

# Design And Enhancement Of Rear Under-Run Protection Device For 15 Tonne Capacity HCV

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**Abstract:** The heavy commercial vehicles are equipped with under-run protection devices (UPD) to enhance safety of occupants in small vehicles in the event of under-run. These UPD are popularly classified as RUPD (rear under-run protection devices), SUPD (side under-run protection devices), and FUPD (front under-run protection devices). These devices primarily work to improve safety of smaller vehicles by changing its interaction with heavy vehicles thereby resulting in change in small vehicle structural engagement for energy absorption. Without UPD, smaller vehicle passenger compartment is likely to interact with stiff commercial vehicle chassis frame structures

**Keywords:** RUPD,ECE R-58 (Economic Commission Europe Regulation-58), GVWR.

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## 1. INTRODUCTION

Under ride occurs when a small passenger vehicle strikes either front or rear or side of the larger vehicle with relatively higher mass and bigger in structure, the front hood part of smaller vehicle goes under the rear, front or side of the bigger vehicle. The small passenger car under rides the larger truck in the worst case, and the large truck's high profiled structure can enter the passenger compartment of the smaller car and will collide with the occupants directly at their head and chest level. This is one of the most highly frequent events that happen in an under ride crash environment. This is called as "passenger compartment intrusion. Out of all these accidents, truck related accidents incur significantly more fatalities. The vehicles with gross vehicle weight ratio (GVWR) of more than 10,000 lbs will be considered as a truck. All these accidents are much more fatal because of mass difference between large truck and small vehicles such as passenger cars and the difference in stiffness of construction structures

## 2. LITERATURE SURVEY

The heavy commercial vehicles are equipped with under-run protection devices (UPD) to enhance safety of occupants in small vehicles in the event of under-run. These UPD are popularly classified as RUPD (rear under-run protection devices), SUPD (side under-run protection devices), and FUPD (front under-run protection devices). do not revise any of the current designations.

Dr. T. Ramamohan Rao formulated head on collision contribute significant amount of serious accidents which causes driver fatalities. The car safety performances can work effectively by providing FUPD to the heavy trucks. The trucks with UPD can reduce the car driver fatalities by 40 % In India, for Front Under-run Protection Device, IS 14812:2005 regulation is required in for the trucks to meet the safety requirement to protect under running of the passenger car.

Mr. George Joseph's objective of the study, one under ride protection device for a rear under ride accident was designed and its performance compared. A quasi static test was performed on guard to test the strength and energy absorption capacity by withstanding the applied loads. All the constrained and boundary condition used for the study worked well. Nearly six designs were studied and run simulation to study the effectiveness of each guard and results were plotted.

Kaustubh Joshi Head on collision contribute significant amount of serious accidents which causes driver fatalities. The car safety performances can work effectively by providing UPD to the heavy trucks. The trucks with UPD can reduce the car driver fatalities by 40 % In India, for Rear Under-run Protection Device, IS 14812:2005 regulation is required in for the trucks to meet the safety requirement to protect under running of the passenger car. In above said design, the maximum displacement of RUPD bar is limited to 50mm and the plastic strain is limited

#### Test Procedure and Requirements:

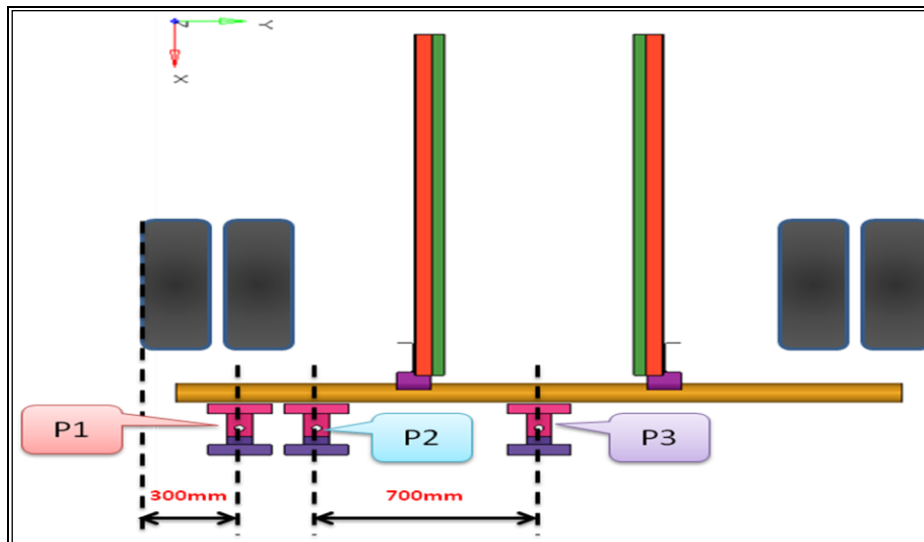


Fig.1 Loading Device Positions

A horizontal force of 100 kN or 50 per cent of the force generated by the maximum mass of the vehicle, whichever is the lesser, shall be applied consecutively to two points situated symmetrically about the centre line of the device or the vehicle whichever is applicable at a minimum distance apart of 700 mm and a maximum of 1 m.

