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Optimization of the Cross-Member Thickness and its Effect of Torsional Rigidity

Shrikant D Yawalkar[1], Srinivasa Rao Pulivarti[2]

[1,2] Department of Mechanical Engineering Christian College of Engineering & Technology, Bhilai, India

shrikantyawalkar88@gmail.com, srinivas.indore@gmail.com

Corresponding author: shrikantyawalkar88@gmail.com

Abstract: According to the tadpole design, the vehicle will have two wheels up front and one wheel in the back. Because it is a perfect fit between the motorcycle and automobile categories, the vehicle must adhere to both motorcycle and automobile laws. The purpose of this project is to design a full-scale chassis concept based on modern and future requirements and regulations. In addition to this, the chassis should have a reasonable price without sacrificing the overall quality of the design. It was estimated that cross-members with a thickness of 200 mm were the best option for increasing the chassis torsional rigidity, and the basis of the chassis is constructed out of frames. It was observed that the C-shaped side members on the chassis were not as robust as the tubular truss side members when subjected to the vertical stresses.

Keywords: Chassis, Dynamic stability, Mild steel, Torsional rigidity, CAD and Tadpole design.

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1. Introduction

The goal of making life simpler, both for oneself and for others, has been a driving force in human history from the beginning, and one of the most significant contributors to this goal has been the invention of the vehicle. Not only are car designers required to create vehicles that are small and efficient in their use of fuel as a result of the rapid growth in population and the increase in the number of vehicles, but they are also required to encourage the next generation of engineers to pursue careers in this sector of automotive engineering in order to reap the benefits of their efforts. In this regard, a large number of compact automobiles are being introduced, and three-wheeled vehicles, for example, are becoming increasingly popular for city commuting due to their lower consumption of fuel, ease of operation, and availability of parking in most nations worldwide [1]. [Citation needed] In spite of the popularity of three-wheelers, they suffer from a severe drawback: they are not stable enough to be used on uneven ground. The tilting of the system and cambering have been proved to be the only two methods that are effective at improving its stability, despite the large amount of research and writing that has been done on the topic. Depending on the needs of the vehicle, tilting can be used for manoeuvring and speedy driving, while camber is used for routine travelling in cities [2]. Tilting and camber are both utilized in the same way. The chassis of a vehicle is the component of the vehicle that is considered to be the most important. It is the physical frame or framework of a vehicle to which all other components are linked, and in terms of appearance, it can be thought of as being comparable to the skeleton of a living entity. The frame of the chassis is where all of the vehicle's components, such as the axles, wheels, and tyres, as well as the suspension, a controlling system such as braking, steering, and so on, and the electrical systems, are mounted [3]. The word "chassis" originates from the French language and was initially utilized to refer to the components of a vehicle's frame as well as the vehicle's fundamental framework. It is there to provide support for the vehicle's structure. The part of a vehicle that is not referred to as the "body" is called the "chassis." Components of the vehicle, including but not limited to the engine, transmission system, axles, wheels and tyres, and suspension, are dissected in minute detail.

The chassis frame is where many components of the controlling systems, such as the braking, steering, and other similar tasks, as well as the electrical system, are located. Because it is the principal mounting point for all of the components, including the body, it is also known as the "Carrying Unit." This term is used interchangeably with "Carrying Unit." The fact that we will be using two different chassis for passenger and load carrying vehicles will result in an increase in the cost of the machinery necessary to produce them. The plan was to develop a single chassis that could be adapted to accommodate any type with only a few tweaks of the design. This was built using the chassis of a passenger vehicle, and additional components were added in the appropriate locations in order to give it the appearance and functionality of a carrier vehicle. As a consequence of this, it will very probably reduce the cost of tooling while simultaneously increasing the rate at which it is manufactured.

2. Methodology

The process of design is systematic in which knowledge of various existing chassis designs, materials used to manufacture are to be known. A 4-seater passenger vehicle chassis is designed which includes a hub motor of around 900 N-m torque. The processes include: Product Discovery – Suitable material and design form is investigated. Top-down approach is chosen. Product Definition – Important dimensions were determined by survey and calculations. Product Design - The chassis is to be designed.

