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Design and Stress Analysis Comparison of Two bogie Frames

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ABSTRACT: The frame of the bogie is the main part in a bogie which holds various other components in it. Bogie frame bears all the stresses and loads applied on a bogie while in motion and all the main forces including vibrations. In this project Linke Hofmann Busch (LHB) or Fabric Italiana de Automobil Torino (FIAT) bogie frame and CASNUB bogie frame designed on solid-works. Both the designs are based on the criteria of impact load, jerk and extra load carrying capacity which in turn may provide better comfort and safety to the passengers. After comparing both the design it has been found that CASNUB bogies are safer than the FIAT bogies.

KEYWORDS: LHB, FIAT Bogie, CASNUB Bogie, Von-Mises Stress.

I. INTRODUCTION

A bogie consists of various other systems and form a complex frame with multiple degrees of freedom. Its motion is influenced by the geometry of the track, the suspension system, and the inertia of the component parts. It is required to make bogies safe for the passengers and also to take less damage if it collides somewhere. In layman's words, a bogie is an underframe or chassis which carry wheels and is attached to a vehicle; hence it serves as a modular sub-assembly of wheels & axles [1].

A bogie controls the wheels in the correct alignment for dynamic stability of train while running straight or curving. At same time, it must also provide acceptable ride levels in the vehicle to which it is fitted, under a wide range of track conditions.

Bogie Components

Bogies are very important in safe railway operations and in performing some functions. The bogies are the undercarriage of the railway vehicle which supports the car body and other necessary parts. In mechanical terms, a bogie is a chassis or framework carrying wheels, attached to a vehicle, thus serving as a modular subassembly of wheels and axles. The bogie has following components [3],

- a) Bogie frame
- b) Bogie transom
- c) Brake cylinder
- d) Primary suspension coil
- e) Motor suspension tube
- f) Gearbox
- g) Lifting Lug
- h) Motor
- i) Neutral section switch Detector
- j) Secondary suspension air bag
- k) Wheel slide protection system lead to Axlebox
- l) Loose leads for connection to car body
- m) Shock absorber
- n) Axlebox cover

Functions of Bogie Frame

Bogie has solid welded bogie frame made up of two longitudinal components connected by two cross beams. The bogie frame is casted or fabricated [4].

- Support railcar body firmly.
- Run stably on both straight and curved track.
- Ensure good ride comfort by absorbing vibration generated by track irregularities and minimizing impact of centrifugal forces when train runs on curves at high speed.
- Minimize generation of track irregularities and rail abrasion.
- Bogie frame have sections for holding bolster, brake arrangement, axle box guide and many other parts which are welded to the frame.
- The main purpose of the bogie frame is to withstand and/or transfer vertical loads of the superstructure with payload, lateral forces caused due to negotiating the curves and interaction between rail and wheel and longitudinal force due to drafting of the coach by the engine.
- To have flexibility in the wheelbase, two bogies are provided per coach, which are pivoted at two points by members called Centre pivot [5].

II. RELATED WORK

Design and Modelling:

1. The FIAT type of bogie is adopted by the EUROFIMA design initially.
2. It is a Y-frame which is manufactured component by component and then fabricated and machined later.
3. It has 4 nested springs as primary suspension and 2 flexi coil suspension in place of two stage or secondary suspension.
4. Over the disc brake assembly, an axle is mounted
5. Shock absorbers are hydraulic type and are as per UIC stipulation
6. Each bogie has 4 primary dampers, 2 secondary vertical dampers, 1 secondary lateral and 2 yaw dampers.