A horizontal force of 50 kN or 25 per cent of the force generated by the maximum mass of the vehicle, whichever is the lesser, shall be applied consecutively to two points located 300 + 25 mm from the longitudinal planes tangential to the outer edges of the wheels on the rear axle and to a third point located on the line joining these two points, in the median vertical plane of the vehicle.

Units –

Table 1 FE Model Unit System

	(a)	(b)	(c)
Length unit	meter	millimeter	millimeter
Time unit	second	second	millisecond
Mass unit	kilogram	tonne	kilogram
Force unit	Newton	Newton	kiloNewton
Young's Modulus of Steel	210.0E+09	210.0E+03	210.0
Density of Steel	7.85E+03	7.85E-09	7.85E-06
Yield stress of Mild Steel	200.0E+06	200.0	0.200
Acceleration due to gravity	9.81	9.81E+03	9.81E-03
Velocity equivalent to 30 mph	13.4	13.4E+03	13.4

**Objective:**

- Regulation study and extraction of design and safety requirements of RUPD.
- Design of RUPD with reference to applied regulations, Cost and Manufacturing considerations.
- Optimization of RUPD structure to lower weight and increase energy absorption using tools like LS Dyna and Hyper Works Module.

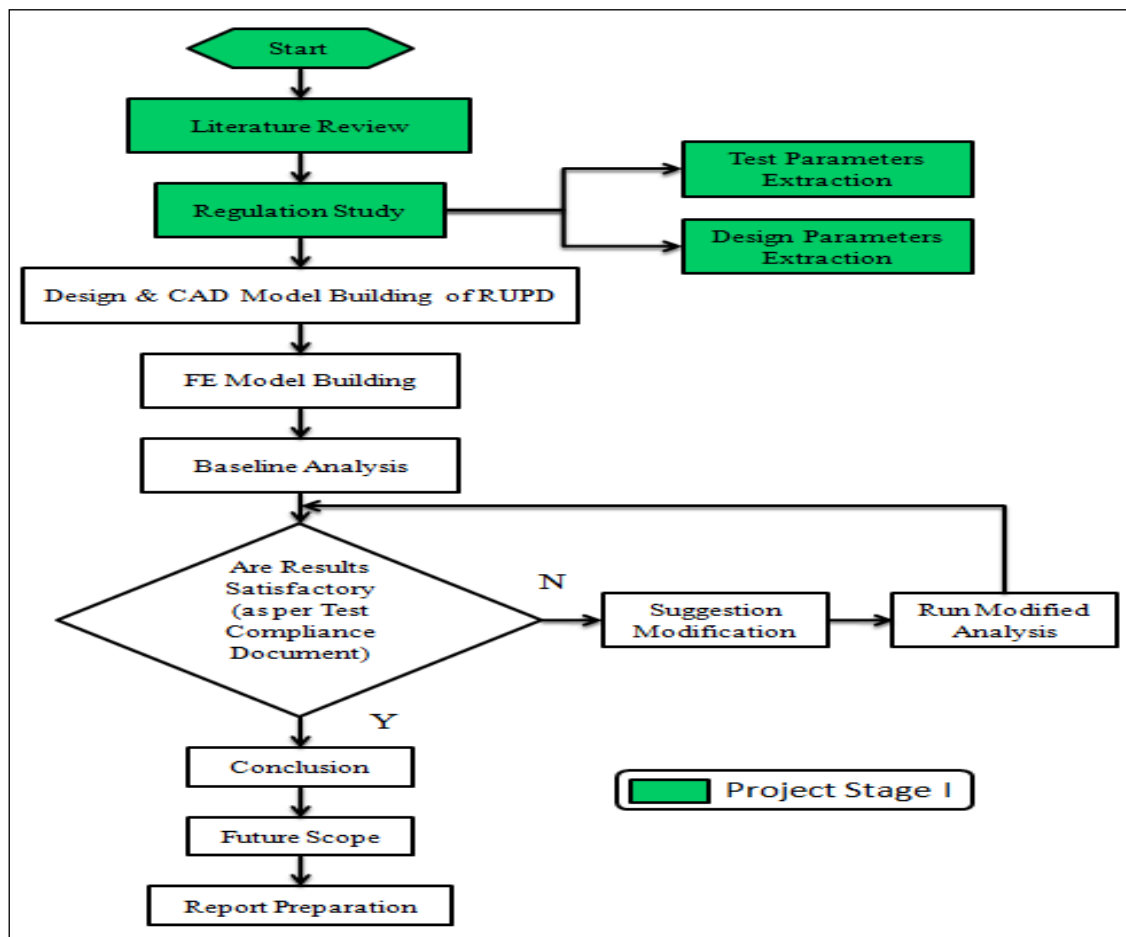


Fig. 2 work flow diagram

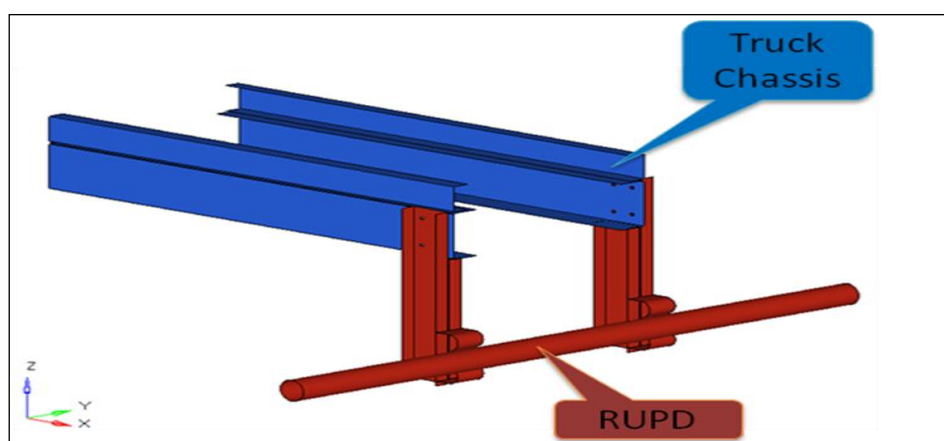
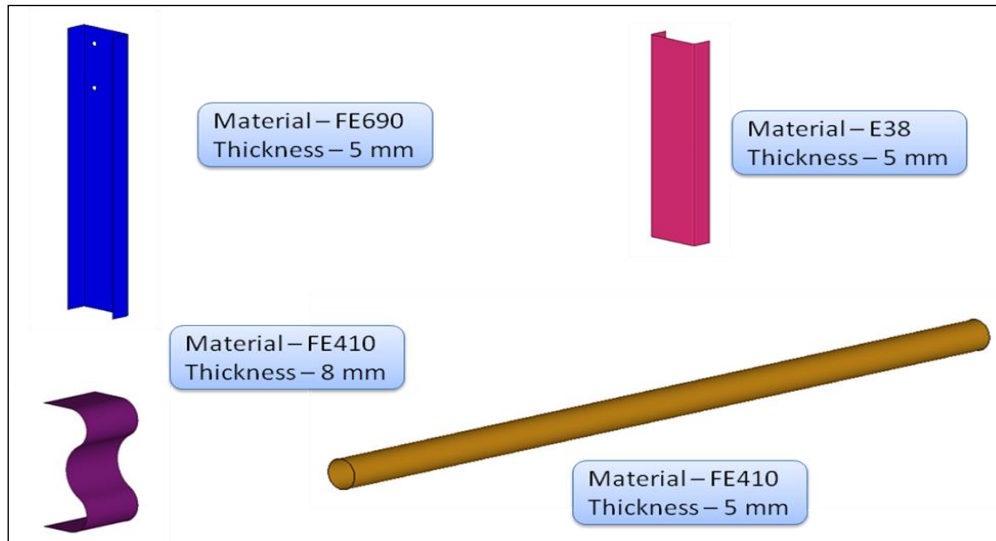
**FE Model Information -**