It is very important to know what is CAE. CAE (computer-aided engineering) is a term used by the electronic design automation (EDA) industry for the use of computers to design, analyse, and manufacture products and processes. CAE includes CAD (Computer Aided Design) for drafting and modeling designs and CAM (Computer Aided Manufacturing) for managing manufacturing processes. In 3D computer graphics, 3D modeling is the process of developing a mathematical, wire frame representation of any three- dimensional object (either inanimate or living) via specialized software. The product is called 3D model. It can be displayed as a two-dimensional image through a process called 3D rendering or used in a computer simulation of physical phenomena. 3D philosophy is simple by using the three-dimensional technique it is used to produce design drawings more quickly and accurately than the two-dimensional techniques. By producing a virtual model of the facility, any drawings required for construction can be produced from the model. The 3D is basically a virtual tour of the facility, offering realistic perspectives. The view can be from any direction, at any desired level of detail, unrestrained by gravity or space with nothing blocking the view. Once the model is complete, the facility will never have to be redrawn. Any discrepancies during the design phase can be incorporated into the model to keep it updated, as opposed to searching through numerous drawings, which can be affected by an undocumented change. The model becomes more accurate as it is updated, while the old, 2D drawing begins to lose accuracy as soon as it is fitted. Table 1 shows the data used of input parameters.

Table 1. Rack and Pinion Calculation

Quantity	Value
Length of Rack (mm)	361.985
Length of Rack Shaft (mm)	804.385
Number of teeth on Rack	37
Pinion Diameter (mm)	36
Rack and pinion module (mm)	3
Number of teeth on Pinion	12
Pressure Angle	20°
Tangential Angle	15°
Addendum	3.03
Dedendum	3.51

3. Results and Discussions

As was discussed before, the chassis structure is susceptible to lozenging, bending, and torsional distortion when the vehicle is in motion. There are a variety of design concepts for cross-sectional forms that have been put forward in order to withstand these scenarios. When it comes to rigidity, these forms each have their own set of advantages and disadvantages. To a significant extent, the increased torsional rigidity is the result of the contributions made by the cross-members of the chassis. In the course of this investigation, a square cross-member with dimensions of 80 mm on each side and thicknesses of 100, 200, and 300 millimetres was analysed and compared. The analysis was conducted using the identical load and boundary conditions for each kind of large commercial vehicle chassis. The focus of the study was on the chassis of these types of vehicles.

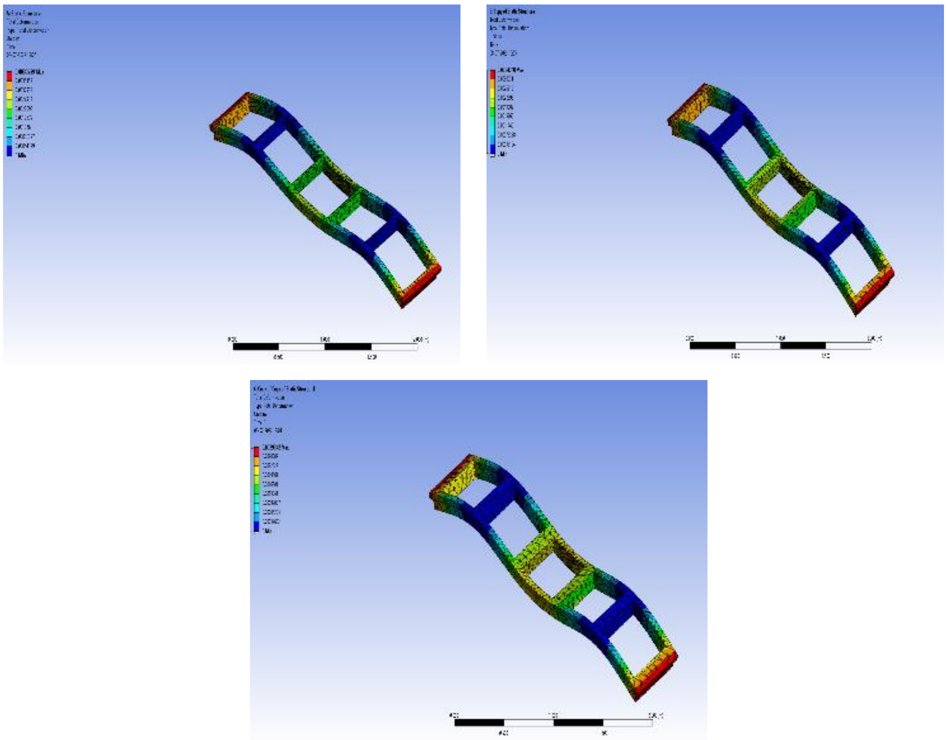

Figure 1. Simulation with rectangular cross members of thickness (a) 100 mm, (b) 200 mm and (c) 300 mm showing deformation in the cross members.

