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Material Optimization of Casnub Bogie Frame

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Abstract: *The bogie frame of a railway is a significant structural component for the support of vehicle loading. In general, more than 25 years' durability is needed. Modeling is carried in Pro-E, followed by analysis using COSMOS. Strength evaluations of the bogie frame were performed to examine the effect of load through the COSMOS. It has been found that the stress and strain due to the applied loads were critical and sensitive. Even the displacement developed has been observed. The main aim of this work is to optimize the design of the Casnub bogie of a train in order to identify suitable material for bogie frame with effective load bearing capacity. Series of analyzing tests were carried by varying material and also the tests were repeated with self load and additional external load. At the end suitable material has been suggested..*

Keywords: *Casnub, Bogie, Frame, FEM,Analysis.*

I. INTRODUCTION:

Traffic safety, transport economy and transport capacity of rails are main goals of any railway industry and train manufacturers. Railway industry has encountered newer stages of progress as: improved running service safety, lightweight structures, and assurance of the maximum loading capacity, reduced product design cycle and in the same time lower costs for construction, maintenance and repair. Most of the railway vehicle studies focus on the complete design process of the key structural components of the railway carriage such as bogie frames, axles, wheels and other components, which includes design procedures, assessment methods, verification and manufacturing quality requirements [1].

The bogie is one of the main parts of trains which plays an important role in sustaining the static load from the dead weight of a car body, controls wheel sets on straight and curved tracks and carries the wheels, axles, brakes and suspensions. Therefore, due to frequent geometric changes which are required in early stages of the design process, effective simulation methodologies are indispensable for predicting the behavior of bogies under severe load conditions [2, 3].

1.1 Introduction to Casnub Bogie:

CASNUB Bogie is used in Freight wagons. CASNUB bogie consists of two cast iron frames, floating bolster, mild steel spring plank, nested springs, and friction snubbers. Bolster is supported on the side frames through two nested of springs. Two cast iron steel frames are connected by spring planks. Frictional snubber acts as a frictional damper, which dampens the oscillations. Frictional snubbers provide damping action proportional to load.

Fig 1: Casnub bogie

Table 1:Salient features of CASNUB bogie.

Feature	
Gauge	1676 mm
Axle load	20.3 T
Wheel diameter	1000 mm
Wheel base	2000 mm
Distance between journal centers	2260 mm
Distance between side bearers	1474 mm

Design in an important industrial activity which influences the quality of the product. The bogie frame assembly is designed by using the modeling software PRO-E. Later this model is imported to COSMOS for the analysis. The COSMOS software is used for analyzing the component by varying the material and load acted and then obtained results are observed. A solver mode in COSMOS software calculates the stresses, strains and displacements.

II. Modeling and Analysis:

Start PRO-E, and select specific workbench (Part Design). The basic requirement for creating a solid model is a sketch. The sketch required is drawn using tools in the workbench. The tools in the part design workbench are used to convert sketch into sketch-based feature. Thus created models are shown in following figures (Fig: 2 to Fig : 5).

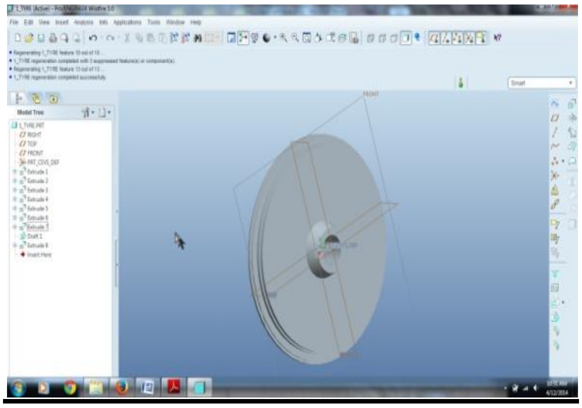

Fig 2: Wheel Base.

