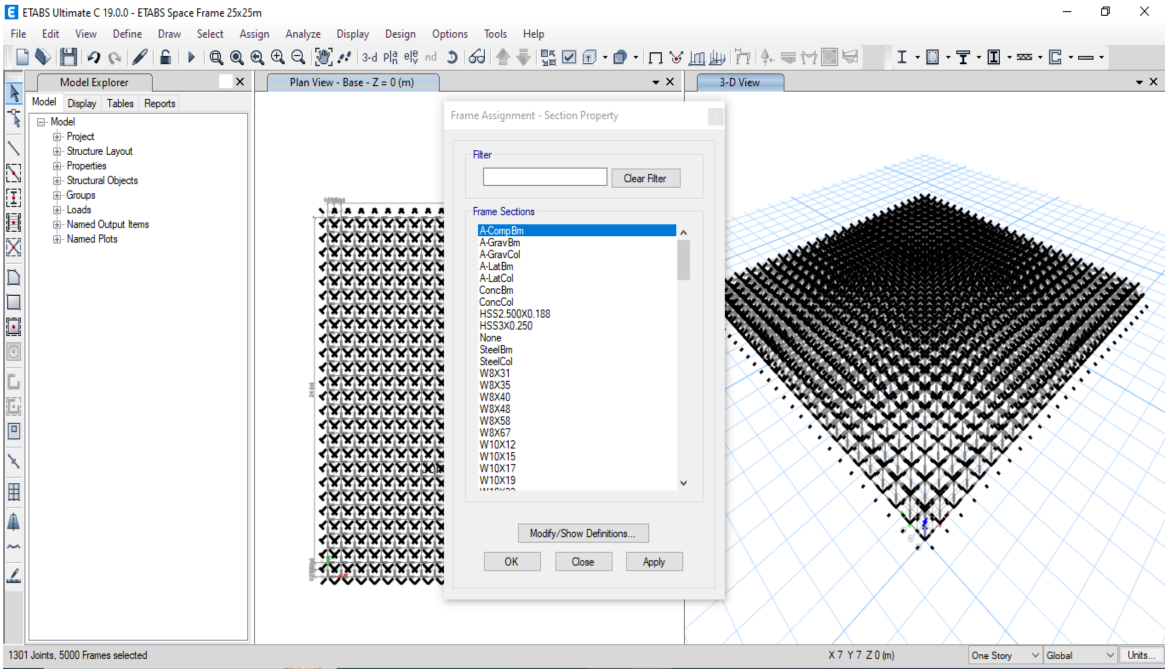


Figure 3.29: Guide to Modeling, Design and Analysis – Step: 7 (a) (ETABS).

Step 7: (b) select HSS 2.5 x 0.188 then click ok.

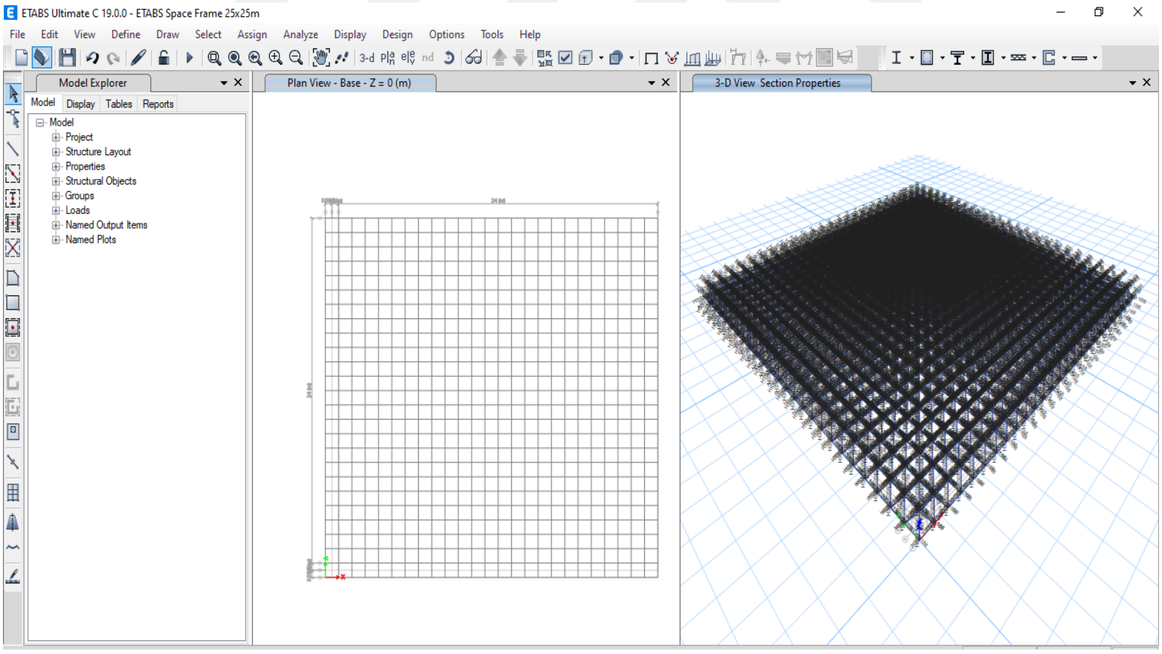


Figure 3.30: Guide to Modeling, Design and Analysis – Step: 7 (b) (ETABS).

Step: 7 (c) now select top and bottom of space frame structure the selected number of member shown 2500 which means only top and bottom frame member.

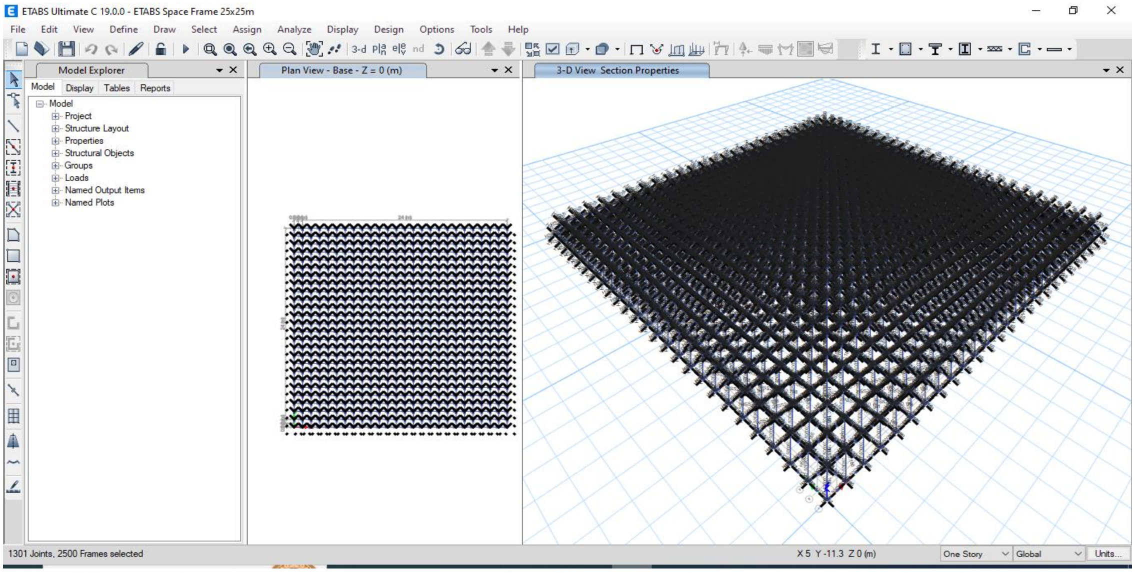


Figure 3.31: Guide to Modeling, Design and Analysis – Step: 7 (c) (ETABS).

Step: 7 (d) now go at assign tab selection frame the click on section property select HSS 3.0 x 0.250 for upper and bottom frame member then click ok.

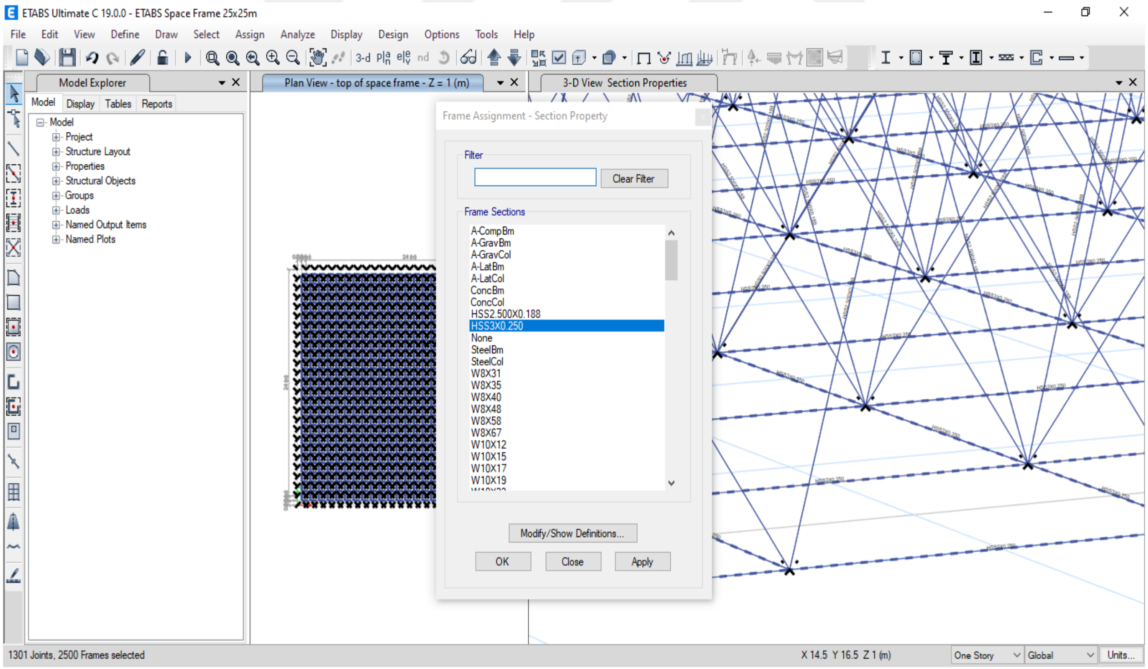


Figure 3.32: Guide to Modeling, Design and Analysis – Step: 7 (d) (ETABS).

Step: 8 (a) Assign support to model, all four sides hinge support were provided, select base of the space frame.

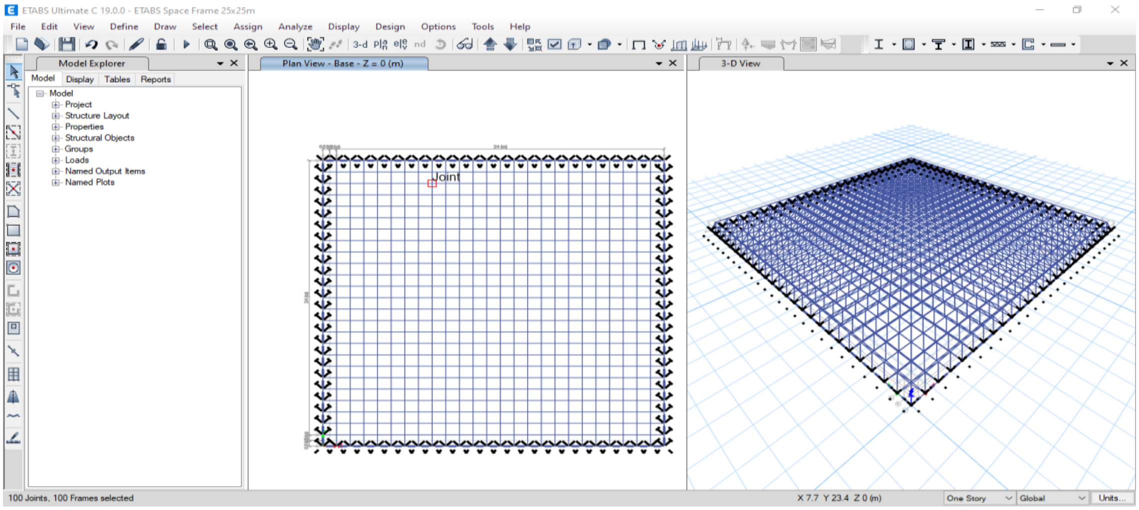


Figure 3.33: Guide to Modeling, Design and Analysis – Step: 8 (a) (ETABS).

Step: 8 (b) go at assign select joint and click on restraint the select hinge support.

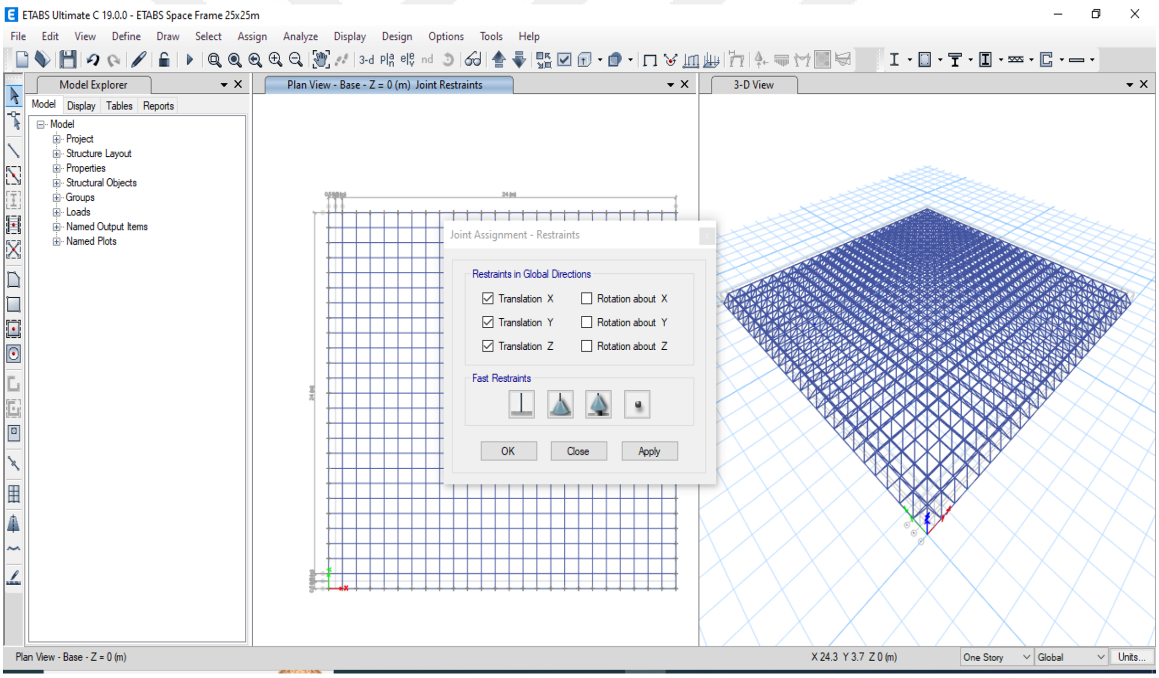


Figure 3.34: Guide to Modeling, Design and Analysis – Step: 8 (b) (ETABS).

Step: 9 (a) Check model for any modeling error go at analyze option check on joints, frames and fix.

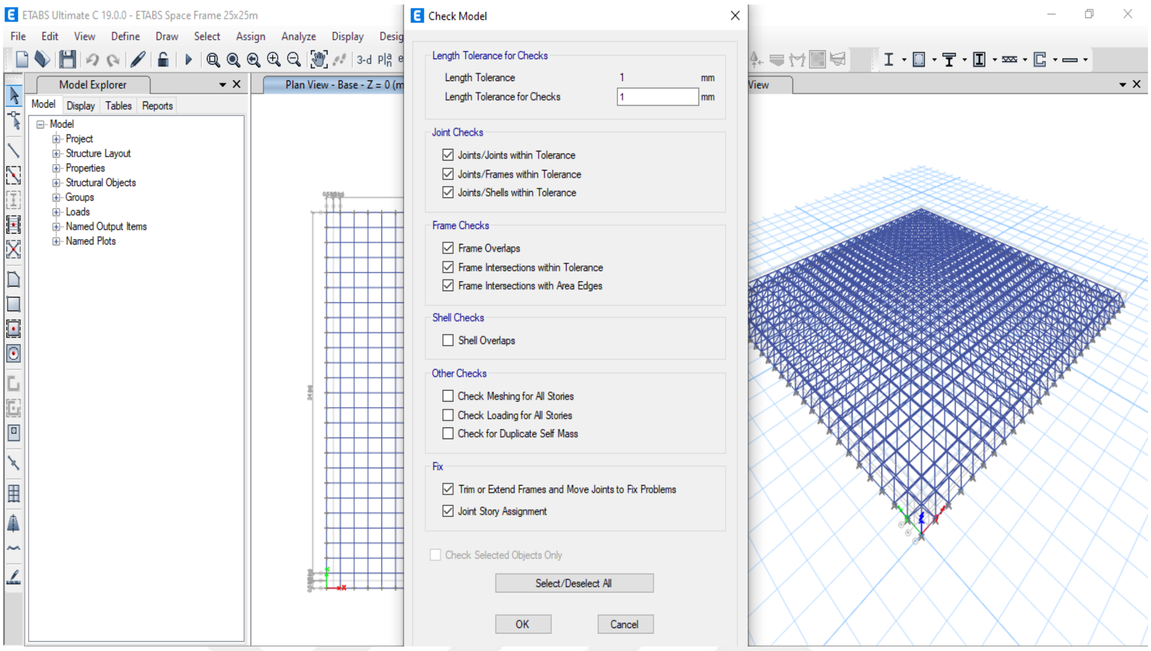


Figure 3.35: Guide to Modeling, Design and Analysis – Step: 9 (a) (ETABS).

Step: 9 (b) click ok.

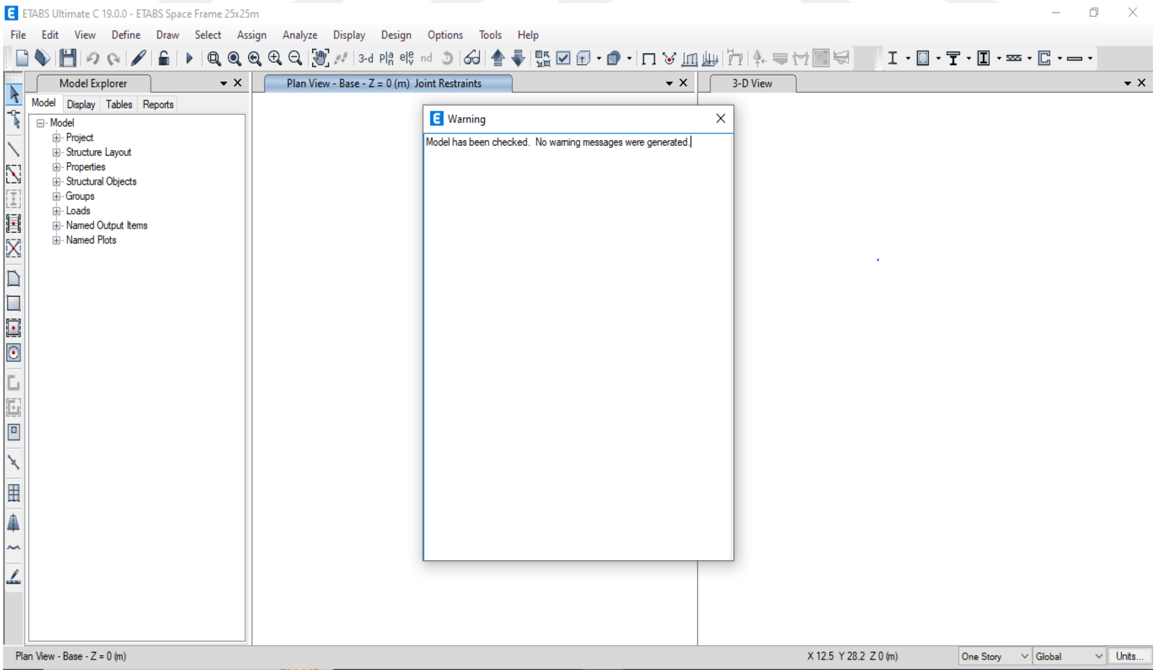


Figure 3.36: Guide to Modeling, Design and Analysis – Step: 9 (b) (ETABS).

