Weight optimization of chassis frame using Pro-Mechanica

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ABSTRACT : *Automotive chassis can be considered as the backbone of any vehicle. Chassis is tasked at holding all the essential components of the vehicle like engine, suspension, gearbox, braking system, propeller shaft, differential etc. To sustain various loads under different working conditions it should be robust in design. Moreover chassis should be stiff and strong enough to resist severe twisting and bending moments to which it is subjected to. The objective is to do weight optimization of Chassis of hydraulic truck (TATA - 2516TC). The design is implemented with size optimization using Pro Mechanica software and the studied chassis with capacity 25 tonne is for carrying the load of truck. The basic model will be a good starting point for further studies and developments of final models.*

Keywords- *Chassis frame, Stress, weight optimization, Pro-Mechanica.*

I. INTRODUCTION

The major challenge in today's ground vehicle industry is to overcome the increasing demands for higher performance, lower weight, and longer life of components, all this at a reasonable cost and in a short period of time. The chassis of trucks is the backbone of vehicles and integrates the main truck component systems such as the axles, suspension, power train, cab and trailer. Since the truck chassis is a major component in the vehicle system, it is often identified for refinement. There are many industrial sectors using this truck for their transportations such as the logistics, agricultures, factories and other industries.

Once the analysis is done and results are obtained the next step is to check the stresses within the permissible range if required. The question arises is how to do stress reduction and the answer to this question is optimization [6, 7, 8]. Many engineering activities are confronted with the relation between behavior and shape so changing the shape makes behaviour of part to change which is shape optimization process but by topological optimization internal cavities can be formed i.e. topology can be altered to optimize the design [8].

II. FE ANALYSIS OF EXISTING CHASSIS FRAME(C-SECTION)

For carrying out the FE Analysis of chassis as per standard procedure first it requires to create merge part for assembly to achieve the connectivity and loading and constraining is required to be applied also idealization of parts is done on structure this will lead to faster analysis since the connected structure will not be physical but it will be a sketch with mechanical properties of mechanical structure. Procedure is followed in this section [1].