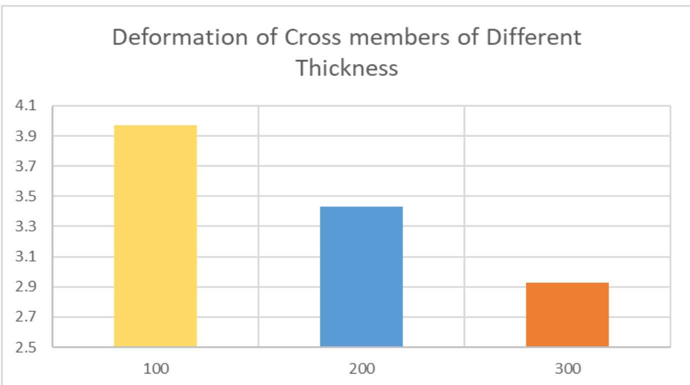

Figure 2. Comparison of deformation of the cross members (a) 100 mm, (b) 200 mm and (c) 300 mm thickness.

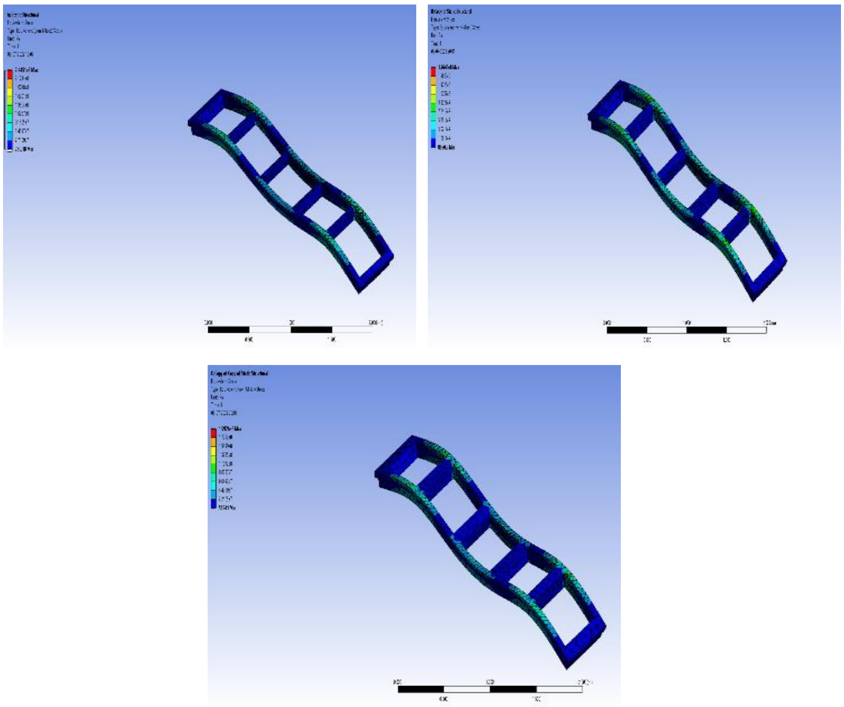

Figure 3. Simulation with rectangular cross members of thickness (a) 100 mm, (b) 200 mm and (c) 300 mm showing stress distribution in the cross members.