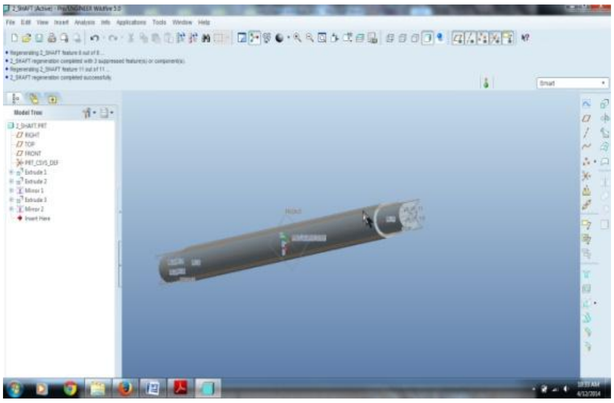

Fig 3: Axle Shaft

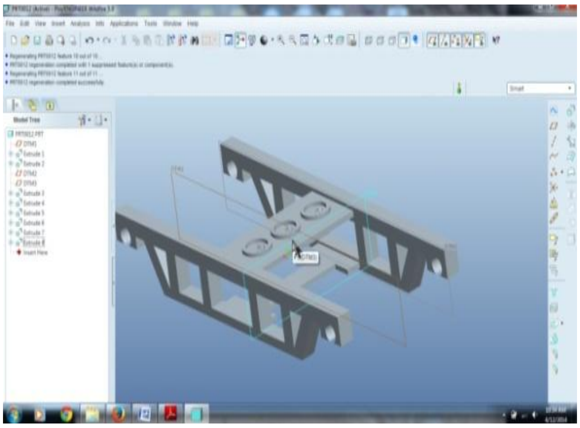

Fig 4: Chassis Frame

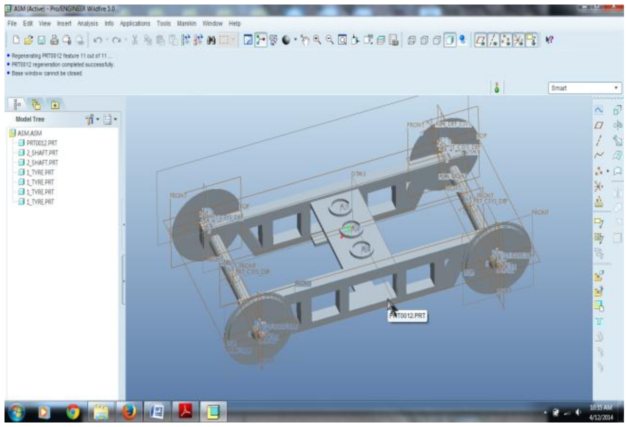

Fig 5: Assembly Unit

2.1 Cosmos Works:

This software uses the Finite Element Method (FEM) to simulate the working conditions of your designs and predict their behavior. FEM requires the solution of large systems of equations. Powered by fast solvers, COSMOS Works makes it possible for designers to quickly check the integrity of their designs and search for the optimum solution.

2.2 Structural Analysis Of Bogie Frame in Cosmos

2.2.1 Cast Iron- Load- 20.3T (Self Load)

Study Properties/ Analysis type: Static / Mesh type: Solid Mesh / Solver type: FFEPlus

Table 2:Material Properties

Name:	Gray Cast Iron
Model type:	Linear Elastic
Default failure criterion:	Mohr-Coulomb Stress
Tensile strength:	1.51658e+008 N/m^2
Compressive strength:	5.72165e+008 N/m^2
Elastic modulus:	6.61781e+010 N/m^2
Poisson's ratio:	0.27
Mass density:	7200 kg/m^3
Shear modulus:	5e+010 N/m^2
Thermal expansion coefficient:	1.2e-005 /Kelvin

Pressure-1: 0.0808 N/mm^2 (MPa)

Table 3: Mesh Information.

Element Size	150
Total Nodes	26842
Total Elements	13999
Maximum Aspect Ratio	33.665
% of elements with Aspect Ratio <	69.1
% of elements with Aspect Ratio >	4.04
% of distorted elements(Jacobian)	0
Time to complete mesh	0:00:12

Total Nodes	26842
Total Elements	13999
Maximum Aspect Ratio	33.665
% of elements with Aspect Ratio <	69.1
% of elements with Aspect Ratio >	4.04
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	0:00:12
Computer name:	ARUNA-PC

After creating model using PRO-E, then model is saved. There after import created model into COSMOS, followed by meshing (select Body and apply). Then giving meshing element size and clicking on generate mesh results in meshing of our model as follows shown in Fig: 3.3.

