

# Structural Analysis of Heavy Vehicle Chassis Using Various Geometries and Materials

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## Abstract

*The present research investigates the significance of the automobile chassis as a crucial section of a vehicle that provides a framework for the body and other parts to rest on. It highlights the need for the chassis to have sufficient bending stiffness for the best handling qualities, as well as enough rigidity to withstand shocks, twists, vibrations, and other loads. The draft and designing model for all the sections (I, C Square/Box) are designed according to the heavy vehicle chassis. The Maximum stress, Maximum strain and Total deformation are all factors that were taken into account when designing the chassis. In this study, optimizing the performance of vehicle chassis is the main significance of the chassis. It takes into account restrictions like max deformation, stress distribution, strain distribution for the I, C, and square/box section tubes are used in the chassis main structure and different materials including A709M Grade 345W structure steel, Grey cast iron, AISI 4130 steel alloy, ASTM A710 steel grade A, AISI4340 are used. Solid Works was used to create a solid model of the chassis during the initial modelling process. The solid model was then loaded into ANSYS 16.0 for analysis.*

**Keywords:** Chassis, Bending Stiffness, Vibrations, Shocks, Deformation.

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## INTRODUCTION

Essentially, an automobile's chassis acts as a structural structure that supports the body, engine, and other key parts of the vehicle. It is essential for giving the entire vehicle general support and rigidity. A chassis typically consists of a number of transverse cross elements that intersect the longitudinally expanding channels. Due to the smaller cross section of these transverse elements, a storage area that extends longitudinally can be created. The chassis, which is focused around the driver's cockpit, is in charge of housing the different parts required for the race car's functionality. The main functions of a motor vehicle frame are to effectively support both the body and the chassis parts.

The frame must be able to endure the twisting forces that are produced when moving across uneven ground, both vertically and torsion ally. In addition, it must endure lateral transverse stresses brought on the side winds, road conditions, and steering actions. The frame must moreover be able to bear the torque that the engine and gearbox

produce as well as longitudinal tensile forces during acceleration and compression forces during braking. The frame should also be able to endure unexpected impacts brought on by crashes. Finite Element Analysis (FEA) was used in the study to simulate the performance of a Ford AC Cobra ladder frame under applied stresses.

The research was carried out in stages, starting with the Autodesk Fusion 360 chassis modelling procedure. After that, static loading was applied to the frame by using a vertical force and fixed constraints. At the frame's front and back wheel bases, the fixed limitations were imposed. The maximum displacement of the chassis was calculated using finite elements, and the safety factor was found to be 1.153. Furthermore, it was discovered that the chassis maximum von-Mises Stress was 264.4 MPa. According to these findings and the material qualities used, the developed chassis can sustain a vertical load of 4900 N while still deforming within the elastic range and staying inside the permissible zone [1]. The performance of urban vehicle chassis, with a particular emphasis on conforming to requirements for energy-efficient vehicle contests as the National Energy Efficient Vehicle Competition or the Shell Eco-Marathon Asia.

In order to determine its effect on performance, the analysis takes into account a particular operational component, namely the material utilised in the chassis. The Autodesk Fusion 360 programme is used for modelling and numerical analysis of the chassis utilising a finite element method. The observed data show a declining trend in strength with decreasing material thickness. Additionally, variations in load distribution are seen in a number of situations, suggesting the impact of diverse materials on force distribution [2]. To improve the passenger truck chassis by figuring out the ideal circumstances that will increase its capacity. The analysis of stress distribution for various cross-sections under varied loading situations with respect for the stress concentration factor is the main objective.

The whole structure of the vehicle depends heavily on the chassis, and faults are frequently brought on by static loading situations. The real carrying capacity of passenger buses is lower in the local area due to uneven loading conditions between haulage and passenger trucks. The maximum stress and maximum deflection are the primary design parameters for the passenger truck chassis. The maximum stress and deflection are calculated in this study to pinpoint the key areas under various loading situations. Under varied loading situations, stress analysis is carried out utilizing a variety of cross-sections. The results underline the significance of I cross-section in boosting chassis capacity and emphasize how crucial it is to take stress concentration factors into account when choosing the right profile.

This information is useful in determining the static properties of the chassis. To forecast regions that are vulnerable to failure under particular loading conditions, finite element analysis is used. The study offers unmistakable insights into chassis stress analysis, showing that I cross-section is the best option because it shows less stress and deflection [3]. For modelling and analysis of a heavy vehicle chassis made of three different composite materials—Carbon Steel, HSLA Steel, Structural Steel, High Strength Steel, Alloy Steel, ASTM A710 Steel, Aluminum 6061T6, and AISI4130 Alloy—subjected to the same pressure as a steel chassis, the dimensions of an existing heavy vehicle chassis of a TATA 2515EX vehicle are used. Stresses and deflections served as design limitations. Three different cross-sections, namely the C, I, and Box type cross sections, have been taken into consideration when modelling each heavy vehicle chassis. Applying vertical loads operating on various horizontal cross sections allows for design validation. Software is employed in this project, including ANSYS Workbench 15 for analysis and SolidWorks for modelling [4]. A 10-noded brick element was used for the truck chassis frame's finite element analysis. Analyses of static and modal data were used to evaluate the effectiveness of the chassis frame. The static analysis was essential in figuring out how much stress was placed where in the chassis frame overall.

The static and modal study used stainless steel and duralumin materials to look at the structure's stress levels and mode forms. Duralumin outperformed structural steel, according to a comparison of the data obtained from Duralumin and stainless steel. The newly developed chassis proved that it could support loads of up to 18 tonnes while maintaining a light weight thanks to the use of Duralumin. The tabular column, which amply demonstrated that Duralumin outperformed Structural Steel, served as confirmation of this. The investigation also showed that Duralumin had a greater factor of safety, demonstrating its superior strength, but having somewhat more deformation than aluminum. Because Duralumin is a lightweight material, including it in the chassis reduced overall weight, which improved the vehicle's efficiency [5]. The ASTM A710 Steel, ASTM A302 Alloy Steel, and Aluminum Alloy 6063-T6 are three different materials that were used to examine the TATA Eicher E2 (Model No. 11.10) truck chassis. To guarantee a fair comparison, these materials are put under the identical load circumstances. We have taken into account three different cross-sections: C, I, and rectangular box (hollow) type cross sections, in order to accurately mimic the various vehicle chassis. Each cross-section has distinct structural features, and each will be assessed for how well it performs and fits the required load conditions.

Gaining knowledge of each cross-section's own strengths and shortcomings through analysis. Given considerations like strength, weight, and overall structural integrity, this thorough study will help choose the best material and cross-section for the TATA Eicher E2 (Model no. 11.10) Truck chassis. The outcomes of this research will help to improve the chassis performance and design [6, 7].

The strength, stiffness, fatigue characteristics, stress, bending moments, and vibrations of commercial vehicles' structures. In order to accomplish this, a combination of static and dynamic analysis approaches will be used, fusing previously developed theoretical frameworks with cutting-edge analytical tools. By doing these studies, the study hopes to produce findings that will improve the general effectiveness and dependability of commercial vehicle architectures [8, 9]. The basic structural framework for a commercial vehicle is the truck chassis. Its main function is to support the many payloads and components that are put upon it.

The unevenness of the road surface causes vibrations to be transmitted to the truck's chassis as it travels down the road. Furthermore, the presence of vibrating components put on the chassis may cause further vibrations [10]. For the building of the chassis, an effort has been made to investigate several cross-sectional shapes, including square, rectangular, and tubular. Using CATIA software, a thorough chassis model that adheres to the fabricated structure has been built. It is based on a number of features. ANSYS software has been used to accomplish the meshing process, which entails geometry clean-up, the creation of 2D and 3D meshes, and the development of nodes and elements with connectivity. The 3D tetrahedral solid elements used in the finite element (FE) mesh model were selected to deliver results that are as accurate as possible. The primary aim of this study is to ascertain the linear static stress distribution within the most stress-prone section of the chassis and predict potential failures. The Finite Element (FE) analysis was conducted on a model representing a lightweight vehicle chassis, utilizing widely recognized commercial software packages such as CATIA and ANSYS [11]. This study involves the modelling and analysis of the dimensions of an existing TATA 2515EX heavy vehicle chassis. The focus is on comparing the performance of the original steel chassis with three distinct composite materials: Carbon/Epoxy, E-glass/Epoxy, and S-glass/Epoxy [12]. This study utilized the ABAQUS large-scale software to analyze the natural vibration frequency and dynamic mode of SX360 dump truck frames. The findings offer essential theoretical insights for the optimization of frame design [13]. An analysis of the structural integrity of a ladder frame chassis has been conducted through Finite Element (FE) analysis, drawing inspiration from the design of the Ford AC Cobra [14]. The objective of this project is to create and assess a chassis frame, ensuring its compliance with safety limits. In reviewing previously published papers, this study seeks to contribute insights into the utilization of Finite Element Analysis (FEA) and design software for the comprehensive analysis of chassis frames. Through this exploration, the paper aims to offer a fundamental understanding of the application of FEA and design tools in the scrutiny of

chassis frame designs [15, 16, 17, 18]. Selecting an appropriate configuration is essential, allowing for versatility in diverse applications by fully grasping the composite's potential. This involves a thorough analysis of stress and strain distribution across the materials to ensure optimal performance across various use cases [19, 20].

## METHODOLOGY

A variety of materials have been chosen for the analysis of the chassis structure of a large vehicle. Their composition and qualities have been looked at. Materials like ASTM A710 steel grade A, A709M Grade 345W structure steel, grey cast iron, AISI 4130 steel alloy, and AISI 4340. A709M Grade 345W structure steel, utilized in the chassis and manufactured by Ashok Leyland, offers improved performance as compared to the current vehicle model. For all the various material structures, the stress, strain, and deformation characteristics are evaluated while taking into account distinct sections like I section, C section, and Square/BOX section. SolidWorks was used to create a solid model of the chassis during the initial modelling process. The solid model was then loaded into ANSYS 16.0 for analysis, where normal load conditions were used to replicate actual-world events. The analysis' main objective was to assess the chassis' stress and deformation properties to make sure they adhere to the required design limitations. The stress distribution and deformation patterns could be evaluated by subjecting the model to these load conditions, giving important insights into the structural integrity and functionality of the chassis design.

The software Ansys is used to develop and assess the chassis construction in order to conduct the study. A709M Grade 345W structure steel was used for the chassis, which is illustrated in Figure 1 as a 2D drafted and designed model of I cross section. The specifications were obtained by comparing them against an existing vehicle model made by Ashok Leyland. Similar to Figures 2 and 3, which show the 2D drawn and design model of the C section and SQUARE/BOX section, respectively, the dimensions are determined using the existing vehicle's requirements. A full investigation of the stress, strain, and deformation behaviors' displayed by the various material structures in various chassis parts is made possible by this exhaustive analysis. Studying these traits can provide important information on the performance and compatibility of the materials selected for heavy vehicle chassis construction. Solid Works is a capable solid modelling programme that builds models and assemblies using a parametric feature-based approach. Its capabilities are based on the Para solid-kernel, which is the structure on which it is constructed. In SolidWorks, parameters are essential because they specify the restrictions that control the models or assembly's shape and geometry.

