Design and analysis of front axle of Heavy commercial vehicle

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***Abstract**:Front axle absorbs the shock due to road surface variations and also carries weight of the front part of the automobile. The front axle is designed to transmit the weight of the automobile from the spring to front wheels so proper design of front axle is essential. The front axle is modelled in CAD software and analysed using ANSYS software. The axle is analysed for four different materials SAE1018, AISI1020, 27cr15, ductile cast iron. The front axle of the truck is designed and analysed by considering the following specifications such as vehicle's gross weight, payload capacity, braking torque, principle stress, tensile stress.*

Index Terms- *Chassis, Finite element Analysis, Structure, Ladder Frame, Static structural analysis, Side Member, Cross Member.*

1.Introduction

Automobile industry is one of the important and key sectors of the indian economy. The automobile sector which includes commercial vehicles. Passenger cars, multi utility vehicles, two wheelers, three wheelers, four wheelers, comes under the auto industry so it becomes essential for an automobile designer to meet system safety needs and to reduce the weight of the vehicle so as to satisfy fuel economy and vehicle performance. One of the main part of the axle. Axle is a central shaft for rotating wheel or gear. Axle is fitted to the wheels rotating with them or fitted to vehicle with the wheels rotating around axle. Bearings or bushings are provided at the mounting pairs where the axle is supported. There are three types of axle i)front axle ii)rear axle iii)stub axle. Front axle transmits the weight of automobile from the spring to front wheels. In static condition the axle might be considered as beam supported vertically upward at ends. Under dynamic condition vertical bending moment increases due to road roughness which causes more stresses and fluctuations in axles. Therefore it is necessary to make sure whether or not the axle resist against the fatigue failure for a predicted service life.

2.Components

For design purpose the front axle beam of ASHOK LEYLAND 1612 trucks was chosen. All standard axles have an 'I' cross section in the middle and circular or ellpitical cross section at the ends. An axle is a higher strength to weight ratio ,usually a forged component. The 'I' type consturction of axles are lightweight and yet great strength. The I-beam axle is shaped to perrmit the body of the vehicle to be mounted lower than it could be if the axles were straight. On the top of axles, springs are placed over flat, smooth surfaces called spring seats. A hole is bored in each end of I-beam, to provide mounting point for kingpin. A small hole is drilled for the steering knuckle pinhole. A lubrication fitting and a drilled passage provide a method of forcing grease onto the bearing surface of bronze bushing. A flange is present between the spindle and yoke. It has holes around its edge inorder to provide mounting surface for brake components. The king pin acts like door hinge as it connects the steering knuckle to end of axle I beam. A ball type thrust bearing is installed between I beam and lower arm of knuckle yoke, so that the end of I beam rest upon the bearings.

3.Construction and Operation

Axle is a central shaft that rotates the wheel. The axle may be mounted to the wheels, rotating with them, or located to its surroundings, or with the wheels rotating around the axle. The axle function is to transmit driving torque to the wheel. It also maintains the wheel position relative to each other and to the vehicle body. Axle
bears the weight of the cargo in addition to the weight of the vehicle body. About 30-40% of the vehicle weight is taken up by the front axle. Front axle is made up of I section in the middle and circular or elliptical section at the ends. The x-section of the axle withstands the bending load due to weight of the vehicle andbraking torque. It contains main beam, stub axle, and swivel pin etc.

Wheels are mounted on the stub axle. The front axles are usually dead axles but in case of small cars and four wheel drive the front axles are live axles.

4. Vehicle Specification

4.1(a) specifications of Ashok Leyland 1612 truck.