2.1 Cross section of main frame

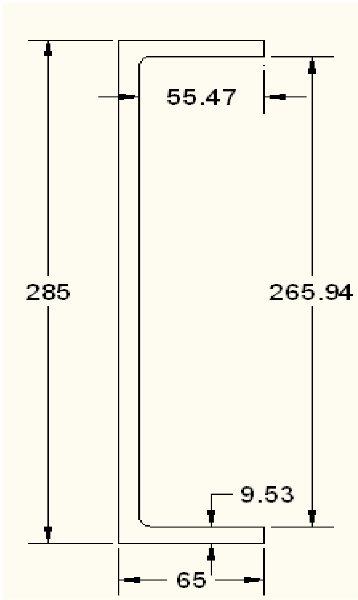

Fig.1 C-Section of Chassis Frame

2.2 Assembly of Existing chassis

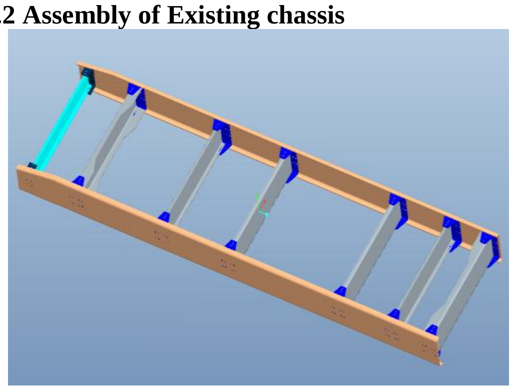

Fig 2 Assembly model of Chassis

2.3 FEA result

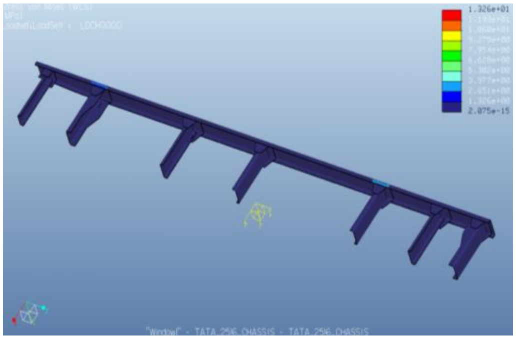

Fig 3 Von Mises Stress Result

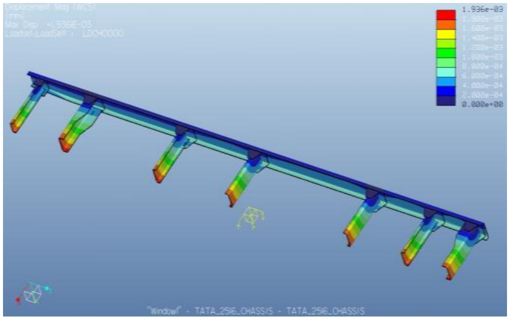

Fig 4 Displacement Result

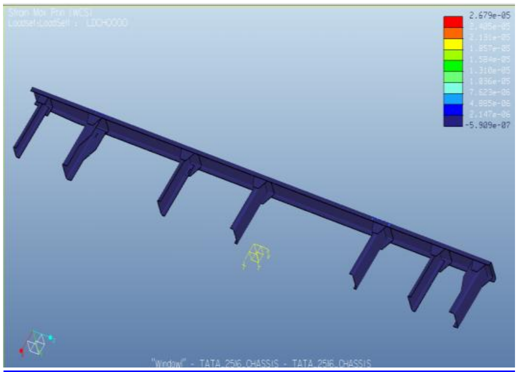

Fig 5 Strain Result

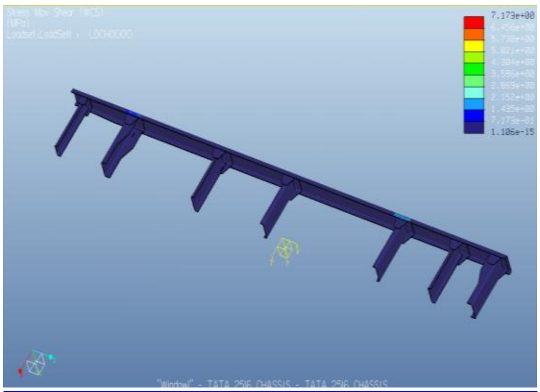

Fig 6 Max. Shear Stress Result

III. Optimization Of Chassis Frame

Optimization is defined as a maximization of wanted properties and minimization of unwanted properties. In case of structural optimization the chassis:

Desired Properties are:
Strength
Stiffness
Deflection etc…

Undesired Properties are:
Material
Cost
Weight etc…

3.1 FEA of Frame/Chassis with Different Cross-section

Case I: FEA of I-Section (Modified)