## MATERIALS SELECTION

The choice of materials used for a vehicle's chassis analysis is crucial in determining the chassis' overall performance, strength, and longevity. The vehicle's chassis acts as its supporting structure, assuring the safety of its occupants and the integrity of its parts. The physical characteristics of the materials chosen for the chassis study are shown in Table 1.

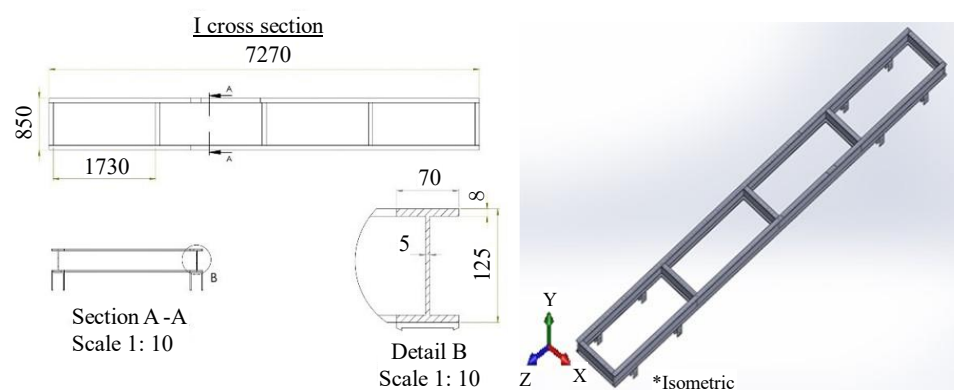


**Figure 1.** Drafting and Designed Model of I Cross Section Chassis.

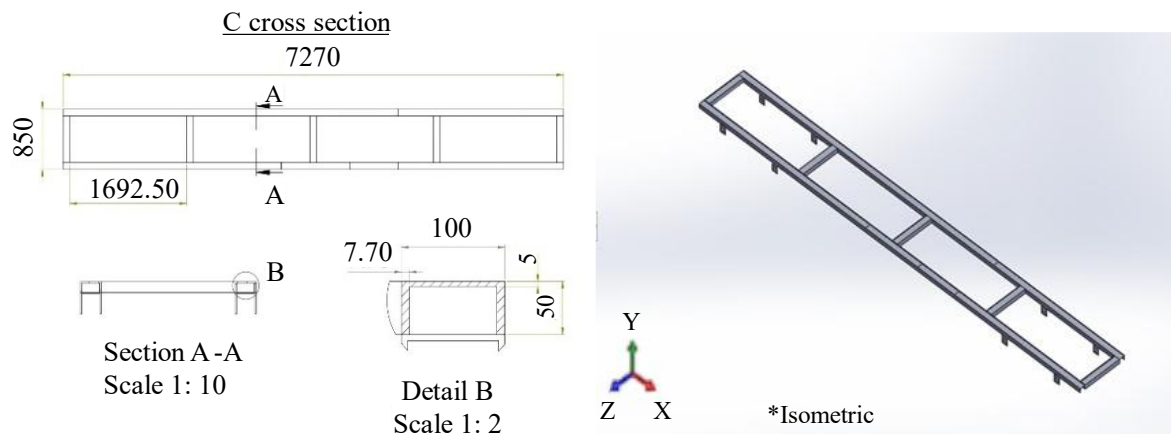


**Figure 2.** 2d Drafting and Designed Model of C Cross Section Chassis.

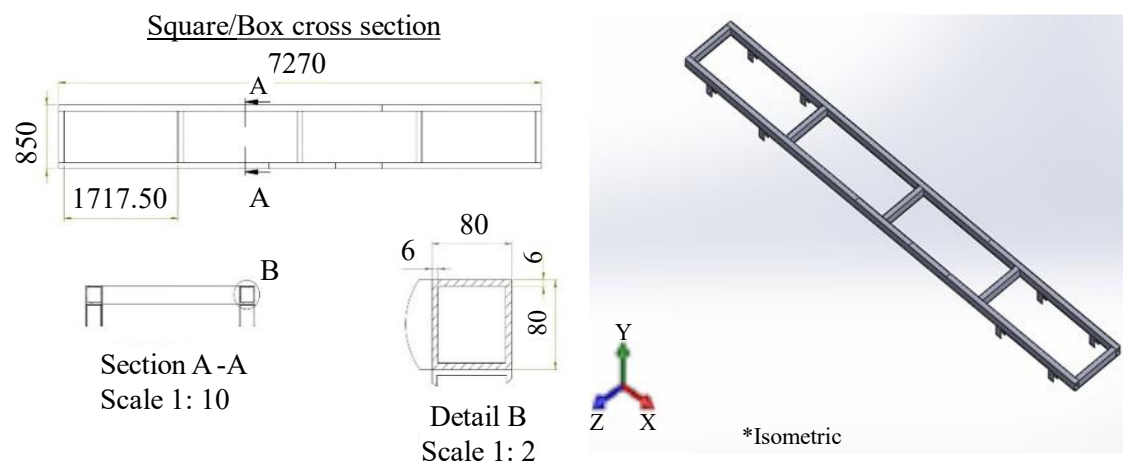


**Figure 3.** 2d Drafting of Drafting and Designed Model of Square/Box Cross Section Chassis.

### A709M Grade 345W Structure Steel

Building A709M Grade 345W High-strength low-alloy (HSLA) steel is a kind that is frequently utilised in the auto industry. It is purpose-built to provide improved structural performance, longevity, and resistance to a range of environmental factors. The following substances are frequently present in A709M Grade 345W steel: Sulphur (S), Silicon (S), Copper (Cu), Nickel (Ni), Chromium (Cr), and Manganese (Mn) are some of the elements that make up the periodic table.

### Grey Cast Iron

Grey iron, often referred to as grey cast iron, holds significant prominence in the automotive industry. Its name, “grey,” stems from the characteristic hue it displays upon fracture. This material boasts several merits, including excellent casting properties, efficient heat conductivity, remarkable machinability, and cost-effectiveness. An in-depth elucidation of the elemental composition of grey cast iron follows:

- **Carbon:** Grey cast iron typically incorporates a carbon content of up to 4%, a factor pivotal in shaping its attributes such as robustness and hardness.
- **Silicon:** With a potential silicon proportion of up to 3%, grey cast iron benefits from heightened fluidity during the casting process and improved resilience against elevated temperatures due to silicon's inclusion.
- **Manganese:** The manganese presence in grey cast iron usually hovers around 0.8%, contributing to amplified strength and enhanced wear resistance.
- **Sulphur:** Normally constituting about 0.07% of grey cast iron, sulphur can exert adverse effects on its mechanical properties, rendering it more susceptible to brittleness.

- *Phosphorus*: The content of phosphorus in grey cast iron approximates 0.2%, promoting greater fluidity and castability of the molten iron.
- *Molybdenum*: Grey cast iron can encompass molybdenum up to 0.75%, thereby bolstering its strength and capacity to endure high temperatures.
- *Chromium*: With an approximate chromium content of 0.35%, grey cast iron attains heightened resistance against oxidation and corrosion.
- *Vanadium*: Typically comprising around 0.15% vanadium, grey cast iron derives augmented strength, hardness, and wear resistance from this component.

### AISI 4130 Steel Alloy

The steel alloy AISI 4130 is frequently employed in the automobile sector for a variety of purposes. It belongs to the chromium-molybdenum (Cr-Mo) family of steels and is classified as a low-alloy steel. The following components are frequently found in AISI 4130:

1. *Iron (Fe)*: The alloy's basic element and the source of its essential mechanical qualities.
2. *Carbon (C)*: Carbon, which is typically found in steel in amounts between 0.28 and 0.33%, makes the metal stronger and harder.
3. *Chromium (Cr)*: Present in concentrations ranging from 0.80 to 1.10 percent, chromium enhances the alloy's capacity to harden and increases its resistance to corrosion.
4. *Molybdenum (Mo)*: Found in concentrations of 0.15 to 0.25%, molybdenum improves the steel's tensile strength, hardness, and stability at high temperatures.
5. *Manganese (Mn)*: Manganese, which is typically present in modest amounts (0.40-0.60%), helps an alloy harden and increases its overall strength.
6. *Silicon (Si)*: Usually found in tiny levels, silicon helps the alloy deoxidize and increases its strength.
7. *Phosphorus (P)*: Phosphorus, which is present in modest amounts, enhances the steel's machinability and strength.
8. *Sulphur (S)*: Sulphur, which is also present in minor amounts, makes the alloy easier to machine.

### ASTM A710 Steel Grade A

A high-strength, low-carbon alloy steel known as ASTM A710 steel grade A was created especially for structural uses in the automotive sector. It is frequently utilised to build heavy-duty automobile parts that need to be exceptionally strong and impact resistant. The following components are frequently found in ASTM A710 steel grade A:

1. *Carbon (C)*: ASTM A710 steel grade A has a low carbon content to facilitate welding and lessen the possibility of fabrication cracking.
2. *Manganese (Mn)*: Manganese is added to steel to improve its capacity to be hardened and its tensile strength.
3. *Phosphorus (P)*: Phosphorus is added to steel in modest quantities to enhance its formability and machinability.
4. *Sulphur (S)*: To improve machinability, Sulphur is also added in very small amounts.
5. *Silicon (Si)*: Silicon is added to steel to increase its tensile strength and oxidation resistance.
6. *Nickel (Ni)*: Nickel is occasionally added to steel to increase its toughness and resistance to impacts.
7. *Chromium (Cr)*: To increase the steel's resistance to corrosion, chromium can be added in tiny levels.

### AISI4340

Due to its remarkable strength and hardness properties, AISI 4340 stands out as a widely utilized alloy steel in both automotive and technical applications. This steel variant falls within the category of nickel, chromium, and molybdenum-containing steels. Here is an overview of the composition of AISI 4340:

- *Iron (Fe)*: Constituting the fundamental bulk of AISI 4340's composition, iron is the primary element.
- *Carbon (C)*: Incorporated to enhance hardness and strength, carbon is a key component of AISI 4340. Typically, the carbon content in AISI 4340 ranges from 0.38% to 0.43%.
- *Chromium (Cr)*: The inclusion of chromium in the steel formulation is aimed at improving hardenability and corrosion resistance. Typically, AISI 4340 contains around 0.7% chromium.
- *Molybdenum (Mo)*: Molybdenum plays a pivotal role in conferring high strength and toughness to AISI 4340. It also contributes to heightened resistance and improved hardenability.
- *Nickel (Ni)*: Of critical significance to AISI 4340, nickel substantially bolsters toughness, impact resistance, and fatigue strength. The nickel content in AISI 4340 varies from 1.65% to 2.00%.

Table 1 presents the physical attributes pertinent to the chassis material used in different sections. Parameters such as density, tensile strength, and yield strength are pivotal in the evaluation of chassis performance. These attributes furnish vital insights into how the chassis responds to diverse loading scenarios. Analyzing these characteristics enables an assessment of the material's suitability for various chassis components, as well as its structural integrity, strength, and other essential attributes.

