DESIGN AND FINITE ELEMENT ANALYSIS OF UNDER FRAME ARRANGEMENT (UNIVERSAL HEADSTOCK) OF DUAL COUPLER FOR RAILWAY COACHES

Pothamsetty Kasi Visweswar Rao[1]

[1]*Assistant Professor, Department of Mechanical Engineering, K.L.University, GunturDist, A.P, India*

Abstract

Designing a new component or modifying the existing component of any system should lead to better result. In this project the modifications in the design of under frame arrangement of Centre buffer coupler is done such that it is capable of dual coupling (It can be used for screw coupling and centre buffer coupling). At present Indian Railway coaches are provided with two types of couplers: 1.Screw coupling with side buffers and 2. Centre Buffer coupling. It is not possible to couple one design coach with other in train formation. Hence, under frame (Universal Headstock) will be designed to fix both couplers as and when necessary so that coach can be coupled to any formation. The necessary modifications are done in the design of under frame arrangement of centre buffer coupler which include fixing of Draft yoke holders to centre sill, provision for introducing side buffers, modeling the front stoppers and draft yoke holders. Thus the design has been proposed for under frame arrangement (Universal Headstock) of Dual coupler. Then finite element analysis is done on that model to get the stress and deformations across the model and to know whether the design is safe or not.

Keywords: *coupler, headstock, buffers.*

---***---

1. INTRODUCTION

A coupling (or a coupler) is a mechanism for connecting rolling stock in a train. The design of the coupler is standard, and is almost as important as the railway gauge, since flexibility and convenience are maximized if all rolling stock can be coupled together.

In order for two railway vehicles to be connected together in a train they are all provided with some form of a coupling device, which is both strong and practical. As the old saying goes, a chain is only as strong as its weakest link. The same can be applied to the couplings on a train of any description.

At present Indian Railway coaches are provided with two types of couplers:
1. Screw coupling with side buffers.
2. Centre Buffer coupling.

1.1 Screw Coupling with Side Buffers

This is a development of the 3-link coupling. To overcome the slack in the three-link coupling, a screwed thread replaces the middle link. By winding the weighted adjustment bar around the threaded screw, this would be taken up any slack between the two end links. The adjustment bar is weighted at one end so that it will always hang downwards when not being used. When the threaded screw is tightened sufficiently, the two vehicles will be bought together so that their buffers just touch. This would then act so as to provide for cushioning by compressing the side buffers. Today, screw couplings are used in-between a locomotive and the rolling stock, in-between the coaches and power cars on the Diesel Multiple Units (DMU), and on goods stock.

1.2 Centre Buffer Coupling

A centre buffer coupling for coupling a first rail car body with a second, adjacent rail car body of a multiple-unit rail vehicle comprising:
a) A linking housing in a rail car body comprising a plurality of pressure devices;
b) An action linked coupling shaft having a longitudinal axis;
c) A coupling head
d) A pivoting unit
e) A pivoting device connecting the guide with the activation

1.3 Necessity Of Dual Coupling

- It is not possible to couple one design coach with other (i.e. screw coupling one with centre buffer one) in train formation.
- Hence only two coaches of screw type can be coupled else two coaches of centre buffer type can be coupled.
- Present CBC coupler trains facing heavy jerk problems. Development of these couplers to avoid jerks is still going on. Till the development is done, coach production cannot be stopped.
- It will be heavy financial loss if the screw coupling coaches are made and later cannot be used to couple with CBCs.

A literature review was conducted to investigate the past research that has been done in railway couplers:

Daunys.M, Putnaite.D studied the Stress – strain analysis for railway carriages automatic coupler SA-3 [1] and the authors also carried research on determination of lifetime for railway carriages automatic coupler SA-3 in the year 2005[2]. Infante V Branco, C.M Brito, A.S. Morgado studied the failure analysis of cast steel railway couplings used for coal transportation [3].

2. MODELING OF UNDER FRAME ARRANGEMENT OF CENTRE BUFFER COUPLER

The Under frame is a rigid member which is constructed in such a way that it is capable of supporting the Centre Buffer coupler. The main parts of under frame arrangement include:

1. Centre sill arrangement.
2. Outer Head stock arrangement.
3. Rear stopper.
4. Front stopper.

The modeling of the above parts is done in Pro/ENGINEER. The modeling procedure mainly includes:

1. Creating 2D Sketches in the Sketch Mode.
2. Converting Sketch into 3D Part in Part mode.

2.1 Two Dimensional Drawing for under Frame of CBC

All the sectional views for under frame arrangement of CBC are shown in the figure 1.