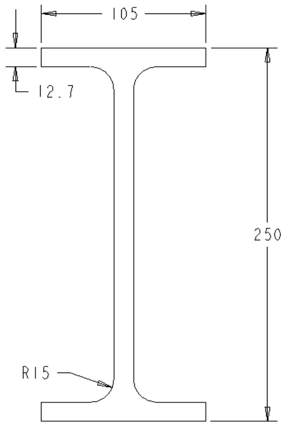

Fig.7 Sketch of "I" section

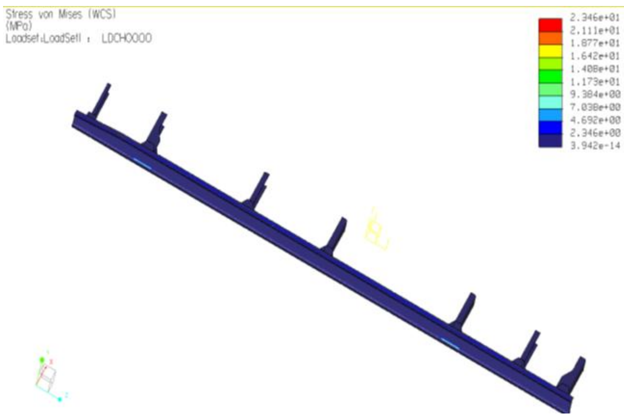

Fig.8 Von Mises Stress of I-section

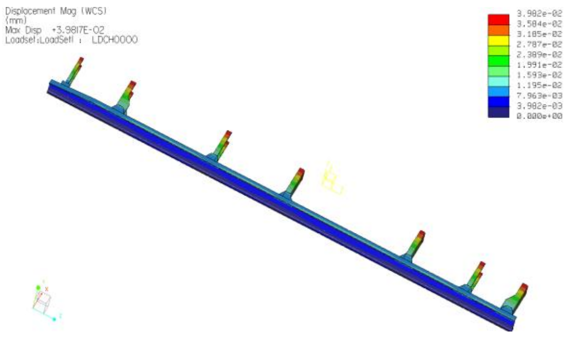

Fig. 9 Displacement Mag. of I-section

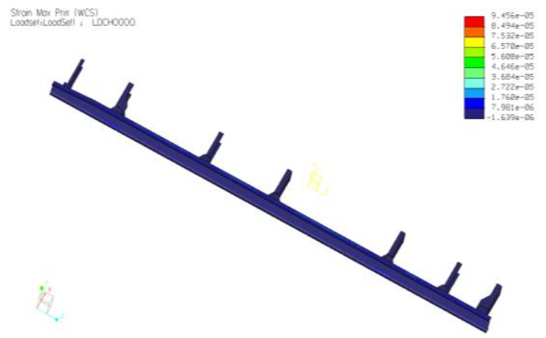

Fig.10 Strain Value of I-section

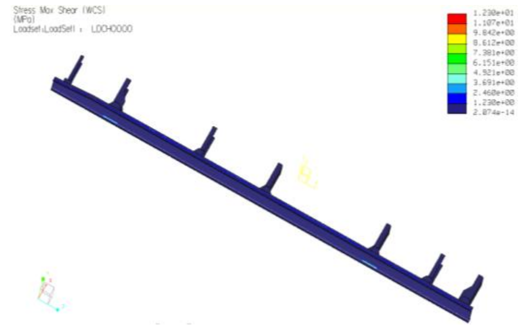

Fig. 11 Max Shear Stress of I-section

Case II: FEA of Rectangular Section

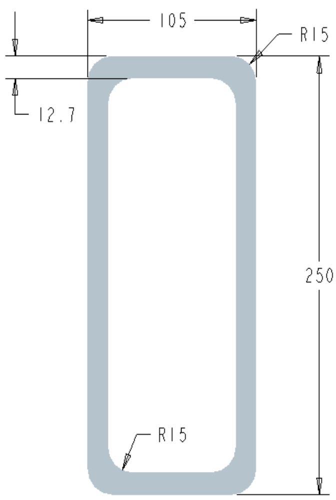

Fig.12 Rectangular Section

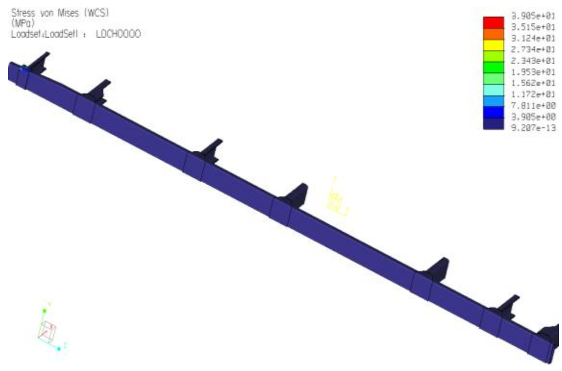

Fig.13 Von Misses Stress of rectangular section

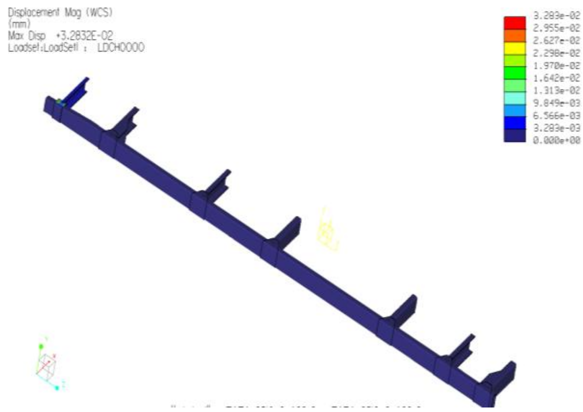

Fig. 14 Displacement Mag. of rectangular section

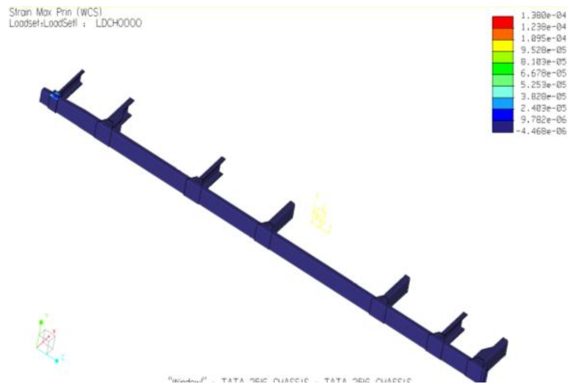

Fig. 15 Max. Strain of rectangular section

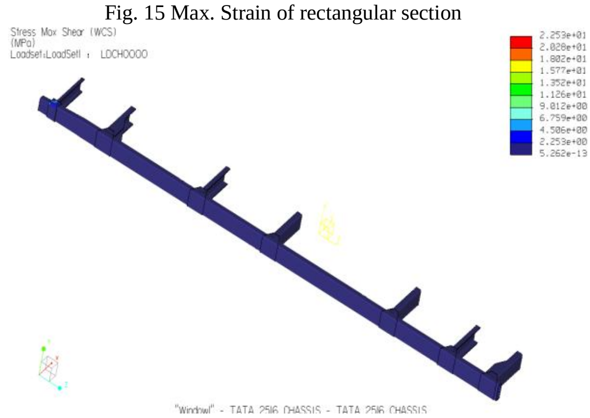

Fig. 16 Max. Shear Stress of rectangular section

Case III: FEA of Modified "C" Section

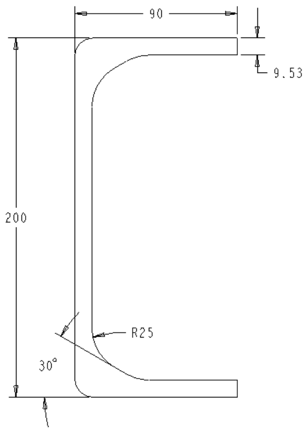

Fig. 17 Modified "C" Section

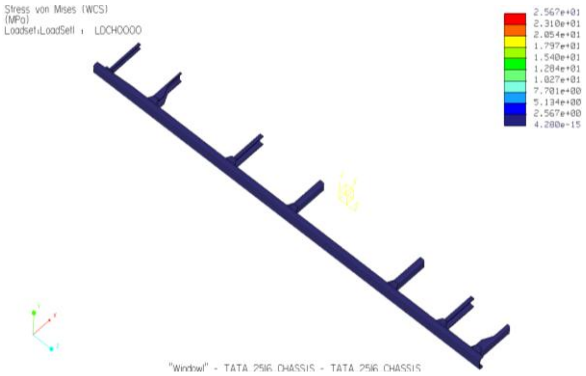

Fig. 18 Von Mises Stress of Modified 'C' Section

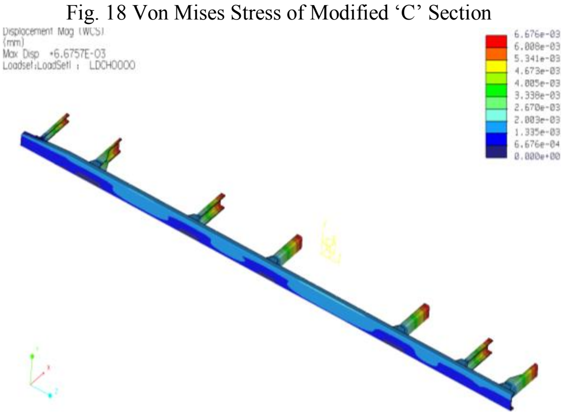

Fig. 19 Displacement Mag. of Modified 'C' Section

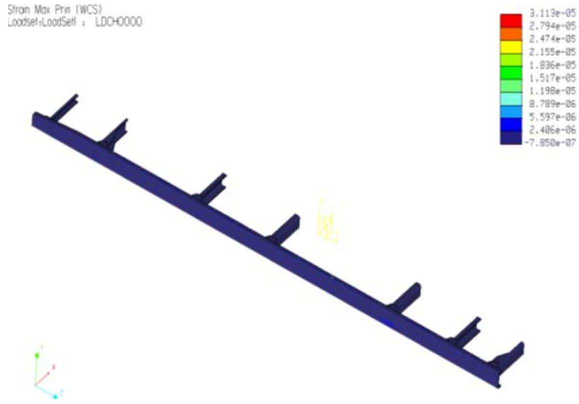

Fig. 20 Max. Strain of Modified 'C' Section

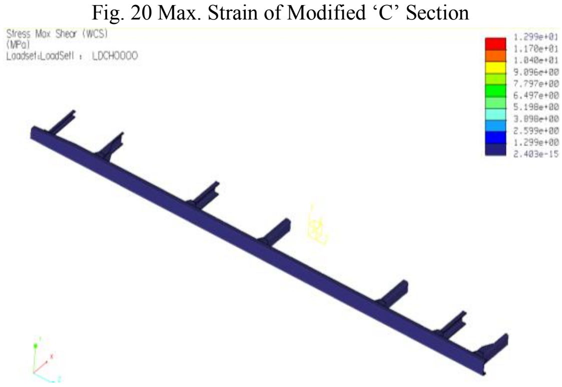

Fig.21 Max. Shear Stress of Modified 'C' Section

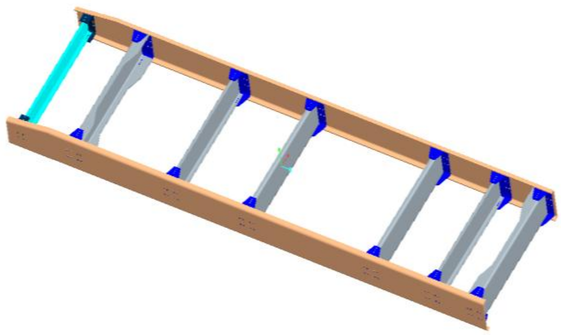

Fig.22 Modified model of chassis

IV. RESULT AND COMPARISON

TABLE 1: COMPARISON TABLE OF EXISTING MODEL WITH MODIFIED MODELS

Sr. No.	Parameters/Sections	Existing "C" Section	"I" Section	Rectangle Section	Modified "C" Section