Engine	H series turbocharged 6 cylinder diesel
Maximum power	114 ps(84kW) @2400 rpm
Maximum torque	42 kg-m @ 1700-1800 rpm
Clutch	356mm dia
Transmission	5 speed synchromesh gearbox
Rear axle	Single speed hypoid gear
Frame	All ladder type bolted construction
Suspension	Semi elliptic laminated multi leaf with centre bolt
steering	Power steering
Brakes	Dual line full air brakes
Battery	4V(2*12V) 80 Amp-Hr
Tyres	Front 10.00*20-16PR Nylon Rear 10.00*20-16PD Nylon

5. Design parameters

5.1.Major Dimensions of Truck 16/12

Wheel Base	4330 mm
Overall Length	7766 mm
Overall Width	2425 mm
Front Track	1915 mm
Rear Track	1816 mm
Min. Ground Clearance	253 mm
Min. Turning Circle Diameter	17500 mm
Loading Body Length	5640 mm
Max. Speed In Top Gear	74.5 kmph
Maximum Gradeability	12%

Weight of Truck 16/12

	Unladen	Laden
Front Axle	2420	6000
Rear Axle	1820	10200
Total	4240	16200

6. Analytical Method

6.1 Sample Calculation

6.1.1 Moment of Inertia of I Cross Section

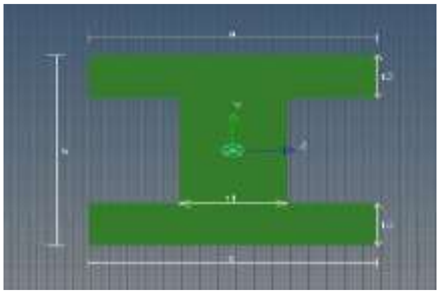

Fig 1: I section

Assumption

H=1.2*B,

h= (H/2)

b= (B/2)

We will design the axle beam by taking consideration of yield stress of both material i.e. Ductile Cast Iron and SAE 1020. The value of yield stress of both materials is 370 MPa.

2**Calculation of weight**

For Truck 16/12,

Laden Weight = 6000 kg.

Actual weight coming on axle is,\

Considering 3g condition (bump load) = 3 * 6000

= 1800kg

Total Weight on axle is given by = 18000 * 9.81

= 176.58 kN

Weight on each spring seat = 176.58 /2

= 88290 N

Vertical deflection at spring pad ,

$Yc=Wa^2 (3L-4a) / 6EI$

Deflection at center of beam (max deflection),

$Ymax=Wa (3L^2-4a^2) / 24EI$

7.Result Table

S.no	Material	Deflection, ymax (mm)	Stresses, σ (N/mm2)
1	Ductile Cast Iron	15	370
2	SAE 1020	18.621	370