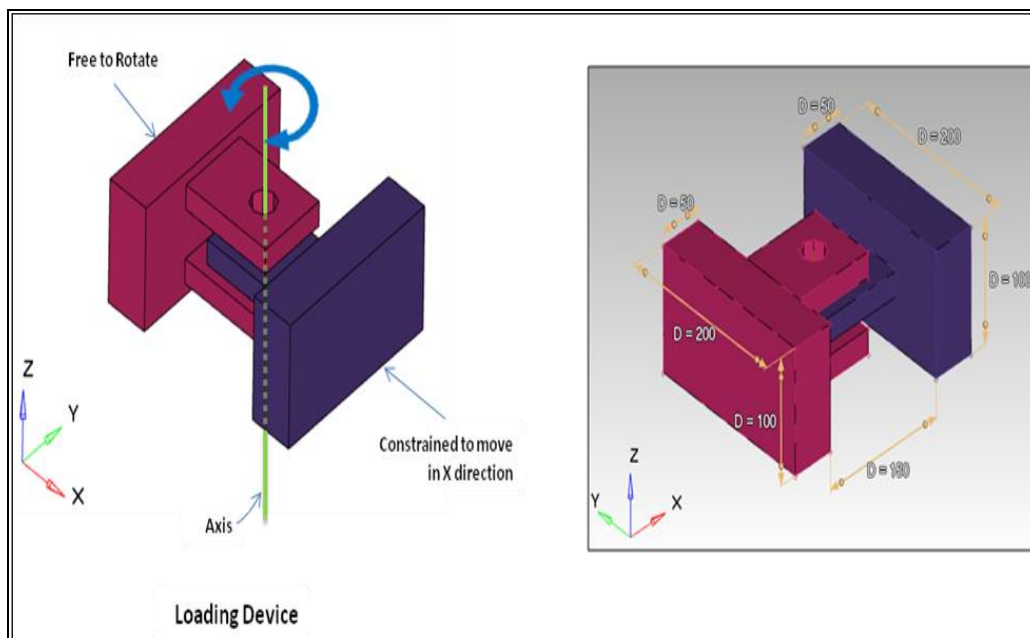
Fig.3 CAD Model of RUPD

The modeling of the Rear Under-Run Protection Device has been done in CATIA V5 R20. The full assembly model of the rear under Guard and its different components are shown in figure.

**Material & Thickness Details:**



**Loading Device Details:**



**Fig.4 Material thickness & Loading Device Details**

The Loading device consists of two blocks which are connected at center using revolute joint so that the device will be always in normal direction at every time during loading process. The loading device is modeled with LS Dyna Material Type 20 rigid material model load requirements.

**Table 2 load requirements**

Loading Device Position	P1	P2	P3
Load Requirements	36.78 KN	73.57 KN	36.78 KN

### 3. RESULTS FOR BASELINE DESIGN

The boundary condition and the load applied are shown in figure

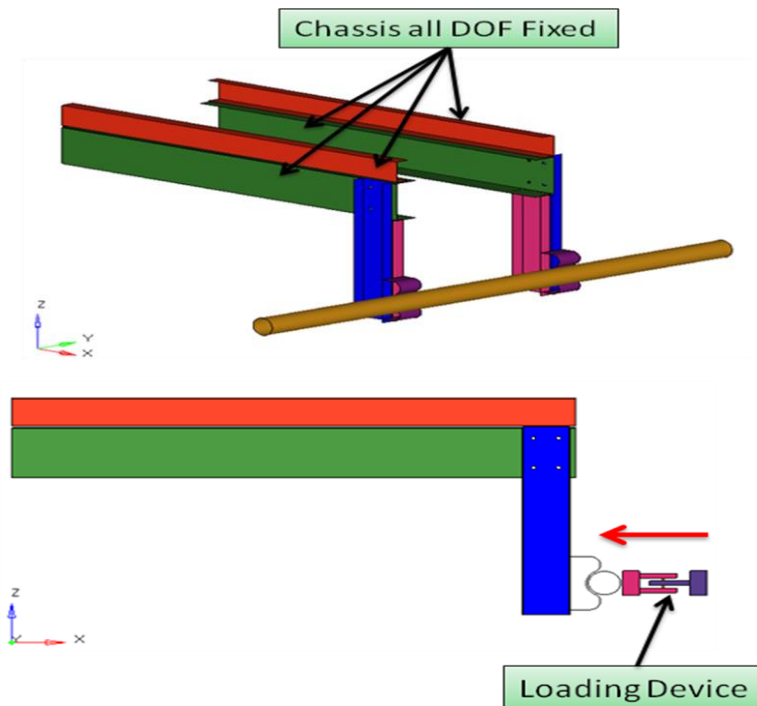
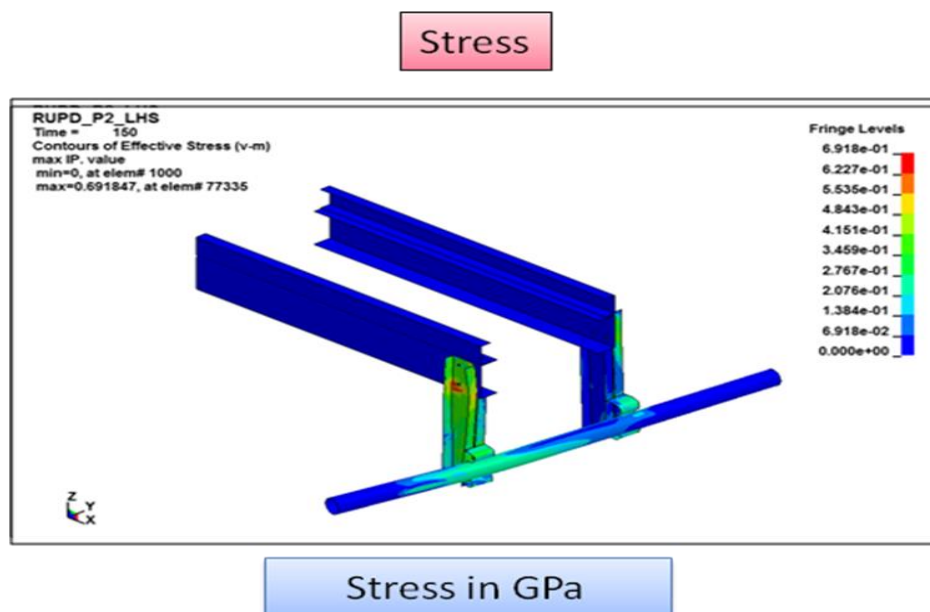