1	Assembly Weight (Kg.)	975.44	1334.34	1744.01	869.94
2	Stress (N/mm2) (Max.)	13.26	23.64	39.05	25.67
3	Displacement (mm) (Max.)	0.001936	0.0398	0.03283	0.0067
4	Strain (Max.)	0.00002679	0.0000945	0.000138	0.0000311
5	Shear Stress (N/mm2) (Max.)	7.173	12.30	22.53	12.99

V. Conclusion

Allowable Tensile strength for St 37 Steel is 370 to 490 N/mm^2. By considering factor of safety is 5 times allowable tensile stress is 74 to 96 N/mm2. Almost all section are within safe limit.

When we compare the all sections for the mentioned parameter, existing "C" sections is better than all the sections with respect to the Stress, Displacement, Strain and Shear stress except the weight. For the weight consideration modified "C" section has less weight than the all sections which are studying in this paper.

In the modified "C" section, the section size of the "C" is reduced and the corner of the "C" section is modified as shown in figure.

When we apply the load, "C" section is working as a cantilever beam, for this reason as we modified the corner dimension of the "C" section, the amount of the stress and all other parameters are also reduced.

As compared to "rectangle section" and "modified C section", the Stress, strain, displacement and shear stress is less in "I" section". But due to clamping reason the "I" section is not used for the practical use.

Rectangle sections have an approximately double weight and also all remaining parameters are higher more than three time. For this reason sections are not used for the practical application.