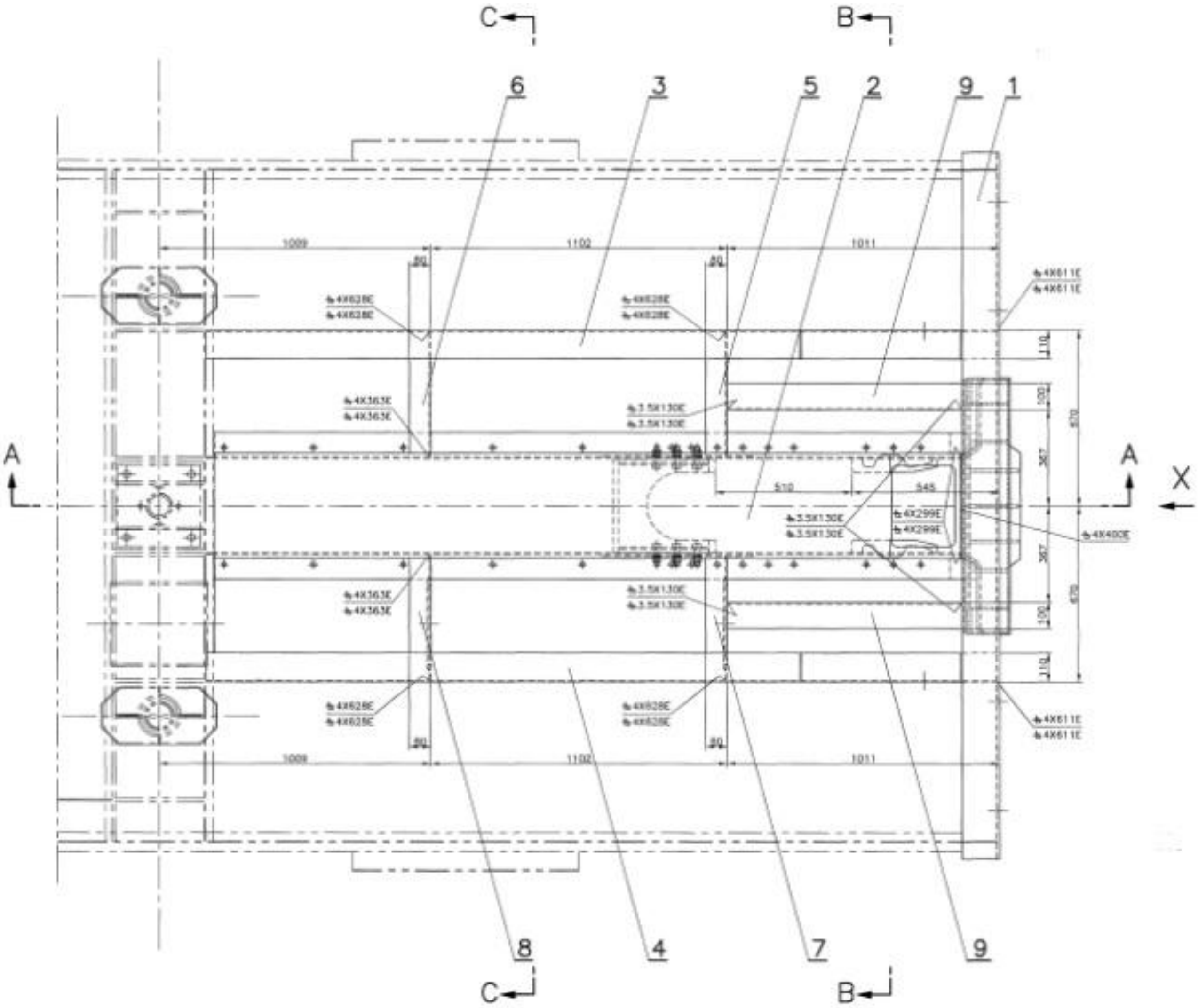

Fig 1(a): Top view of under frame arrangement of CBC

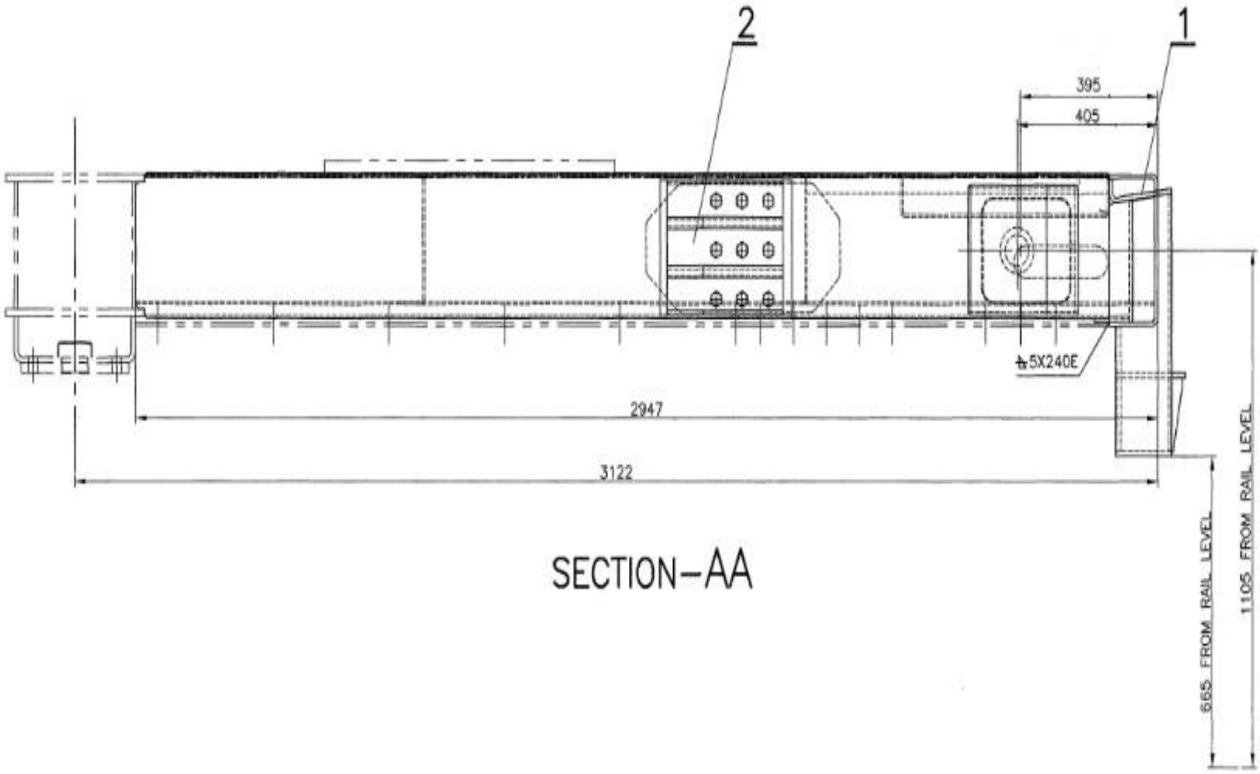

Fig 1(b): Front section view at A-A

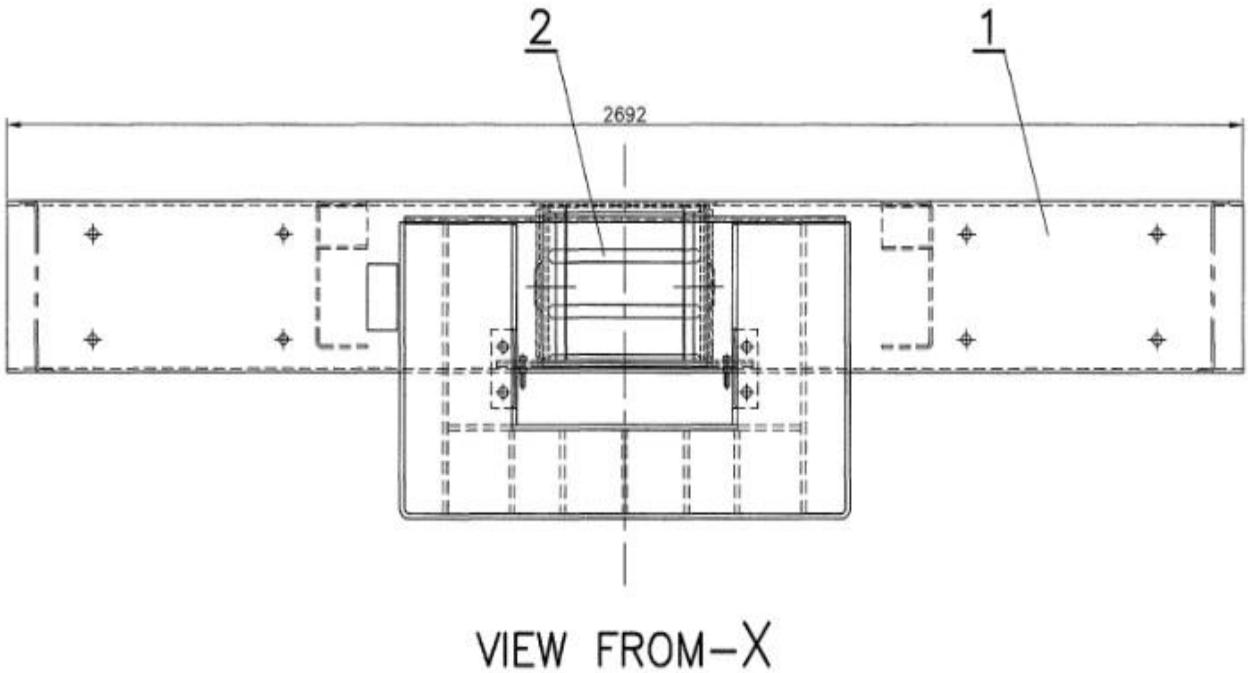

Fig 1(c): Side view from X

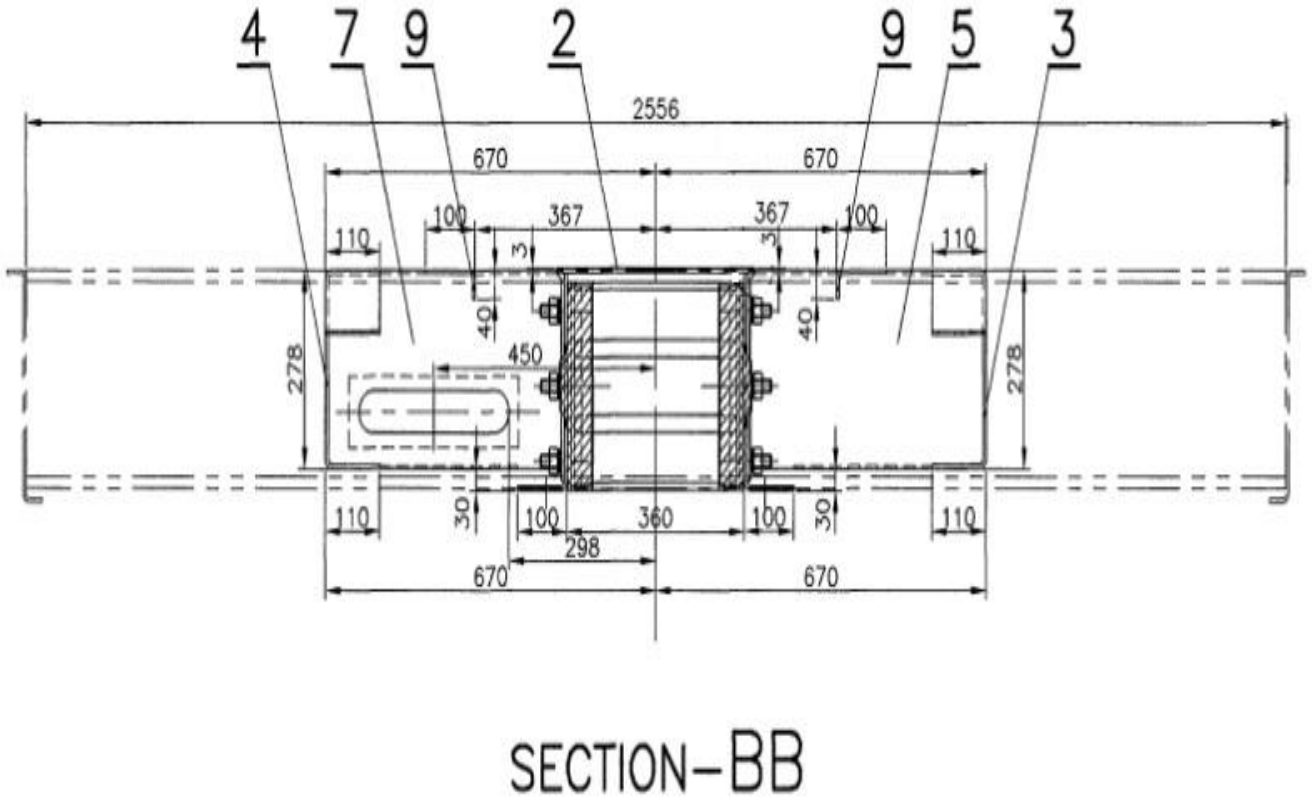

Fig 1(d): Side view at section B-B

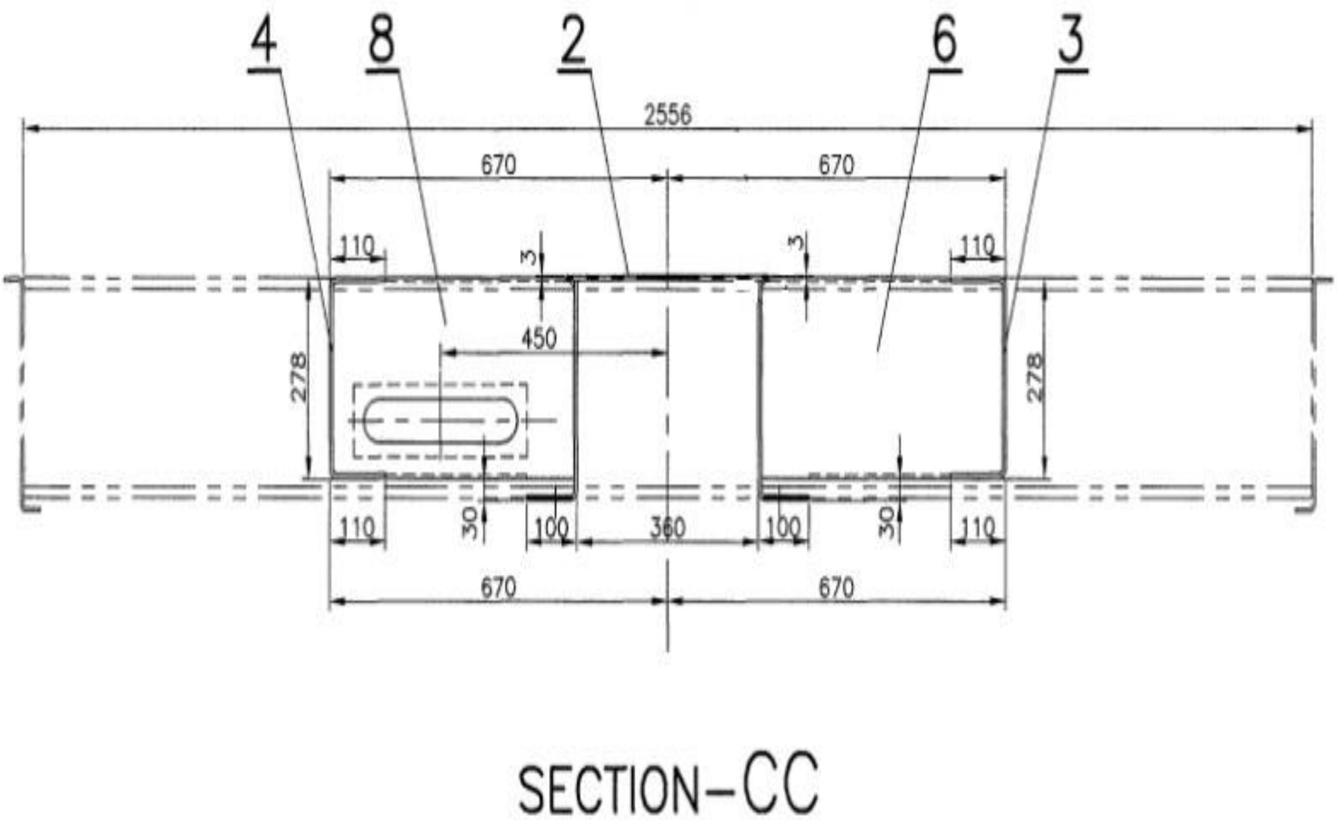

Fig 1(e): Side view at section C-C

Table 1: List of parts mentioned in Figures 1(a) to 1(e)

Part No	Part Name	No. of Parts
1	Outer Headstock	1
2	Centre sill Arrangement	1
3	Longitudinal member	1
4	Longitudinal member	1
5	Channel	1
6	Channel	1
7	Channel complete	1
8	Channel complete	1
9	Channel	2

The sectional views shown in the above figures provide the complete information for interior regions of a component. Here Section–AA gives the half sectional front view, Section-BB and Section-CC gives right sectional views at position BB and CC respectively.