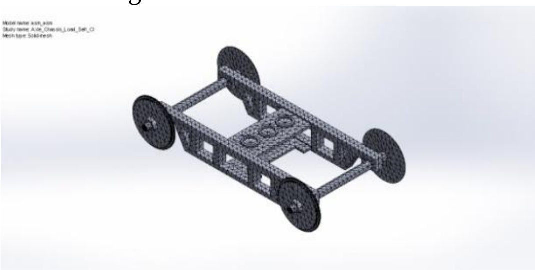

Fig 6: Meshing model of Bogie frame assembly

Finite element models of the bogie frames are illustrated as follows.

2.2.2 Analysis of Cast Iron (20.3T Load)

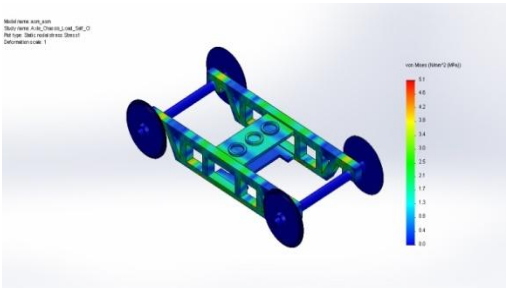

Fig 7: Stress analysis at 20.3 T (cast iron)

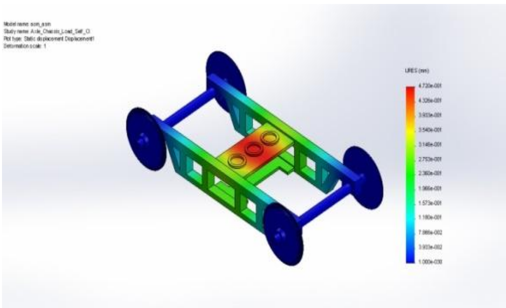

Fig 8: Displacement analysis at 20.3 T(cast iron)

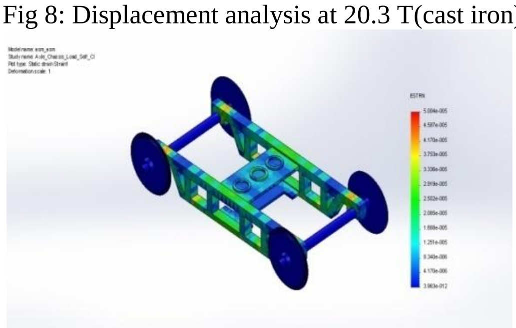

Fig 9: Strain analysis at 20.3 T (cast iron)

2.2.3 Analysis of Cast Iron (23T Load)

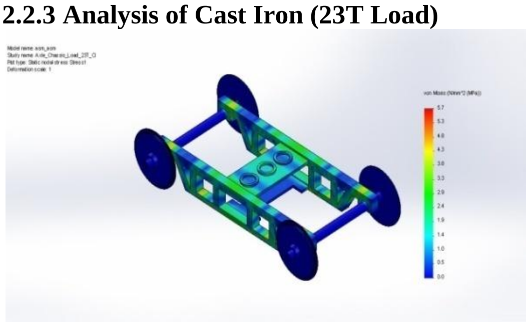

Fig 10: Stress analysis at 23 T (cast iron)

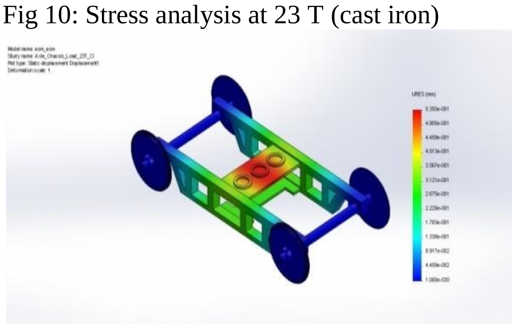

Fig 11: Displacement analysis at 23 T (cast iron)