STEP 1: Modelling of different components

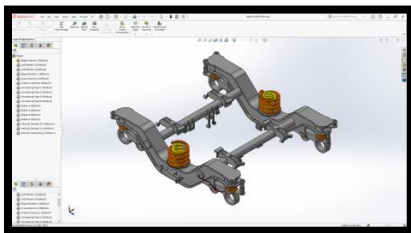


Fig:1 Bogie Frame

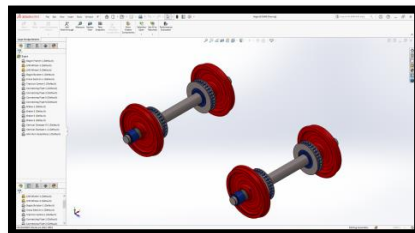


Fig:2 Wheel Sets

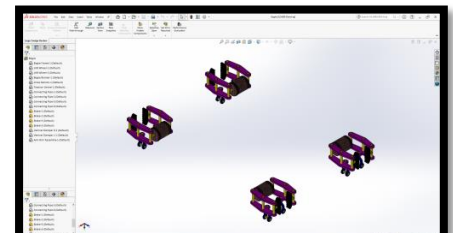


Fig:3 Brake Assembly

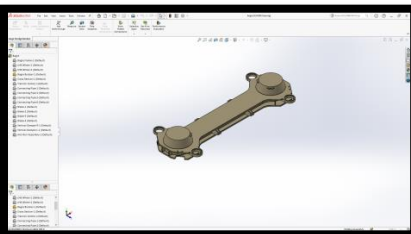


Fig:4 Bolster

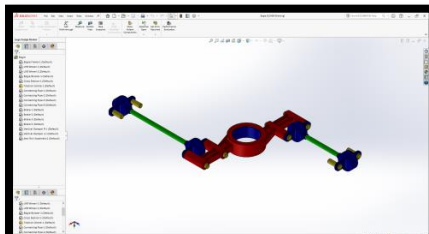


Fig:5 Traction arrangement

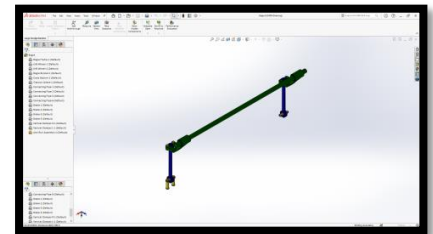


Fig:6 Anti-Roll Assembly

STEP 2: Assembly

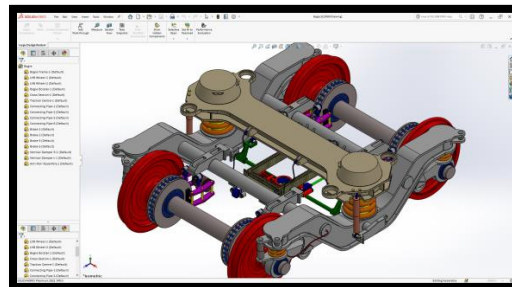
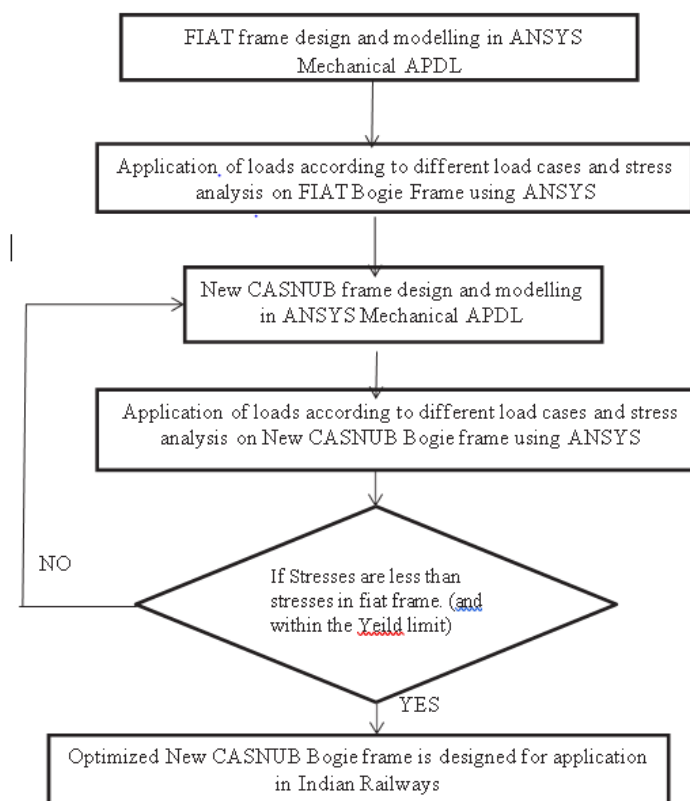


Fig:7 Assembled LHB Bogie Frame

III. METHODOLOGY

METHOD OF STRESS-ANALYSIS



STRESS-ANALYSIS

➤ Load-Cases for Static Stress Analysis

Static stress investigation of a design is led to guarantee as far as possible to break down the exceptionally focused on zones inside that construction. This interaction is completed to decrease the odds of disappointment during the activity [6]. Construction is supposed to be inside the edge, or say, wellbeing limits, when ratio b/w the yield stress & the most extreme stress actuated anytime in the entire design, is multiple. Higher the worth, the more prominent the variable of security for the construction considered. In this strategy, 4 load cases are chosen for stress examination[1-2, 8].