**Table 1.** Characteristics of Chassis Substances in Terms of Their Physical Properties.

| S.N. | Materials                        | Modulus of Elasticity (Gpa) | Density (Kg/M <sup>3</sup> ) | Tensile Strength (Mpa) | Yield Strength (Mpa) |
|------|----------------------------------|-----------------------------|------------------------------|------------------------|----------------------|
| 1    | A709M Grade 345W structure steel | 200                         | 7850                         | 450                    | 345                  |
| 2    | Grey cast iron                   | 110                         | 7200                         | 240                    | 150-300              |
| 3    | AISI 4130 steel alloy            | 207                         | 7798                         | 1030                   | 910                  |
| 4    | ASTM A710 steel grade A          | 205                         | 7649                         | 690                    | 620                  |
| 5    | AISI4340                         | 205                         | 7698                         | 930                    | 785                  |

A comprehensive study was conducted on the structural evaluation of a sizable vehicle chassis, employing different metal types and diverse cross-sectional arrangements. The primary objective was to gauge the chassis response and behavior when subjected to different loading conditions. The investigation encompassed a range of alloy compositions, such as AISI 4340, Grey cast iron, AISI 4130, A709M Grade 345W structural steel, and AISI 4130 steel alloy. Parameters including strength, rigidity, and ability to withstand stress and deformation were evaluated for each individual alloy. The results demonstrated that the chassis exhibited varying performance characteristics based on the specific alloy employed.

From the Figures 4–18. It shows that the deformation, stress distribution and strain distribution of the I section, C section, Box section for the material A709M Grade 345W structure steel, Grey cast iron, AISI 4130 steel alloy, ASTM A710 steel grade A, AISI4340 it indicates the maximum load withstands and acting on the chassis. The points of connection for the chassis beams near the midpoint were where the most significant deformation was observed. Upon subjecting the chassis to a simulated load that matched its maximum capacity, these junctions exhibited the greatest displacement. This information holds immense importance as it ensures the chassis structural integrity remains intact without compromising safety, especially during extended periods of transporting heavy loads.

Upon analyzing stress distribution, it was evident that the weld joints connecting the chassis beams to the suspension mounts had the highest stress concentrations. These specific areas underwent elevated stress due to the combined influences of the vehicle's weight and the vibrations induced by the road. The examination of strain distribution highlighted that the chassis longitudinal beams,

particularly in the midsection, experienced the most strain. This underscores the significance of selecting materials with appropriate ductility and tensile strength to accommodate this strain without approaching critical failure thresholds.