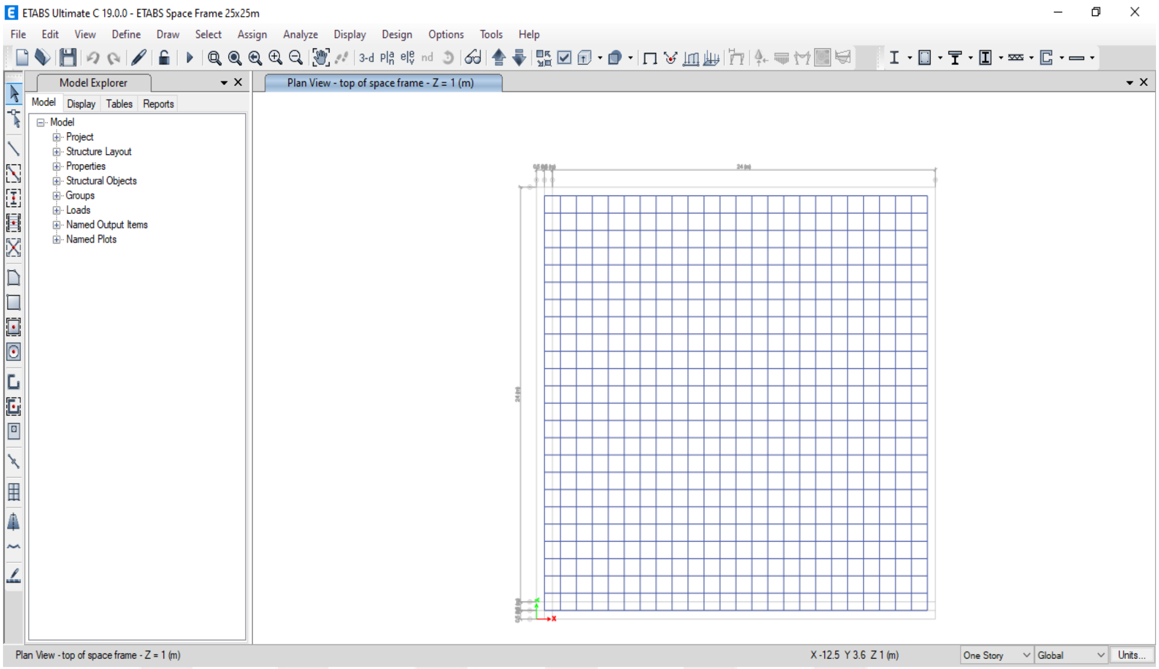


Figure 3.37: 2D Plan of 25 x 25m Space Frame Structure, in ETABS.

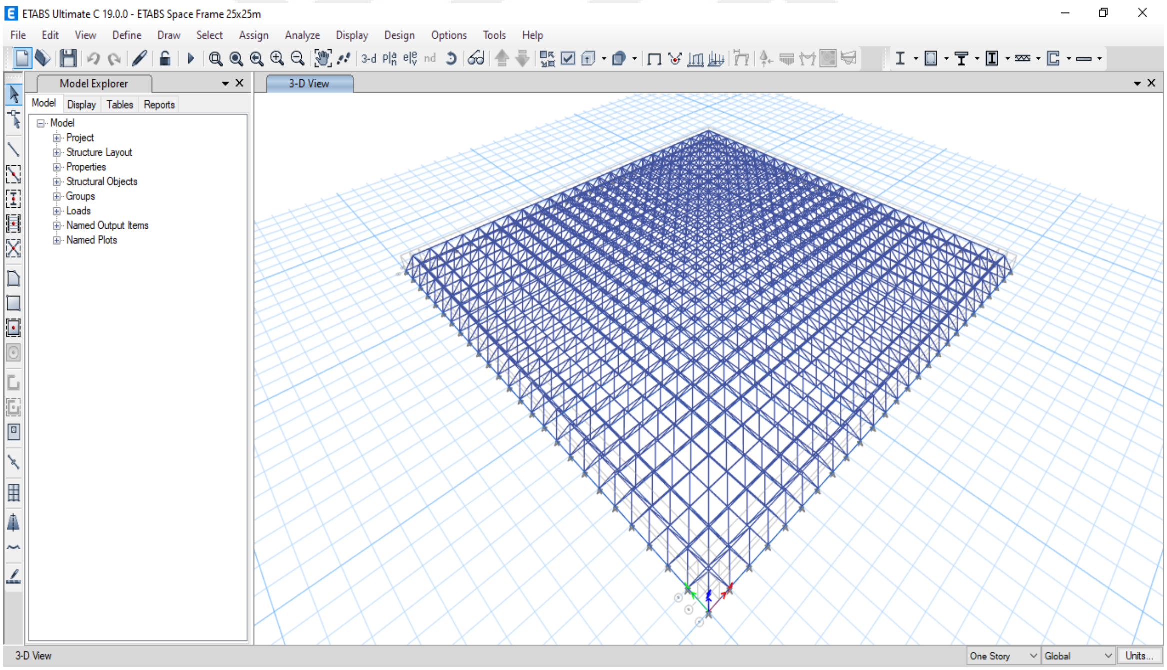


Figure 3.38: 3D Model of 25 x 25m Space Frame Structure in ETABS.

4. ANALYSIS AND RESULTS

4.1 INTRODUCTION

The ETABS software was used to define the load combinations and load cases for the proposed space frame structure. The software also assigned the loads to the structure. This chapter is part of the overall project. The analysis was carried out, and the results that it produced were obtained.

4.2 DEFINING OF LOAD PATTERNS FOR LOAD CASES

Step 10 (a) click on define tab select load patterns from list.

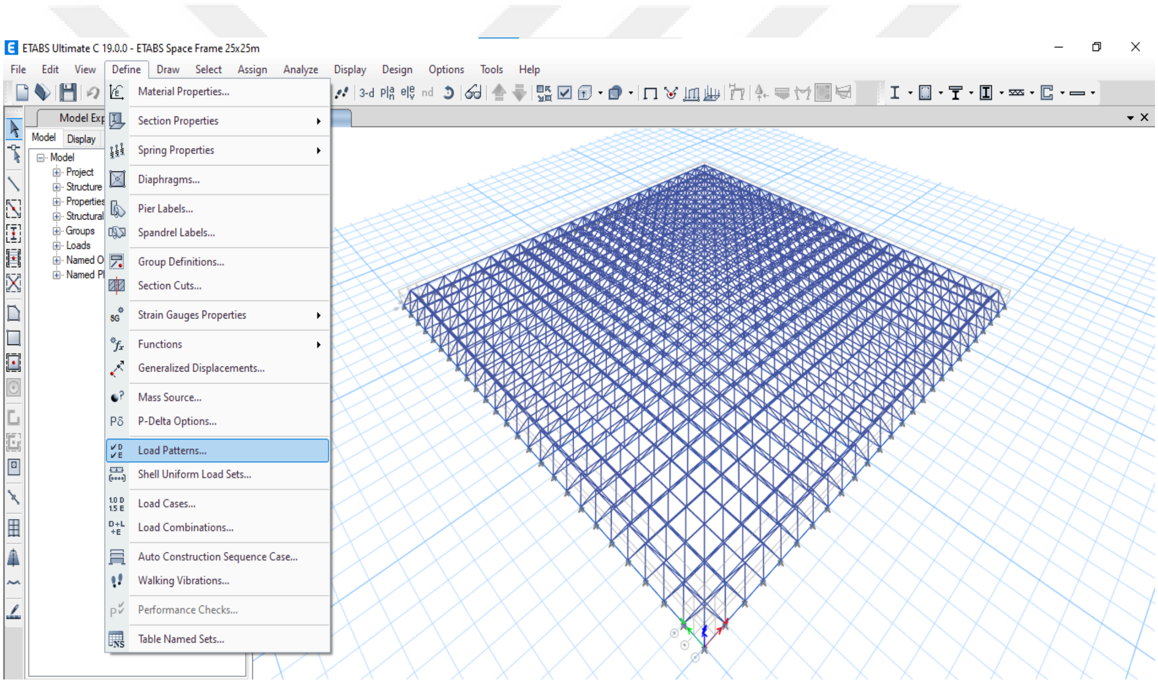


Figure 4.1: Guide to Define Loads and Analysis Step 10 (a) ETABS.

Step 10 (b) after selecting the load patterns from the define tab list define load patterns dial box were open DL, LL were defining.

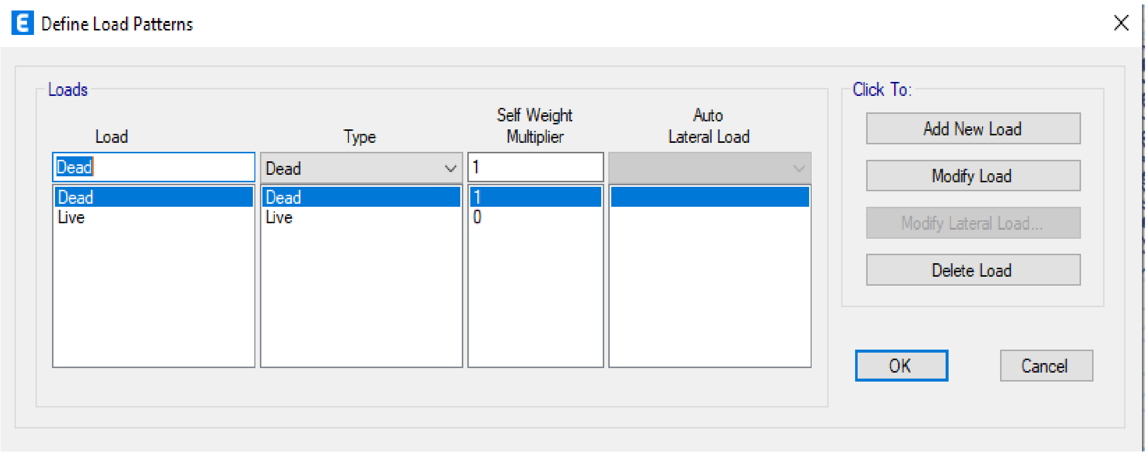


Figure 4.2: Guide to define loads and analysis Step 10 (b) ETABS.

Step 10 (c) define the load patterns SIDL as super dead type WLX, WLY, as wind ELX, ELY as seismic according to ASCE-702

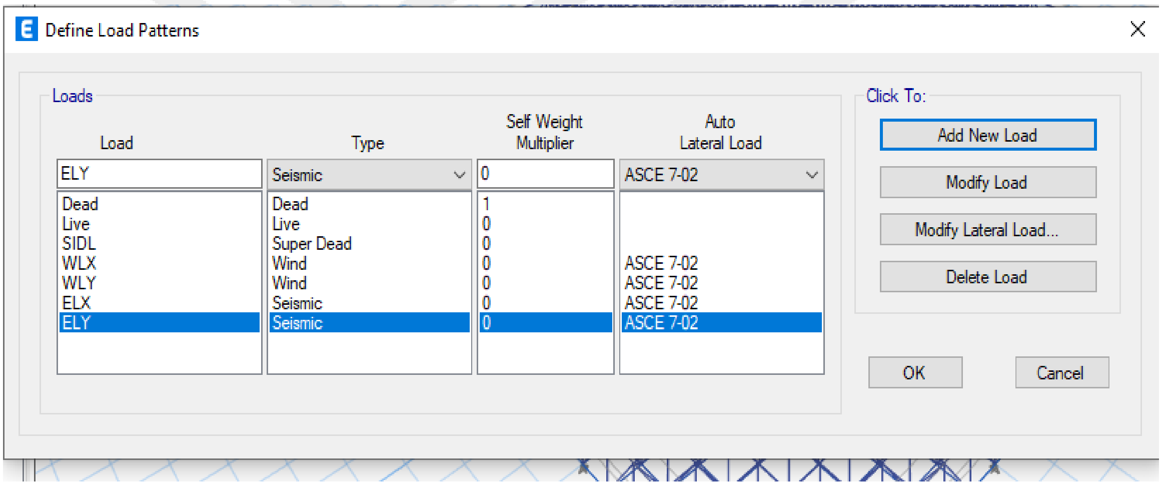


Figure 4.3: Guide to Define Loads and Analysis 10 (c) ETABS.

Step 10 (d) select wind load both x and y-direction click on modify lateral load dial check on exposure from frame and shell object box and wind speed select 100 (mph), exposure type C and importance factor 1.25.

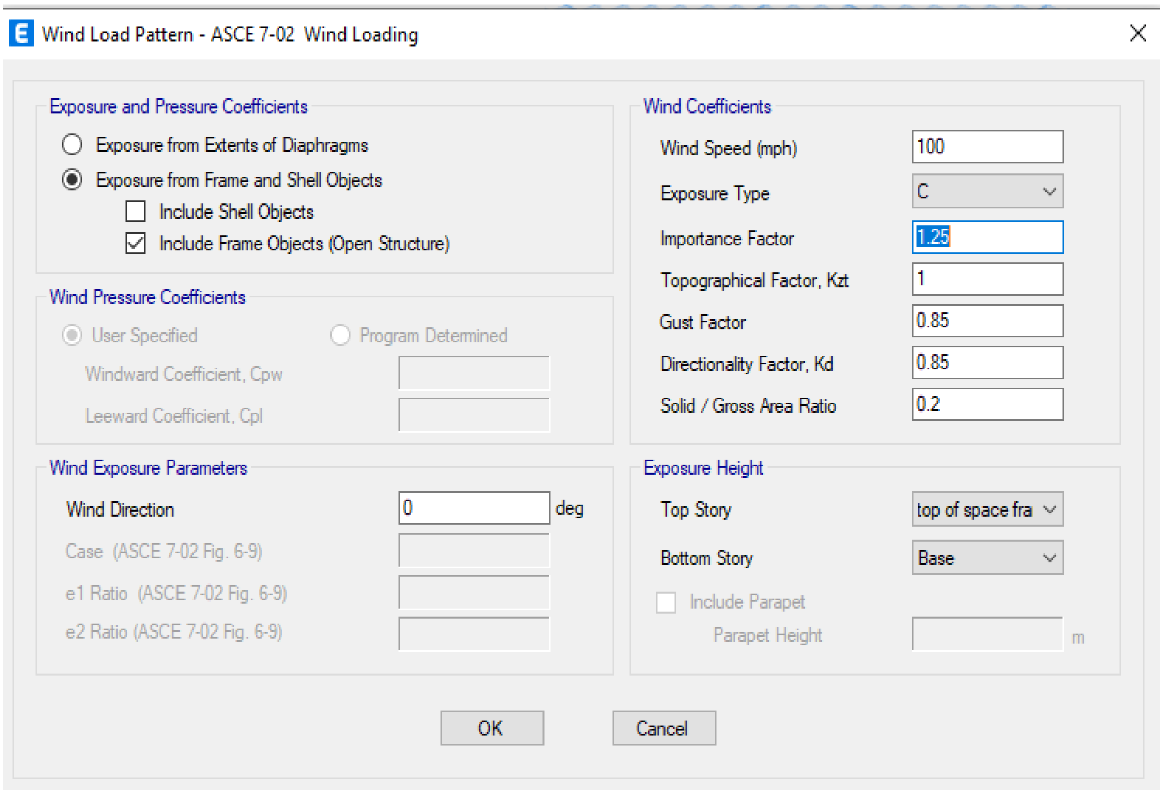


Figure 4.4: Guide to Define Loads and Analysis 10 (d) ETABS.

Step 10 (e) select seismic load in both in x and y direction click on modify lateral load

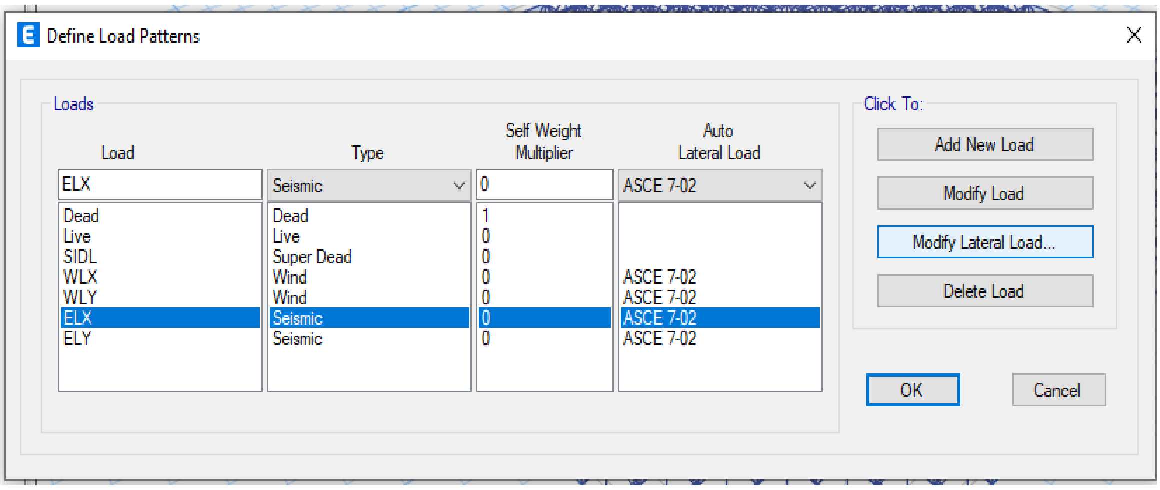


Figure 4.5: Guide to Define Loads and Analysis 10 (e) ETABS.

Step 10 (f) the seismic load pattern dial box were open in direction and eccentricity check on x in ELX and check on/yin ELY seismic-II and site class C.