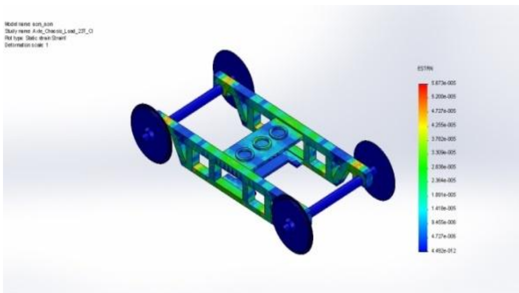

Fig 12: Strain analysis at 23 T load of cast iron.

2.2.4 Analysis of Cast Iron (29T Load)

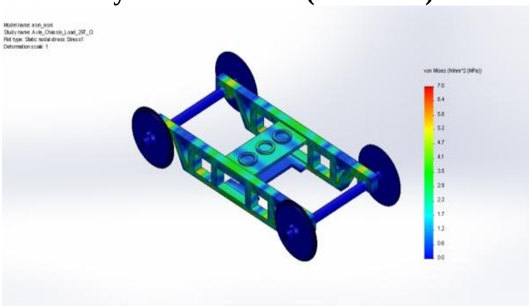

Fig 13: Stress analysis at 29 T (cast iron)

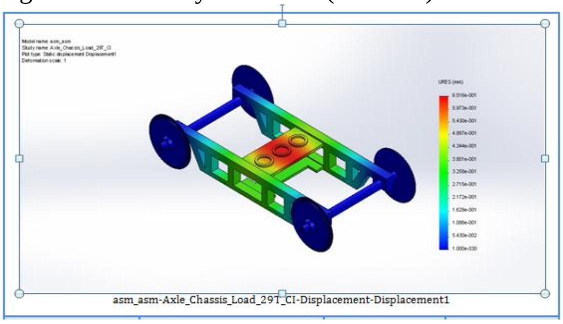

Fig 14: Displacement analysis at 29 T (cast iron)

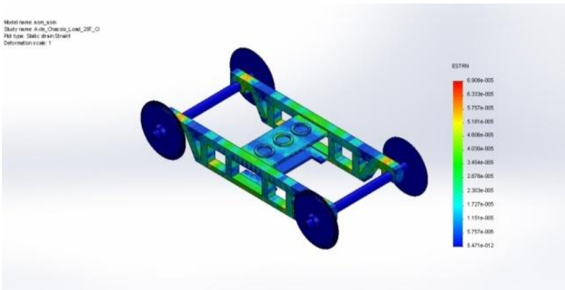

Fig 15: Stain analysis at 29 T load (cast iron)

2.3 Analysis Of Bogie Frame Using Aluminium Alloy And Stainless Steel

Applying the procedure similar as that applied to the cast iron, for the bogie frame made of aluminium alloy and stainless steel, the following results were obtained.

2.3.1 Analysis of Aluminium (20.3T Load)

Name	Type	Min	Max
Stress1	VON: von Mises Stress	8.20217e-007 N/mm^2 (MPa) Node: 4976	5.05037 N/mm^2 (MPa) Node: 17398

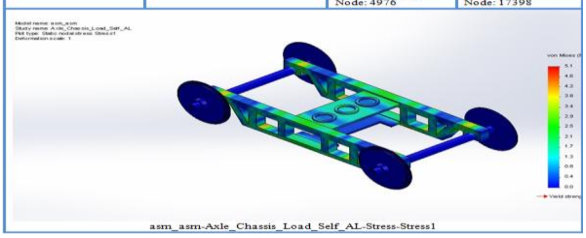

Fig 16: Stress analysis at 20.3 T (Aluminium)