2.2 Three Dimensional Isometric View of under Frame of Centre Buffer Coupler

The under frame arrangement of centre buffer coupler has been modelled in Pro/ENGINEER is as shown in figure 2.

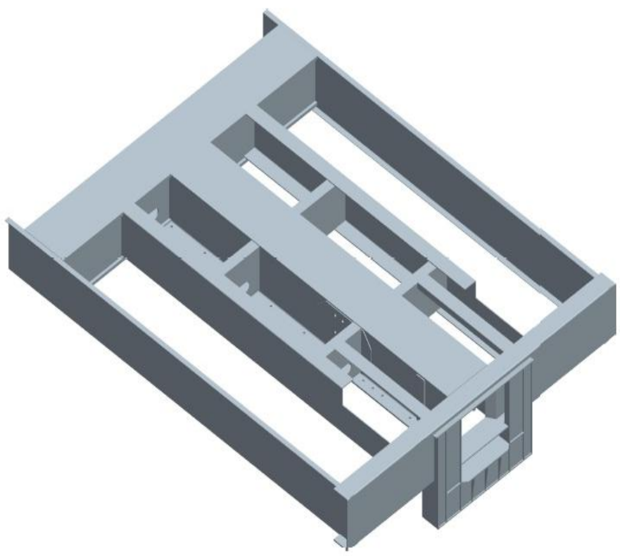

Fig 2: 3D Isometric view of under frame of CBC

This model is the present existing usage one in Indian railways for centre buffer coupling of two coaches. Necessary modifications have to be done to this model in order to suit this under frame for dual coupling. Those modifications and designs are shown briefly in the next chapter.

3. DESIGN OF UNDERFRAME ARRANGEMENT (UNIVERSAL HEADSTOCK) OF DUAL COUPLER

The Dual coupler under frame design is done by modifying the existing design of Centre buffer coupler under frame.

The Modifications done on the existing design are:
1. Provision for introducing the side buffers.
2. Modification in the Centre sill design.
3. Fixing Front stoppers (which are removable).
4. Fixing Draft yoke holders (which are removable).