Fig.5 Boundary conditions

#### Baseline Results (Load case – P2 LHS):

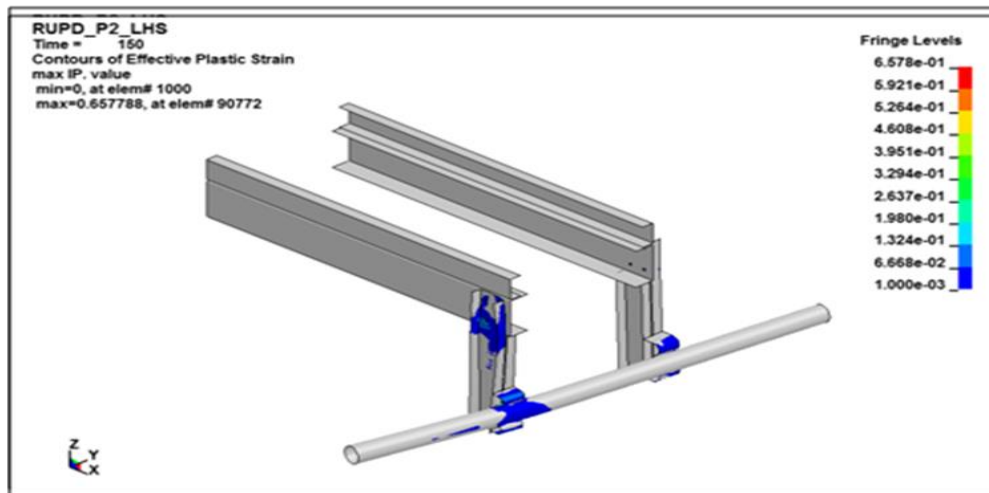
The baseline model is been designed according to the ECE R-58 and AIS 14812-2005 Regulation but it fails to meet the load requirement. All other parts like the vehicle body and engine are not taken into consideration

#### Overall Plots:

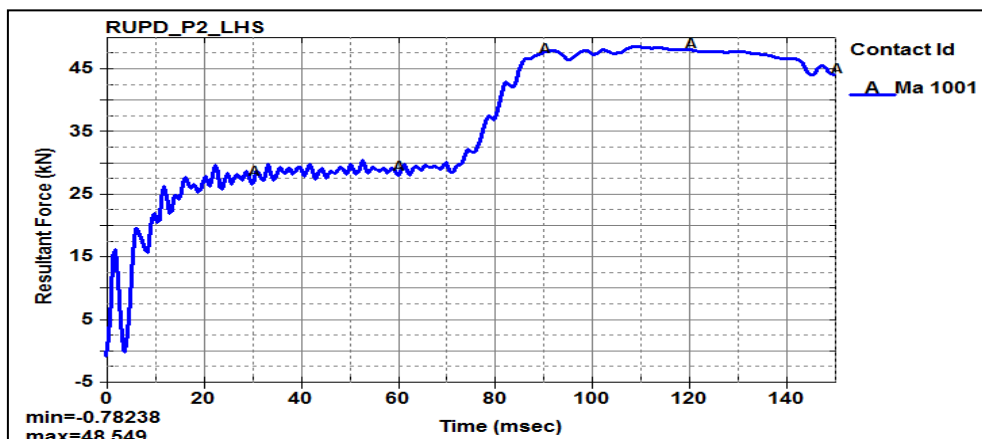


We have taken FE 690 material for the c channel. The material is not able to withstand the impact load. The stress value of the material does not meet the regulation