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	0.451562 mm Node: 19033

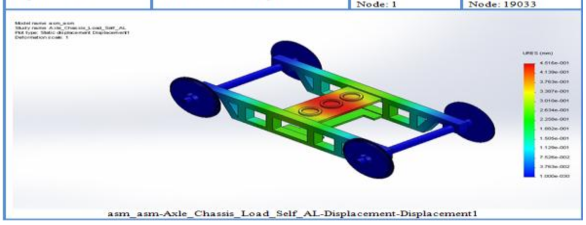

Fig 17: Displacement analysis at 20.3 T Aluminium

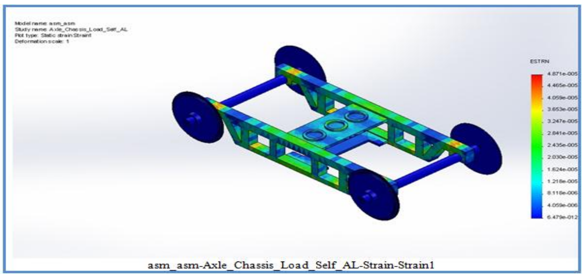

Fig 18: Strain analysis at 20.3 T (Aluminium)

2.3.2 Analysis of Aluminium (23T Load)

Name	Type	Min	Max
Stress1	VON: von Mises Stress	7.01798e-007 N/mm^2 (MPa) Node: 6580	5.8179 N/mm^2 (MPa) Node: 17398

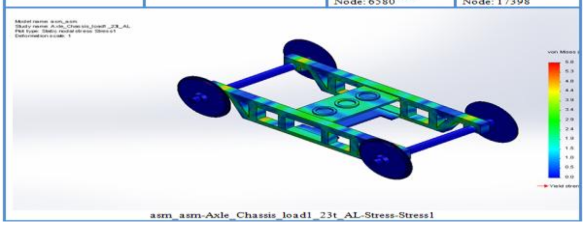

Fig 19: Stress analysis at 23 T (Aluminium)

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	0.544255 mm Node: 25840

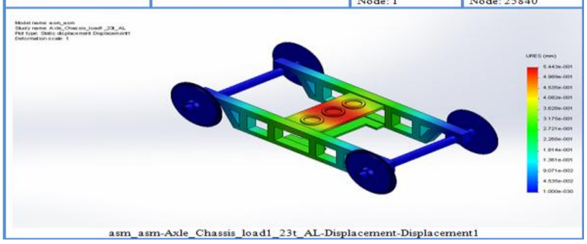

Fig 20: displacement analysis at 23 T (Aluminium)

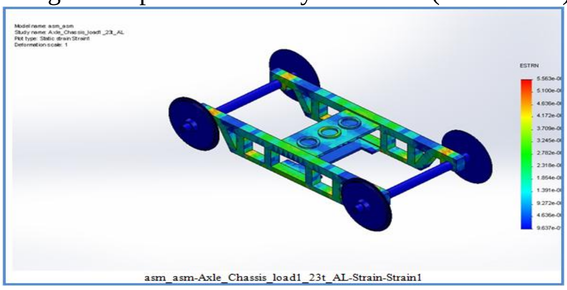

Fig 21: Strain analysis at 23 T (Aluminium)

2.3.3 Analysis of Aluminium (29T Load)

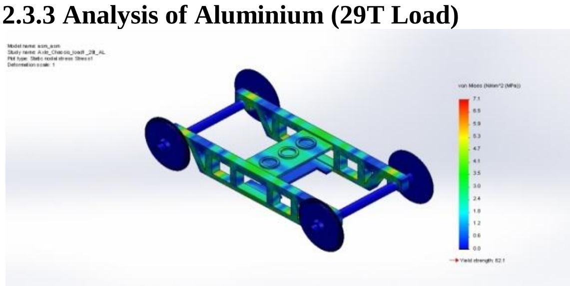

Fig 22: Stress analysis at 29 T(Aluminium)

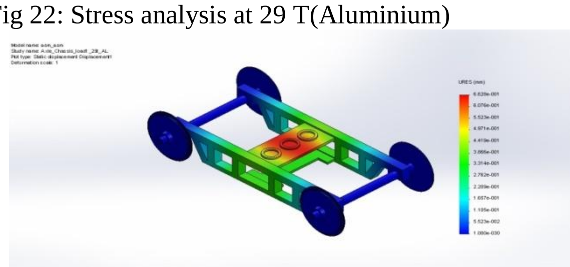

Fig 23: Displacement analysis at 29 T (Aluminium)