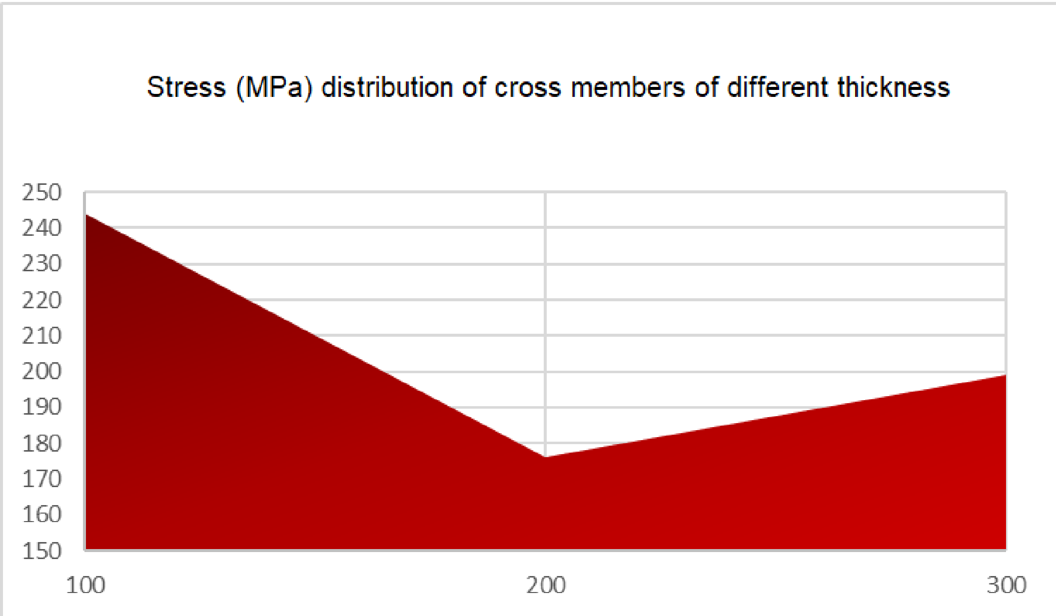

Figure 4. Comparison of Stress (MPa) of the cross members (a) 100 mm, (b) 200 mm and (c) 300 mm thickness.

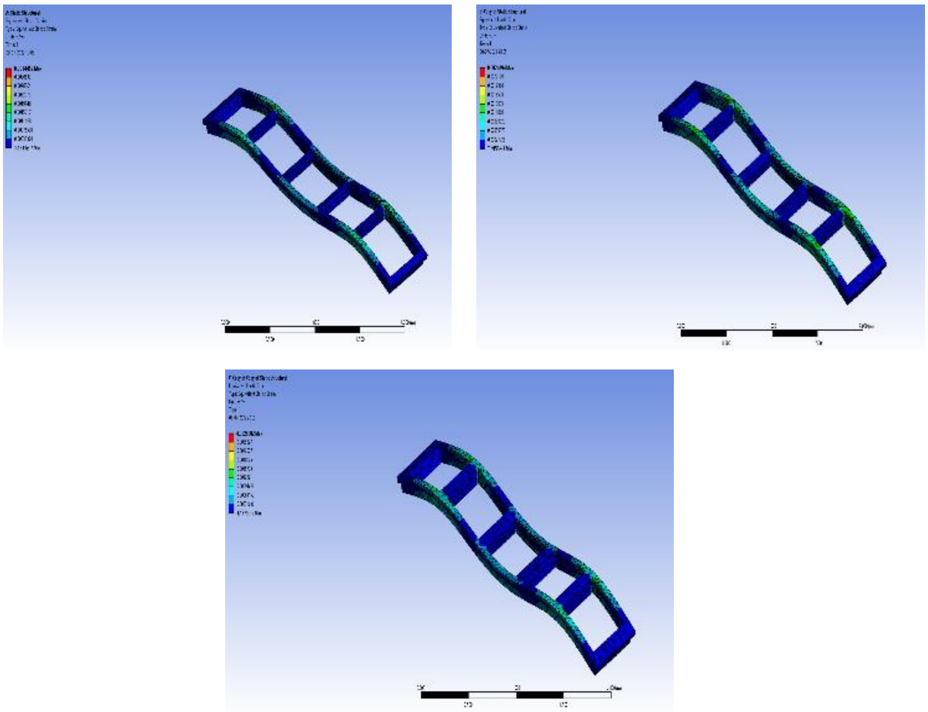

Figure 5. Simulation with rectangular cross members of thickness (a) 100 mm, (b) 200 mm and (c) 300 mm showing strain distribution in the cross members.