### RESULTS OF I-CROSS SECTION CHASSIS A709M Grade 345W structure steel

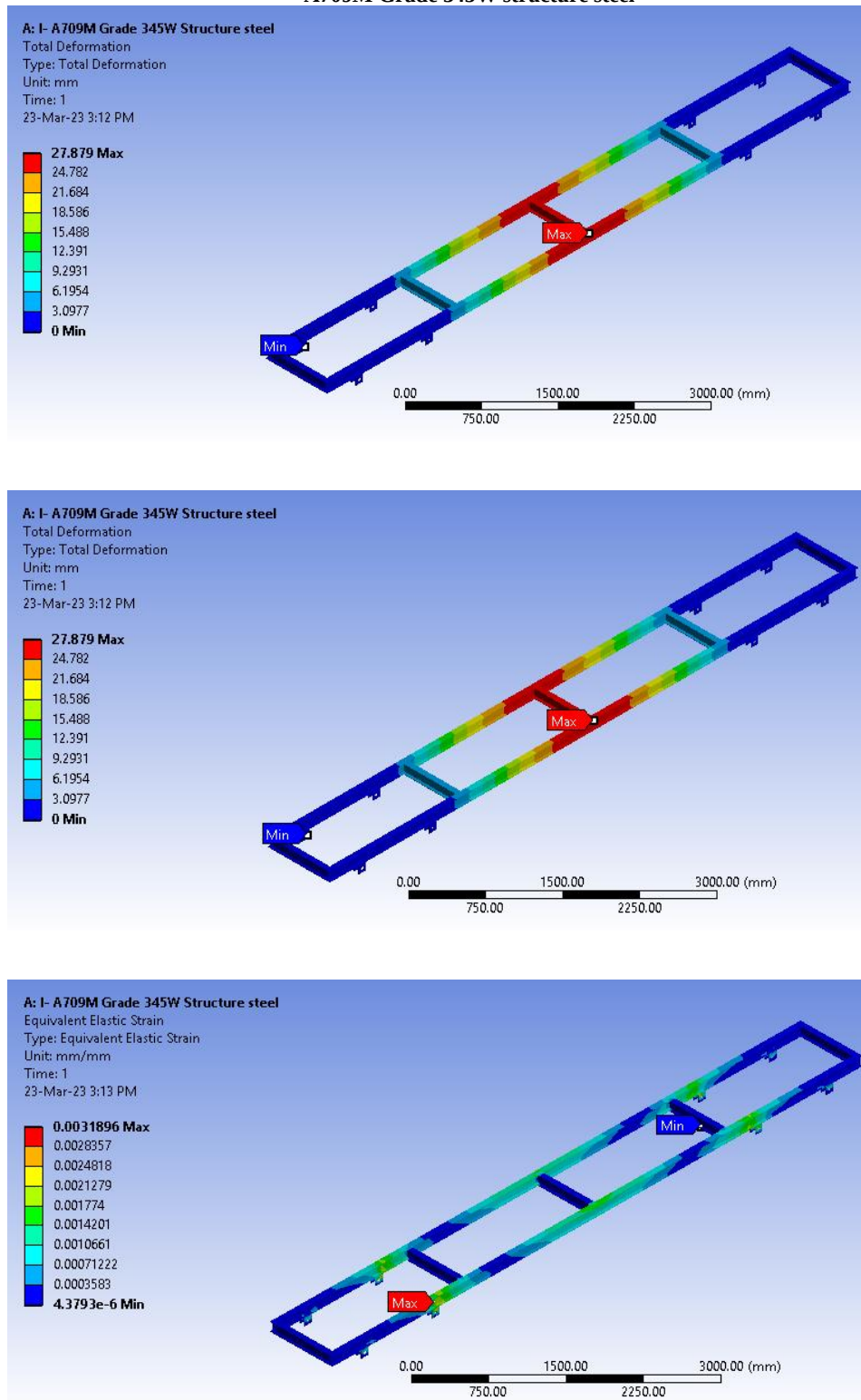


**Figure 4.** Total Deformation, Stress Distribution, Strain Distribution.

## ii. Grey cast iron

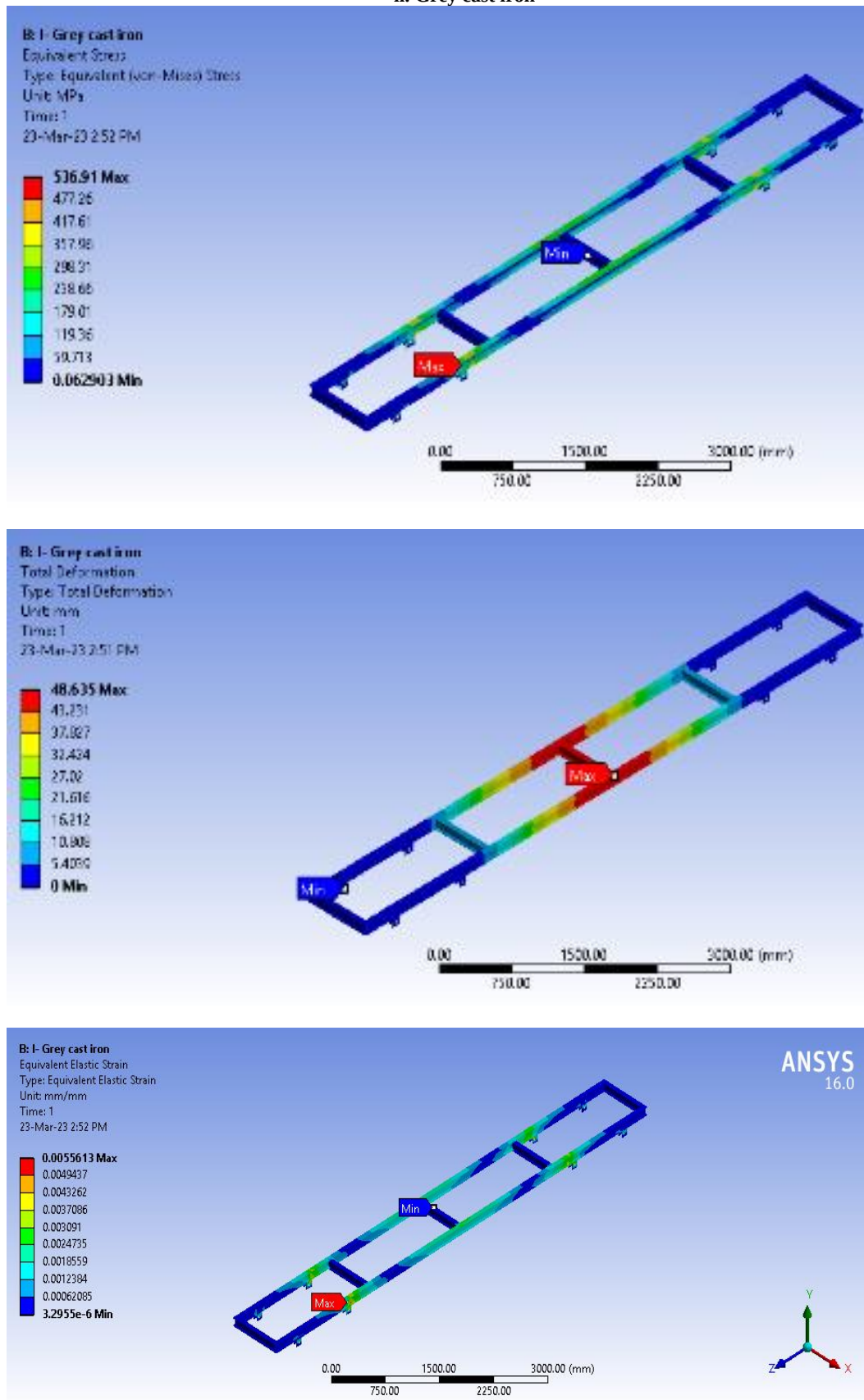


**Figure 5.** Total Deformation, Stress Distribution, Strain Distribution.

## iii. AISI 4130 steel alloy

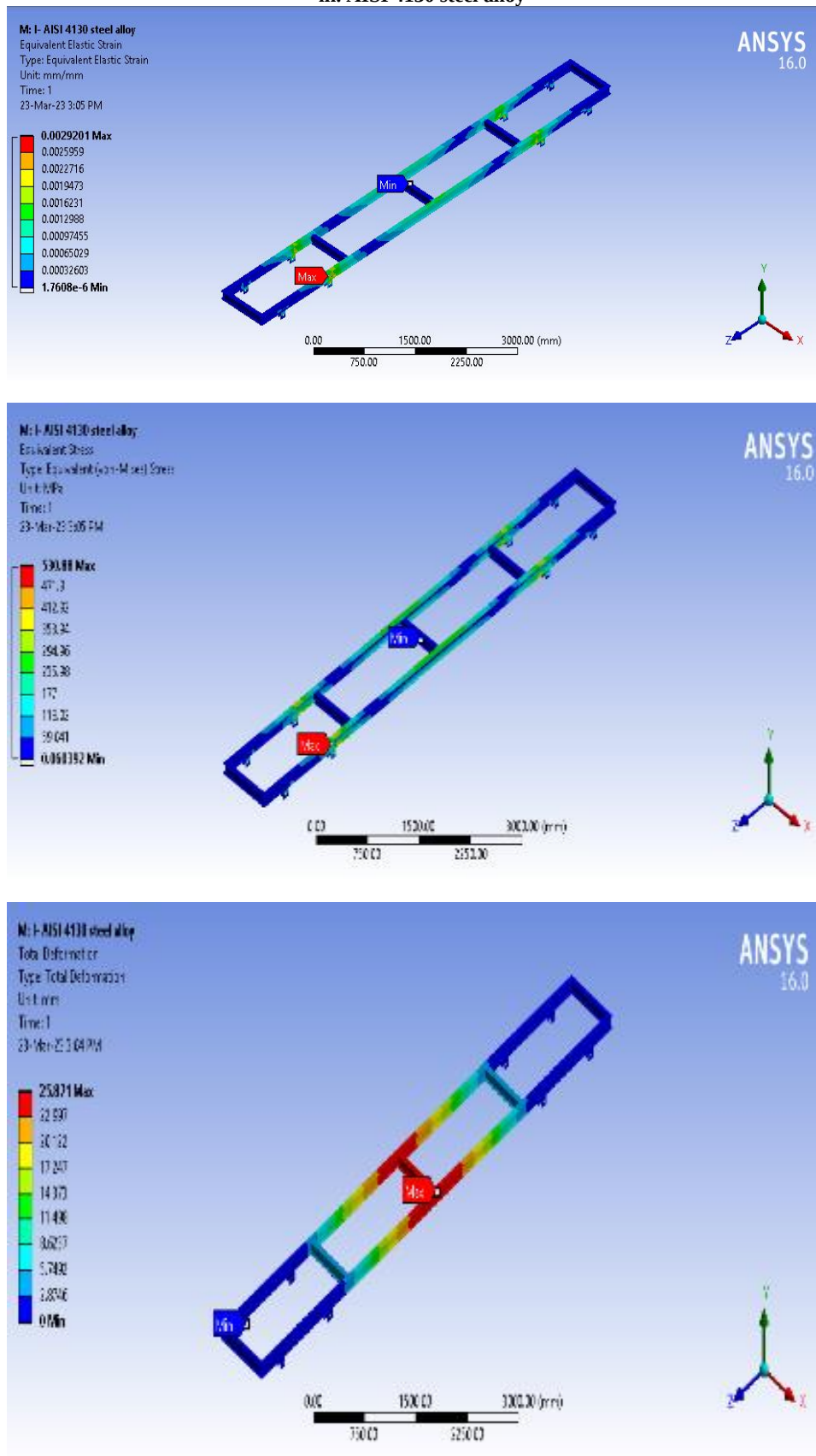


Figure 6. Total Deformation, Stress Distribution, Strain Distribution.