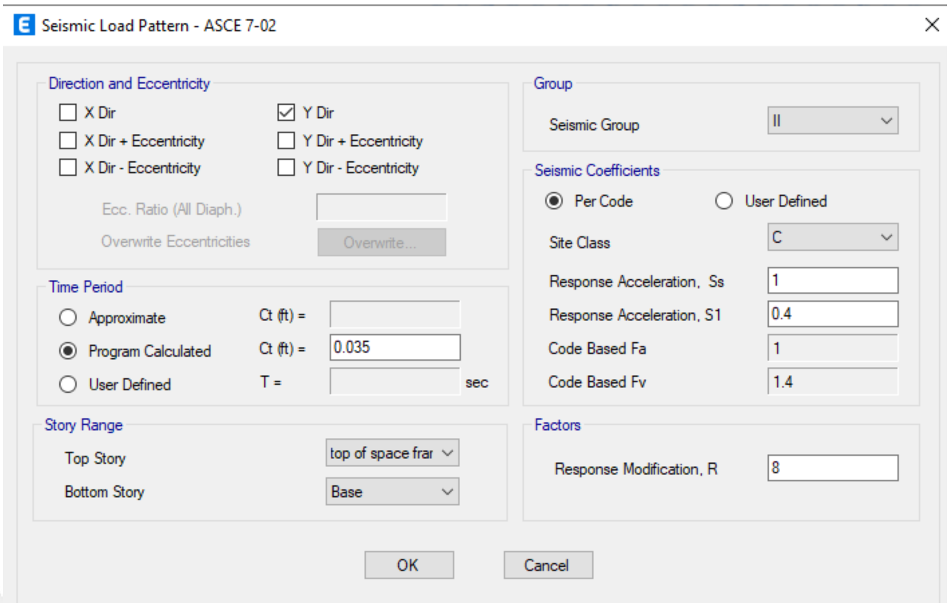


Figure 4.6: Guide to Define Loads and Analysis 10 (f) ETABS.

4.3 SET LOAD CASES

Step 11 (a) go to define tab and select the load cases option

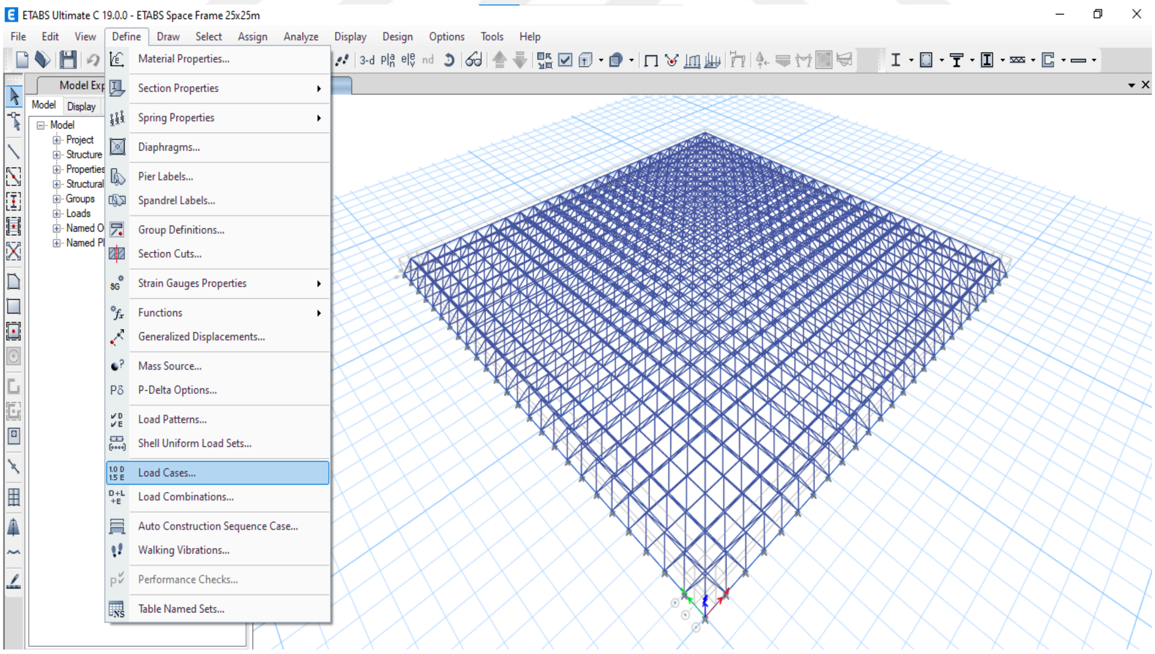


Figure 4.7: Guide to Define Loads and Analysis 11 (a) ETABS.

Step 11 (b) the define load patterns were display in load cases select modify/show case option.

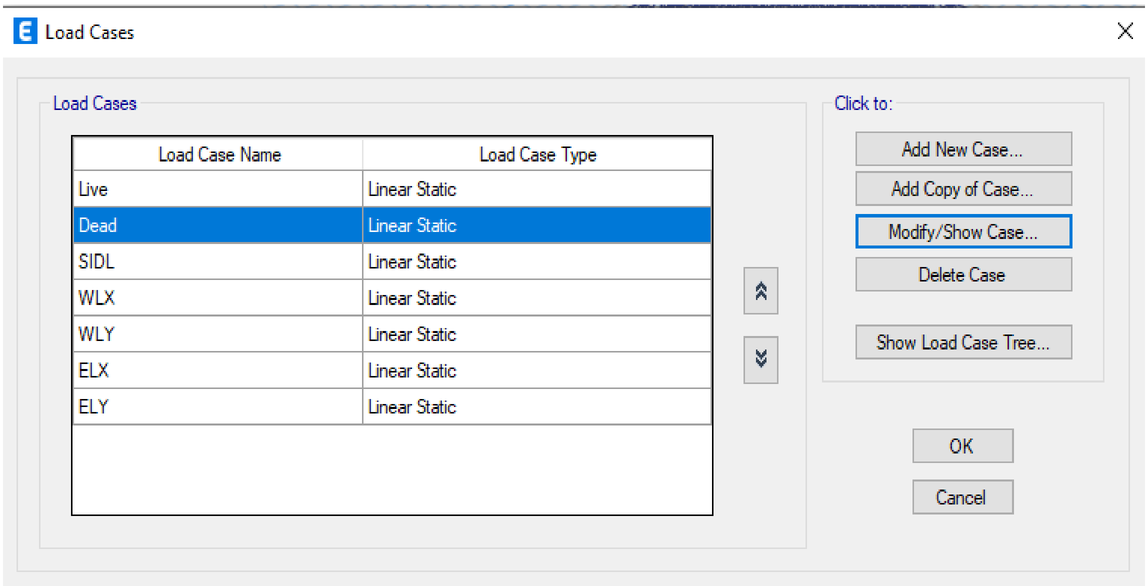
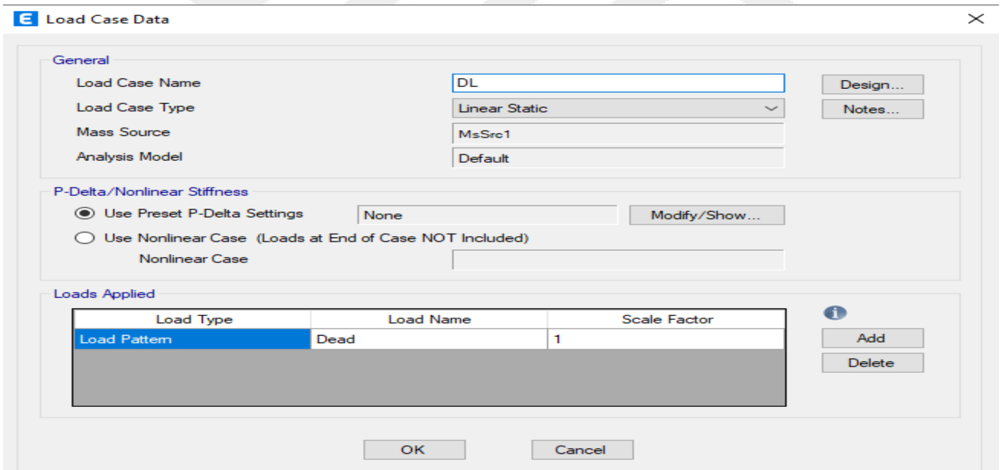
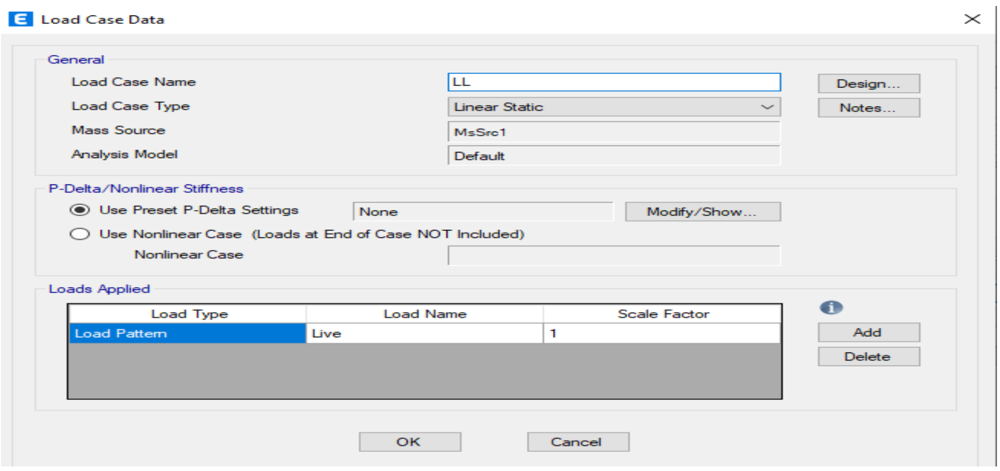


Figure 4.8: Guide to Define Loads and Analysis 11 (b) ETABS.

Step 11 (c) edit names of dead and live to DL and LL.





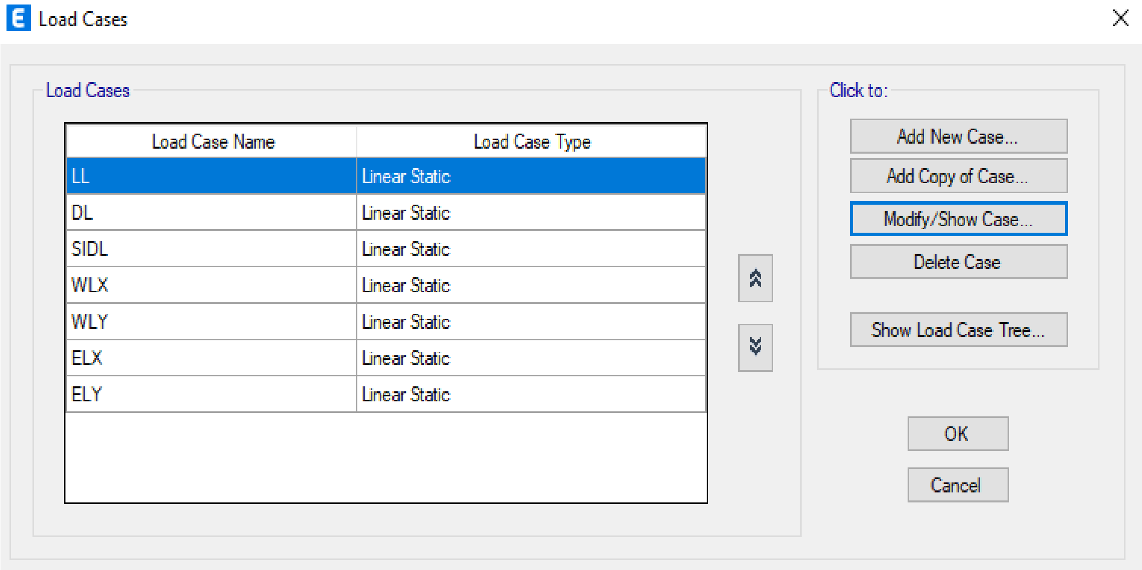


Figure 4.9: Guide to Define Loads and Analysis 11 (c) ETABS.

Step 11 (d) Assign loads to structure select the whole frame structure in plain view.

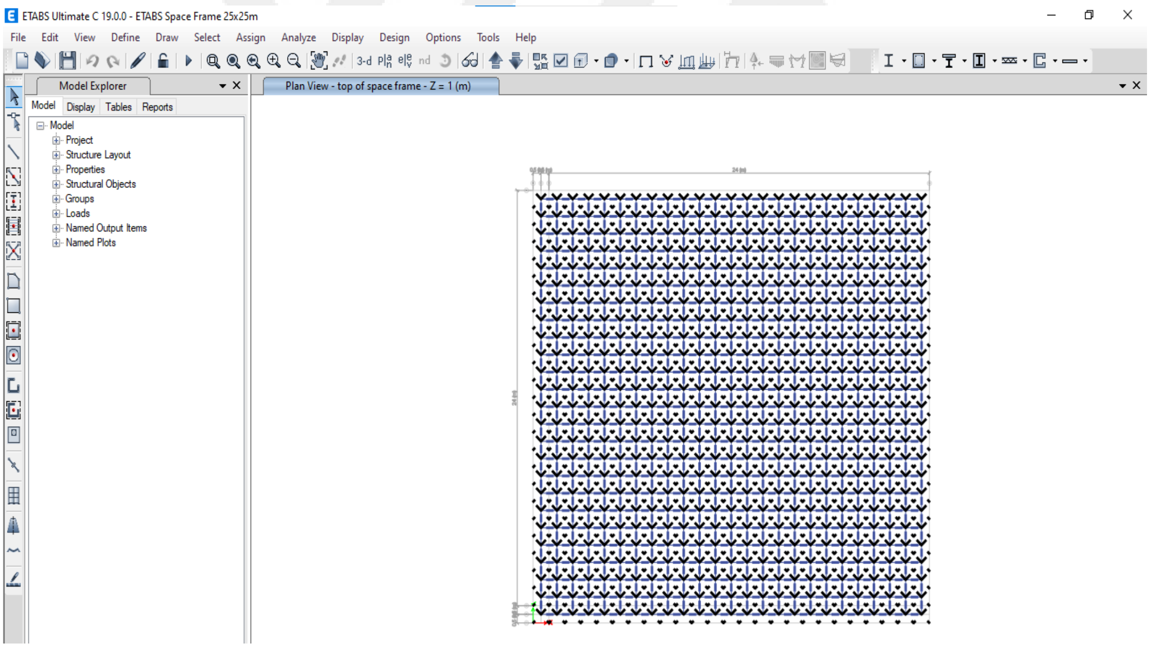


Figure 4.10: Guide to Define Loads and Analysis 11 (d) ETABS.

Step 11 (e) go to select tab click on deselect option select the object type from check list.

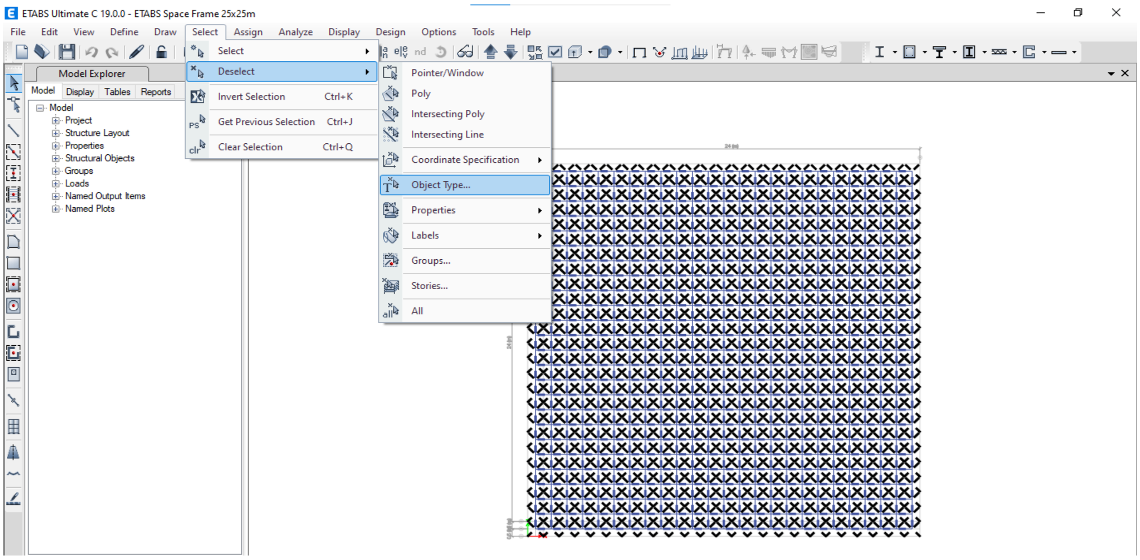
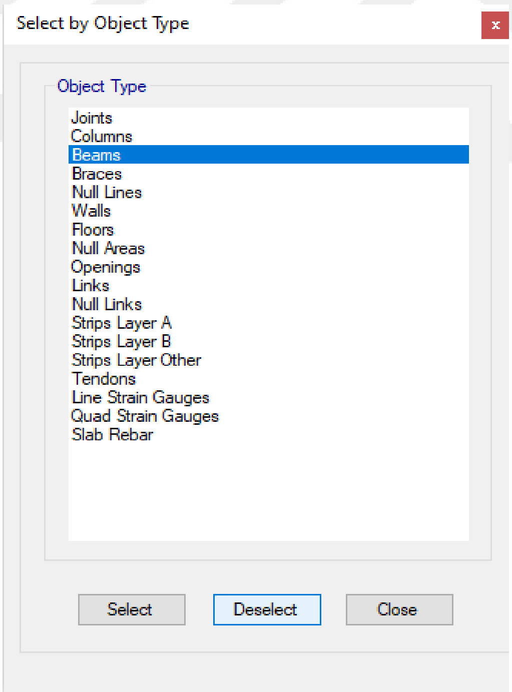


Figure 4.11: Guide to Define Loads and Analysis 11 (e) ETABS.

Step 11 (f) select the beams from the dial box and click on deselect option.



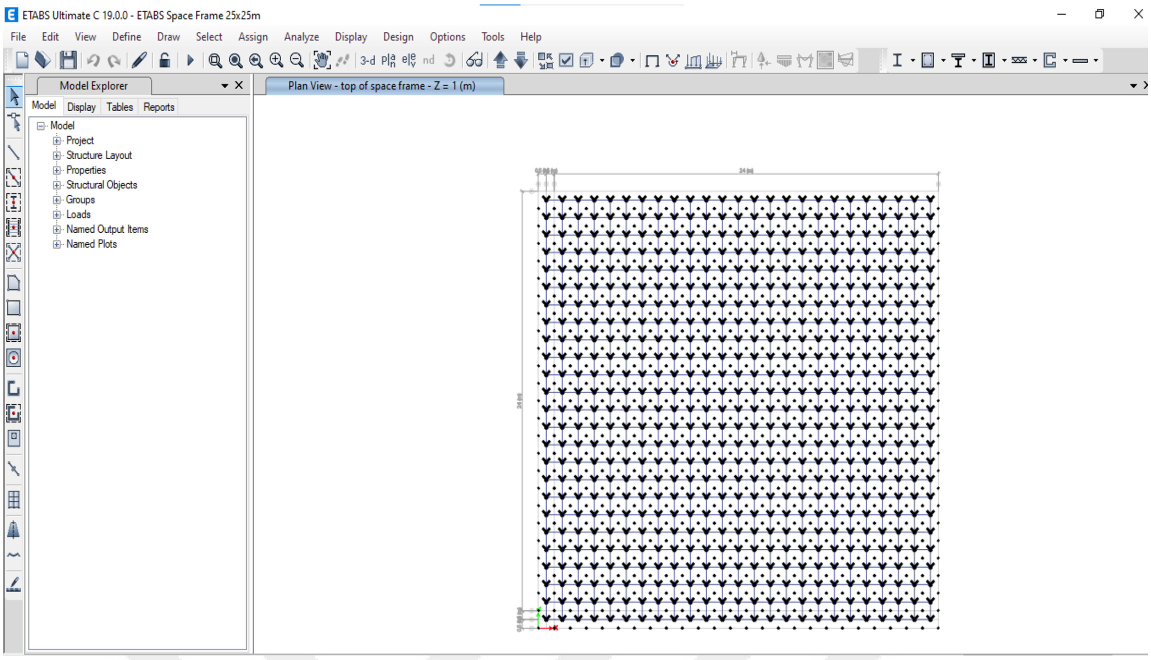


Figure 4.12: Guide to Define Loads and Analysis 11 (f) ETABS.