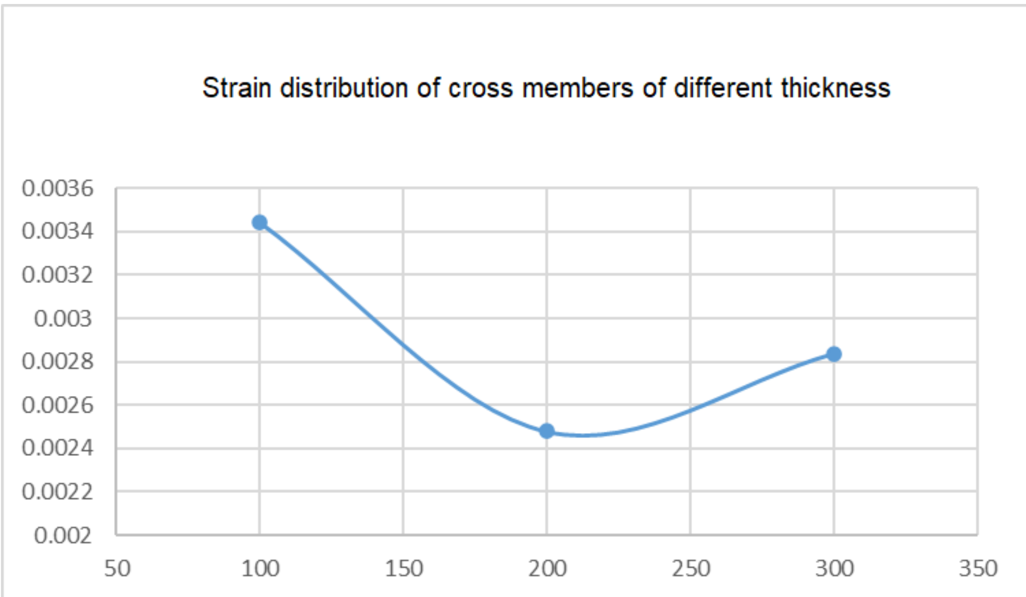

Figure 6. Comparison of Stain of the cross members (a) 100 mm, (b) 200 mm and (c) 300 mm thickness.

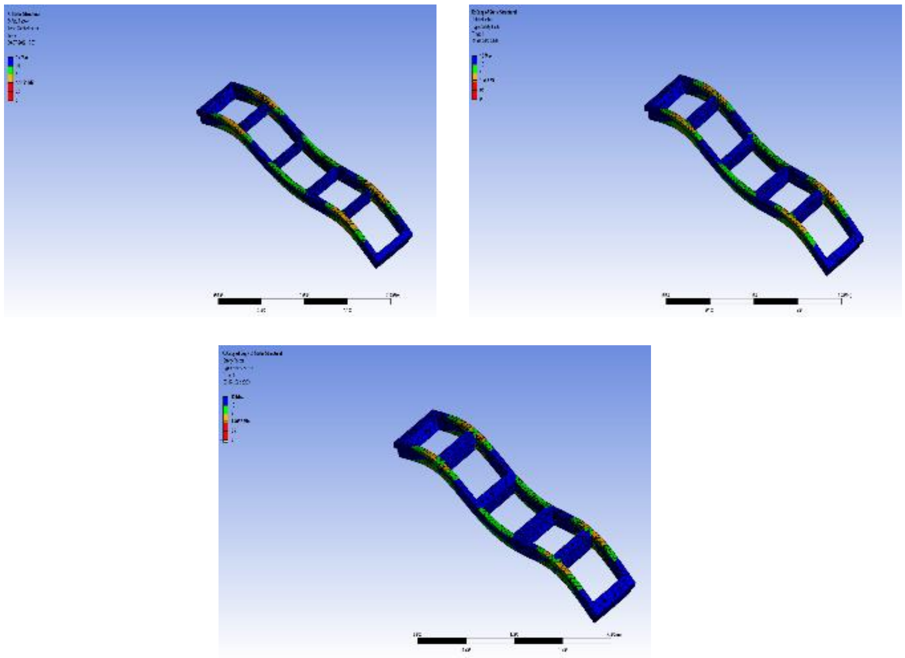

Figure 7. Simulation with rectangular cross members of thickness (a) 100 mm, (b) 200 mm and (c) 300 mm showing safety factor distribution in the cross members.