- Vertical Force Case
- Vertical & Transversal LoadCase
- Vertical transversal &Longitudinal force case
- Potential-Collision with Normal-Service Loads Case

TABLE:1 RESULTS FROM STRESS-ANALYSIS OF A FIAT BOGIEFRAME

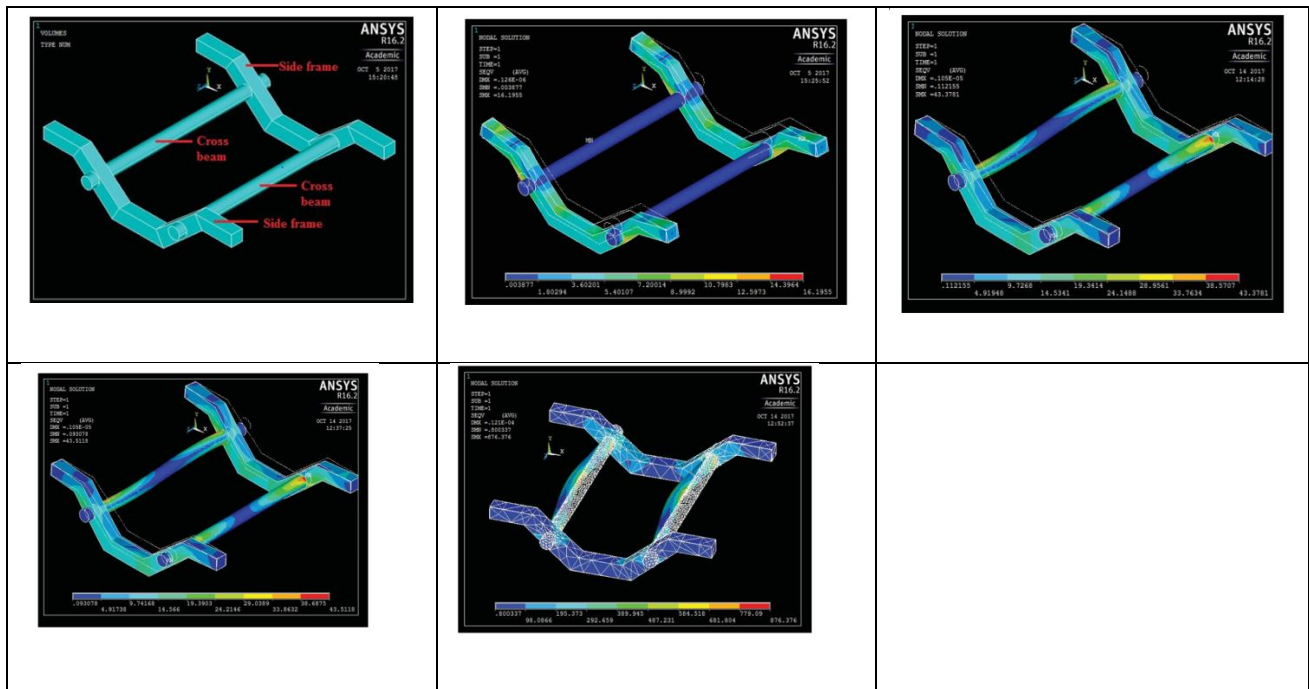
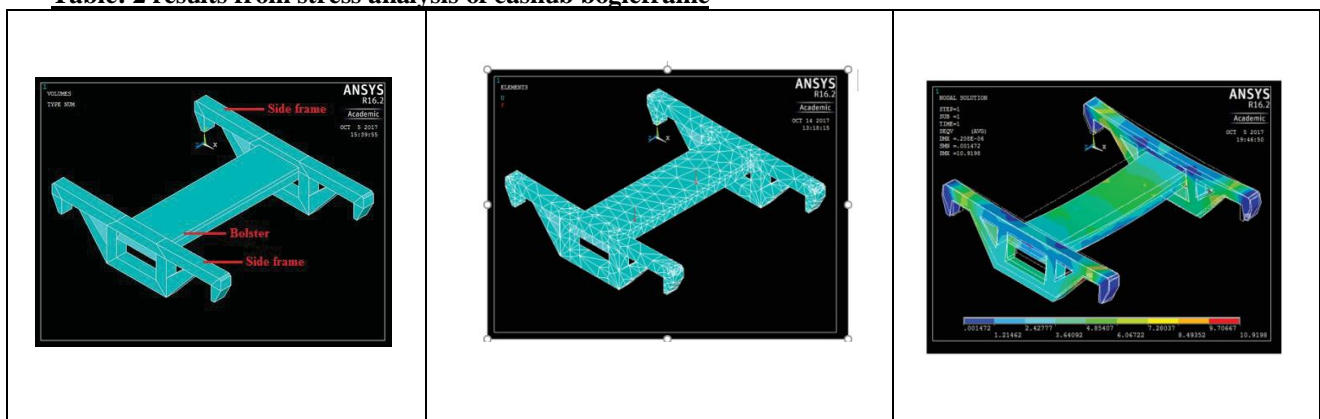
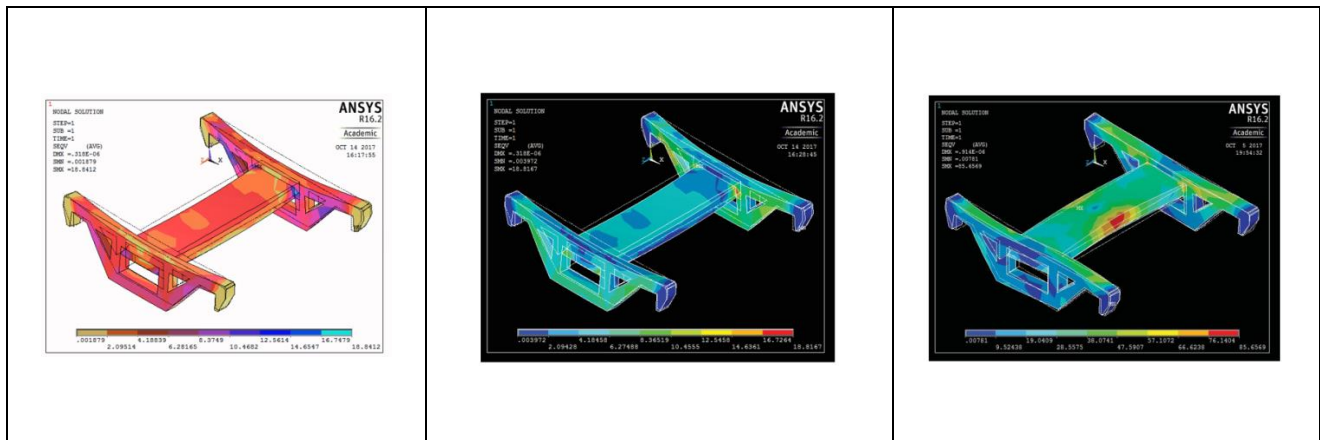