4.4 ASSIGN LOADS

Step 12 (a) go to assign tab click on the joint load and select force option.

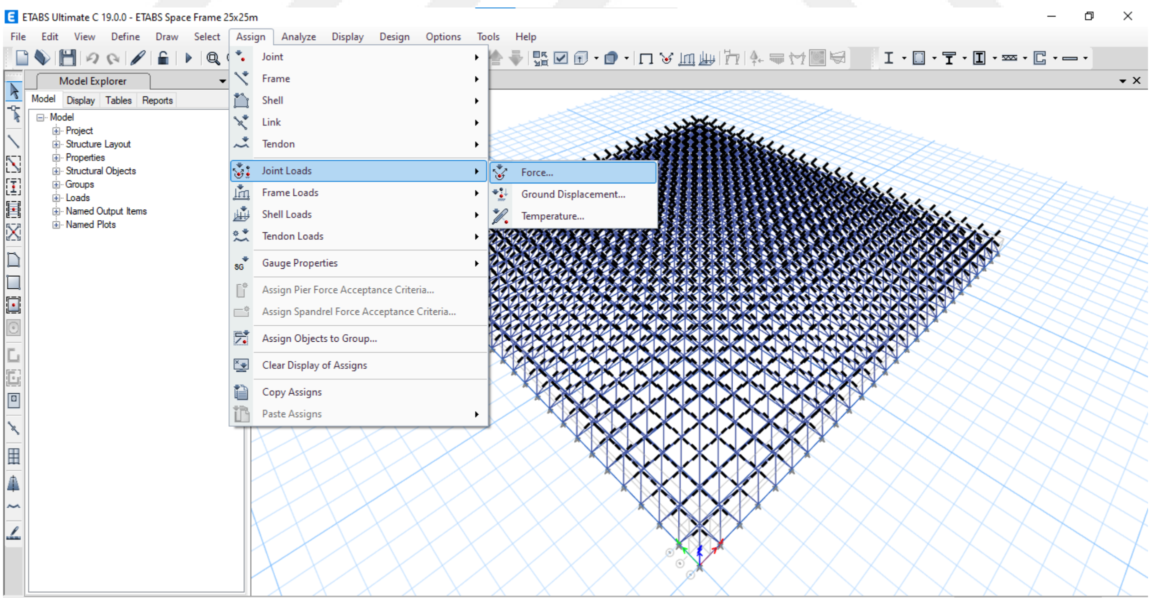


Figure 4.13: Figure 1 Guide to Define Loads and Analysis 12 (a) ETABS.

Step 12 (b) the joint load assignment dial box were open select load pattern of SILD magnitude of 1.25 and LL 1.5 in global z direction 3d view.

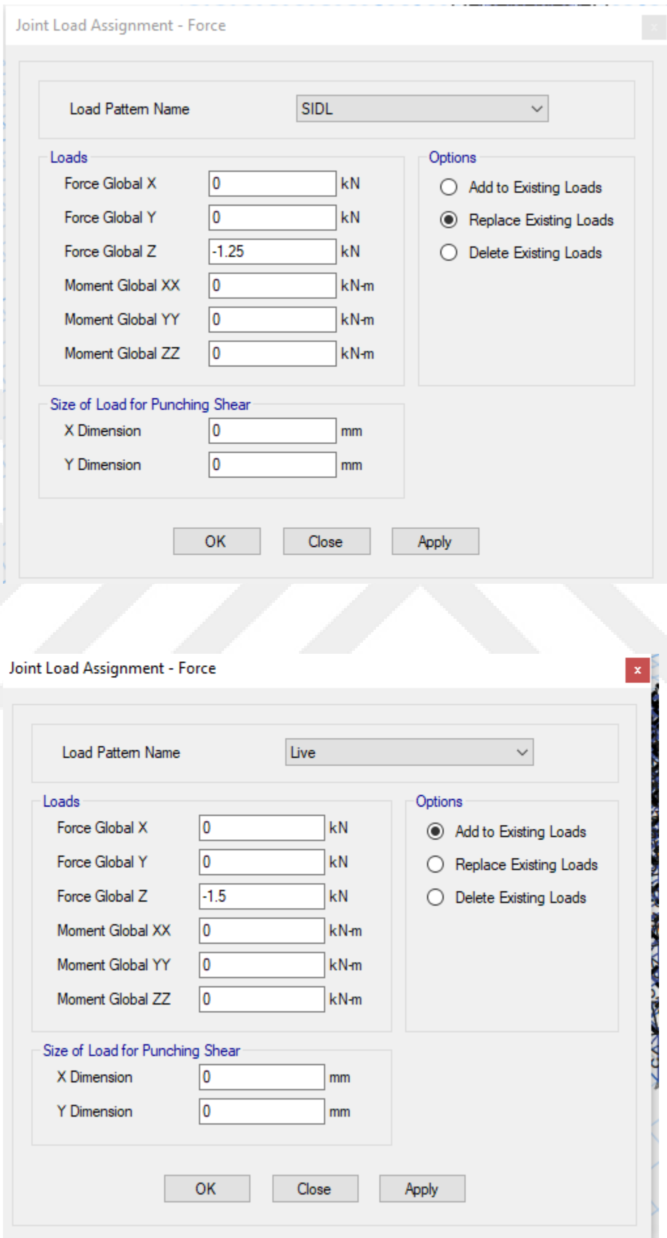


Figure 4.14: Guide to Define Loads and Analysis 12 (b) ETABS.

Step 12 (c) define the load combination go to define tab and click on load combination option.

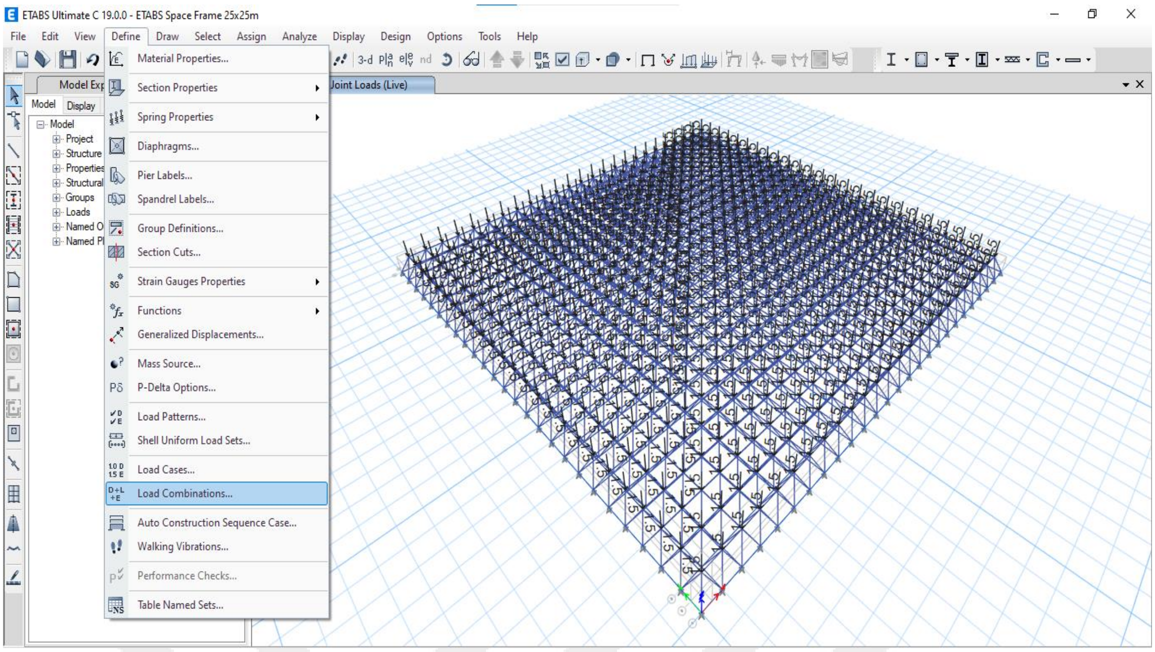
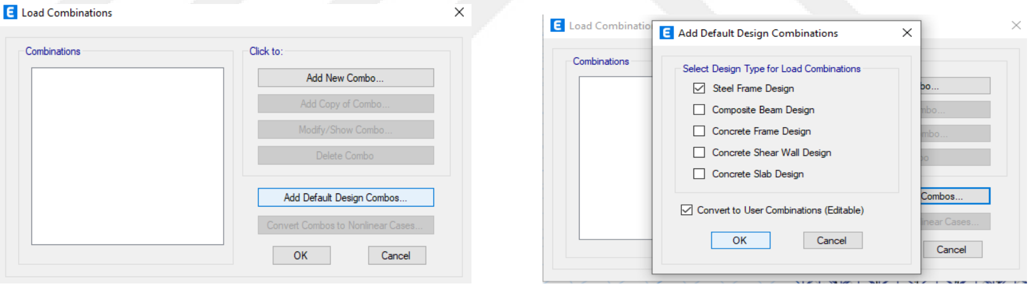


Figure 4.15: Guide to Define Loads and Analysis 12 (c) ETABS.

Step 12 (e) the load combination dial box were open click on Add default design combos the add default design combination dial were open check on steel frame design or convert to user combination then click on ok the built in American standards load combination for structure were



shown

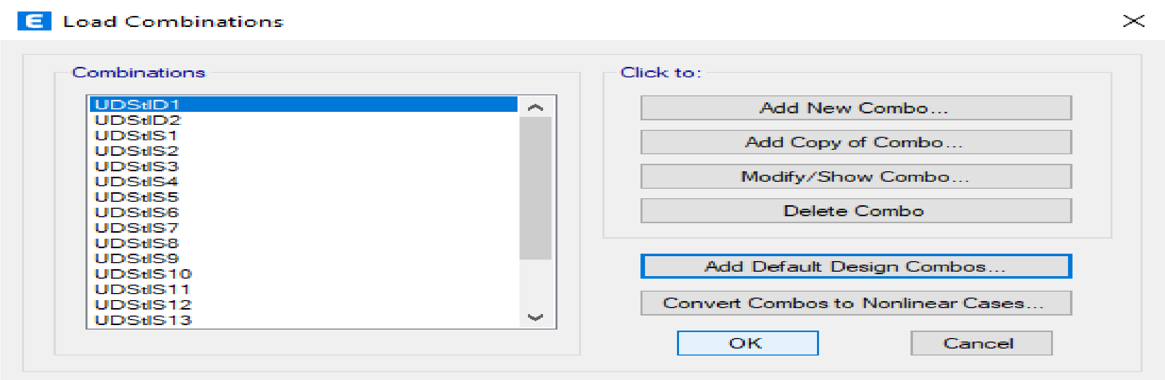


Figure 4.16: Guide to Define Loads and Analysis 12 (e) ETABS.

4.5 ASSIGN THE MESHING

Step 13 (a) go to assign tab click on fame and then select frame auto mesh options then select the dial box were open the whole structure and click on apply.

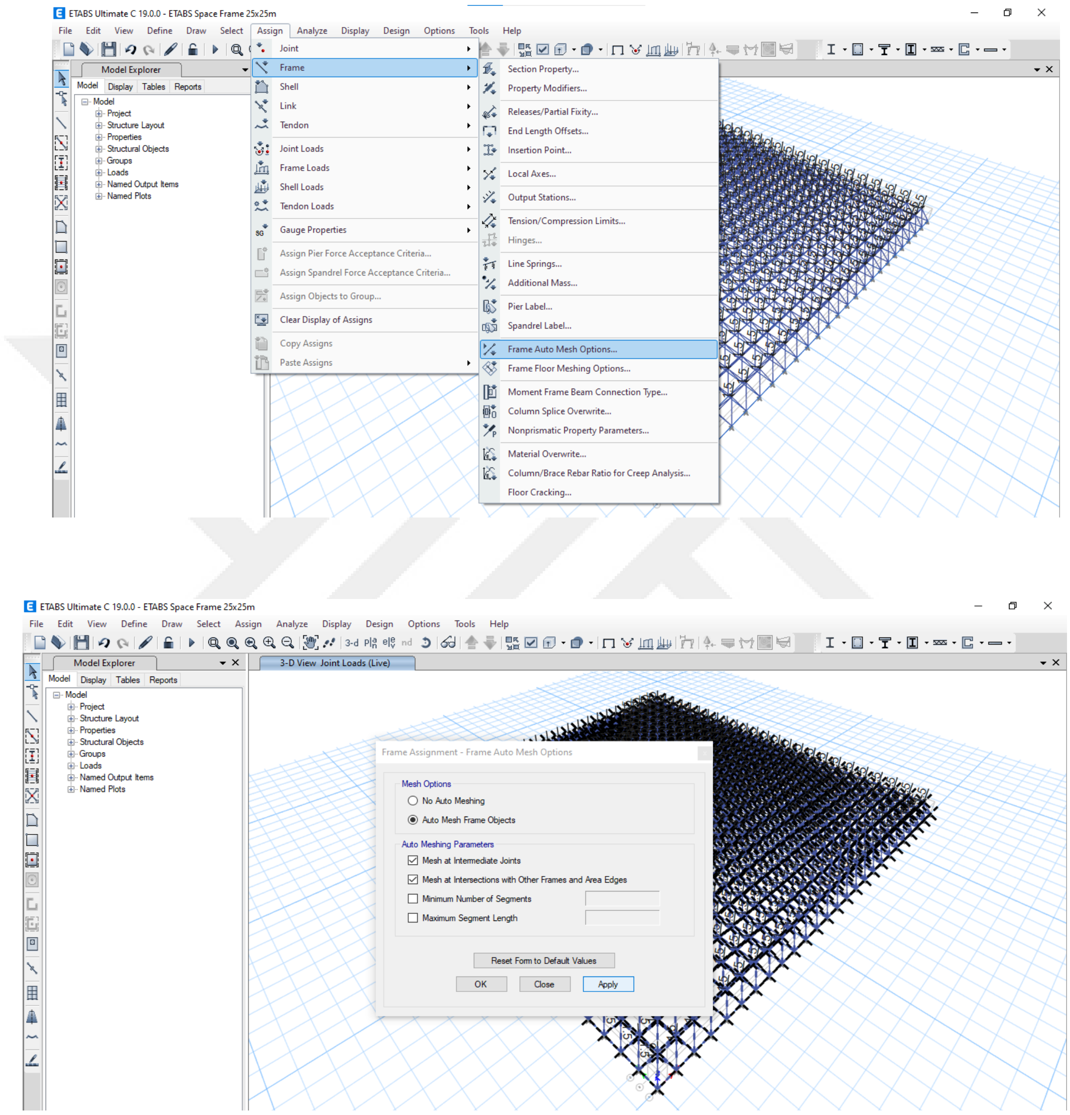


Figure 4.17: Guide to Assign Meshing and Analysis 13 (a) ETABS.

Step 13 (b) go to analyze tab click in check model the check on the joint checks, frame checks, fix and check meshing for all stories and loading for all stories then click on ok output shows no warning the model is ok.

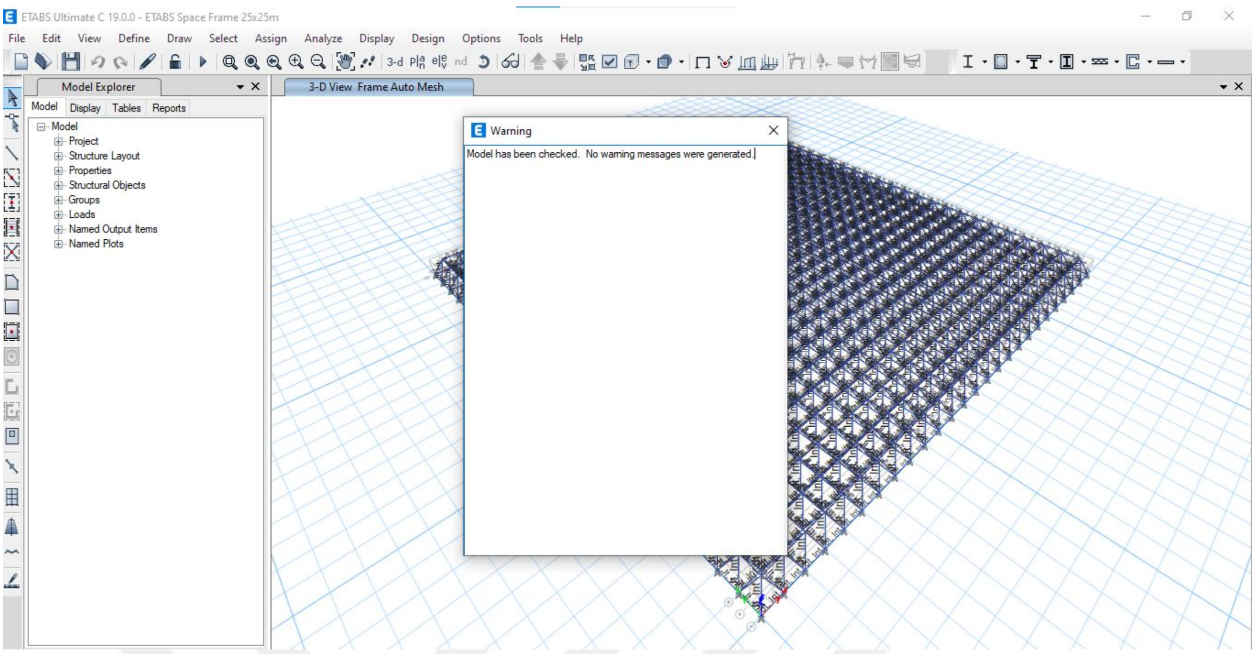
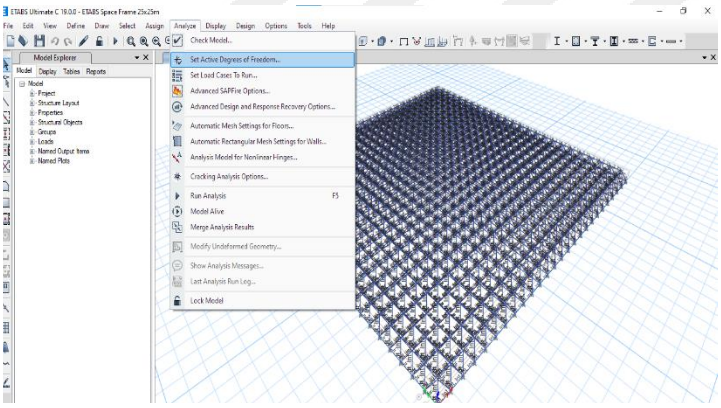
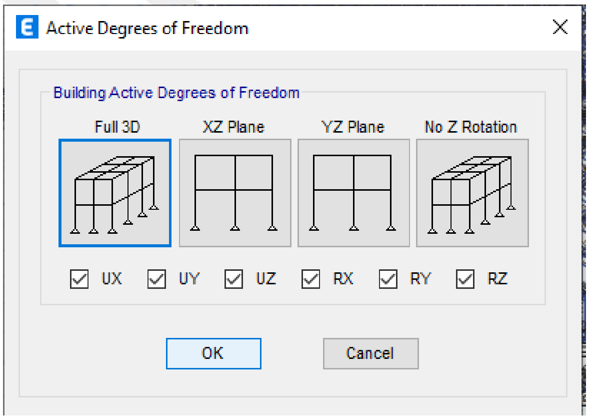


Figure 4.18: Guide to Check Model and Analysis 13 (b) ETABS.