iv. ASTM A710 steel grade A

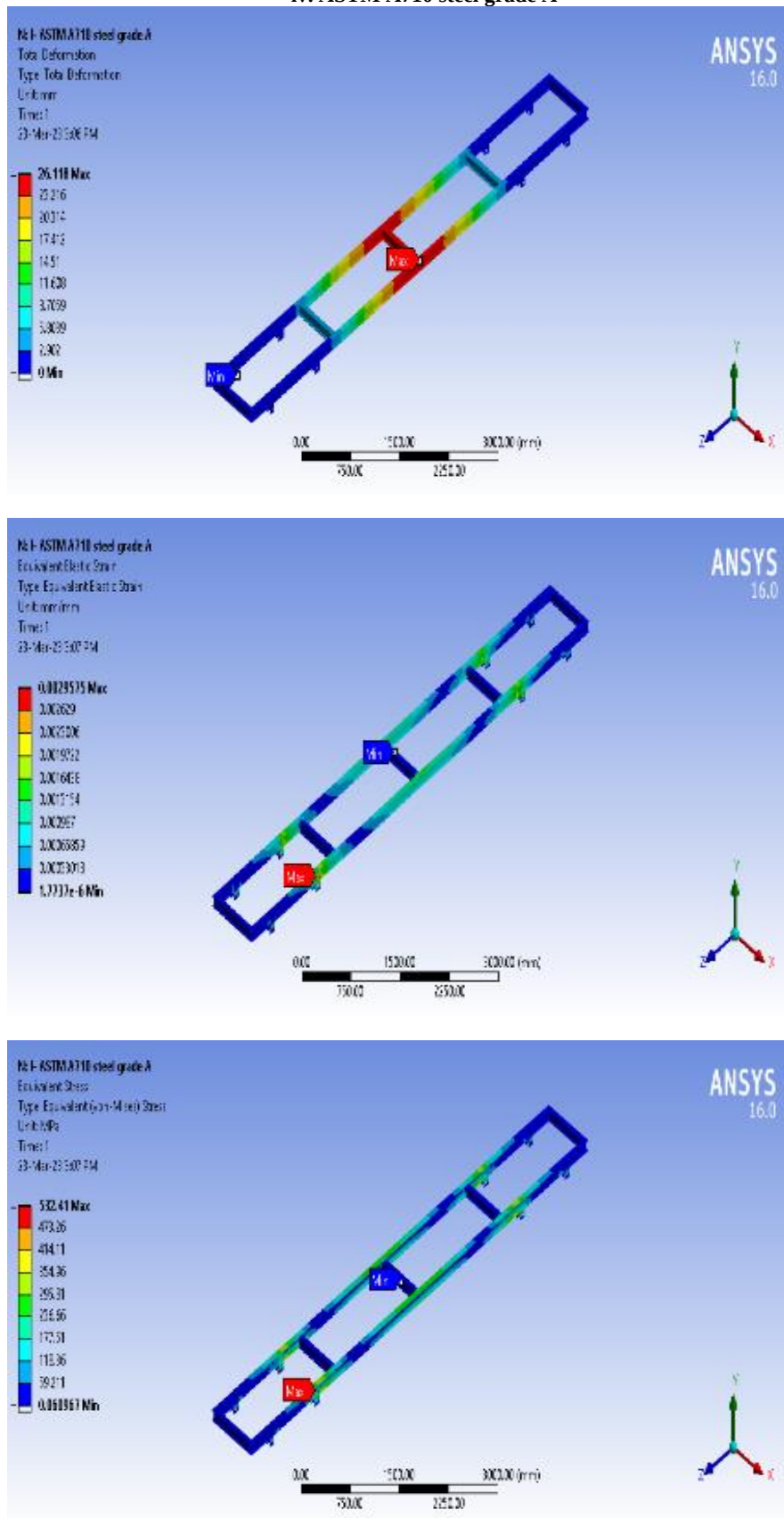


**Figure 7.** Total Deformation, Stress Distribution, Strain Distribution.

## v. AISI4340

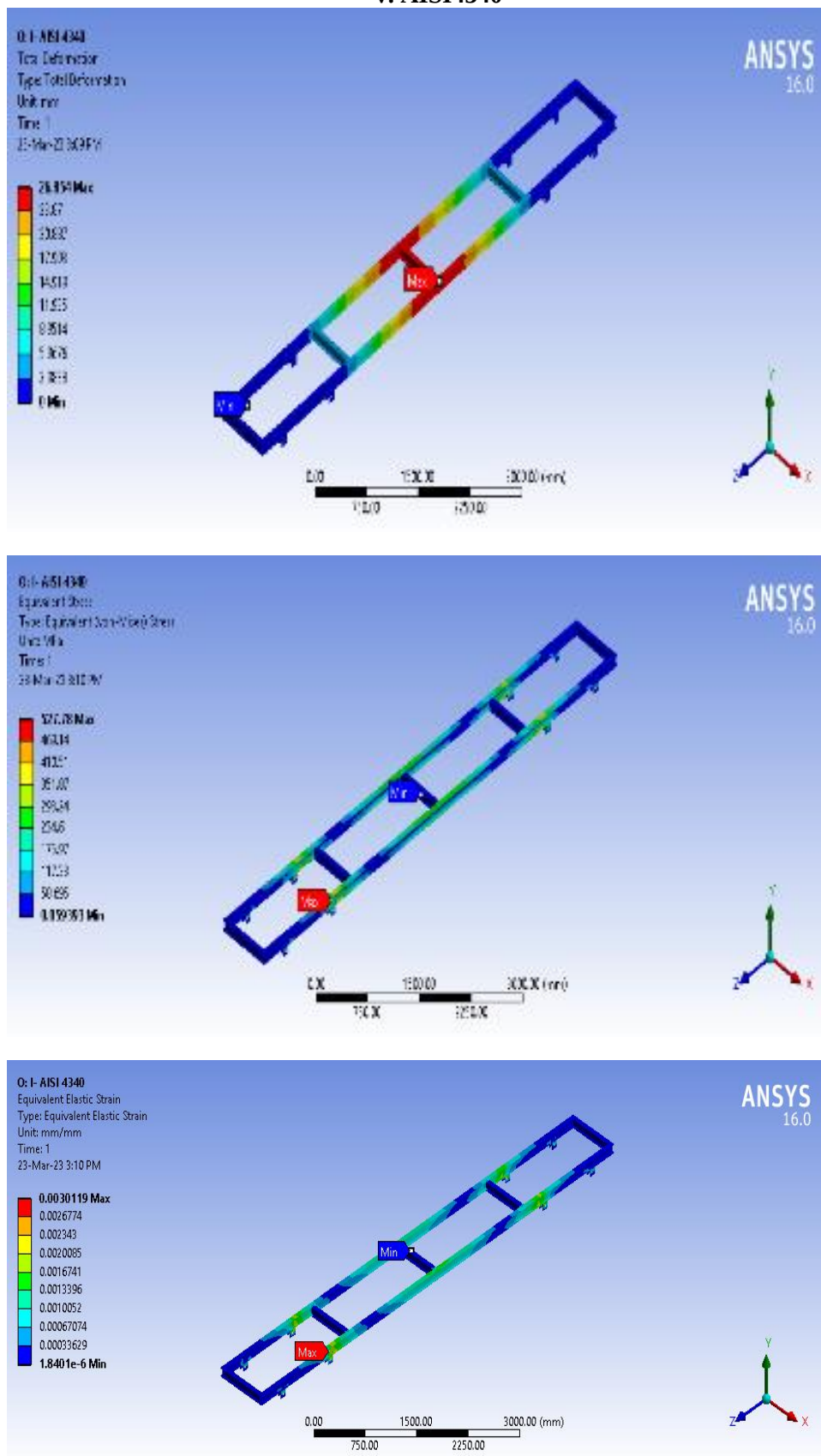


**Figure 8.** Total Deformation, Stress Distribution, Strain Distribution

## RESULTS OF C CROSS SECTION CHASSIS

### i. A709M Grade 345W structure steel

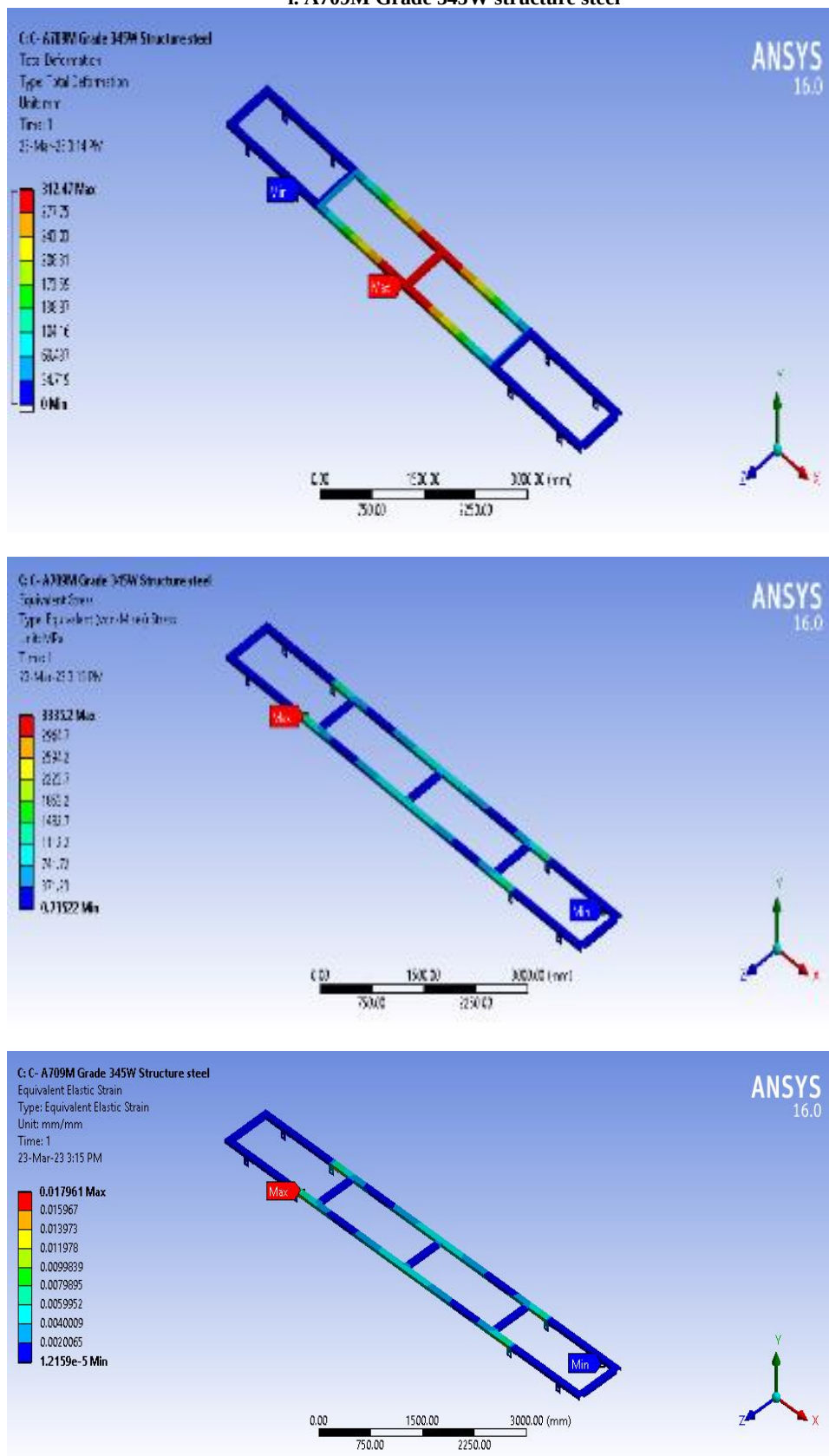


**Figure 9.** Total Deformation, Stress Distribution, Strain Distribution.

## ii. Grey cast iron

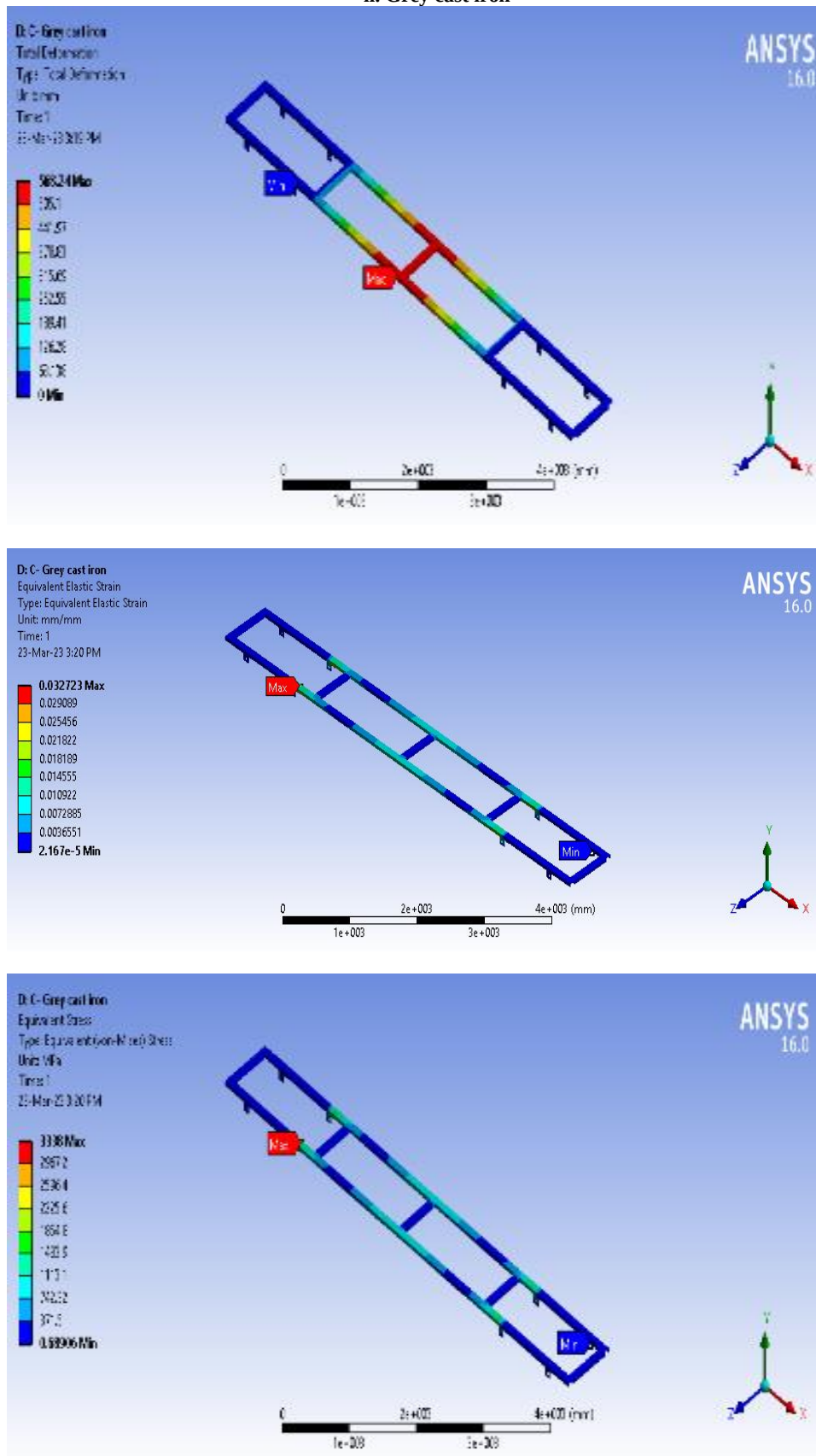