Table 3. Analytical Results

8. Cad Modelling

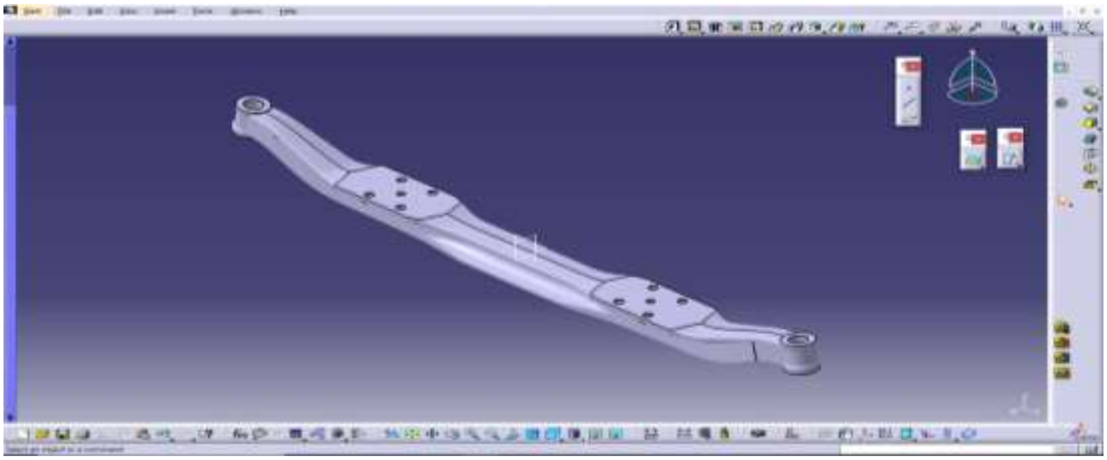

Fig 2: Isometric View

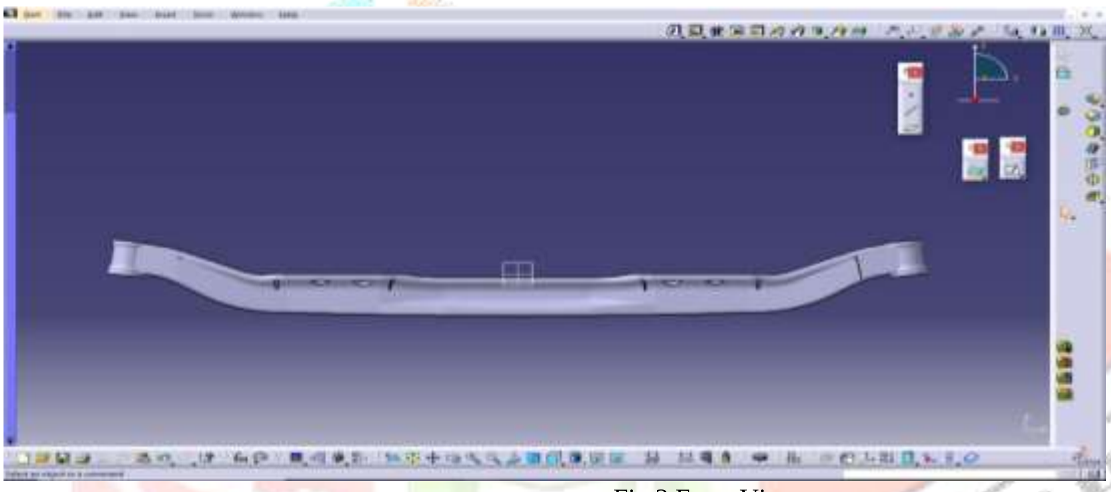

Fig 3.Front View

The front axle with the design paramters of ashokleyland 1612 truck was modelled using catiaV5 6-R2017 in the part modelling interface.

9. Finite Element Analysis

9.1 For ductile cast iron

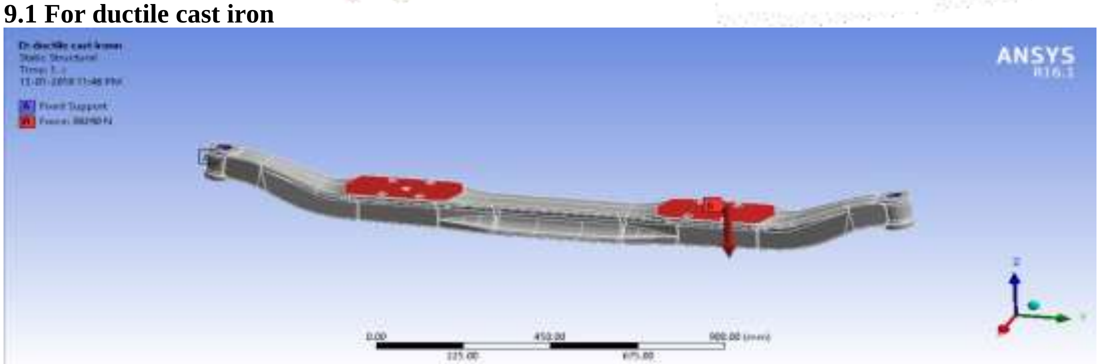

Fig 4: Loading at spring seats(88290 N)