Step 13 (c) check active degree of freedom go to analyze tab select active degree of freedom the dial box was open select full 3D click on ok.

4.6 ANALYZE STRUCTURE AND CHECK THE BEHAVIOR

Step 14 (a) go to analyze tab the click on run analysis.

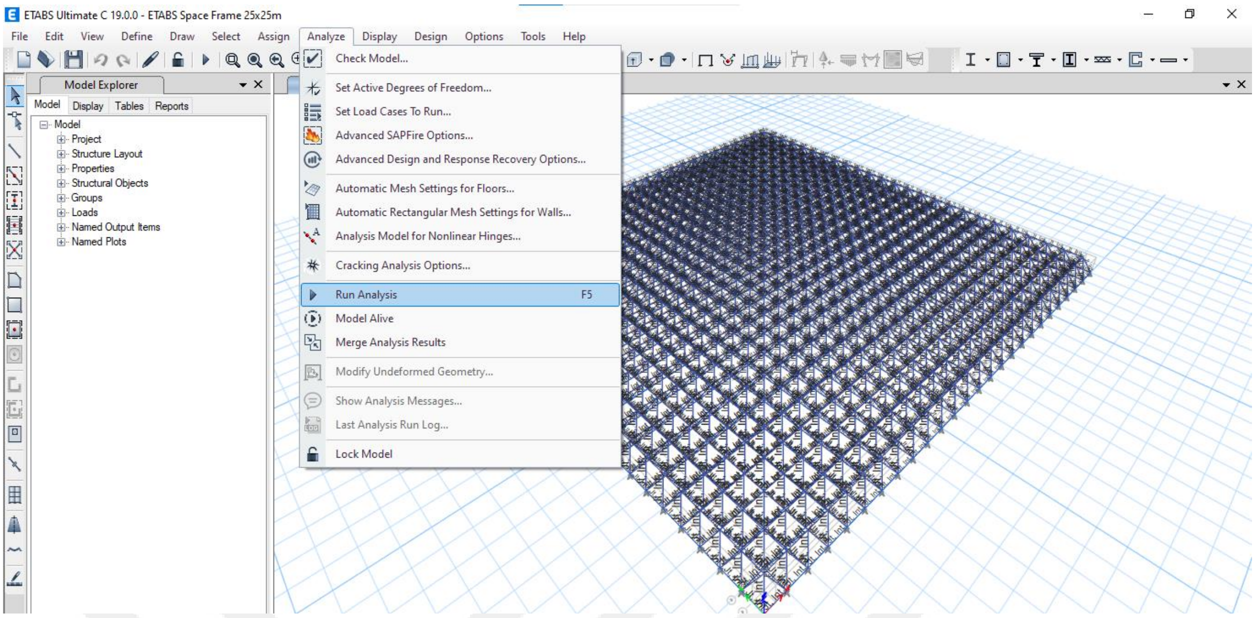


Figure 4.19: Guide to Check Model and Analysis 14 (a) ETABS.

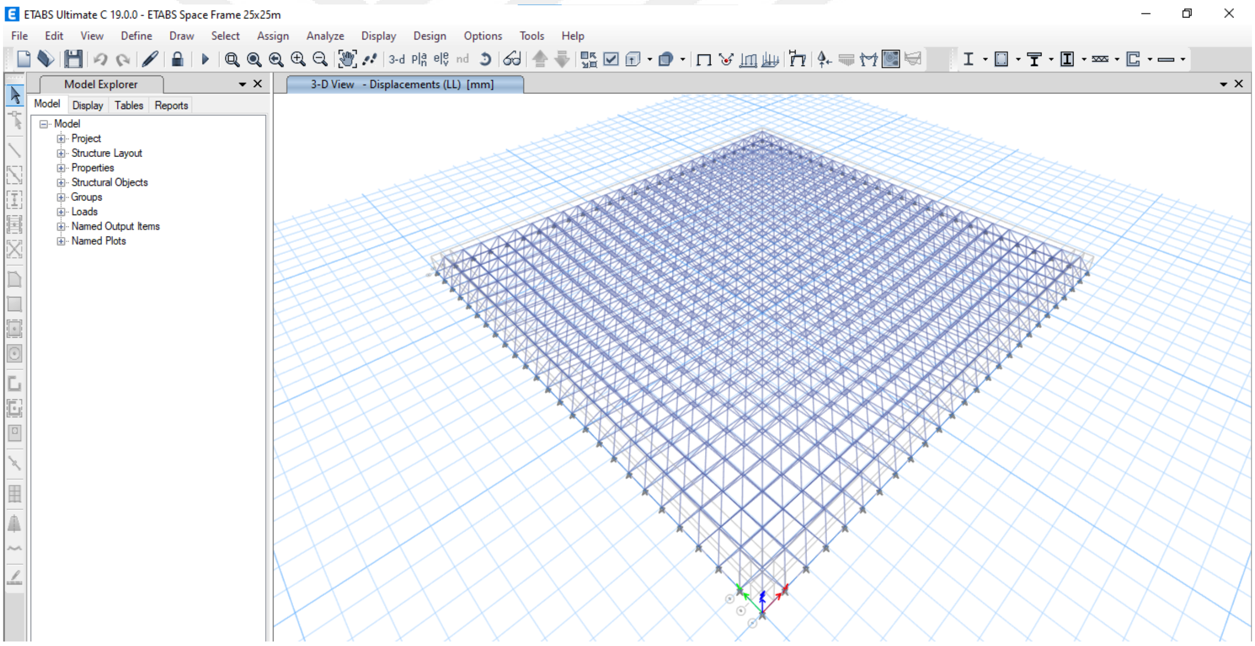


Figure 4.20: Guide to Check Model and Analysis 14 (a) ETABS.

Step 14 (b) check the last analysis run logs from analyze tab the complete report of analysis was appear check the basic stability checks for linear load cases is it observed that the basic stability checks for linear load cases is ok.

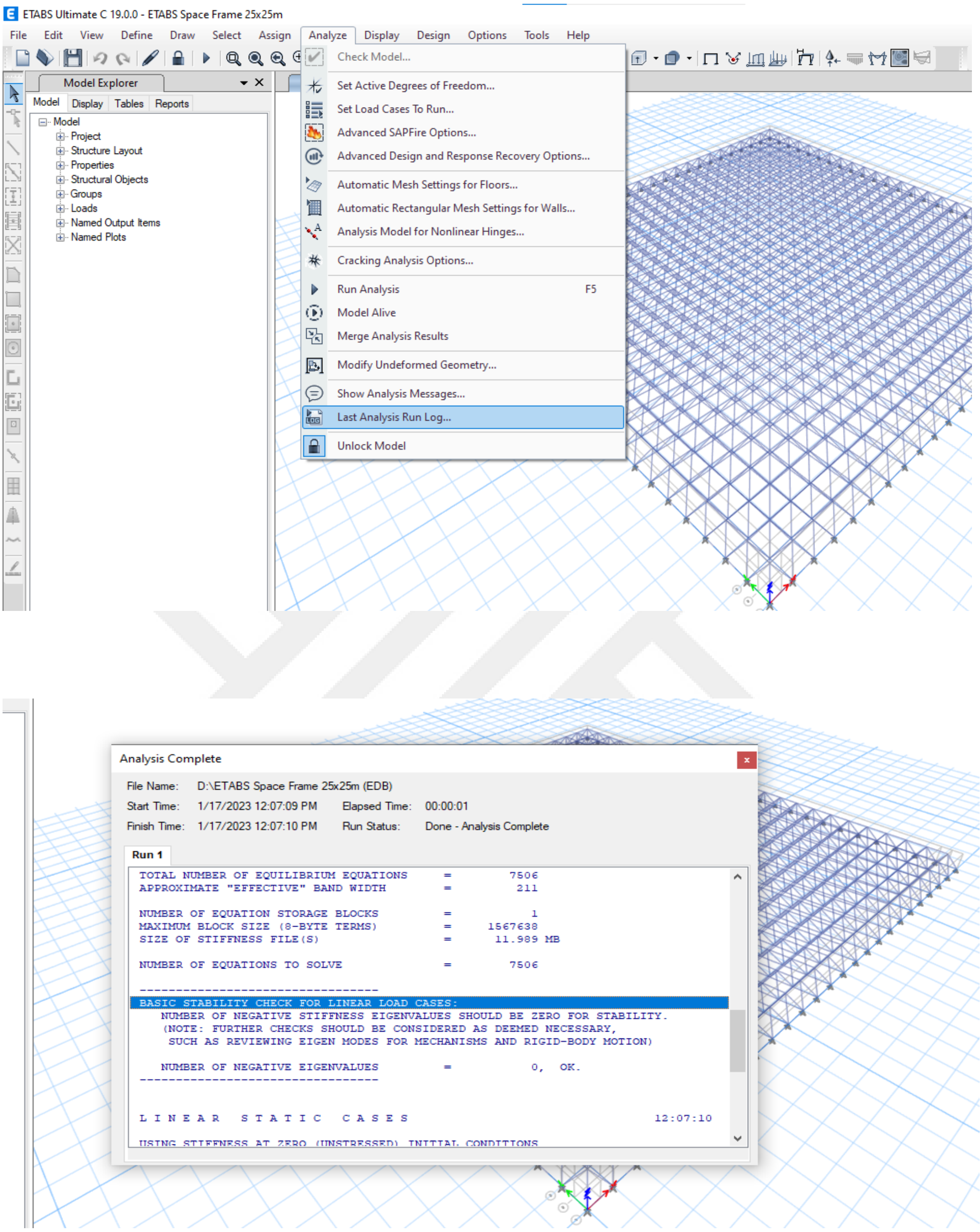


Figure 4.21: Guide to Check Model And Analysis 14 (b) ETABS.

4.7 CHECK THE DEFLECTIONS CAUSE BY DIFFERENT LOAD COMBINATIONS

Step 15 (a) go to display click on deformed shape.

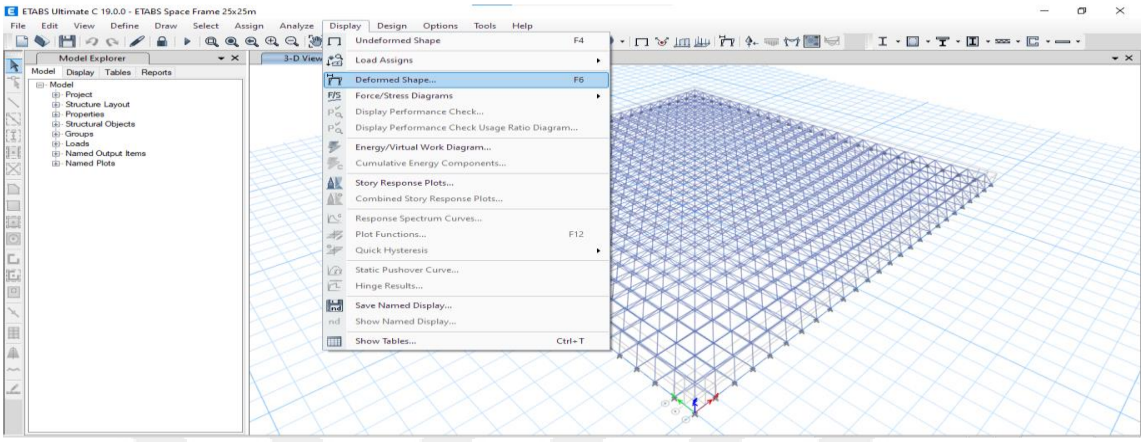


Figure 4.22: Guide to Analysis and Results 15 (a) ETABS.

4.7.1 Deflection by Udstld1

The serviceability load combination UDSdD1 with combination type linear that contains DL and SIDL with scale factor 1 apply on 25 x25m space frame structure the maximum deflection is 3.011mm and minimum is -28.91mm shows in figure 72

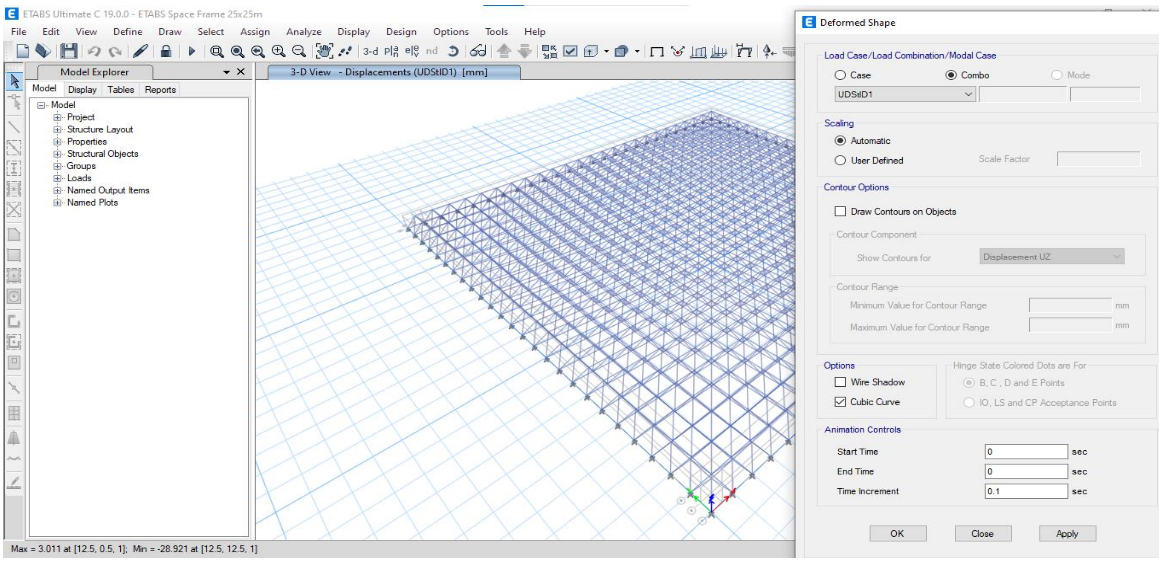


Figure 4.23: Guide to Analysis and Results ETABS.

4.7.2 Deflection by Udstld2

Serviceability load combination UDStlD2 linear type load combination which contains LL, DL and SIDL with scale factor 1. The deflection of structure is shown in figure 73. The maximum deflections are 4.313 mm and minimum -51.031mm

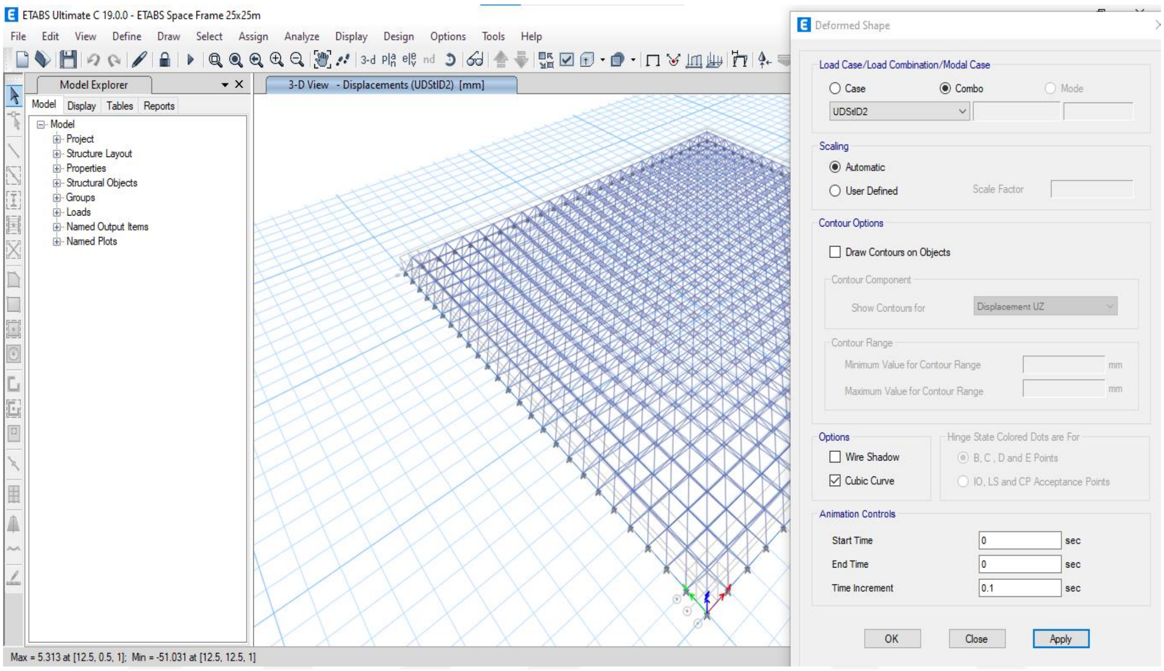


Figure 4.24: Guide to Analysis and Results ETABS.

4.7.3 Deflection by Udstls1

Strength load combination UDStlS1 linear type load combination which contains DL and SIDL with scale factor 1.4. The deflection of structure is shown in figure 74. The maximum deflections are 4.25 mm and minimum -40.49mm

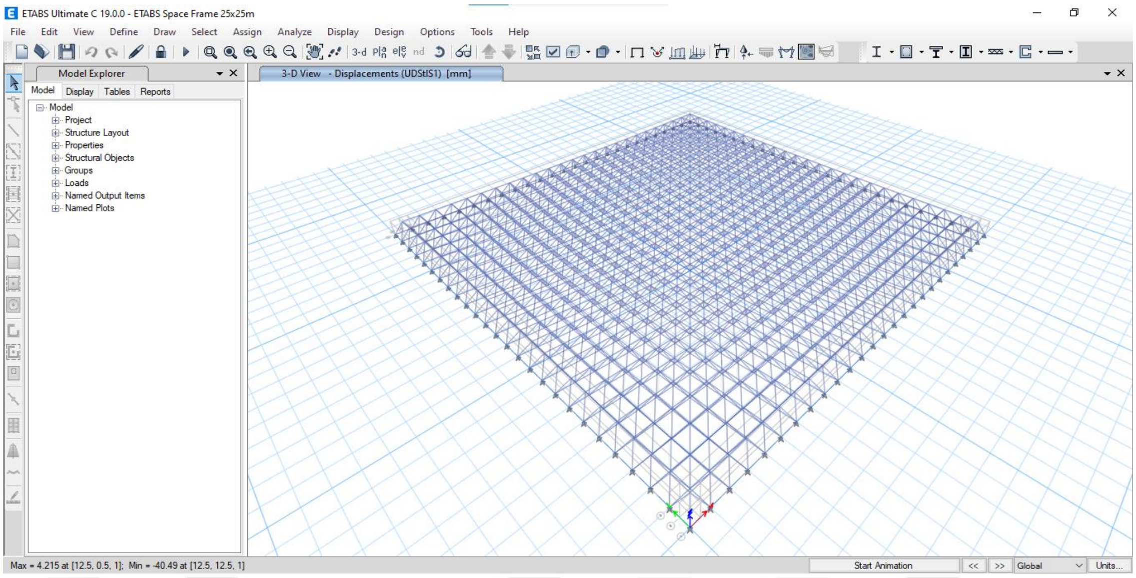


Figure 4.25: Guide to Analysis and Results ETABS.