**Figure 10.** Total Deformation, Stress Distribution, Strain Distribution.

### iii. AISI 4130 steel alloy

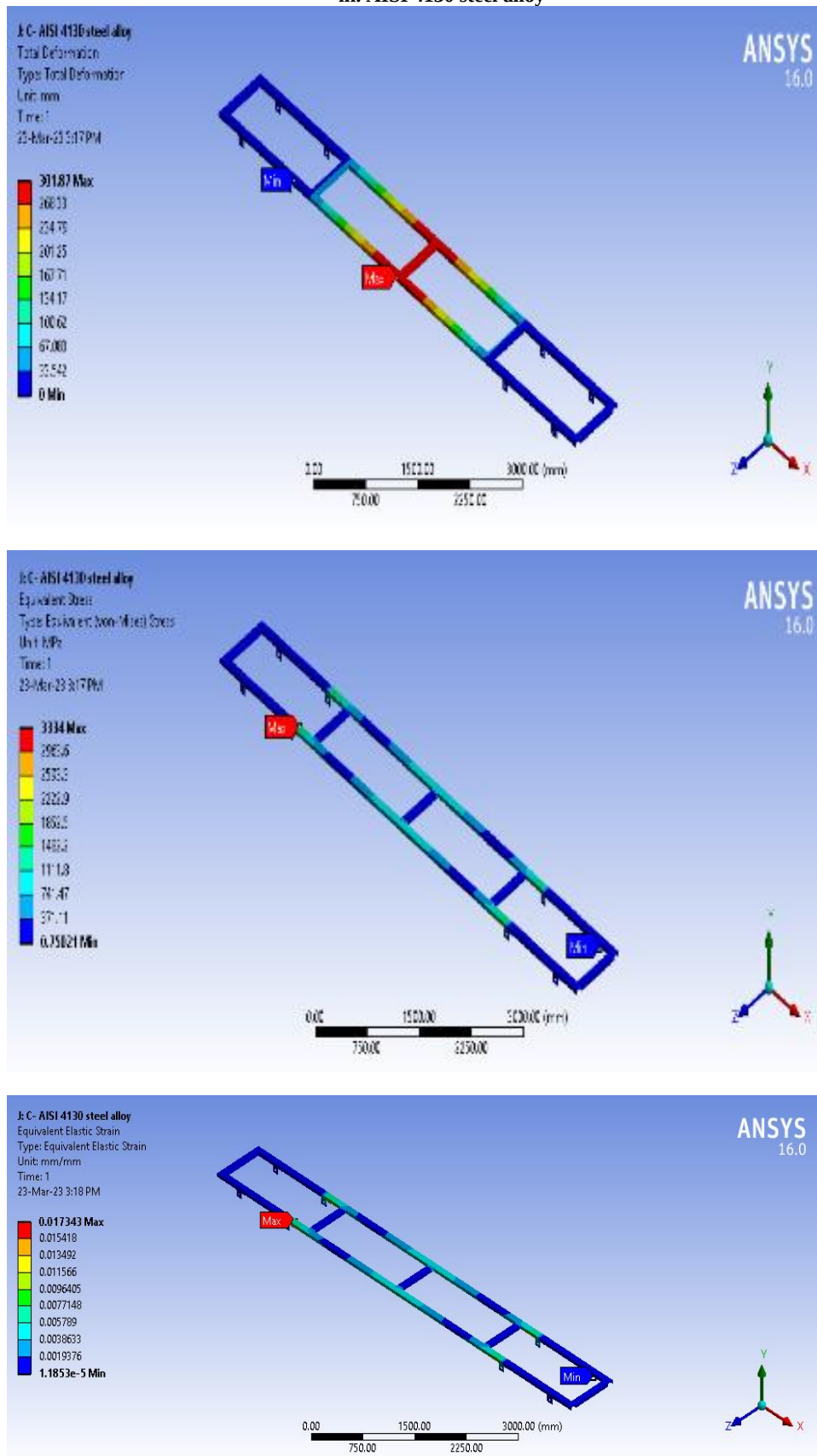


**Figure 11.** Total Deformation, Stress Distribution, Strain Distribution.

## iv. ASTM A710 steel grade A

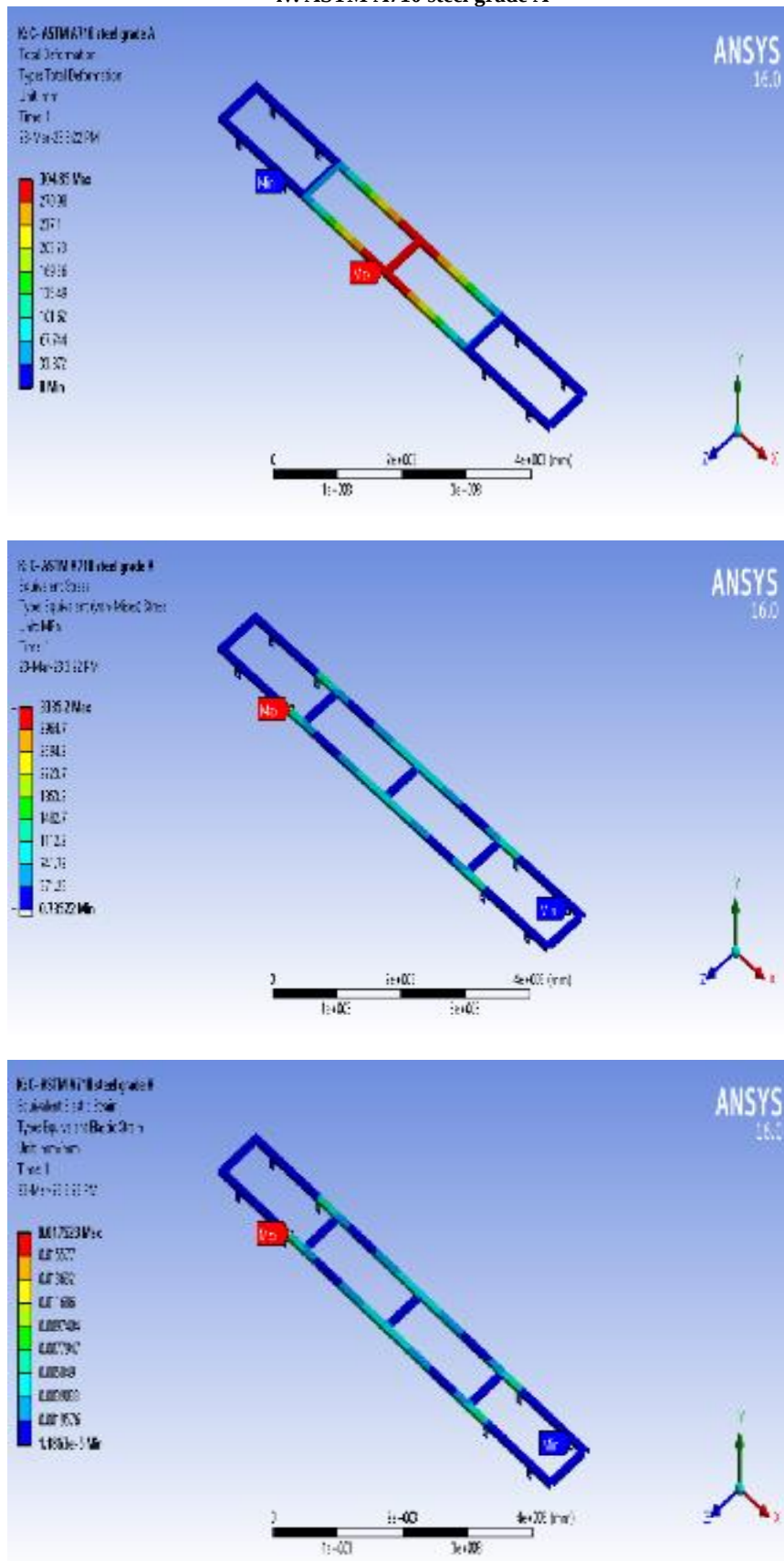


**Figure 12.** Total Deformation, Stress Distribution, Strain Distribution.

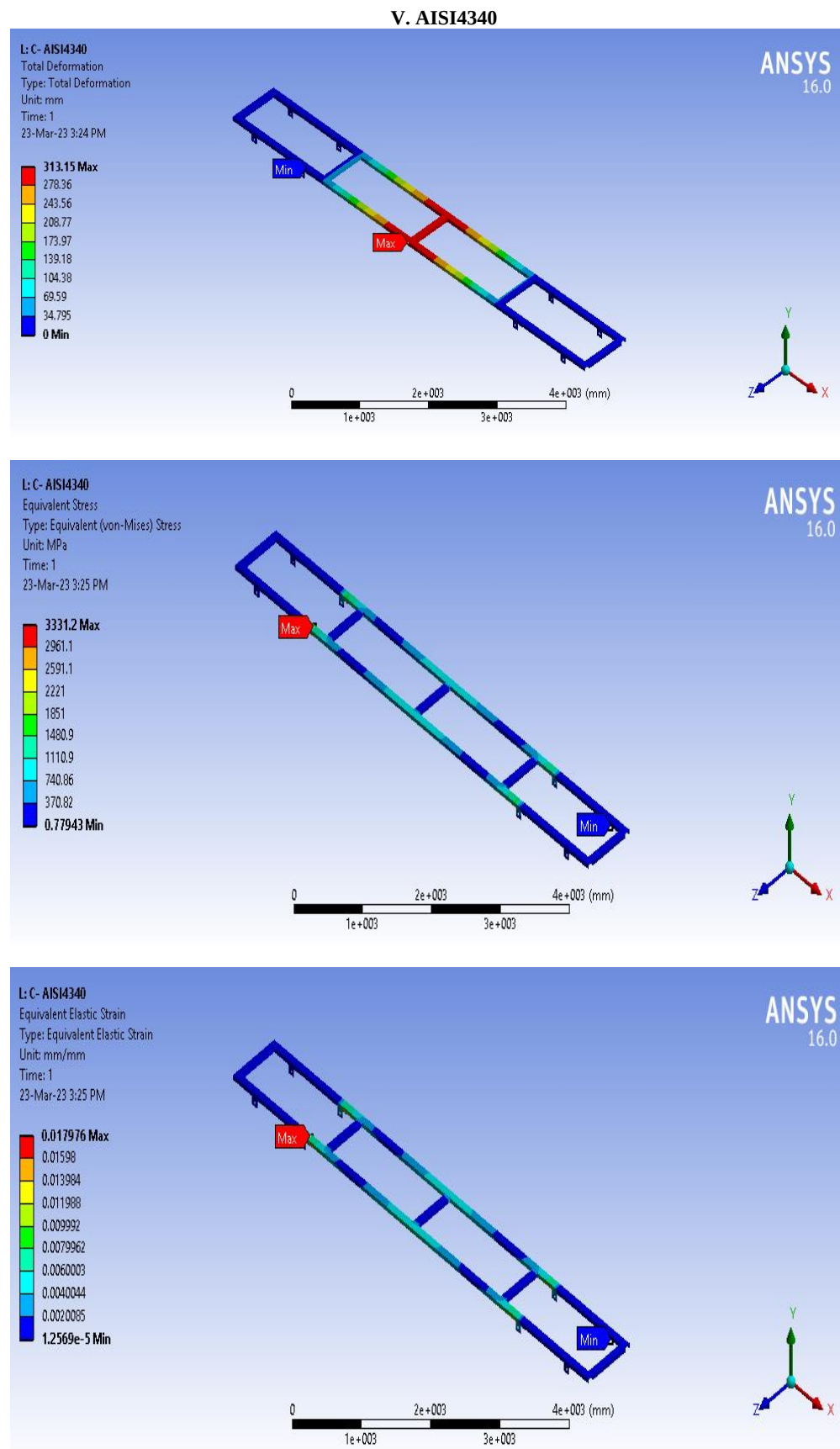
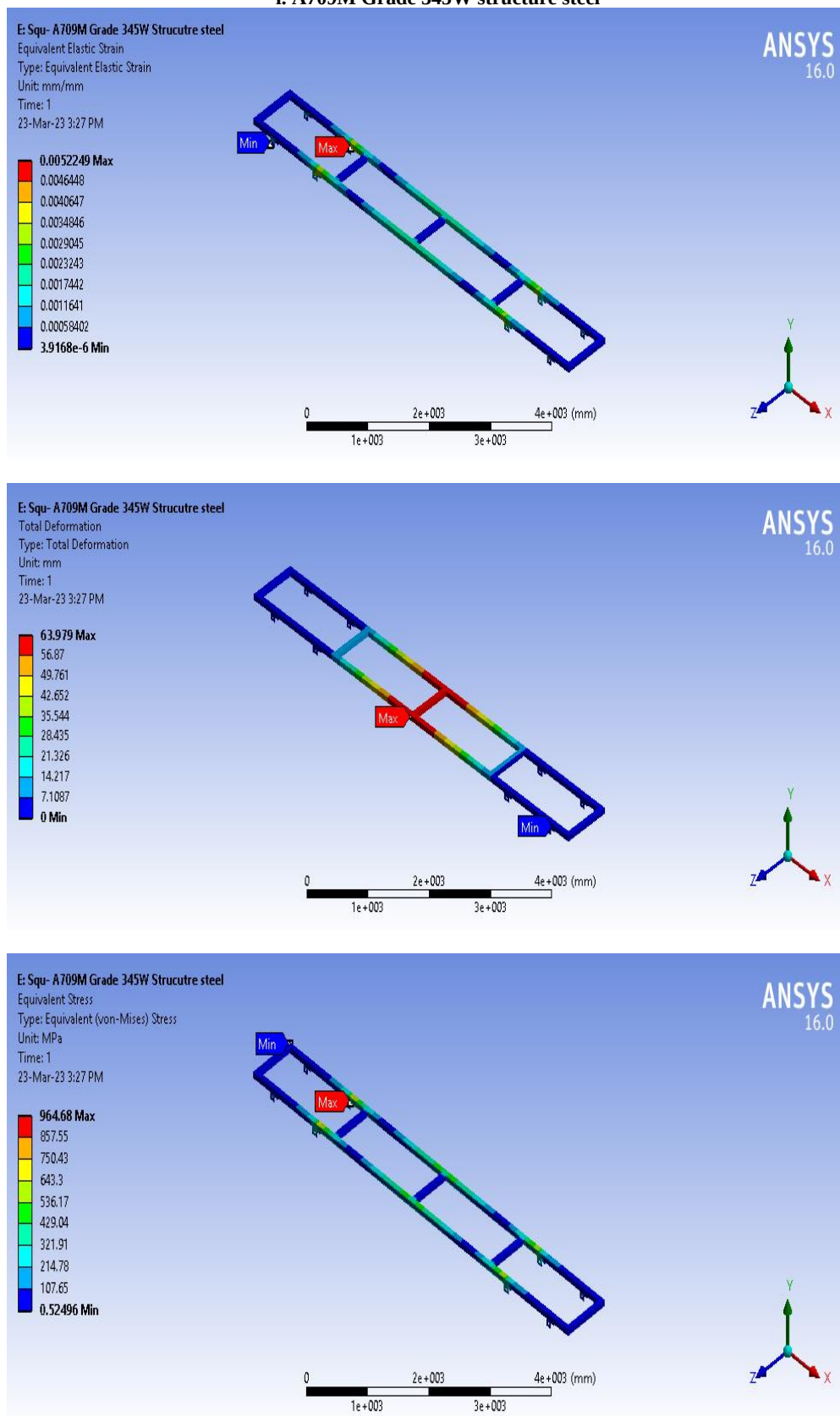