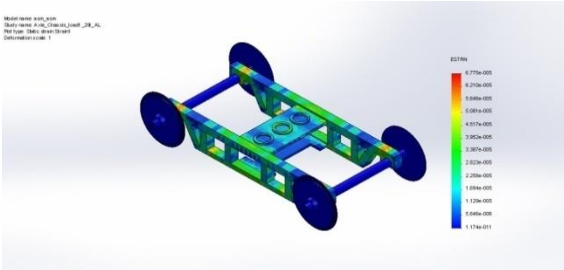

Fig 24: Strain analysis at 29 T load of Aluminium

2.4.1 Analysis of Stainless steel (20.3T Load)

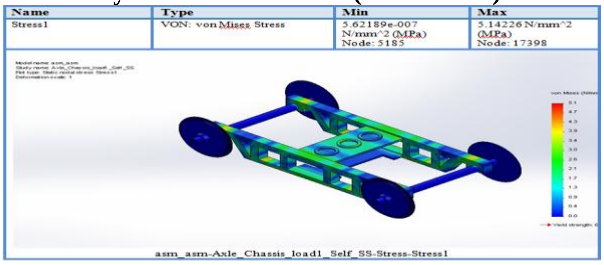

Fig 25: Stress analysis at 20.3 T (Stainless steel)

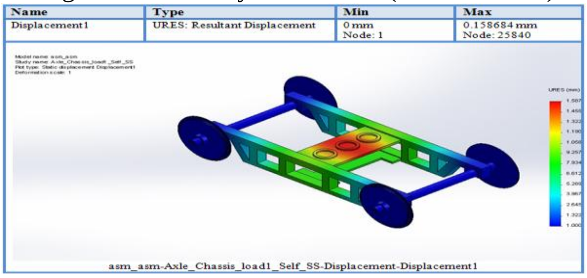

Fig 26: Displacement at 20.3 T (Stainless steel)

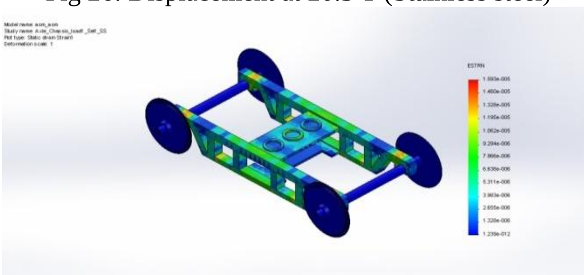

Fig 27: Strain analysis at 20.3 T (Stainless steel)

2.4.2 Analysis of Stainless steel (23T Load)

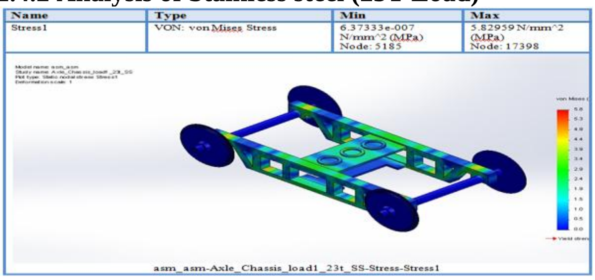

Fig 28: Stress analysis at 23 T (Stainless steel)

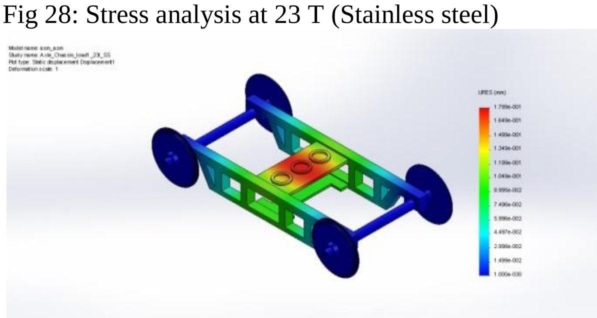

Fig 29: Displacement at 23 T (Stainless Steel)