3.1 Provision for Introducing the Side Buffers

The side buffers are introduced in order to provide smooth suspension during pull and brake. These buffers are used in screw coupling, each buffer assembly consists of a housing which is attached to the framework of the craft and in which is housed a spring-loaded section, extending out of the housing.

The face of each buffer on the car should then be in contact with the face of the corresponding buffer on the other car. When the train is started or running, the screw coupling carries the pulling load. In running stopping, and starting, the buffers protect the cars and lading by obstructing the jolts and shocks and preventing the cars from running together.

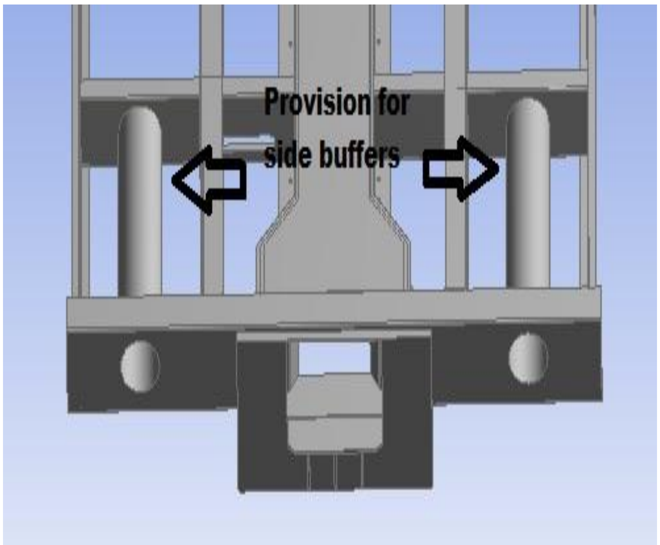

Fig 3: Buffer position in the under frame arrangement

The support frames are extended from the centre sill to support the buffers. These buffers are rigidly fixed to the under frame. While centre buffer coupling is used the buffers remains same although they are used for screw coupling.

3.2 Modification in the Centre Sill Design

The design of centre sill arrangement is modified in order to provide space for fixing the front stoppers (which are removable) as well as draft yoke holders (which are removable).

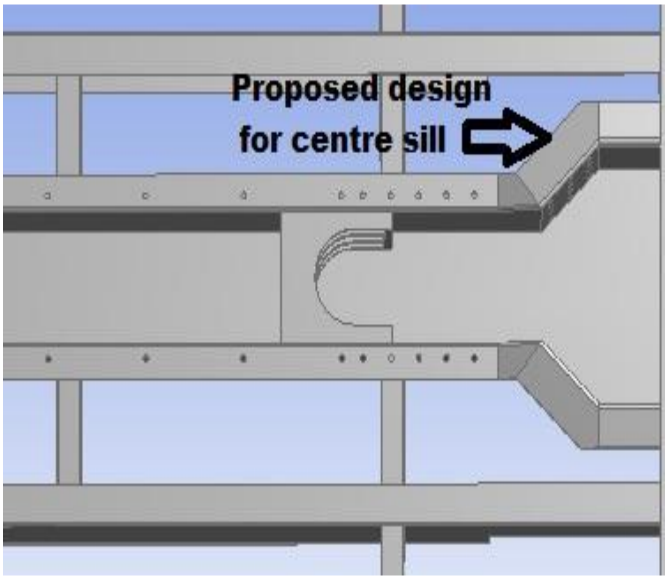

Fig 4: Design for centre sill arrangement

3.3 Fixing the Front Stoppers

The Front stoppers are two in number and are bolted to the centre sill arrangement. These are used in centre buffer coupling only, so when we go for screw coupling they should be removed. In under frame of centre buffer coupler they were rigidly fixed, but here in dual coupling they are removable type.

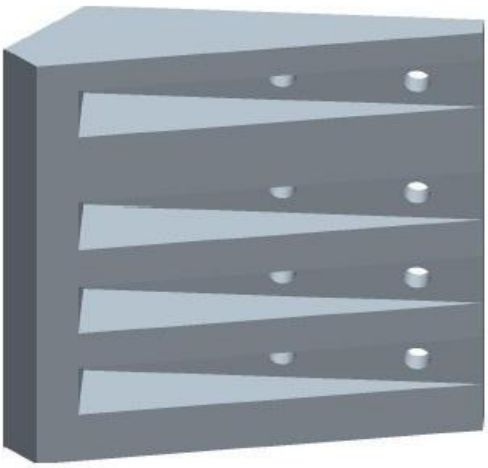

Fig 5: Model of Front Stopper

3.4 Fixing the Draft Yoke Holders to the Centre Sill Arrangement

The draft yoke holder is screwed to centre sill which is used to hold the draft yoke with help of a pin. This member is used for screw coupling purpose, when we go for centre buffer coupling we can remove the draft yoke holder from centre sill.

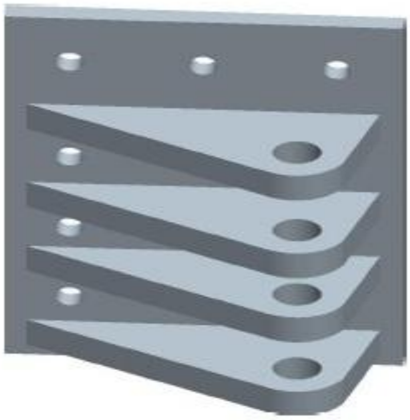

Fig 6: Model of Draft yoke holder.

3.5 Proposed Design for Under Frame (Universal Headstock) of Dual Coupler

From the above modifications made on the existing centre buffer coupler, finally the design of under frame (universal headstock) dual coupler is obtained.

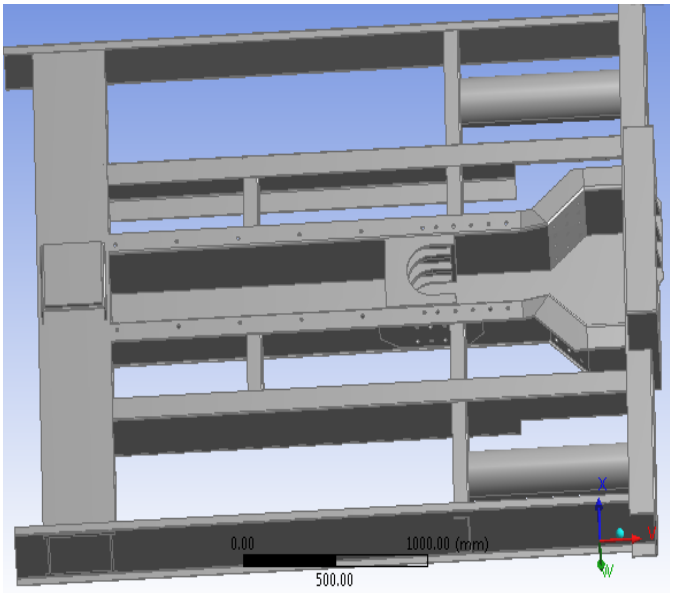

Fig 7: Proposed model for under frame (universal headstock) of dual coupler

In order to go for screw coupling, just fix the draft yoke holder to the centre sill as shown in fig 8.

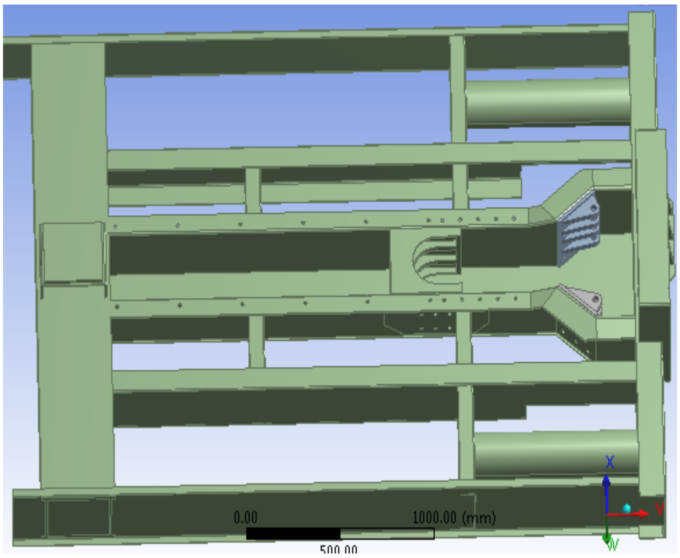

Fig 8: Proposed model of under frame arrangement of dual coupler that suits screw coupling.