**Figure 13.** Total Deformation, Stress Distribution, Strain Distribution.

## RESULTS OF SQUARE/ BOX CROSS SECTION CHASSIS

## i. A709M Grade 345W structure steel

**Figure 14.** Total Deformation, Stress Distribution, Strain Distribution.

ii. Grey cast iron

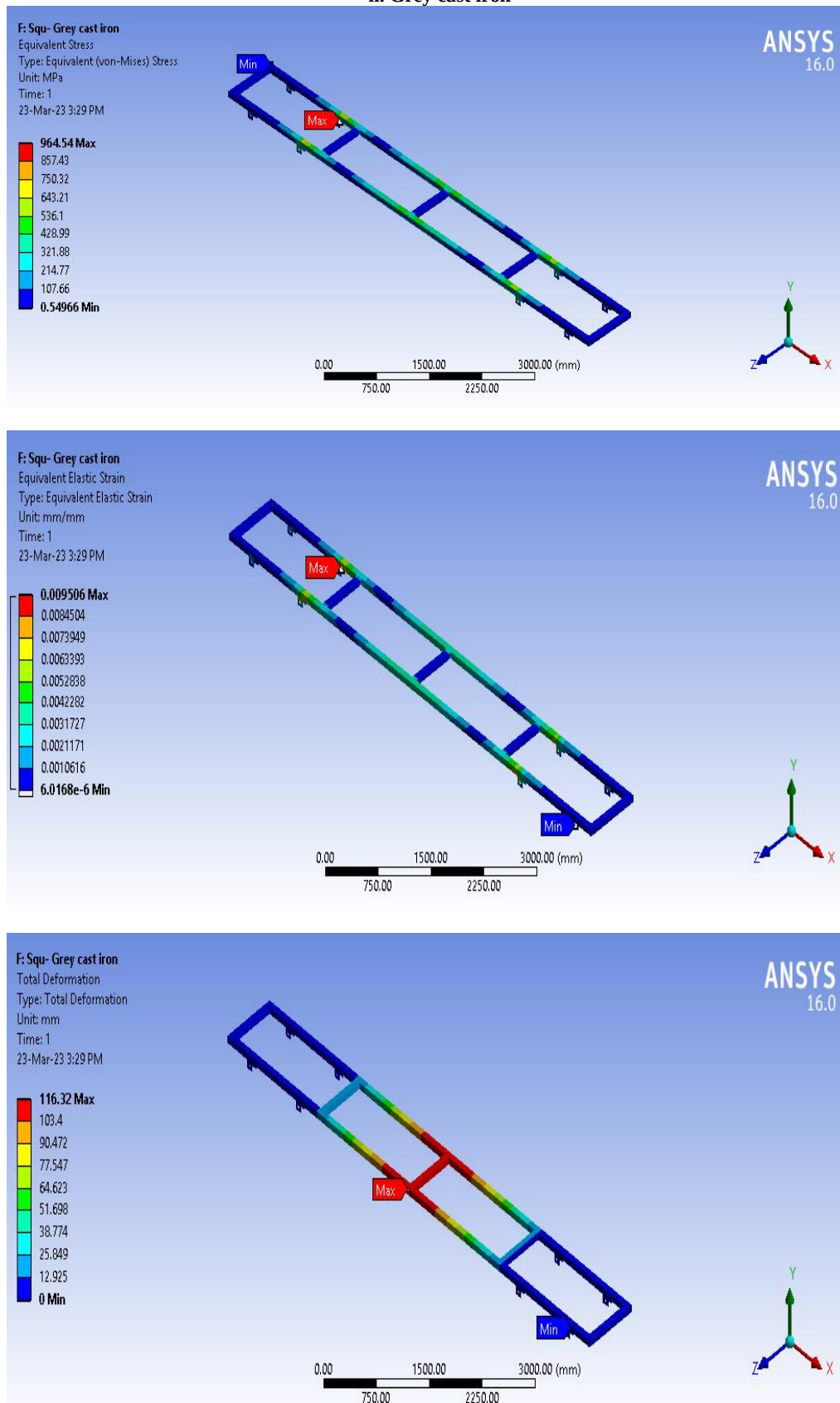


**Figure 15.** Total Deformation, Stress Distribution, Strain Distribution.

## iii. AISI 4130 steel alloy

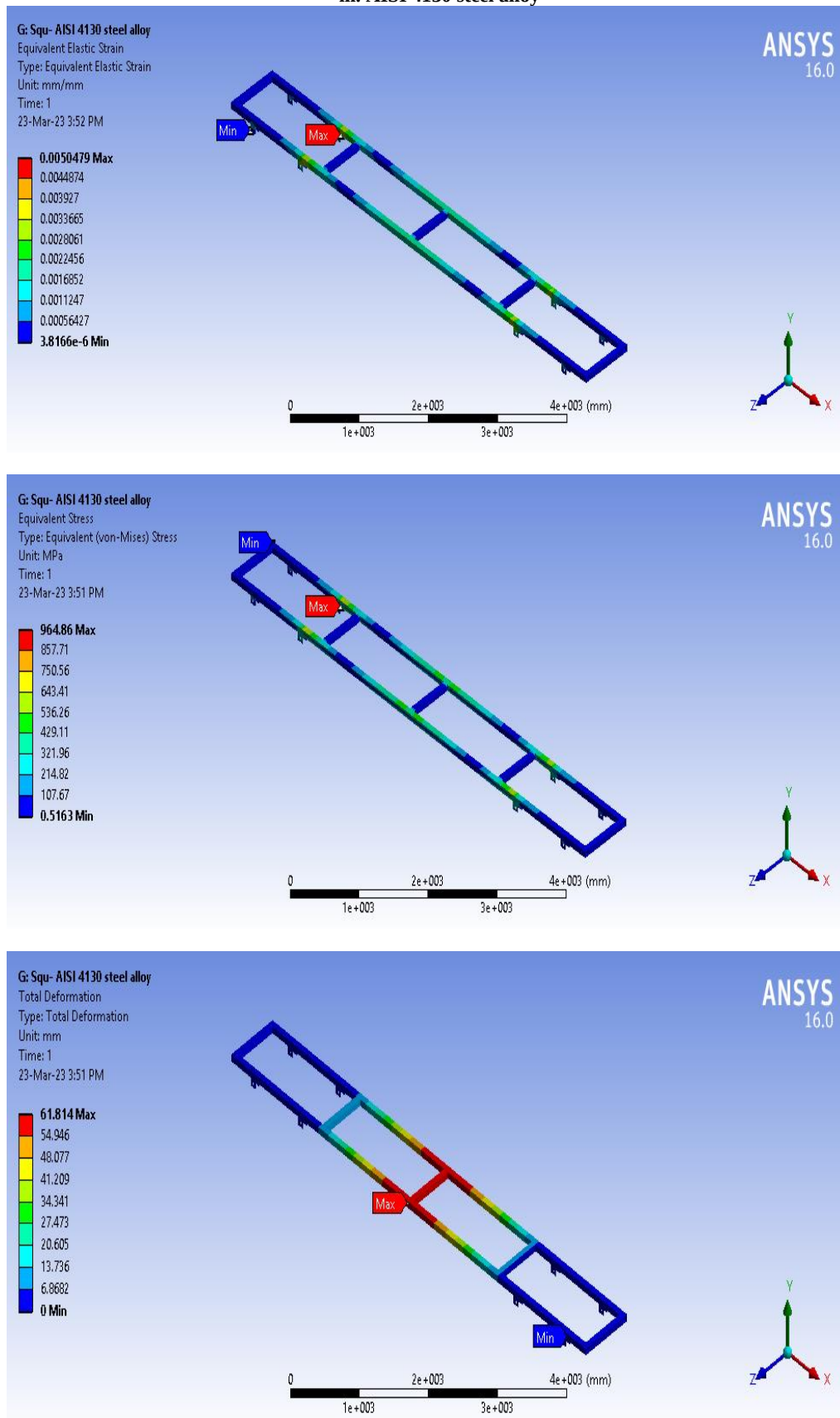


**Figure 16.** Total Deformation, Stress Distribution, Strain Distribution.

iv. ASTM A710 steel grade

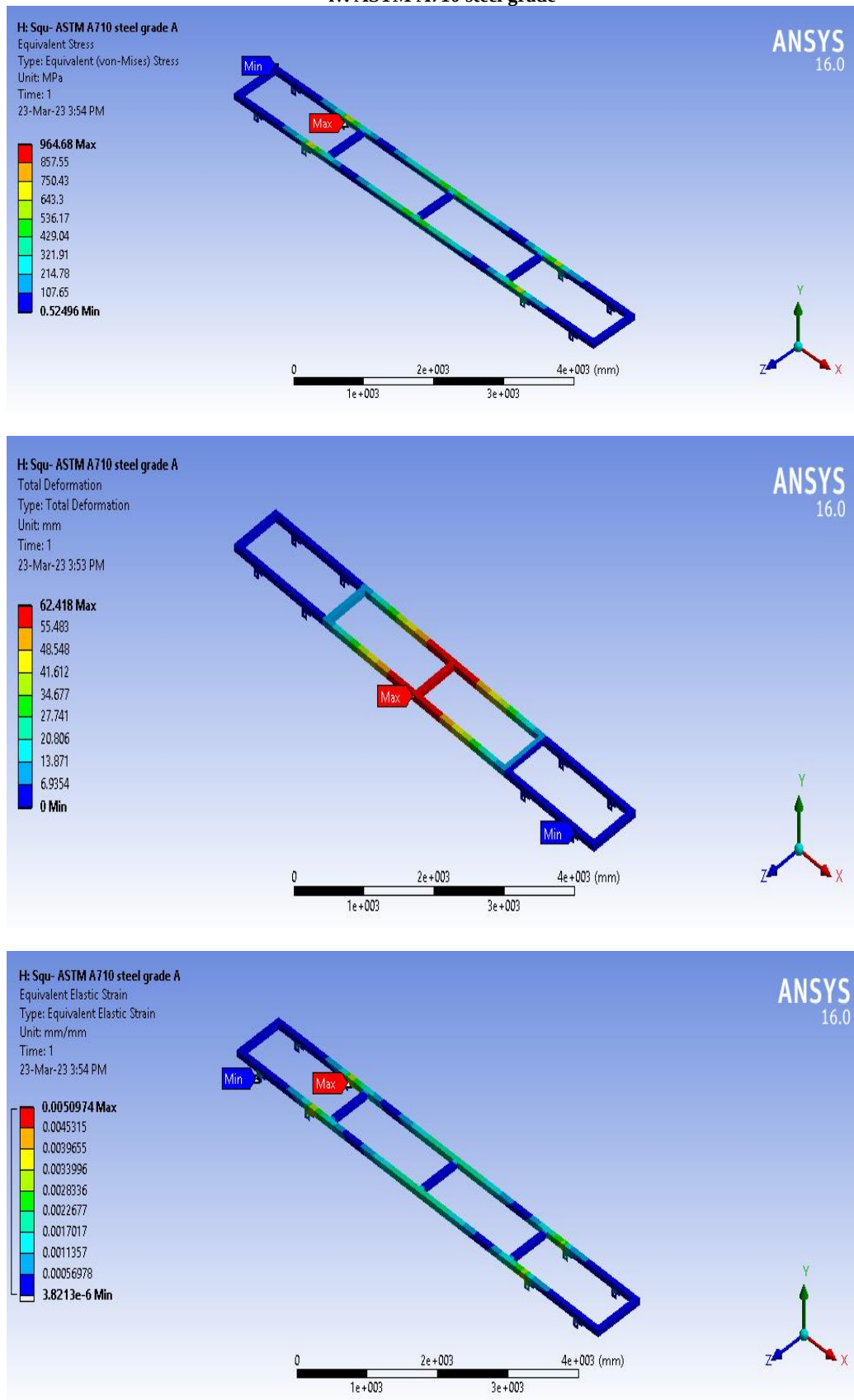


**Figure 17.** Total Deformation, Stress Distribution, Strain Distribution.

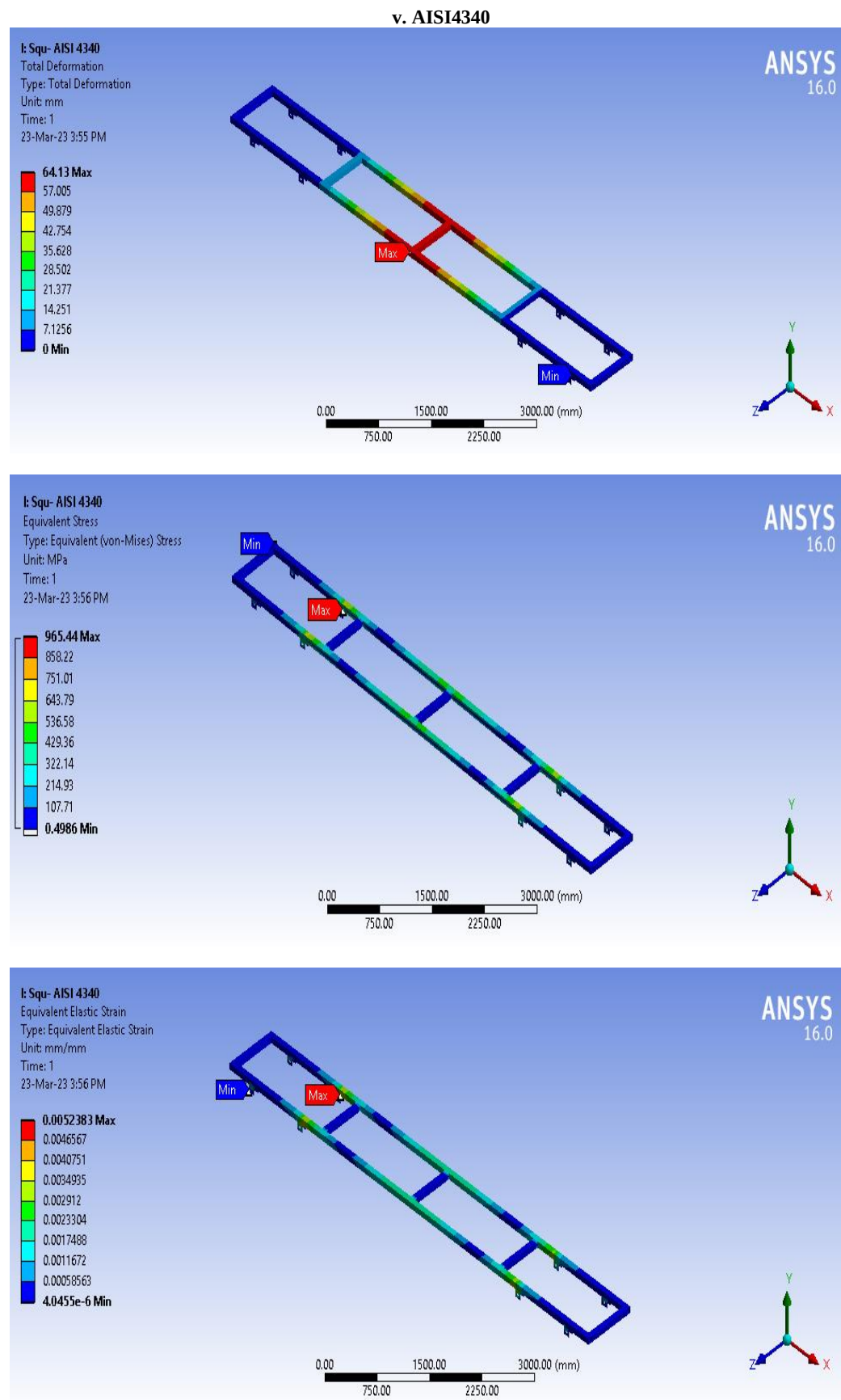


**Figure 18.** Total Deformation, Stress Distribution, Strain Distribution.

**Table 2.** Results of Different Sections and Materials Analysis

| Structure  | Material                         | Total deformation (mm) |        | Stress (Mpa) |        | Strain |        | Mass (Kg) |
|------------|----------------------------------|------------------------|--------|--------------|--------|--------|--------|-----------|
|            |                                  | Min                    | Max    | Min          | Max    | Min    | Max    |           |
| I          | A709M Grade 345W Structure steel | 0                      | 27.87  | 0.174        | 559.75 | 4.3e-6 | 3.1e-3 | 247.02    |
|            | Grey cast iron                   | 0                      | 48.63  | 6.29e-2      | 536.91 | 3.2e-6 | 5.5e-3 | 226.57    |
|            | AISI 4130 steel alloy            | 0                      | 25.87  | 6.03e-2      | 530.88 | 1.7e-6 | 2.9e-3 | 245.38    |
|            | ASTM A710 steel grade A          | 0                      | 26.11  | 6.09e-2      | 532.41 | 1.7e-6 | 2.9e-3 | 247.02    |
|            | AISI 4340                        | 0                      | 26.85  | 5.93e-2      | 527.78 | 1.8e-6 | 3.0e-3 | 246.3     |
| C          | A709M Grade 345W Structure steel | 0                      | 312.47 | 0.735        | 3335.2 | 1.2e-5 | 1.7e-2 | 176.92    |
|            | Grey cast iron                   | 0                      | 568.24 | 0.689        | 3338   | 2.1e-5 | 3.2e-2 | 162.27    |
|            | AISI 4130 steel alloy            | 0                      | 301.87 | 0.75         | 3334   | 1.1e-5 | 1.7e-2 | 175.75    |
|            | ASTM A710 steel grade A          | 0                      | 304.85 | 0.735        | 3335.2 | 1.1e-5 | 1.7e-2 | 176.92    |
|            | AISI 4340                        | 0                      | 313.15 | 0.779        | 3331.2 | 1.2e-5 | 1.7e-2 | 176.41    |
| Square/Box | A709M Grade 345W Structure steel | 0                      | 63.97  | 0.524        | 964.68 | 3.9e-6 | 5.2e-3 | 258.84    |
|            | Grey cast iron                   | 0                      | 116.32 | 0.549        | 964.54 | 6.0e-6 | 9.5e-3 | 237.41    |
|            | AISI 4130 steel alloy            | 0                      | 61.81  | 0.516        | 964.86 | 3.8e-6 | 5.0e-3 | 257.13    |