4.7.4 Deflection by Udstls2

Strength load combination UDStlS2 linear type load combination which contains DL and SIDL with scale factor 1.2 and LL with scale factor 1.6. The deflection of structure are shown in figure 75. The maximum deflections is 7.29 mm and minimum -70.08mm.

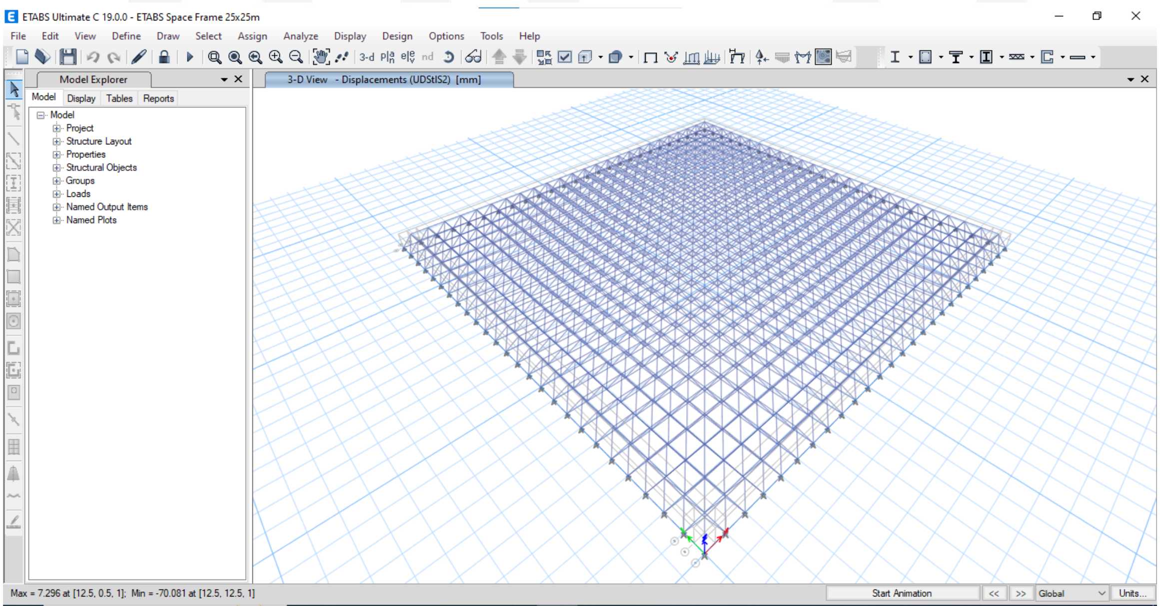


Figure 4.26: Guide to Analysis and Results ETABS.

4.7.5 Deflection by Udstls7

Strength load combination UDStlS7. The deflection of structure is shown in figure 76. The maximum deflections are 2.78 mm and minimum -26.02mm

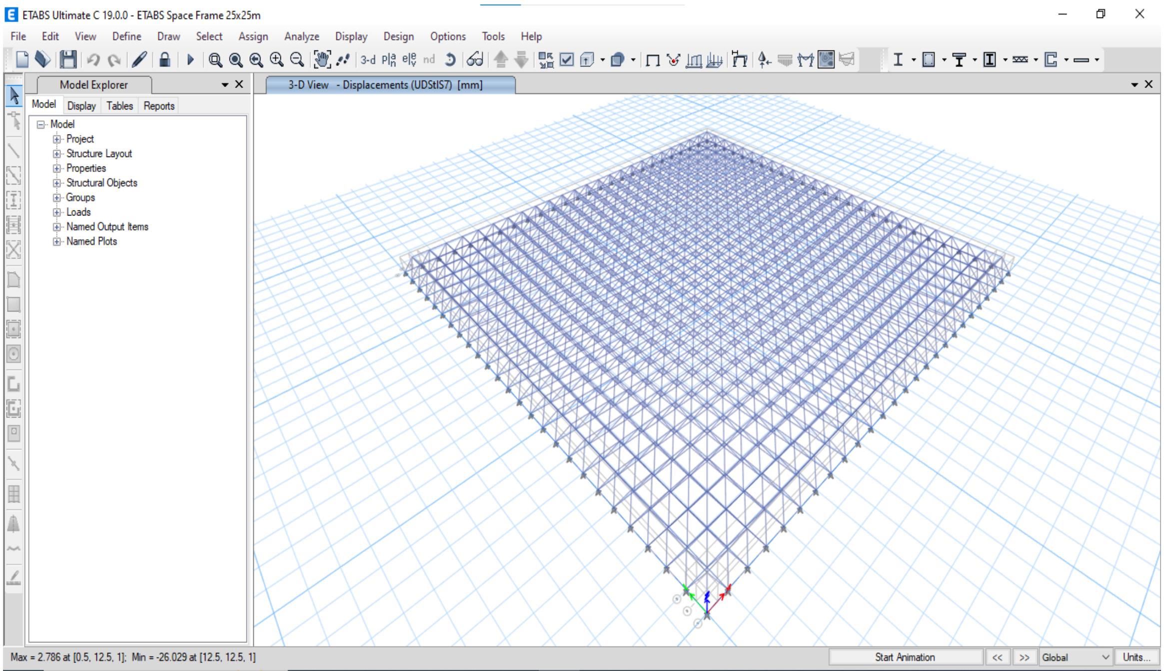


Figure 4.27: Guide to Analysis and Results ETABS.

4.7.6 Deflection by Udstls11

Strength load combination UDStlS11. The deflection of structure is shown in figure 77. The maximum deflections are 6.22 mm and minimum -59.70mm.

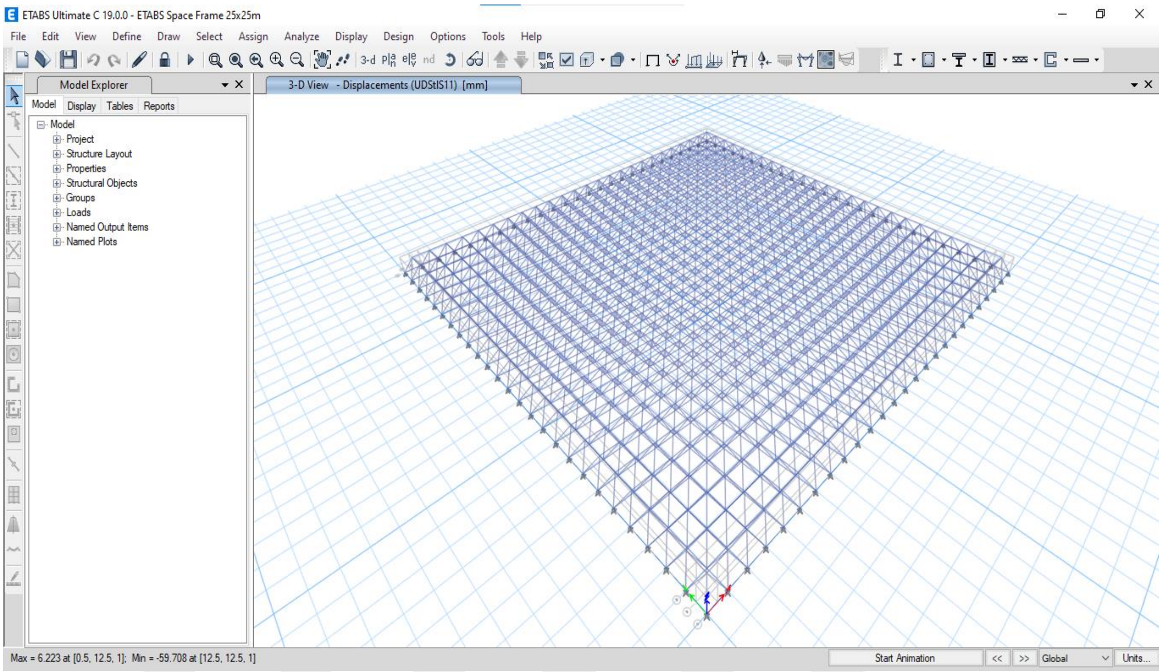


Figure 4.28: Guide to Analysis and Results ETABS

4.8 DEFLECTION CAUSE BY LOAD CASES

4.8.1 Deflection by Ll

The 25 x 25m space frame structure was analyzed under the LL. The obtained results are shown in figure 78 the maximum value of deflection under LL is 2.301mm and minimum value of deflection under LL is -22.1mm.

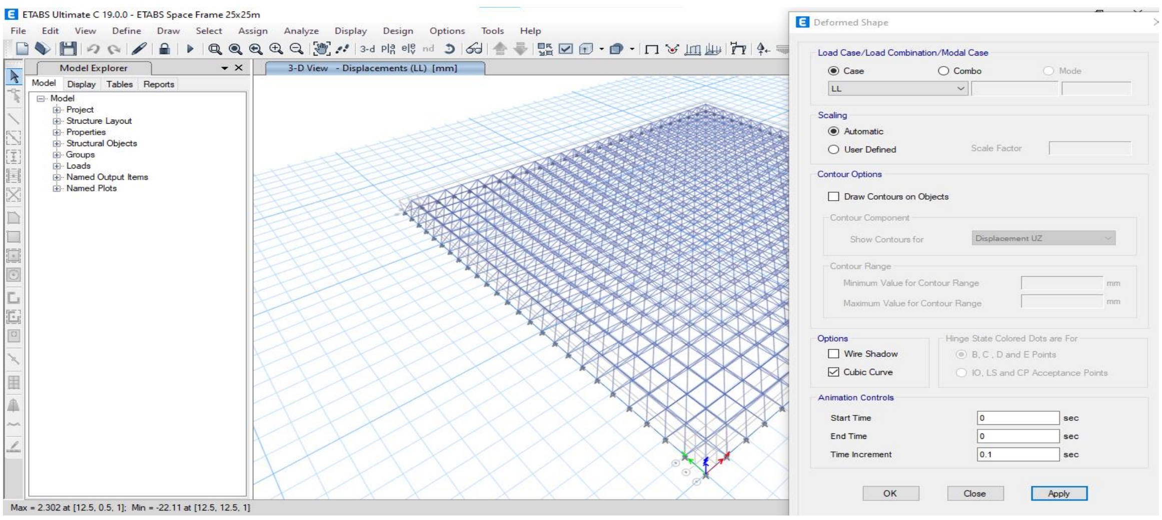


Figure 4.29: Guide to Analysis and Results ETABS.

4.8.2 Deflection by Sidl

The deflection occurred in proposed space frame structure shown in figure 79. The maximum value is 1.901mm and minimum value -18.425mm.

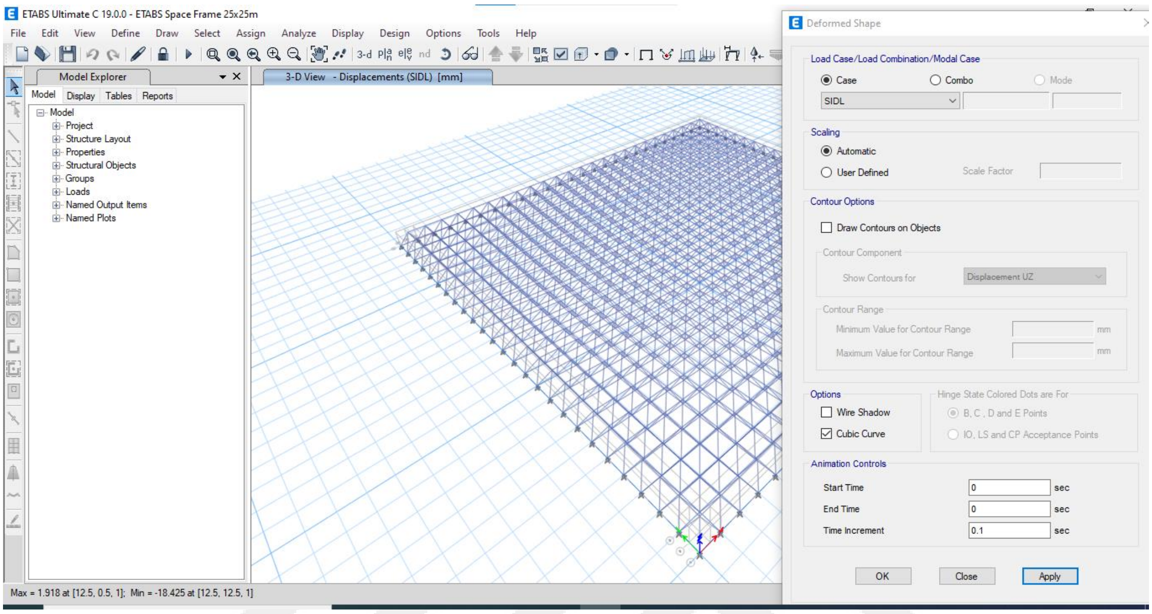


Figure 4.30: Guide to Analysis and Results ETABS.

4.8.3 Deflection by Earthquake Load

In figure 80 the deflection cause by ELX and ELY is shown. For the proposed space frame the deflection values for both cases ELX and ELY were same the maximum value was measured 0.018 mm and minimum -0.018 mm.

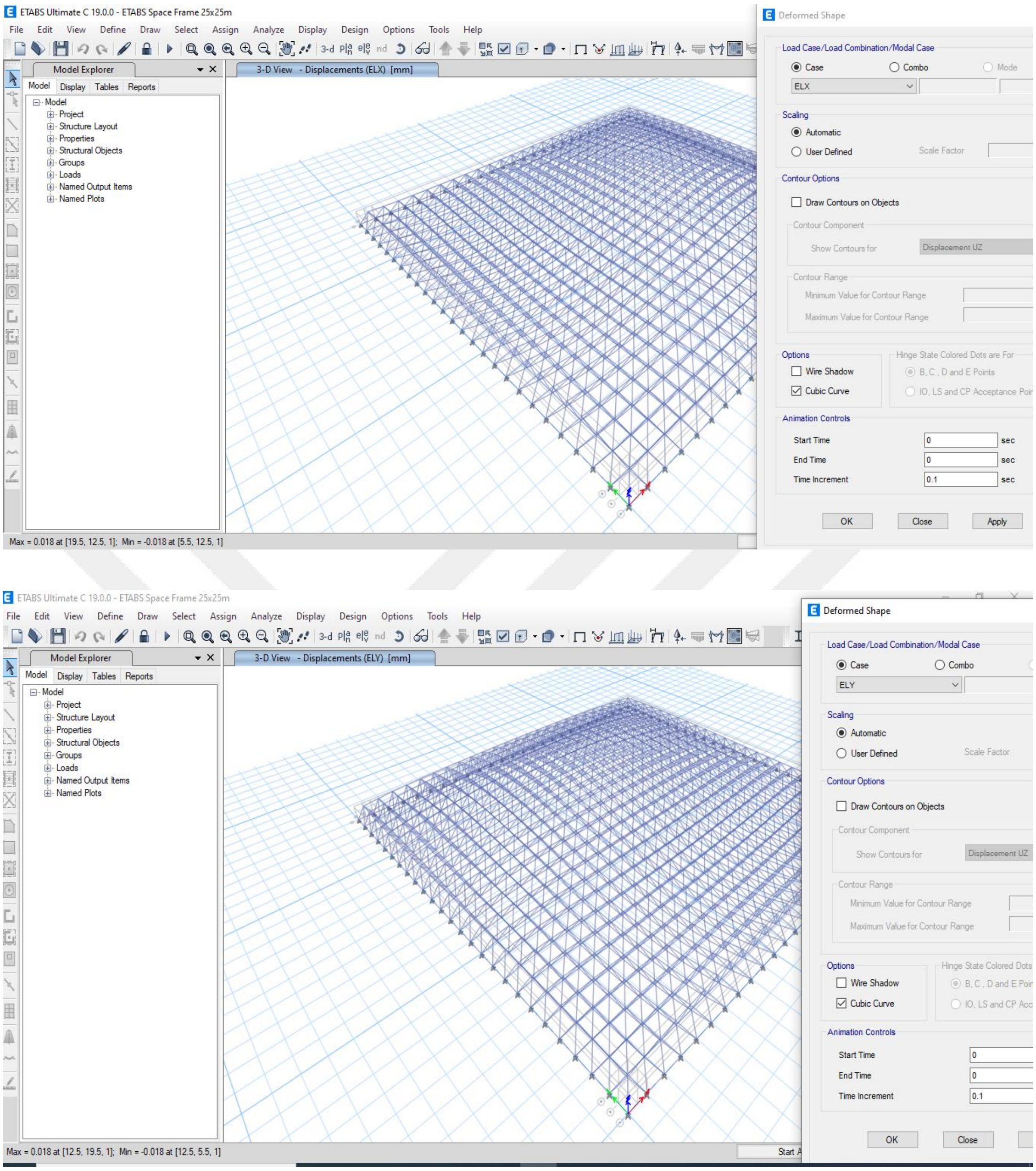


Figure 4.31: Guide to Analysis and Results ETABS.

4.8.4 Deflection by Wind Load

In figure 81 the deflection cause by WLX and WLY is shown. For the proposed space frame, the deflection values for both cases WLX and WLY were same the maximum value was measured 0.182 mm and minimum -0.182 mm.

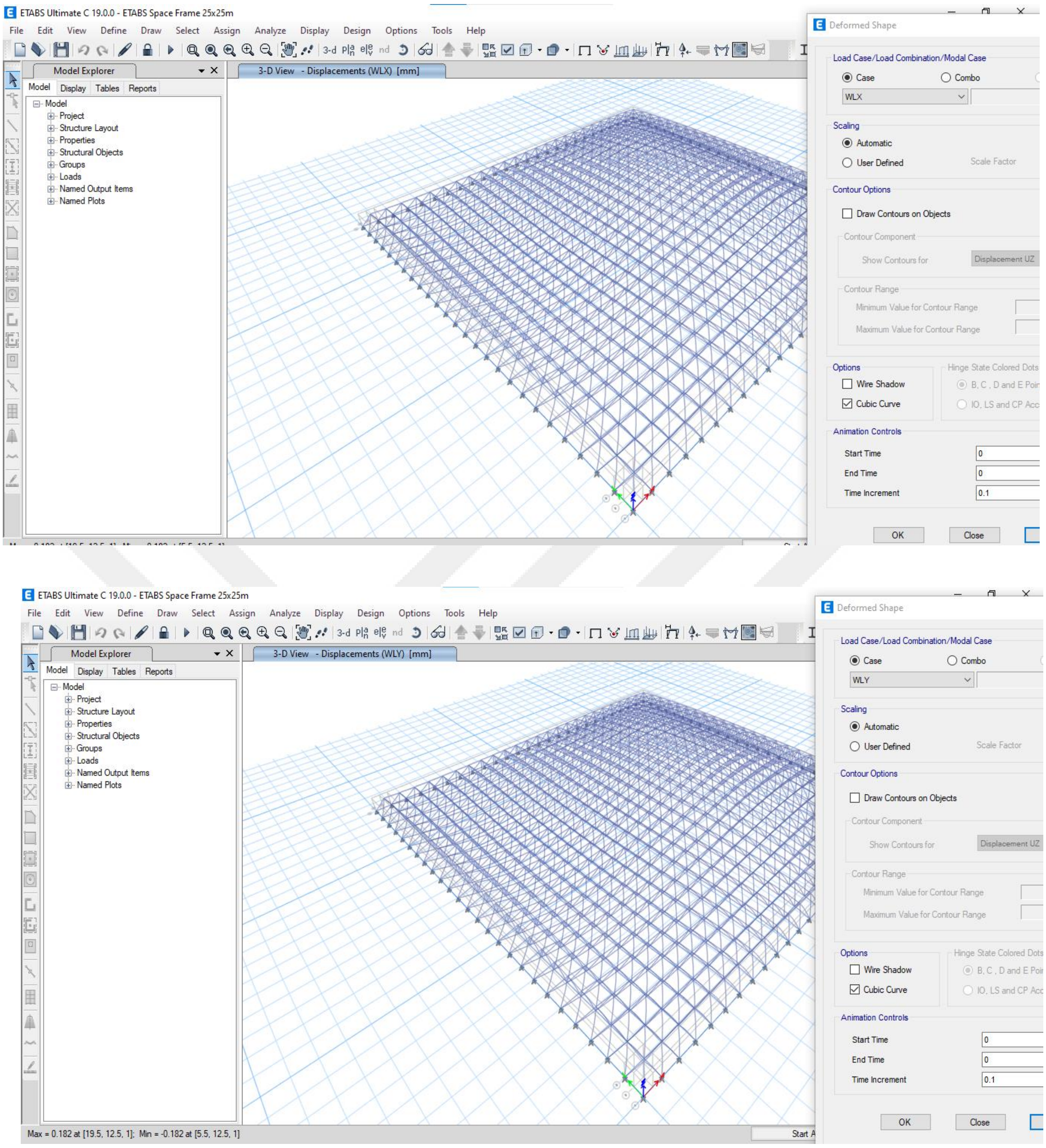


Figure 4.32: Guide to Analysis and Results ETABS.