In order to go for Centre buffer coupling, fix the front stoppers to the centre sill by removing the draft yoke holders as shown in fig 9. Hence the centre sill is designed with 12 holes for bolting the either holders or front stoppers rigidly when required.

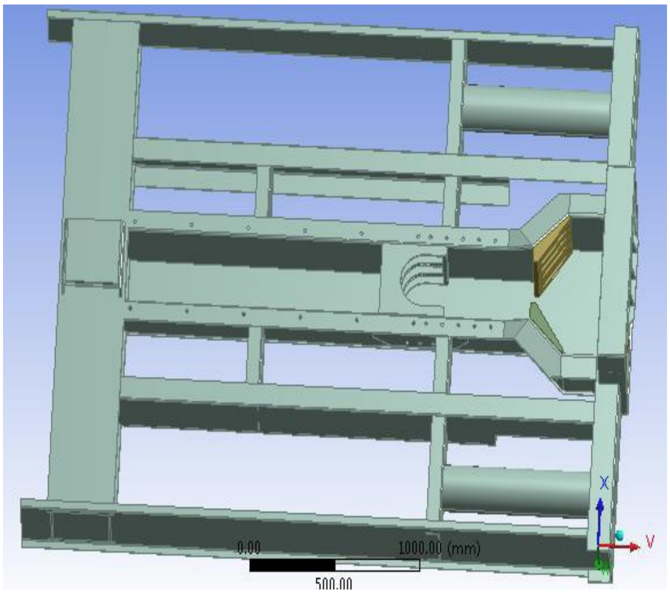

Fig 9: Proposed model of under frame arrangement of dual coupler that suits centre buffer coupling

4. ANALYSIS OF UNDER FRAME (UNIVERSAL EADSTOCK) OF DUAL COUPLER

The Analysis is done by using ANSYS Work Bench12.0 software. The Model is initially meshed with fine meshing option and then subjected to loading conditions. Then Solving for stress and Deformation values, to know whether the design is safe or not.

4.1 Material Data

The selection of material is important task for manufacturing any component. Here corrosive resistance structural steel is being used for manufacturing the under frame arrangement of dual coupler.

In Integral coach factory (ICF), the structural steel is used for making the railway components.

Table 2: Structural steel chemical composition %

C	Mn	Si	Ni	Cu	Cr	S	P
0.1 max	0.25 to 0.45	0.28 to 0.72	0.20 to 0.47	0.30 to 0.60	0.35 to 0.60	0.03 max	0.075 to 0.140

4.2 Meshing the Model

The Meshing is an important task in the Analysis procedure to get the accurate solution. The details of the model are given below

Meshing details:

- Element size: default
- Nodes : 220010
- Elements: 110996

Model Geometry details:

- Length X : 3544 mm
- Length Y : 604.98 mm
- Length Z : 2692 mm
- Volume : 1.93 e+008 mm^3
- Mass : 1519.1 kg

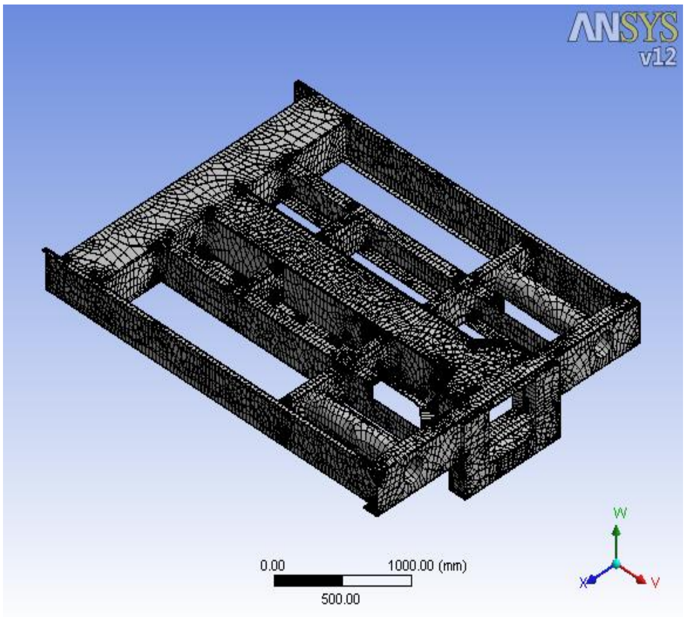

Fig 10: Meshed model of under frame of Dual coupler

4.3 Loading Conditions

Case 1:

- Force is applied on the Front stoppers alone.
- Tensile force of 100 tons (i.e. 981000 N) is applied during forward movement of train, coupled using centre buffer coupler.

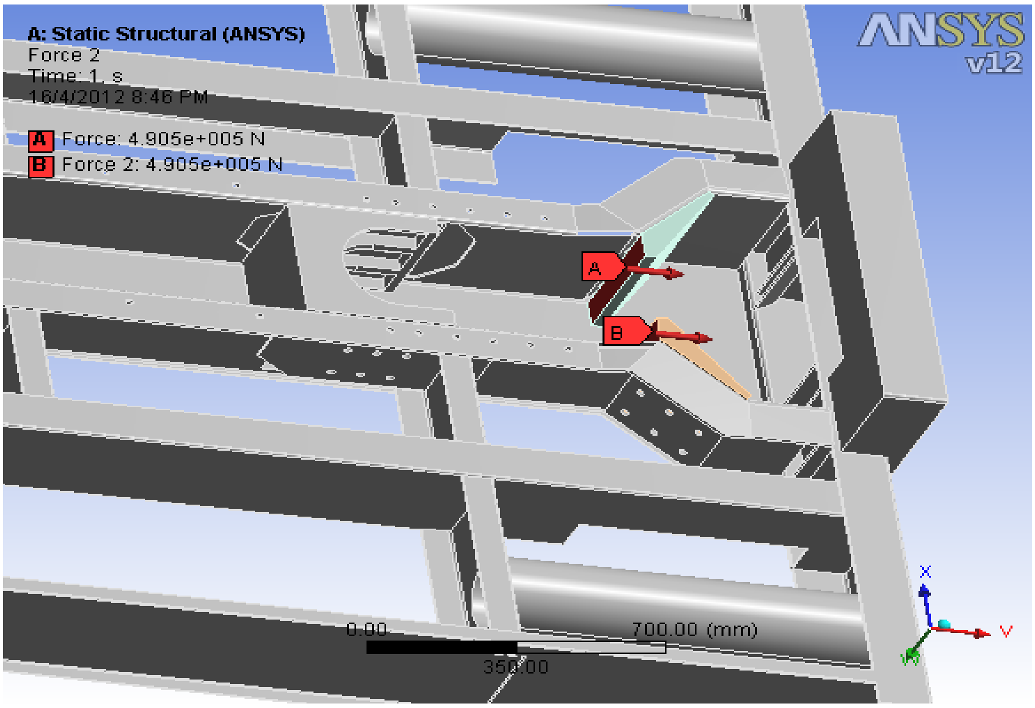

Fig 11: Loading Condition of Front stoppers

Case 2:

- Force is applied on the Rear stoppers alone.
- Compressive force of 200 tons (i.e. 1962000 N) is applied during backward movement of the train, coupled with centre buffer coupler.