Table: 2 results from stress analysis of casnub bogieframe





FORCES CALCULATIONS

VERTICAL FORCES(F_y)

$$F(y) = 1.4g \frac{M(v) - 2m^4}{2}$$

F_y - Vertical forces on one bogie

M_v - M of bogie in the motion

m^+ - mass of bogieframe

g - acc dueto the gravity

TRANSVERSAL FORCES

$$F(z) = 2 \times \left(10^4 + \frac{(M(v) + C(1))g}{3n(a)n(b)} \right)$$

F_z -Transverse forces on one bogieframe

M_v - M of bogie in motion

g - acc due to gravity

C_1 - Mass of driver

n_a – No. of axles

n_b – No. of bogie in a loco

LONGITUDANAL FORCES

$$F(x) = 0.1 \times \left(\frac{M(v)g}{n(a)} \right)$$

F_x - longitudinal force on one bogieframe

M_v - M of bogie in motion

g - acc dueto gravity

n_a – No. of axle

FORCES ON a POTENTIAL COLLISION

$$\text{Impact Force} = 5g \times M(v)$$

FORCE CALCULATIONS OF FIAT BOGIEFRAME

The calculations of forces in a bogieframe is simply done taking help from below mentioned values and above-mentioned formulations,

M of the locomotive in motion (M_v) = 52,500a Kg

M of bogieframe (m^+) = 6300Kg

M of the driver C_1 = 85 Kg

No. of axles $n_a = 2$

Number of bogies $n_b = 2$

Acc dueto gravity $g = 9.81 \text{ m/s}^2$

Vertical forces calculation

$$F(y) = 1.4g \frac{M(v) - 2m}{2}$$

$$F(y) = 1.4 \frac{(9.81)(52500 - 2(6300))}{2}$$

$$F(y) = 273993.3 \text{ N}$$

Transversal Force Calculation

$$F(z) = 2 \times \left(10^4 + \frac{(M(v) + C(1))g}{3n(a)n(b)} \right)$$

$$F(z) = 2 \times \left(10^4 + \frac{(52500 + 85)9.81}{3 \times 2 \times 2} \right)$$