4.9 BENDING MOMENT AND SHEAR FORCES UNDER LOAD COMBINATION

4.9.1 Shear Force and Bending Under Load Combination Udstls1

The shear force and bending moment envelopes of HSS3X0.250 Section under load combination UDStlS1 are shown in figure 82. The shear force value was measured 0.1055 KN and bending moment value as 0.1052 KN-m.

Figure 4.33: Guide to Analysis and Results ETABS.

4.9.2 Shear Force and Bending Under Load Combination UDStlS2

The shear force and bending moment envelopes of HSS3X0.250 Section under load combination UDStlS2 are shown in figure 83. The shear force value was measured as 0.1209 KN and Bending moment value was 0.1920KN-M

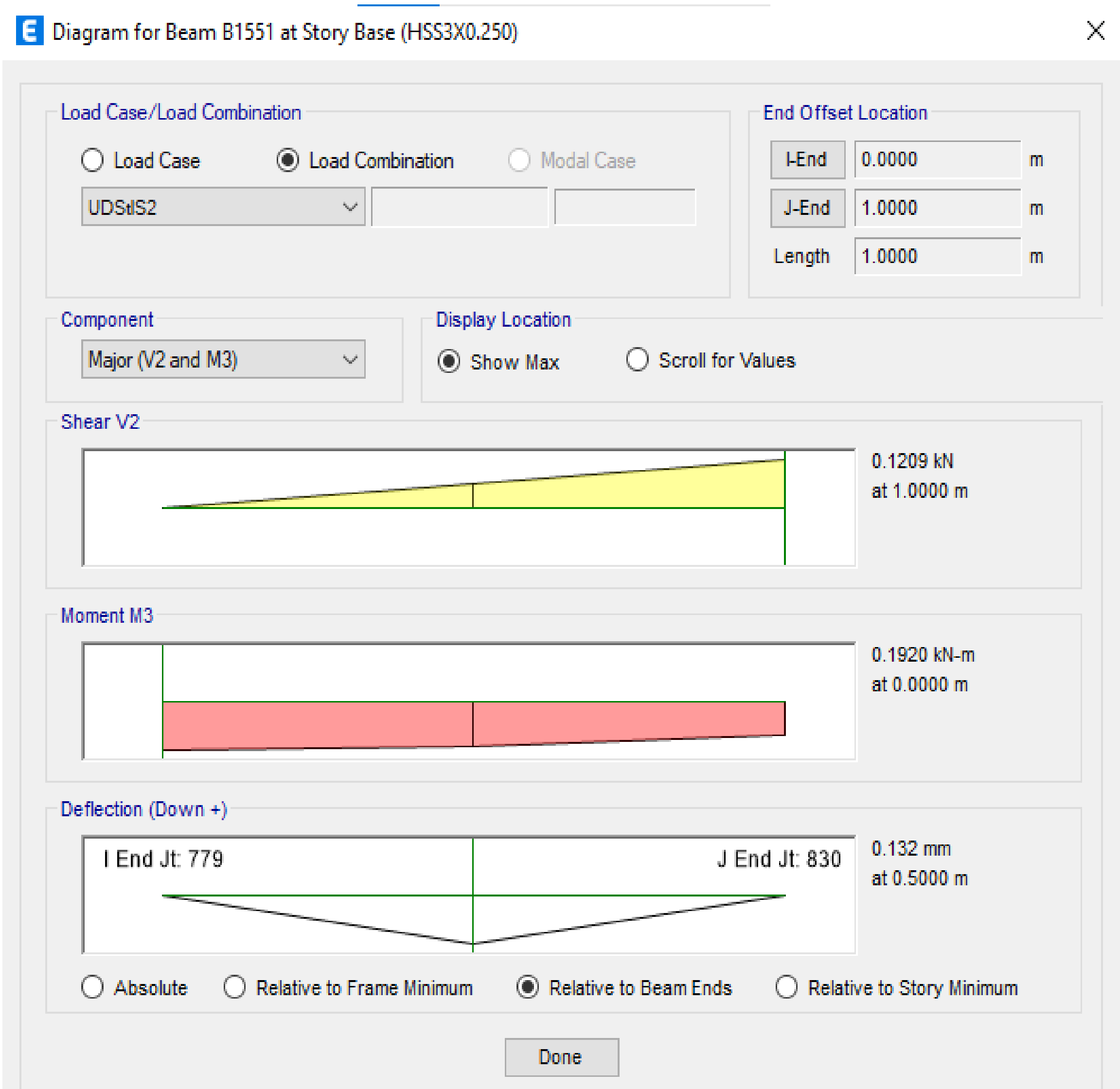


Figure 4.34: Guide to Analysis and Results ETABS.

4.9.3 Shear Force and Bending Under Load Combination Udstls7

The shear force and bending moment envelopes of HSS3X0.250 Section under load combination UDStlS7 are shown in figure 84. The shear force value was measured as 0.0678 KN and Bending moment value was 0.0676 KN-m.

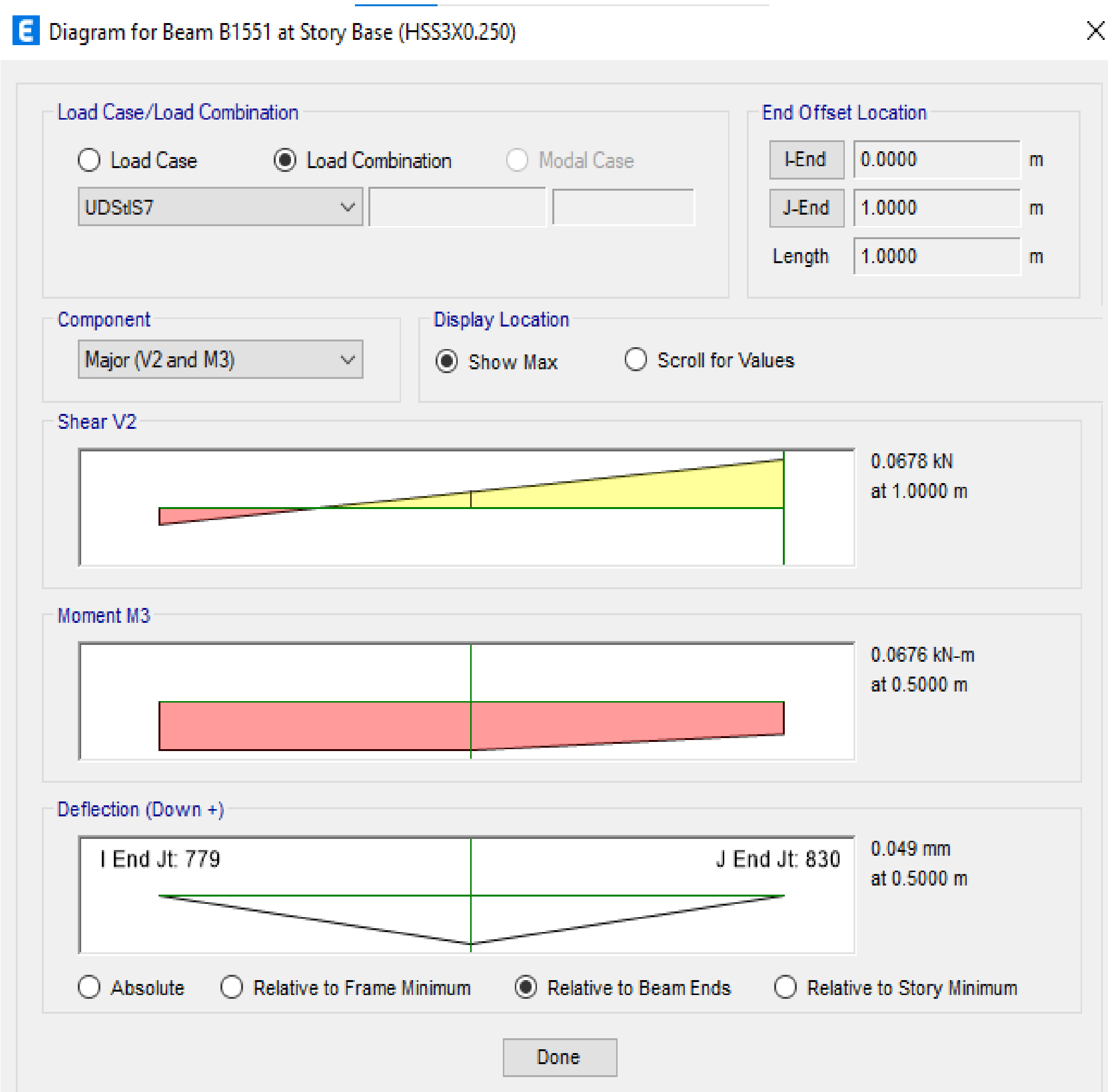


Figure 4.35: Guide to Analysis and Results ETABS.

4.9.4 Shear Force and Bending Under Load Combination Udstls11

The shear force and bending moment envelopes of HSS3X0.250 Section under load combination UDStlS11 are shown in figure 85. The shear force value was measured as 0.11170 KN and Bending moment value was 0.1613 KN-m.

Figure 4.36: Guide to Analysis and Results ETABS.

4.9.5 Shear Force and Bending Under Load Combination Udstls11

The shear force and bending moment envelopes of HSS2.500X0.188 Section under load combination UDStlS11 are shown in figure 86. The shear force value was measured as -0.03650 KN and Bending moment value was -0.0296 KN-m.

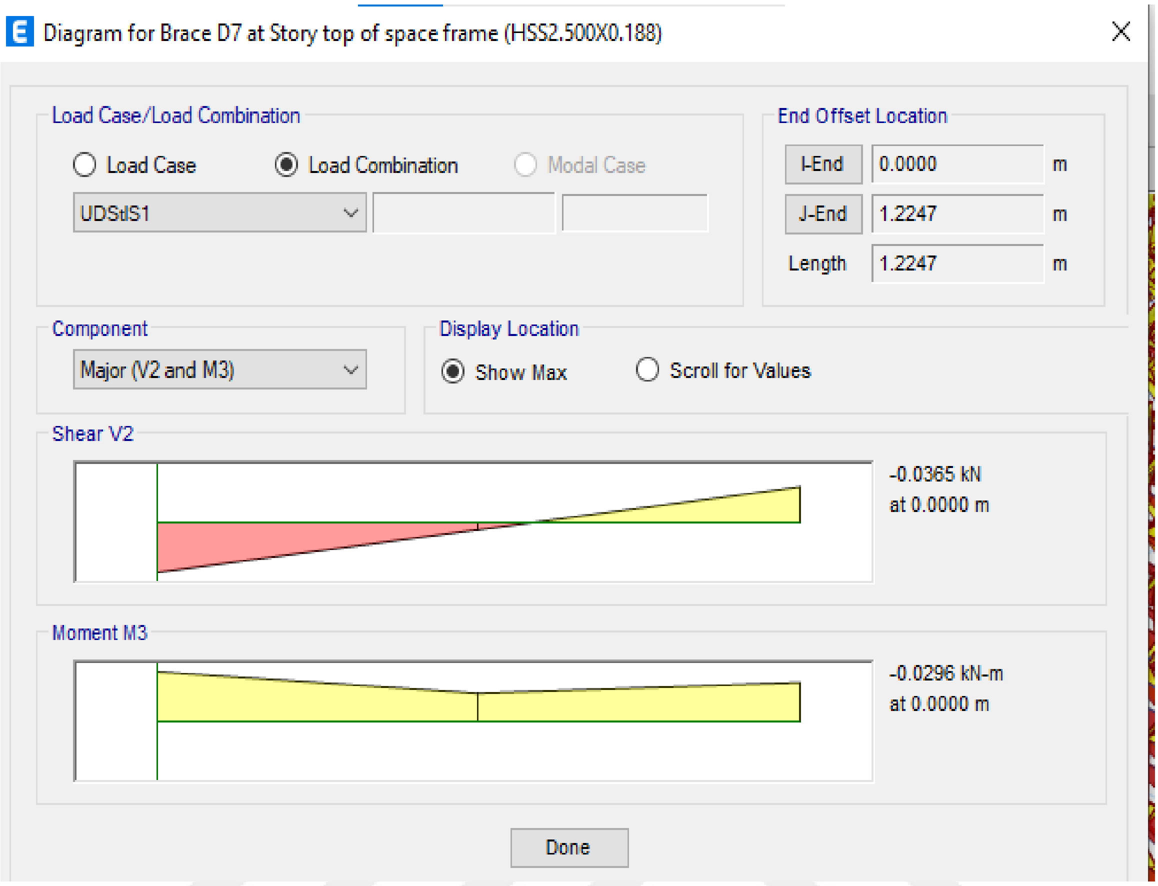


Figure 4.37: Guide to Analysis and Results ETABS.

4.9.6 Shear Force and Bending Under Load Combination Udstls2

The shear force and bending moment envelopes of HSS2.50X0.188 Section under load combination UDStlS2 are shown in figure 87. The shear force value was obtained -0.0408 KN and Bending moment value was -0.0492 KN-m.

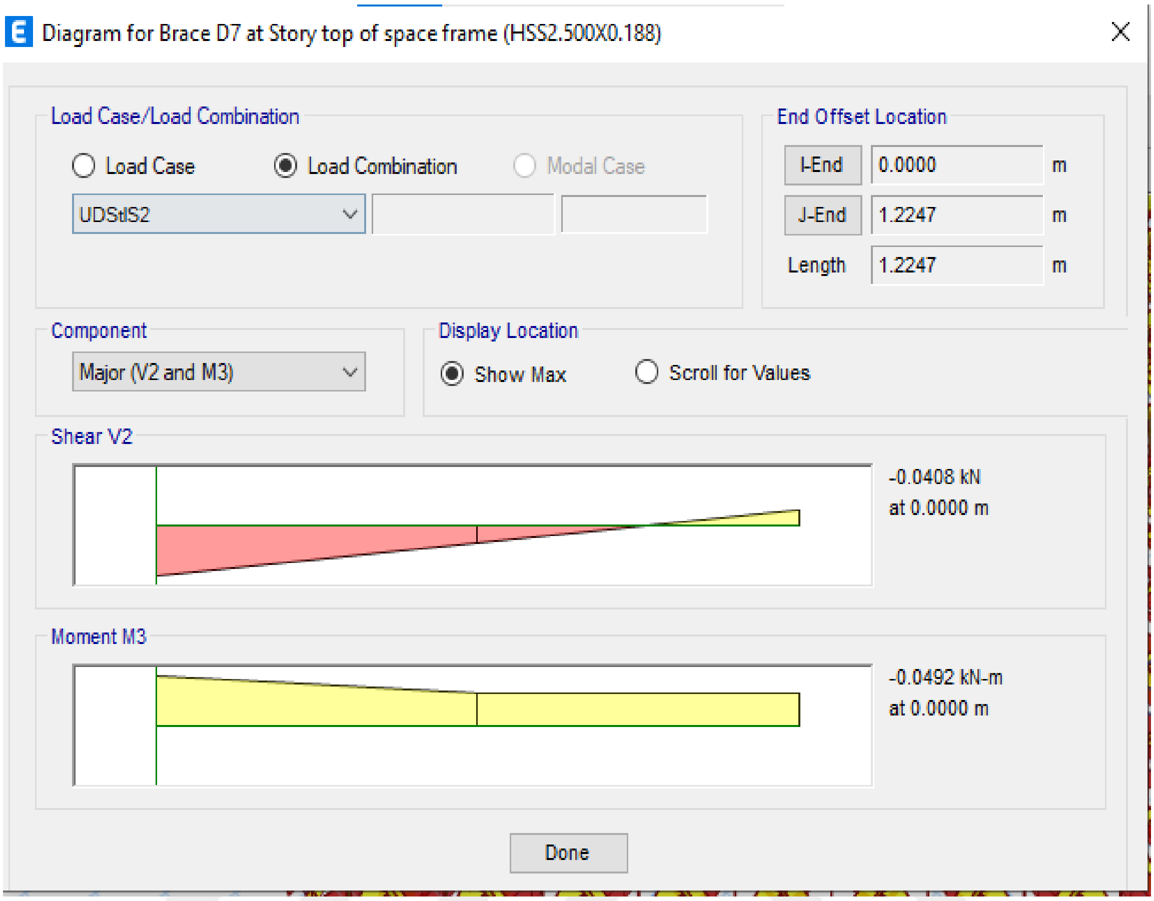


Figure 4.38: Guide to Analysis and Results ETABS.

4.9.7 Shear Force and Bending Under Load Combination Udstls7

The shear force and bending moment envelopes of HSS2.5X0.188 Section under load combination UDStlS7 are shown in figure 88. The shear force value was obtained as 0.0678 KN and Bending moment value was obtained 0.0676 KN-m.

Figure 4.39: Guide to Analysis and Results ETABS.

4.9.8 SHEAR FORCE AND BENDING UNDER LOAD COMBINATION Udstls11

The shear force and bending moment envelopes of HSS2.5X0.188 Section under load combination UDStlS11 are shown in figure 89. The shear force value was obtained -0.0401 KN and Bending moment value was -0.0426 KN-m.