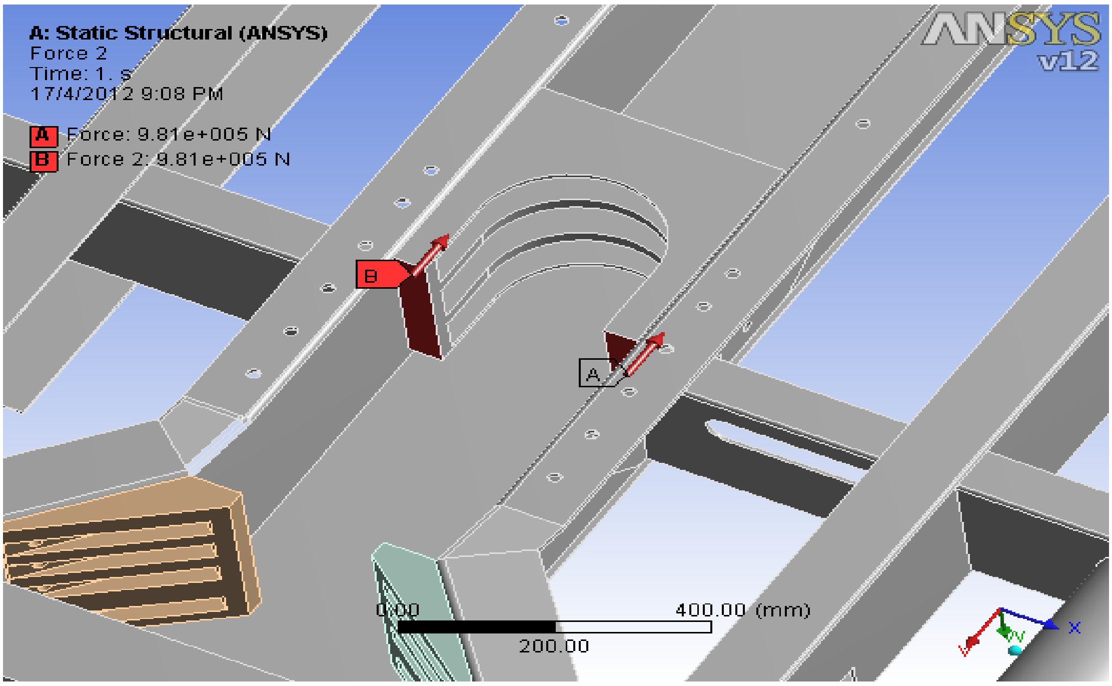

Fig 12: Loading Condition of Rear stoppers

Case 3:

- Force is applied on the Draft yoke holders alone.
- Tensile force of 75 tons (i.e.735750 N) is applied during forward movement of the train with Screw type coupling.

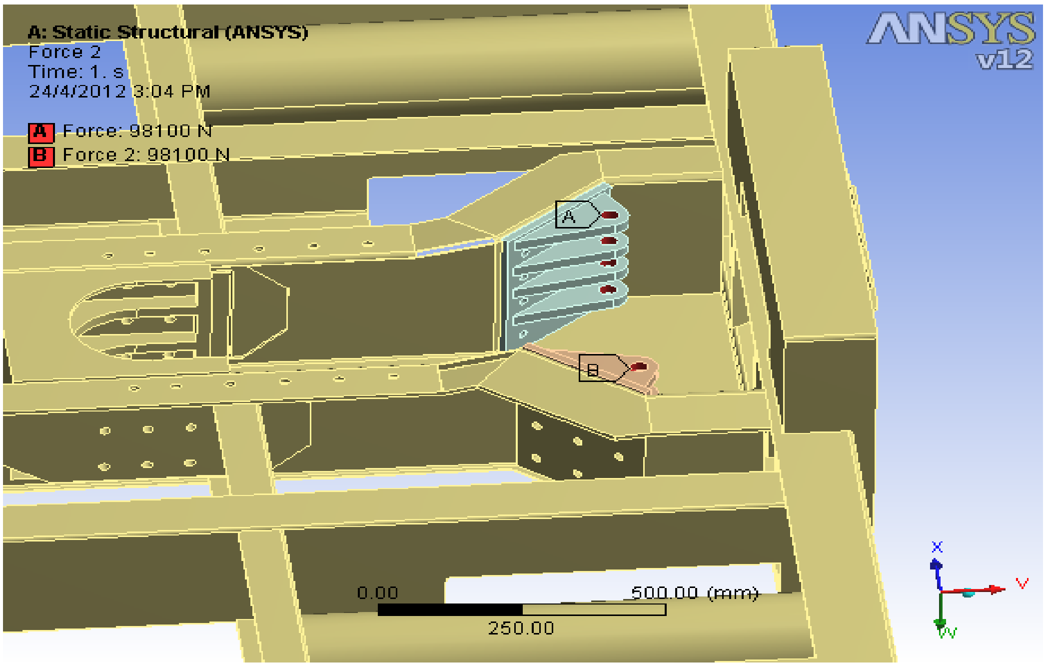

Fig 13: Loading Condition of Draft yoke holders

4.4 Analysis

After giving all the constraints, the solving option is used to get the values for stress and deformations. From these obtained values the safe condition if the model can be judged.

Case 1:

a) Equivalent Stress:

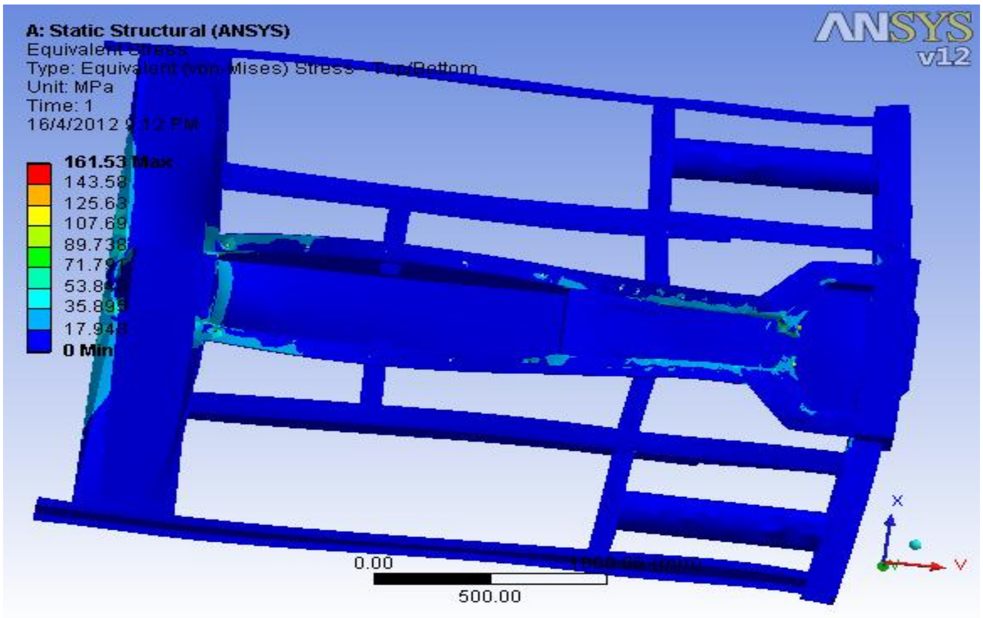

Fig 14: Stress when load applied on Front Stoppers

b) Total Deformation:

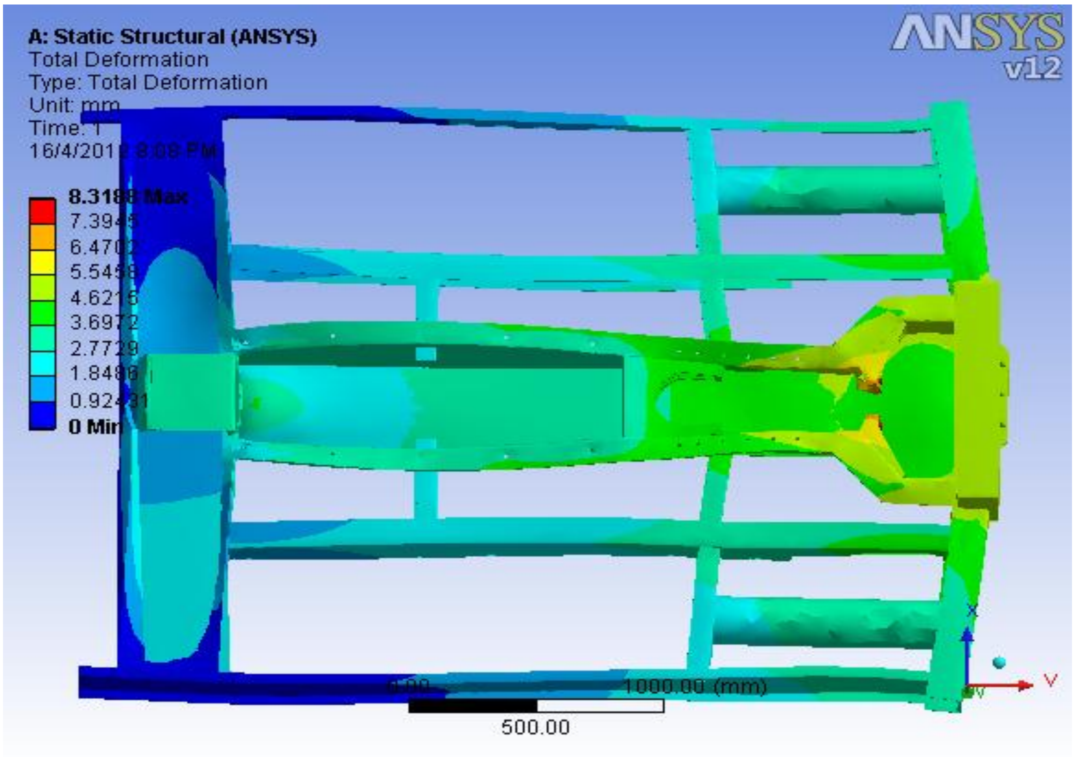

Fig 15: Deformation when load applied on Front stoppers

Case 2:

a) Equivalent Stress:

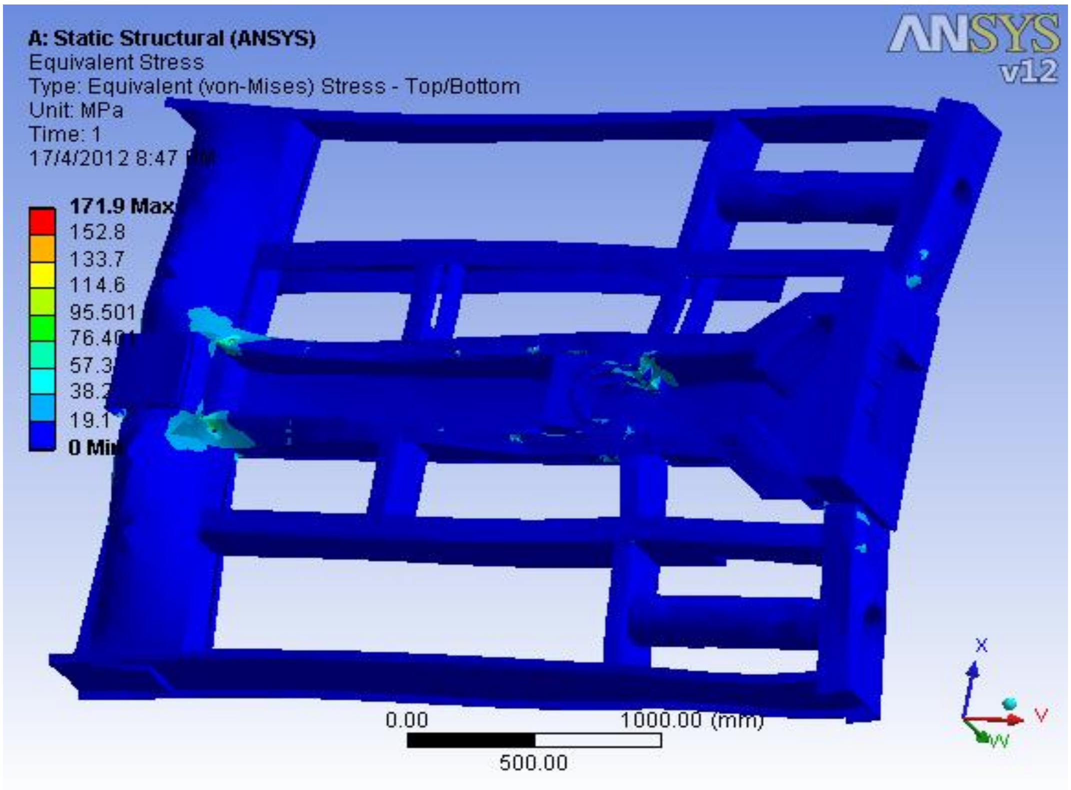

Fig 16: Stress values when load applied on Rear Stoppers

b) Total Deformation:

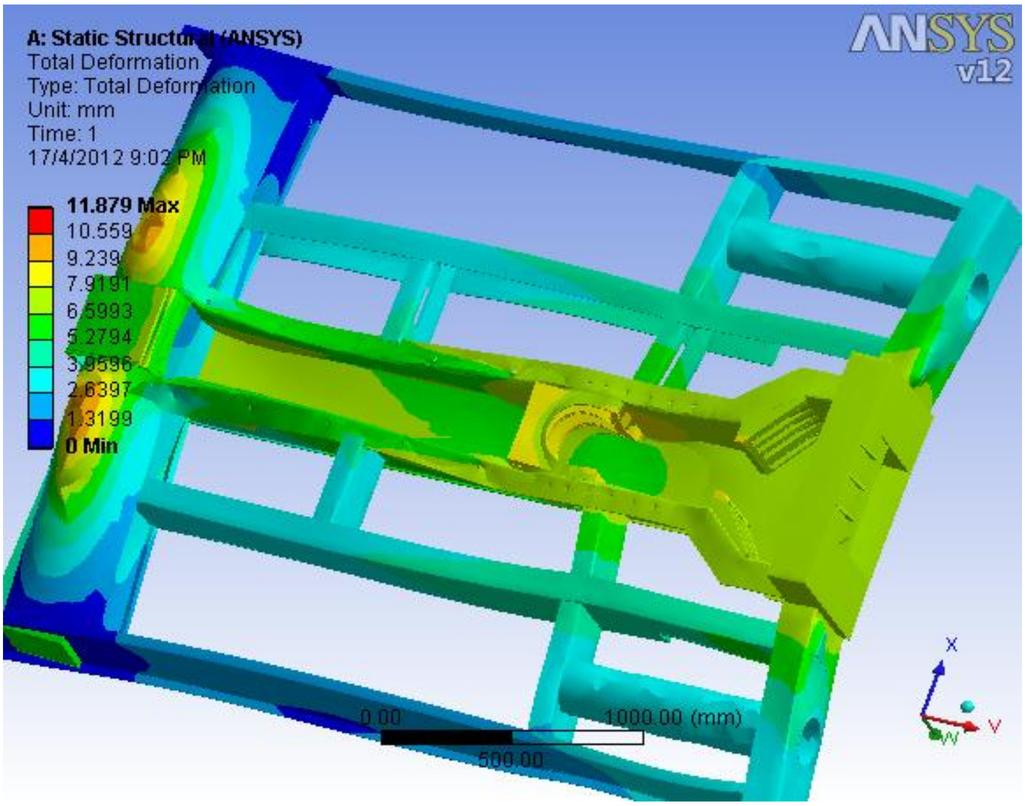

Fig 17: Deformation values when load applied on Rear stoppers

Case 3:

a) Equivalent Stress:

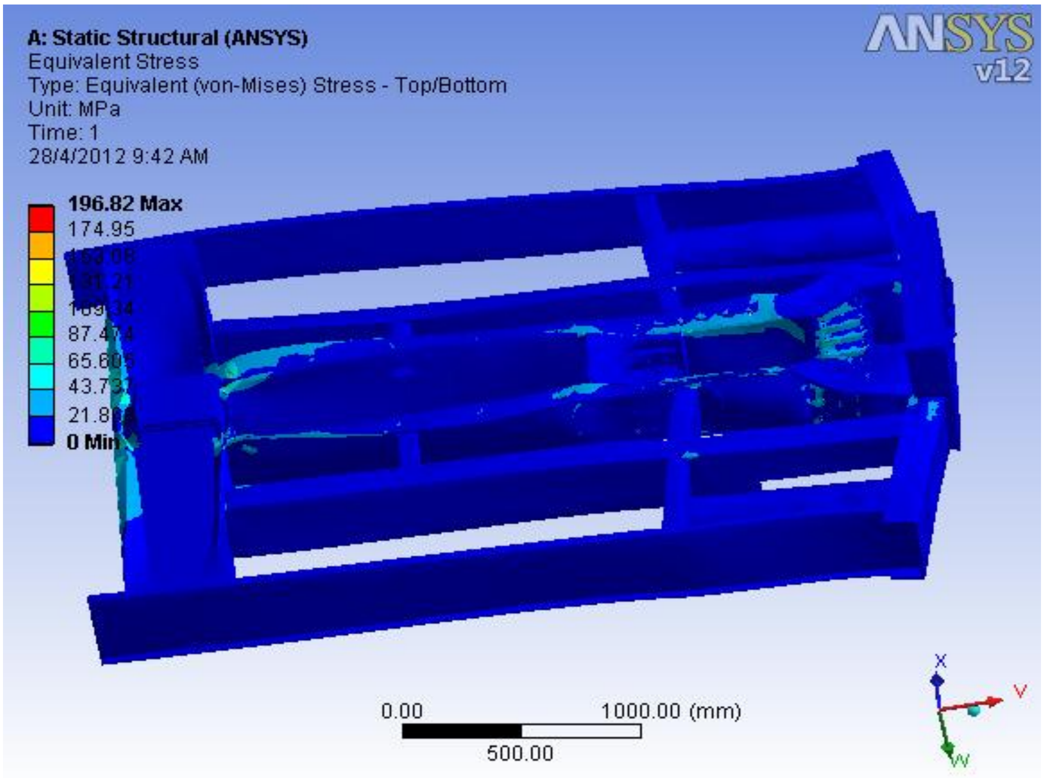

Fig 18: Stress values when load applied on Draft yoke holders

b) Total Deformation:

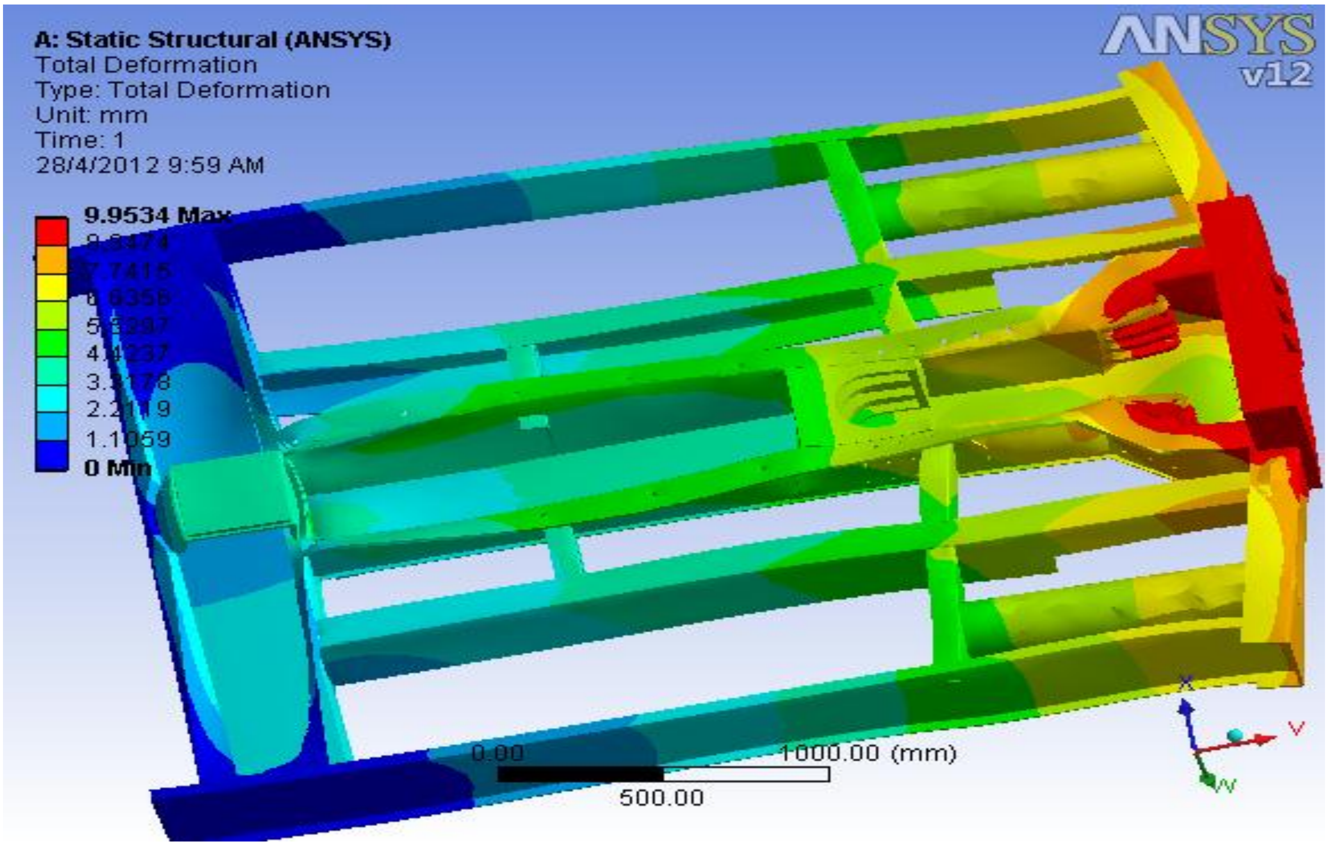

Fig 19: Deformation values when load applied on Draft yoke holders

5. RESULTS AND DISCUSSIONS

The allowable yield stress for structural steel is 340 Mpa. By considering the factor of safety as 1.5, we get the working stress value as 226.67 Mpa. Hence the obtained stress values should be compared with working stress to know the safety of designed model. If the obtained stress value is more than the working stress value, the design will not be a safe one, which needs to be re designed. Here obtained stress values are less than working stress, so the designed model is a safe one and can be implemented.

Table 3: Validation of results

	Obtained Stress (Mpa)	**Working Stress =Allowable stress/ Factor of safety(1.5)**	**Allowable yield Stress for structural steel (Mpa)**
Case 1	161.53	226.67	340
Case 2	171.90	226.67	340
Case 3	196.82	226.67	340

6. CONCLUSION

The results obtained are well below the failure limits, which show that the proposed design for under frame arrangement of dual coupler is a safe one. The deformation values are also under acceptable range as the steel is ductile material which undergoes a large deformation before breaking. In future there is a scope for better and simple designing of parts to decrease the weight of the model, and to decrease the stress values further.

REFERENCES

[1]. Daunys.M, Putnaite.D (2004) “Stress – strain analysis for railway carriages automatic coupler SA-3” Mechanika.- Kaunas: Technologija, Nr.2 (46), p.14-20.
[2]. Daunys.M, Putnaite.D (2005) “Determination of lifetime for railway carriages automatic coupler SA-3” ISSN 1392 - 1207. MECHANIKA Nr.2 (52).
[3]. Infante V Branco, C.M Brito, A.S. Morgado (2003) “A failure analysis study of cast steel railway couplings used for coal transportation” - Engineering Failure Analysis, No10, p.475-489.
[4]. ANSYS is a trademark of SAS Inc. www.ansys.com (version-2013)
[5]. Pro/Engineer is a trademark of PTC Inc.www.ptc.com (version-2012)
[6]. User Guide for ANSYS (version 5.4).