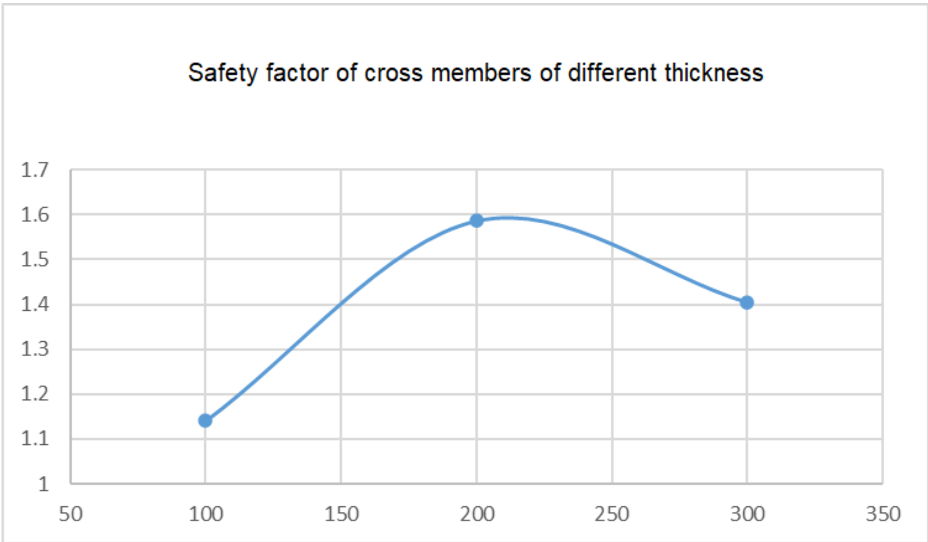

Figure 8. Comparison of Safety Factor of the cross members (a) 100 mm, (b) 200 mm and (c) 300 mm thickness.

Figure 1 and Fig. 2 illustrates how the torsional stiffness and lateral stiffness of cross-members with a thickness of 200 millimetres are significantly enhanced in comparison to cross-members with a thickness of 100 millimetres. Despite the fact that the deformation is reduced even further for cross members with a thickness of 300 millimetres, the optimal value for the other parameters was determined to be cross members with a thickness of 200 millimetres. One may get the conclusion that the cross-members with a thickness of 200 millimetres are the greatest alternative for improving the torsional stiffness when it comes to this specific purpose. It is possible to add four more cross members, which will allow for the lateral stiffness to be increased even further. The results of the stress and strain are depicted visually in figures 3 and 5, respectively. A reduction of sixty percent in the maximum shear stress was achieved by increasing the thickness of the cross member. When compared to the yield-strength, a safety margin of 8.6 may be judged to be satisfactory. Since the deflection, the length, and the forces that are being applied are all known, it is possible to determine the torsional stiffness in Nm/deg. The values of stress and strain in the cross members are displayed in Fig. 4 and Fig. 6 for a range of cross member thicknesses. Similar results were obtained for safety factor of the cross members as discussed previously for stress and strain and the results are indicated in Fig. 7 and the distribution is shown in Fig. 8 respectively.

As can be observed from the figures presented above, the new chassis have shed a significant amount of weight owing to the utilization of side members that are somewhat separated from one another in order to accommodate the increased thickness of the cross members. A steel plate will be used to cover the side elements of the structure. The vertical forces that are applied to the chassis will be distributed uniformly throughout the entirety of the surface area that the side members cover.

4. Conclusions

The purpose of this project was to design a full-scale chassis concept based on modern and future requirements and regulations. The passenger compartment, together with the baggage compartment, should have sufficient space. It should also be lightweight while yet being able to handle all of the loading conditions that will occur over the amount of time that the vehicle will be in operation, bearing in mind that safety is an important consideration. One of the most important criteria that has come from is that the chassis be flexible. Because regulations imposed on the transportation industry concerning harmful emissions over the entirety of a vehicle's life cycle are getting stiffer, the environmental effect of the chassis must to be reasonable. In addition to this, the chassis should have a reasonable price without sacrificing the overall quality of the design. It was estimated that cross-members with a thickness of 200 mm were the best option for increasing the chassis torsional rigidity, and the basis of the chassis is constructed out of frames. It was observed that the C-shaped side members on the chassis were not as robust as the tubular truss side members when subjected to the vertical stresses.

Major conclusion obtained from the study are summarized below:

1. Torsional stiffness and lateral stiffness of cross-members with a thickness of 200 mm are significantly enhanced in comparison to cross-members with a thickness of 100 and 300 mm.
2. Despite the fact that the deformation is reduced even further for cross members with a thickness of 300 mm, the optimal value for the other parameters was determined to be cross members with a thickness of 200 mm.

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