$F(z) = 105976.45 \text{ N}$

Longitudinal Force Calculation

$$F(x) = 0.1 \times \left(\frac{M(v)g}{n(a)} \right)$$

$$F(x) = 0.1 \times \left(\frac{52500 \times 9.81}{2} \right)$$

$$F(x) = 25751.25 \text{ N}$$

Impact Forces Calculations

The force that occurs because of jerks which induces an acceleration of 5g for bogieframe applicable at the centre of the gravity of the bogie[9].

$$\text{Impact Force} = 5g \times M(v)$$

Force Comparison

Table: 3 Force comparison of two bogie frames

Force Type	Forces Magnitude (KN)	
	FIAT BogieFrame	CASNUB BogieFrame
Vertical Forces	27. 4	28. 4
Transversal Forces	10. 6	10. 6
Longitudinal forces	2. 6	2. 6
Impact Forces	257. 5	257

IV. EXPERIMENTAL RESULTS

Table: 4 Forces in fiat bogie frame

Force location on the frame	Directionofforce	LoadMagnitude[N]
Side-frame	FYin-ve	68498. 325
	FYin-ve	68498. 325
Side frame(other)	FYin -ve	68498. 325
	FYin-ve	68498. 325
Forcelocation on the frame	Directionofforce	Load Magnitude [N]
	FYin-ve	68498. 325

Side-frame	FYin-ve	68498. 325
	FZin +ve	26494
	FZin +ve	2649
Side frame(other)	FYin-ve	68498. 325
	FYin-ve	68498. 325
	FZin -ve	26494
	FZin +ve	26494
Force location on the frame	Directionofforce	Load Magnitude [N]
Side-frame	FXin+ve	25751. 25
	FXin+ve	25751. 25
	FYin-ve	68498. 325
	FYin-ve	68498. 325
	FZin +ve	26494
	FZin +ve	26494
Side frame(other)	FXin-ve	25751. 25
	FXin-ve	25751. 25
	FYin-ve	68498. 325
	FYin-ve	68498. 325
	FZin +ve	26494
	FZin +ve	26494

TABLE: 5 FORCE IN CANSUB BOGIE FRAME

Force location in the bogie frame	Directionofforce	Load Magnitude[N]
Bolster	FYin-ve	142490.25
	FYin-ve	142490.25
Force location in the bogie frame	Directionofforce	Load Magnitude[N]
Bolster	FYin-ve	142490.25
	FYin-ve	142490.25
	FZin +ve	52988. 2375
	FZin +ve	52988. 2375
Force location on the frame	Directionofforce	Load Magnitude [N]
Bolster	FYin-ve	142490.25
	FYin-ve	142490.25
	FZin +ve	52988. 2375
	FZin +ve	52988. 2375
Sideframe	FXin+ve	25751. 25
	FXin +ve	25751.25
Sideframe(other)	FXin-ve	25751.25
	FXin-ve	25751.25

RESULTS**Table: 6 Results from the comparison of stress analysis of the two bogie frames**

Load case (Forces applied on the bogie frame)	Max Von-Mises Stress Values(N/mm^2)		%Decrease in stresses induced
	FIAT bogie frame	New CASNUB Bogie frame	
Vertical load-case	16. 1955	10. 9198	32. 58
Vertical & transversal load-case	43. 3781	18. 8412	56. 57
Vertical,transverse& longitudinal load case	43. 5118	18. 8167	56. 75
Potential-collision with normal service-load	876. 376	85. 6569	90. 23

v. CONCLUSION

- The new CASNUB bogie frame is more reliable as the stresses and the forces induced in it is much lesser than the stresses induced in FIAT bogie frame.
- As we see in the results that stresses induced while collision taken into consideration is way higher and due to this FIAT bogies cannot be considered as safe for passengers.
- New CASNUB bogie frame easily bears huge impact forces as seen in the results the stresses induced is much lesser.
- While considering Potential-collision with normal service-load case, the stresses induced in the CASNUB bogie frame is 90.23% lesser than in FIAT bogie frame.

Hence, CASNUB bogie frame helps in increased energy efficiency.

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