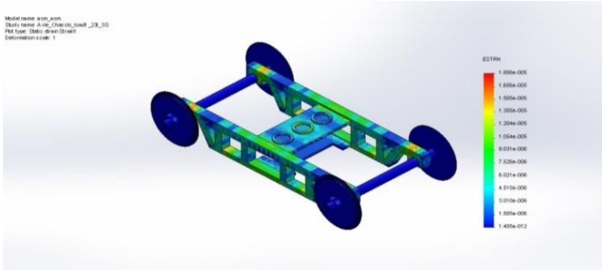

Fig 30: Strain analysis at 23 T (Stainless steel)

2.4.3 Analysis of Stainless steel (29T Load):

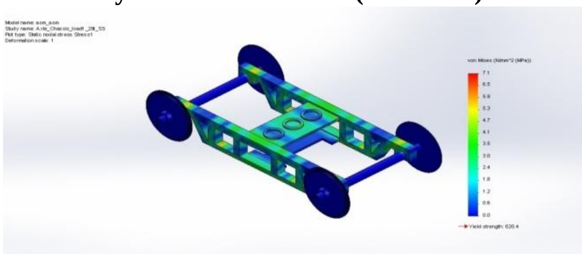

Fig 31: Stress analysis at 29 T (Stainless steel)

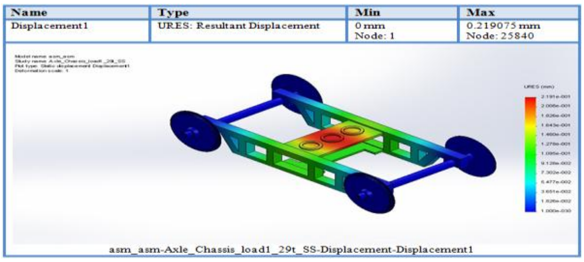

Fig 32: Displacement analysis at 29 T(Stainless steel)

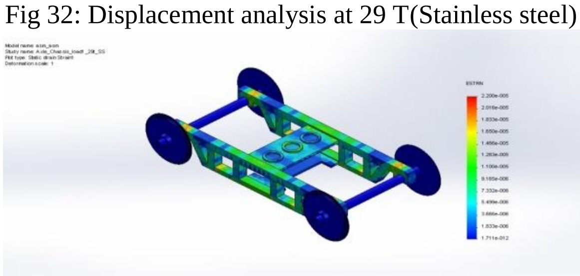

Fig 33: Strain analysis at 29 T (Stainless steel)

III. NUMERICAL RESULTS.

The numerical results obtained from COSMOS work are observed as follows.

Table 4: Results of Cast iron bogie

Load(T)	Displacement(mm)	Stress (N/mm^2)	Strain
20.3	0.471959	5.06449	5.00E-05
23	0.535043	5.74143	5.67E-05
29	0.651572	6.99188	6.91E-05

Table 5: Results of Aluminium bogie.

Load(T)	Displacement(mm)	Stress (N/mm2)	Strain
20.3	0.451562	5.05037	4.87E-05
23	0.544255	5.8179	5.56E-05
29	0.66279	7.085	6.77E-05

Table 6: Results of Stainless steel bogie

Load(T)	Displacement(mm	Stress (N/mm^2)	Strain
20.3	0.158684	5.14226	1.59E-05
23	0.179895	5.82959	1.81E-05
29	0.219075	7.09925	2.20E-05

From the fig 34 to fig 36, it has been observed from the results that the displacement, stress and strain developed in the Casnub bogie model increases with increase of load as expected. The increase in displacement as well as strain in the models made of aluminium and cast iron is at higher rate than that of the stainless steel model. Whereas the rate of variation of stress with respect to load is almost same in all the models (cast iron, aluminium and stainless steel). This is because of having sufficient energy storage capacity at initial load application which decreases at higher loads due to their material properties.