Strain



RUPD Load Carrying Capacity:

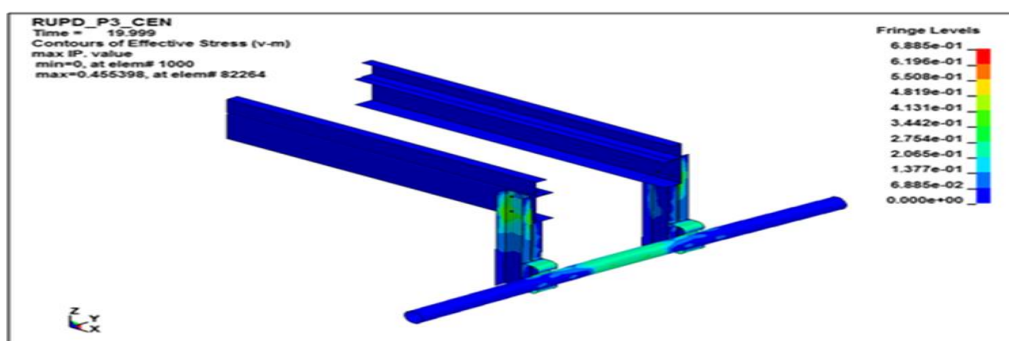


**Observation** - The maximum load carrying capacity of RUPD observed is 48.55 kN. Hence does not meet regulatory requirement of 73.575kN. All parts show localized high plastic strains hence structural integrity is assumed safe

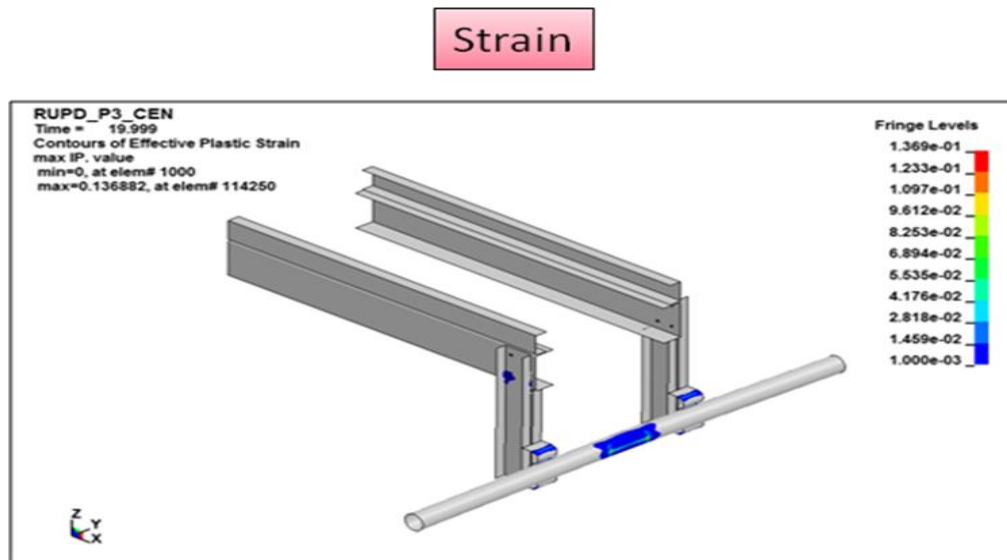
**Conclusion** Attachment bracket connecting Pipe & C – channels shows large displacement & need to be strengthened.

Baseline Results (Load case – P3 LHS)