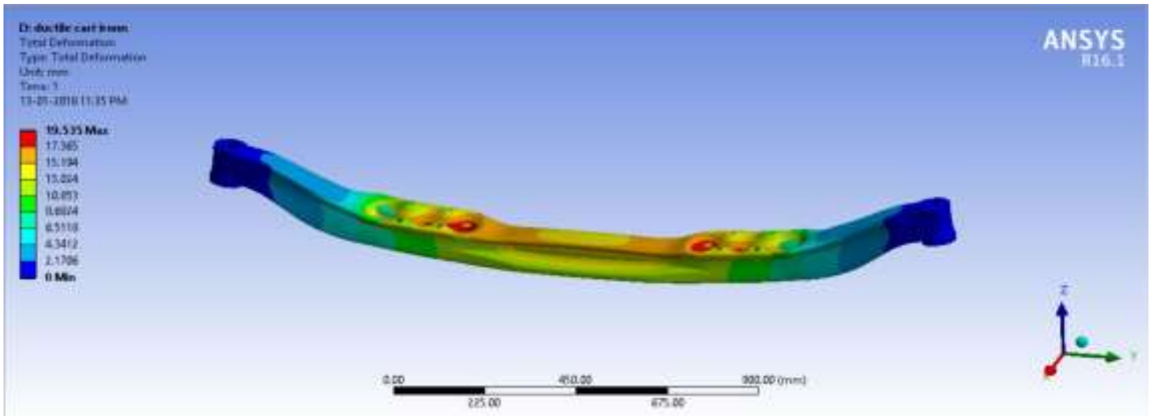

Fig 5: Total deformation plot

Maximum deformation occurs at the centre with 19.535 mm along -ve Z direction.