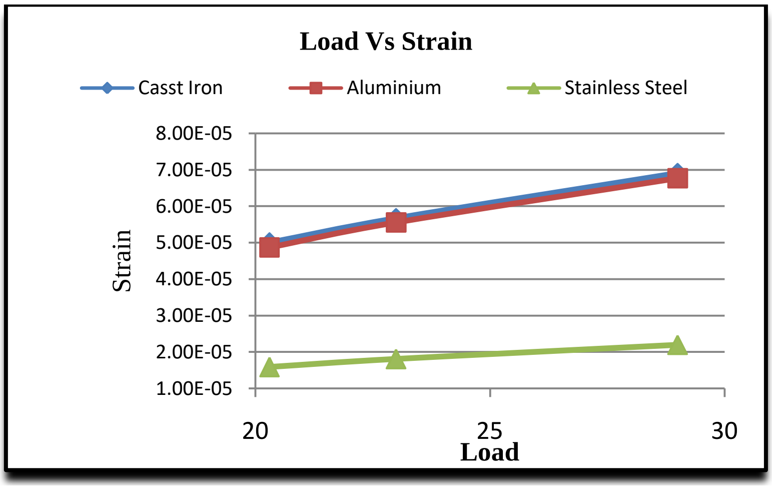

Fig 34: Load Vs Strain.

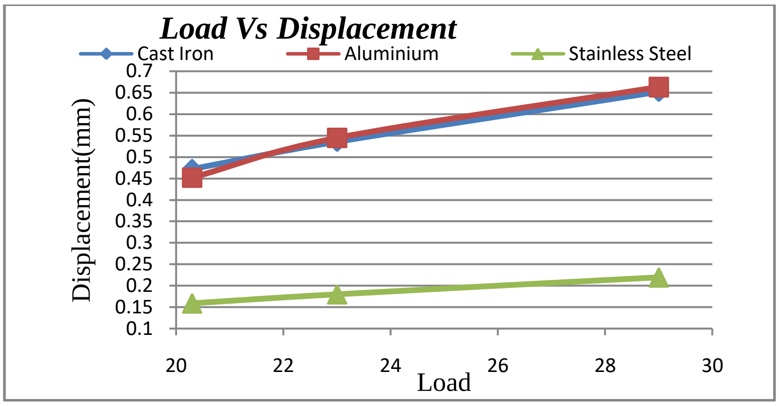

Fig 35: Load Vs Displacement

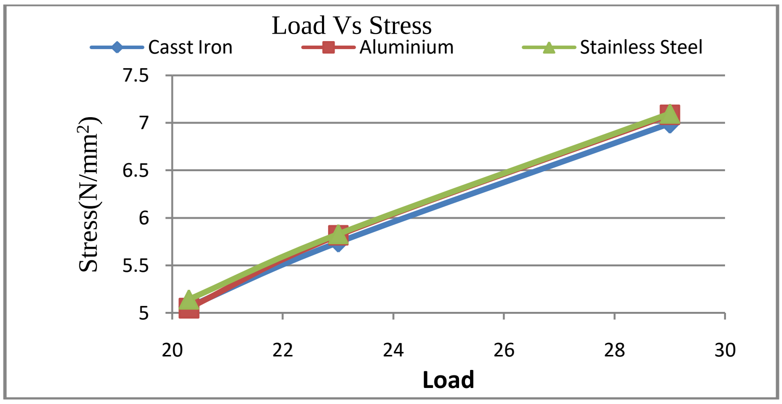

Fig 36: Load Vs Stress

IV CONCLUSIONS

- On the basis of maximum stress developed, it is observed that aluminium material element is having 1.33% higher than that of cast iron. Where as it is 1.53% higher for steel. It shows that steel and aluminium are almost all equally competent to the cast iron on strength point of view.
- On the basis of deflection, steel is well preferable having very less deflection compare to both cast iron and aluminium. Whereas aluminium is equally strong compare to cast iron.
- In analyzing axel, self weight together with external load was considered. In the present study for the same design, it is observed that the weight of alminium is 58% lower than that of cast iron. Whereas for steel it is 6.5% higher than that of cast iron.
- Therefore collectively together considering the self and external weight the stress and deflection together gets reduced and therefore aluminium is the optimum material for effective railway bogie.
- The cost of aluminium is less than the cost of cast iron. Therefore it suits economically to the present marketing demand.

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