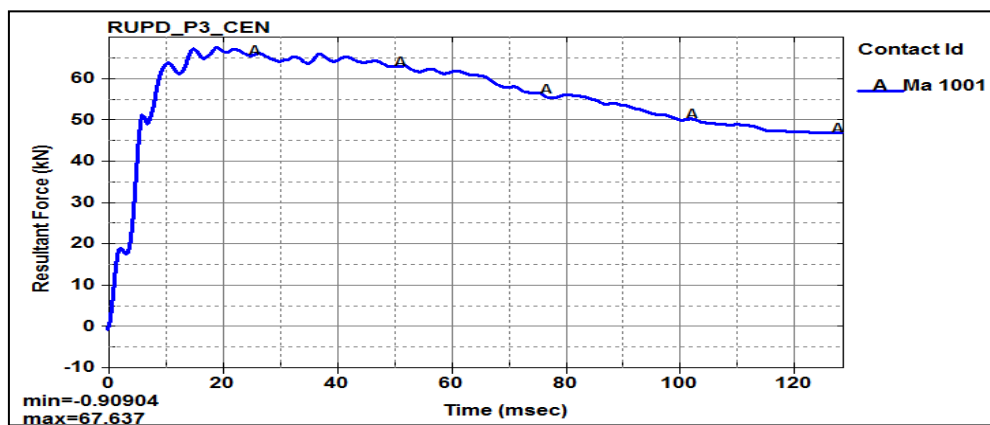
Stress



Stress in GPa



**RUPD Load Carrying Capacity for P3 load case:**

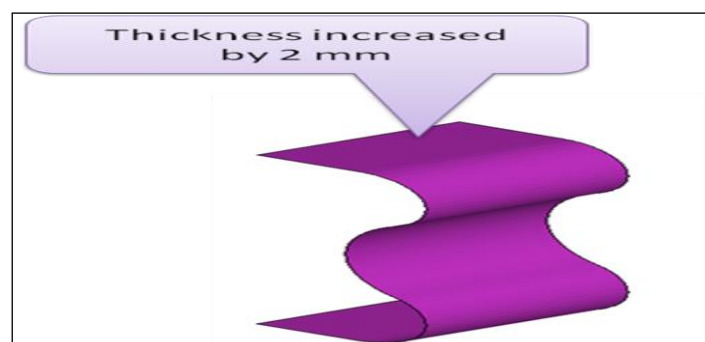


Observation and conclusion- The maximum load carrying capacity of RUPD observed is 67.637 kN. Hence meets regulatory requirement of 36.7875 kN. All parts show plastic strains below material failure limit. Hence structural integrity is met.

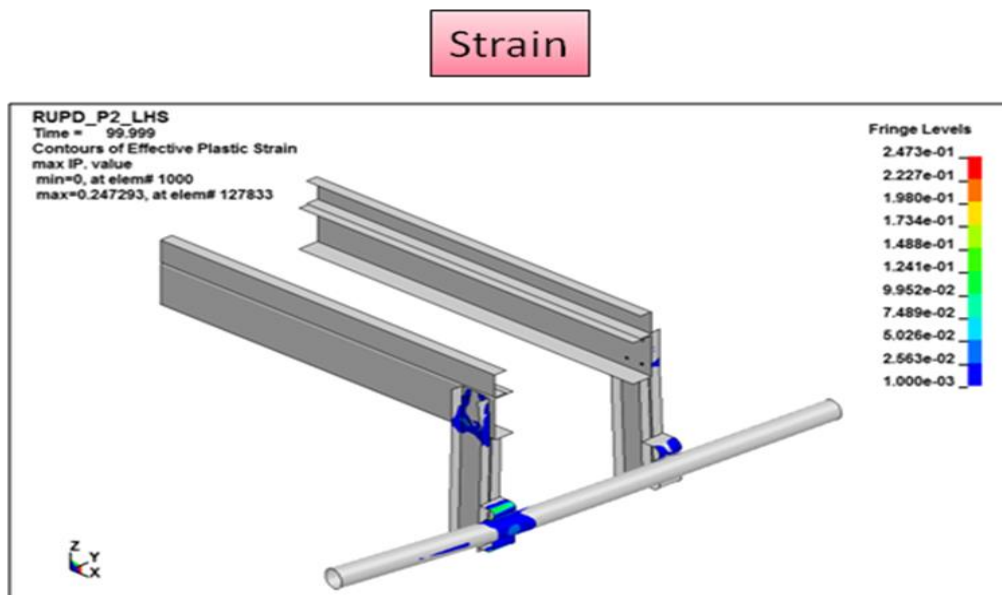
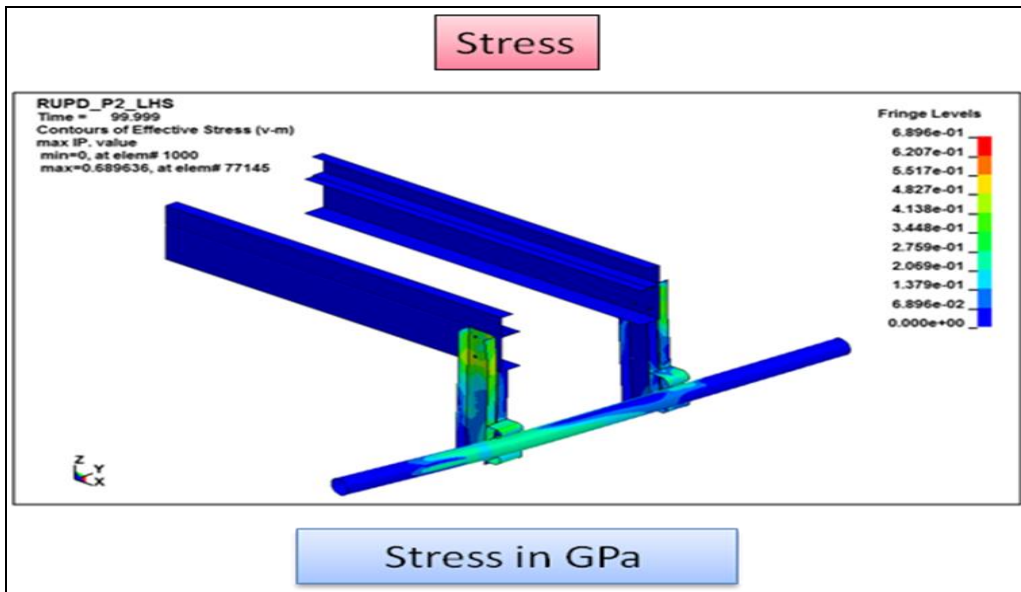
**Conclusion for entire baseline results** - RUPD baseline design meets P3 load case requirements. It does not meet P2& P1 load case requirement. As P2 load is high we will first design and optimize the structure for P2 load case iteratively and then check it for P1 & P3 load case respectively.