|            | ASTM A710 steel grade A          | 0                      | 62.41  | 0.524        | 964.68 | 3.8e-6 | 5.0e-3 | 258.84    |
|            | AISI 4340                        | 0                      | 64.13  | 0.498        | 965.44 | 4.0e-6 | 5.2e-3 | 258.09    |

The findings from the analysis of the chassis, considering its different segments and material makeups, have been presented in Table 2. To assess how well the chassis performs in relation to factors such as weight, stress resistance, strain tolerance, and structural deformation, it was intentionally engineered and subjected to a range of distinct loads for thorough evaluation. The findings show that the evaluation of I section, C section, and Box section/Square section chassis. It is clear from comparing the results of the chassis frames made from different materials that AISI 4340 performs better. In terms of mass reduction, stress distribution, strain resistance, and deformation control, this material exhibits advantageous properties. The potential for improved chassis performance and increased structural integrity makes AISI 4340 highly recommended for real-time manufacturing applications.

## CONCLUSIONS

To enhance structural stability and operational effectiveness while minimizing stresses and deflections, a thorough design and optimization process was undertaken for the chassis. Initially, the design hinged on real-time model specifications for certain dimensions. Subsequently, by subjecting the created model to the prevailing operational conditions and juxtaposing the outcomes with the optimized results, the most advantageous configuration was ascertained. Upon analyzing various cross sections of the chassis frame, such as square, “I,” and “C” profiles, it became evident that the square and “I” cross sections exhibited favorable attributes. Particularly, the “I” cross section outperformed the rectangular one in terms of deformation and the dispersion of stress. While the “C” cross section displayed relatively lesser significance compared to other profiles, its properties bore resemblance to those of the “I” shape.

Despite a slightly greater mass distribution, the “I” cross section demonstrated minimal deformation, coupled with a uniform distribution of stress and strain. Consequently, this configuration was selected for further phases of analysis. Furthermore, when evaluating chassis frames composed of different materials, AISI 4340 emerged as the superior choice, yielding superior outcomes. Hence, its utilization in real-time production was strongly recommended.

The superior characteristics of the “I” cross section in relation to deformation, stress distribution, and operational performance led to its identification as the optimal chassis structure through the

optimization process. Additionally, the preference for AISI 4340 in chassis frame construction underscored its capability to deliver superior results.

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