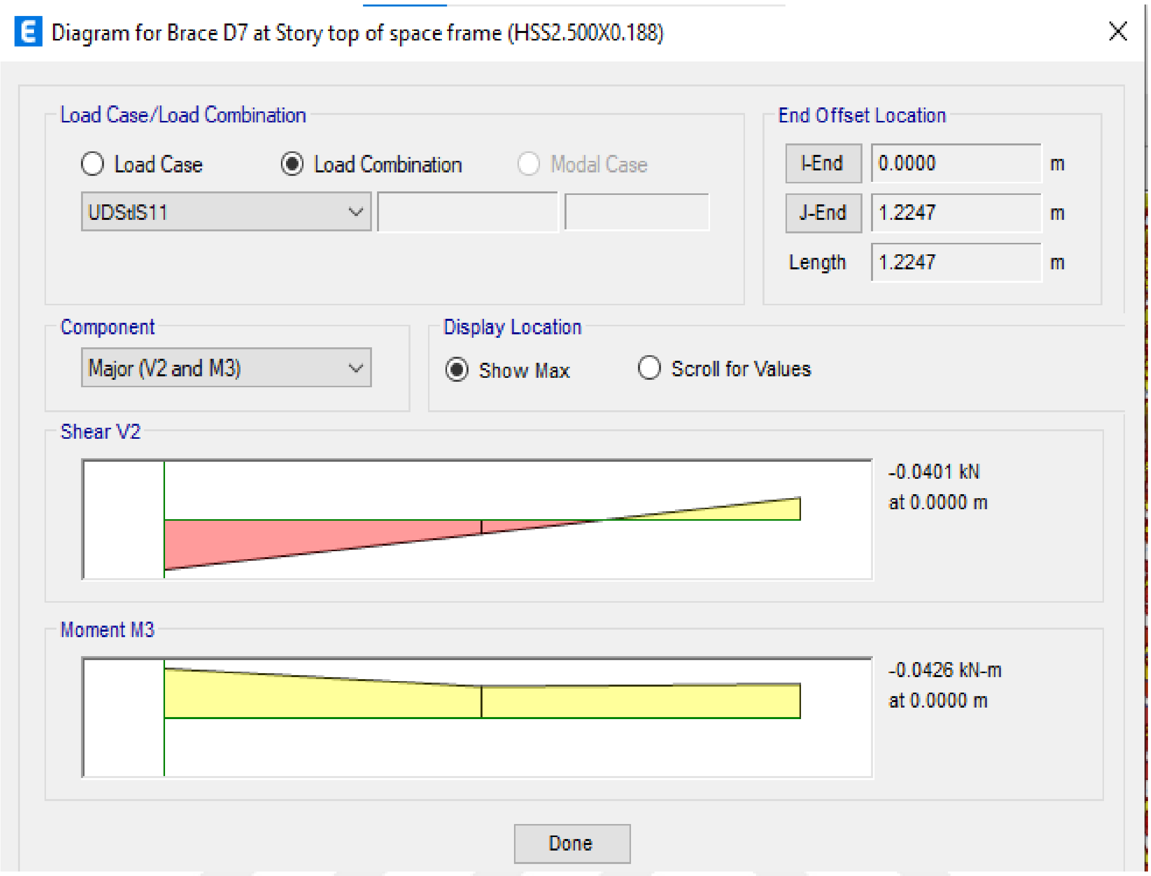


Figure 4.40: Guide to Analysis and Results ETABS.

4.10 DESIGN THE STRUCTURE AS PER ASIC 360-16

4.10.1 Revise The Preferences

Click on the design tab select steel frame design and click on view / revise preferences.

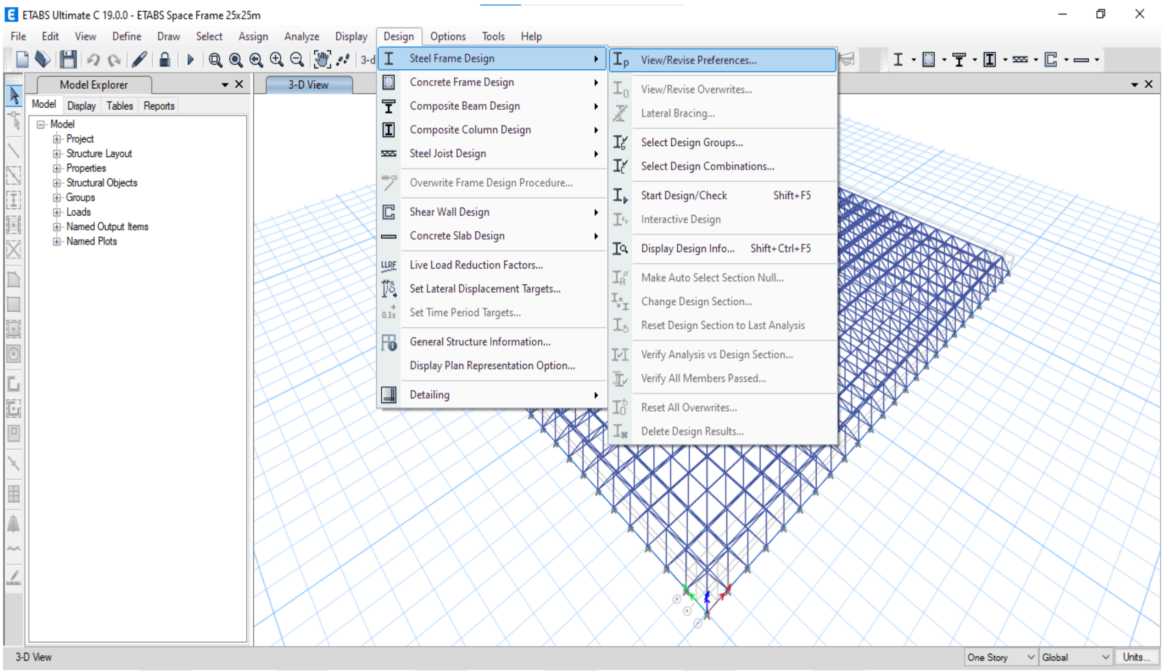


Figure 4.41: Guide to Analysis and Results ETABS.

Steel frame design preferences for AISC 360-16 were open

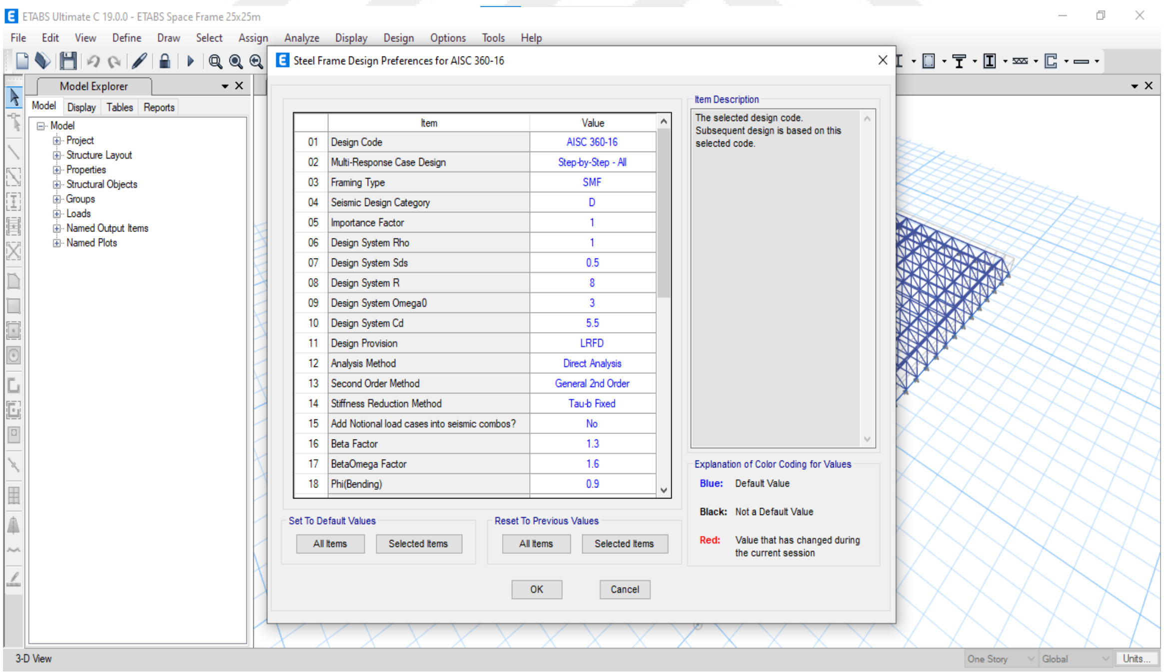


Figure 4.42: Guide to Analysis and Results ETABS.

Modify the importance factor, system over strength factor and Cd as per ASCE 7-02.

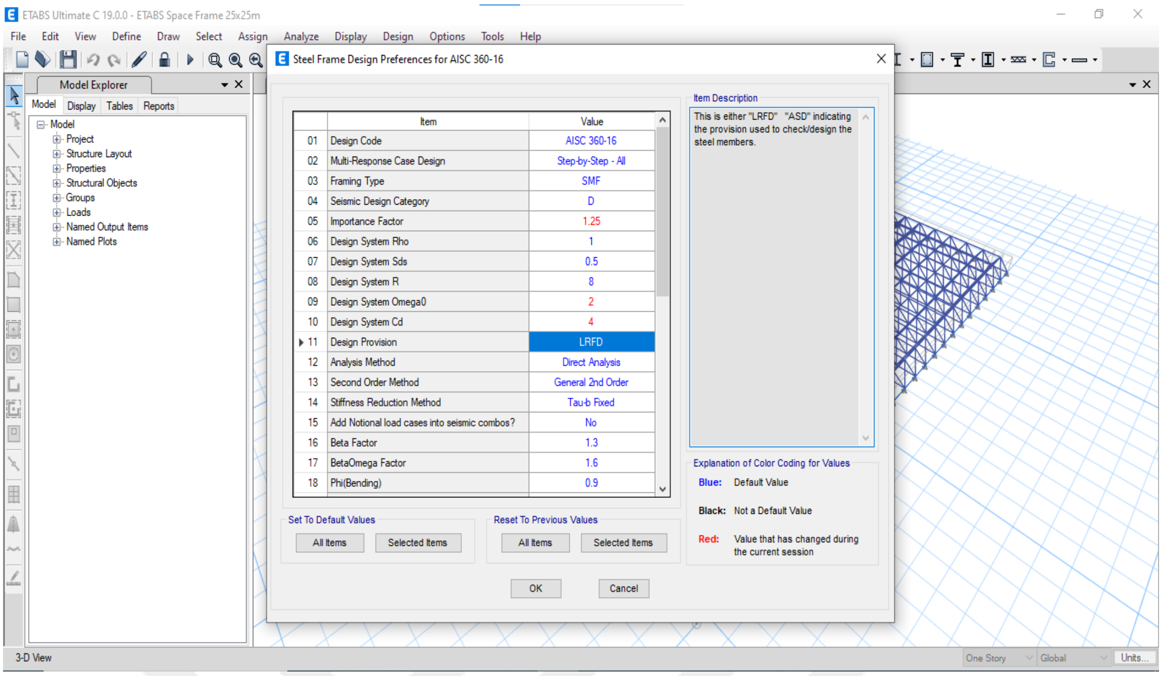


Figure 4.43: Guide to Analysis and Results ETABS.

Click on the design tab select steel frame design and click on start design check.

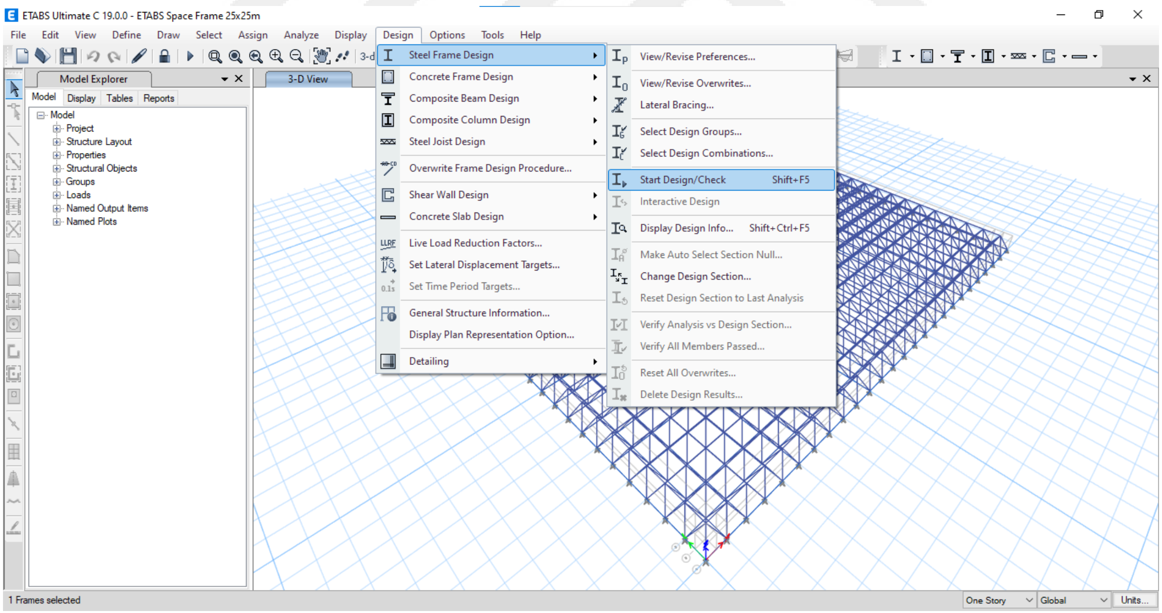


Figure 4.44: Guide to Analysis and Results ETABS.

The obtained result of P-M ratios shows that the at the mid-sections of the structure P-M ratios lies 0.5 to 0.7 shown in figure 94 and the sides-sections lies between 0.0 to 0.50.

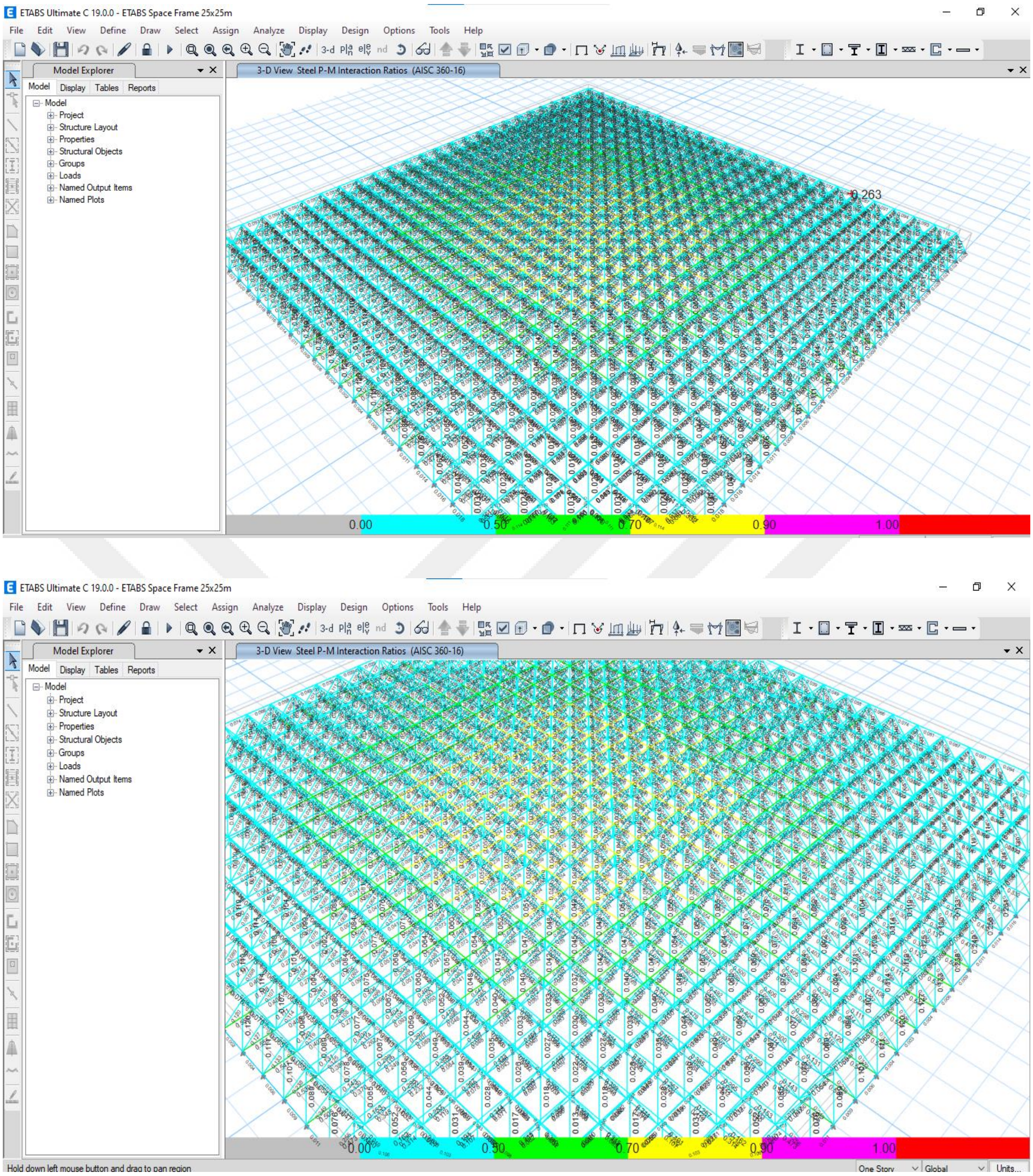


Figure 4.45: Guide to Analysis and Results ETABS.

5. CONCLUSION

5.1 CONCLUSION

This study modeled and analyzed the space frame structure using ETABS V19 and American Standards. Structure was 25 x 25 m. Standard ASTM A36 and A36 grade used ASIC-14 HSS3X0.250 and HSS 2.5X0.188 steel sections. Load cases included LL, SIDL, WLX, WLY, ELX, and ELY. ASCE-7-02 determined seismic loads. American Standards defined the built-in load combination.

The proposed structure was analyzed using 18 ETAB-constructed load combinations. The load combination UDStlD2 resulted in the maximum deflection of 5.01mm for the proposed structure. The load combination UDStlS2 resulted in the maximum deflection of 7.26 mm.

Results were obtained for the major load combinations UDStlS1, UDStlS2, UDStlS7, and UDStlS11 based on an analysis of the shear force and bending moment envelops for the proposed structure in terms of section strength. For HSS 3 X 0.250, the highest shear force and bending moment values obtained were 0.1920KN, while for HSS 2.5 X 0.188, the highest shear force value was -0.03650KN and the bending moment value was -0.0296KN. The obtained results of shear force and bending moment for both sections indicate that the structure is both strong and cost-effective. The obtained P-M ratios values lies between 0.5 to 0.70 at the mid- sections and 0.0 to 0.5 at side-sections

The following are some of the indications this study suggests.

a. The observed deflection under serviceability load combination value was measured extremely low, indicate that the proposed model is safe in terms of deflection for both HSS sections.

b. The observed deflection under strength load combination value was measured extremely low, indicate that the proposed model is safe in terms of deflection cause by strength load combinations for both HSS sections.

c. The bending moment and shear force values obtained show that the both HSS section are internally stronger to resist the bending stress in terms of strength with different load combinations.

d. The P-M ratios values shows that the side sections of the proposed model are not economical. It indicates that the side section should be replaced with the smaller sections for economic structure.

5.2 RECOMMENDATION

Based on the findings of this study, it is recommended to carry out analyses utilizing various steel sections and various design codes in order to understand the behavior of structures in various regions based on the codes. In addition, to determine the behavior of the structure using a greater variety of distinct load cases and combination loads, as well as stability under a variety of conditions. Furthermore, to carry out research on the structure in terms of its strength and economy under a variety of loading conditions and section configurations.

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