By the use of modified "C" section, 105.50 Kg (11 %). Weight is saved per chassis assembly and in same manner cost may also be reduced approximately 11%. From the results, modified "C" sections are used as an optimized section.

VI. Acknowledgement

We would like to thankful to our supporters and technical guide for extending their support and for valuable suggestions.

References

[1] Vijaykumar V. Patel and R.I. Patel, "structural analysis of ladder chassis frame" , *ISSN 2231 2581, Mechanical department, Government engineering college, Gujrat.*

[2] Sairam Kotari and V. Gopinath , "Static and dynamic analysis on tatra chassis", *vol 2, ISSN: 2249-6645 department of mechanical engineering, QIS college of engineering, Andhra Pradesh.*

[3] Keith J. Wakeham, Introduction to chassis design, *Memorial University of Newfoundland And Labrador.*

[4] Chetan J. Choudhury and akash lodhi, "Static loadanalysis of TATA-407 chassis" -an approach , *ISSN 2231-5063,Mechanical department, K.D.K. college of engineering , Maharashtra.*

[5] PSG Design Data Book for Standard Data-M/sKalaikathir Achchagam, Coimbatore2004

[6] J. GADUŠ, Optimization of frameworks by means of FEM use, *Slovak Agricultural University, Nitra, Slovak Republic, RES. AGR. ENG., 49, 2003 (1): 32–36*

[7] Wesley Linton, Analysis of Torsional Stiffness and design improvement study of a Kit Car Chassis Prototype.

[8] Roopesh Shroff, "Structural Optimization Automotive Chassis" *Department of Mechanical Engg. , IIT ,Bombay – Academic year 2002*