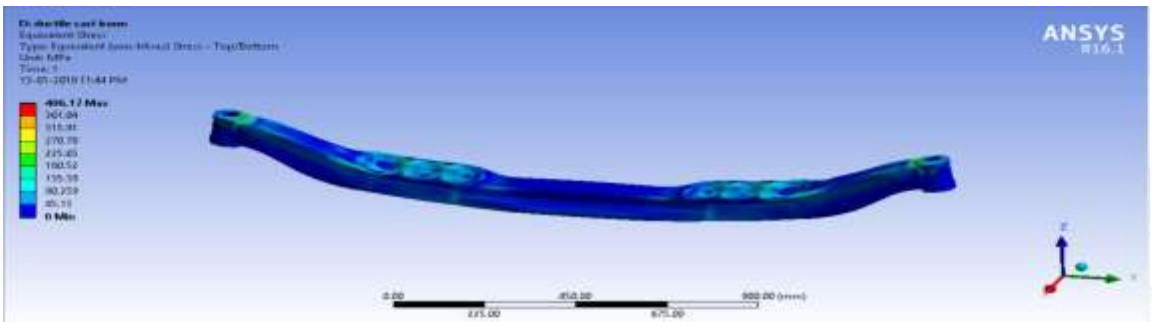

Fig 6: Von-messies stress plot

9.2 For SAE1020

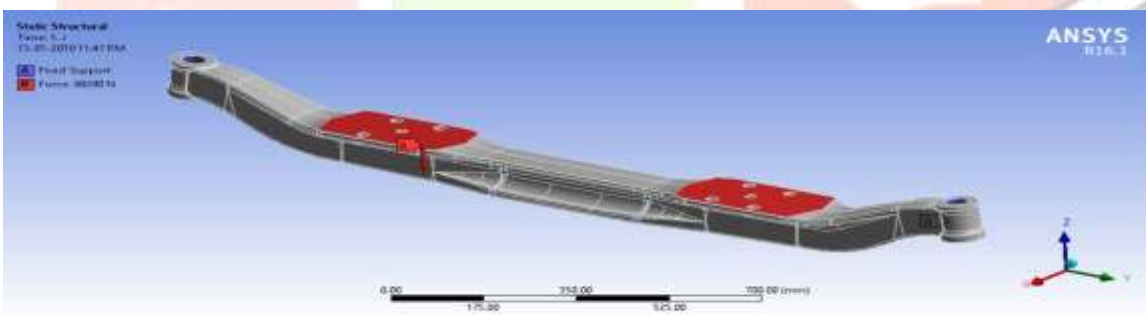

Fig 7: Loading at spring seats

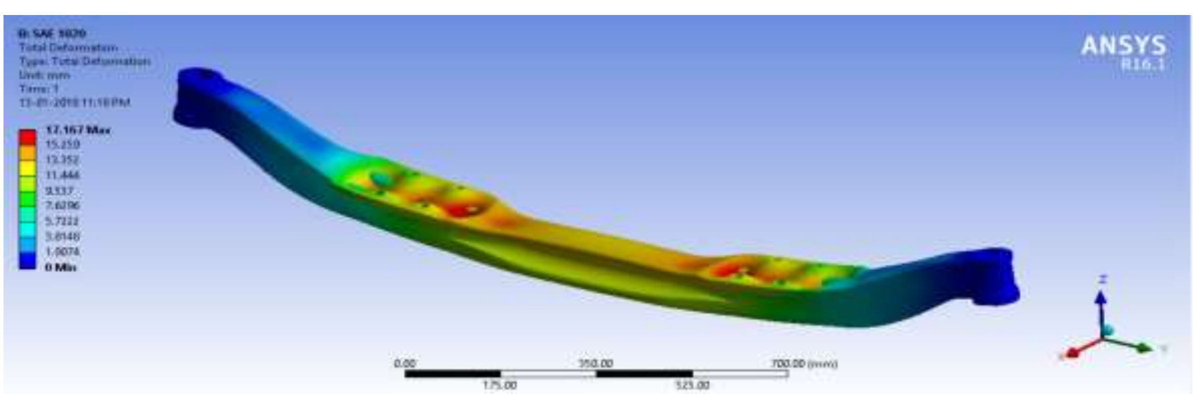

Fig 8: Total deformation plot

Maximum deformation occurs at the centre with 17.167 mm along -ve Z direction

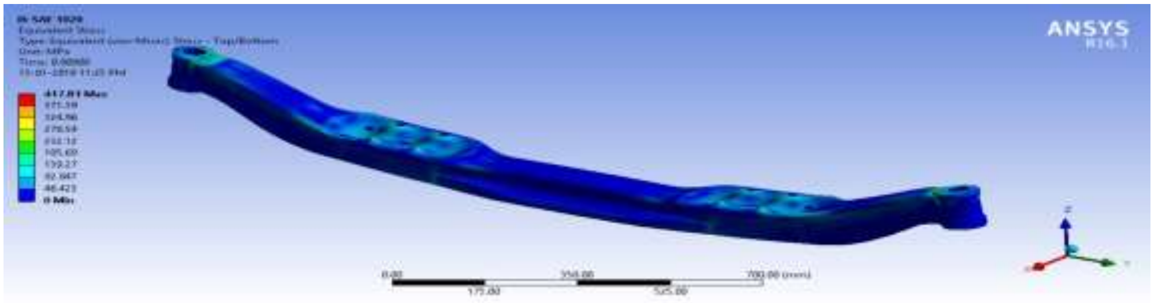

Fig 9: Von-messies stress plot

10. Comparison of Results

1	Materials	Parameters	Analytical Results	FEA results	% Error
1	Ductile CI	Deflection (mm)	15	19.535	29
		Stress (N/mm2)	370	406.17	8.91
2	SAE 1020	Deflection (mm)	18.62	17.167	7.80
		Stress (N/mm2)	370	417.8	9.42

11.Conclusion

The results shows the maximum stress distribution is low for SAE 1020 than Ductile Cast Iron but SAE 1020 material has maximum deflection in axle . Hence the better material SAE 1020 for manufacturing of axle than Ductile Cast Iron. Also this present thesis we have established a satisfactory co relation between hand calculations done analytically and the FEA results. The displacements predicted in the FEAgave the confidence that the boundary conditions for beam are correctly simulated. Correlation between stress results from analytical calculation and from FEA assures that the mesh size and modeling approach used for the component were well defined. Finally we were able to deliver a safe and validate design to suit the requirements of the project.

12.Acknowledgements

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13.References

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