#### 4. RESULTS OF DESIGN ITERATIONS

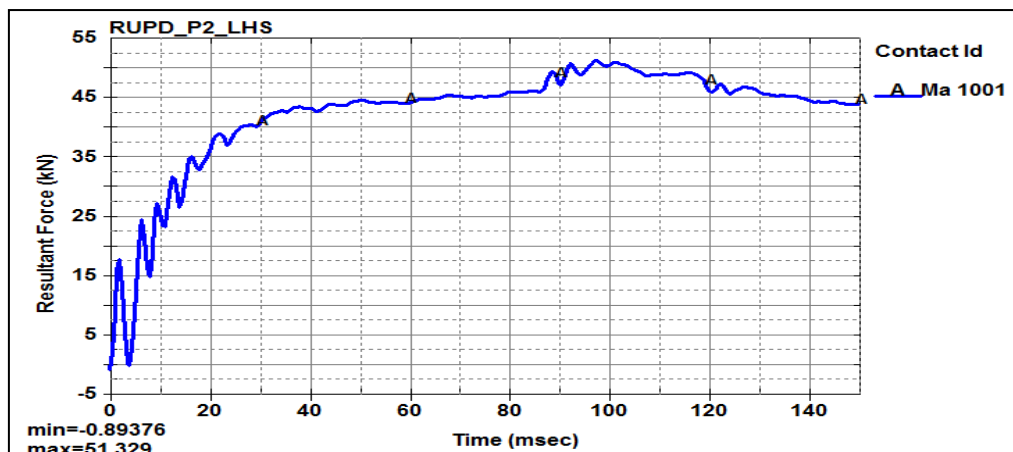
**Loadcase – P2 LHS – Iteration 1**



Overall Plots -



RUPD Load Carrying Capacity:

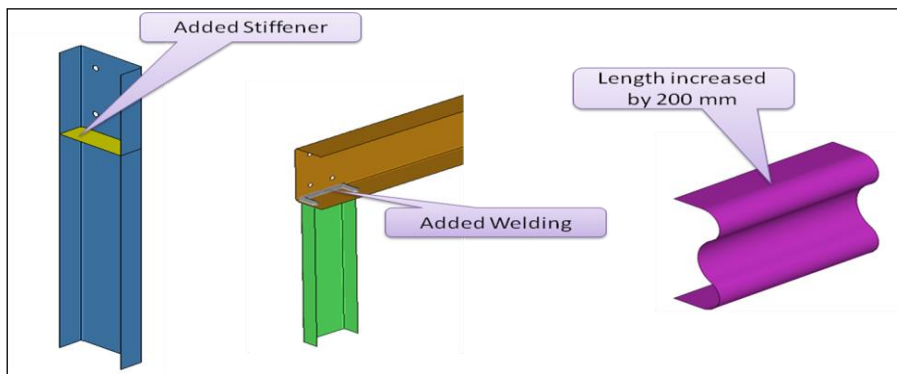




Observation & Conclusion - The maximum load carrying capacity of RUPD observed is 51.329 kN. Hence does not meet regulatory requirement of 73.575kN. Adding of additional welding to inner C channel can increase RUPD strength. Length of attachment bracket should be increased to increase its load carrying capacity in initial phase. A stiffener can be added to outer c channel to increase strength

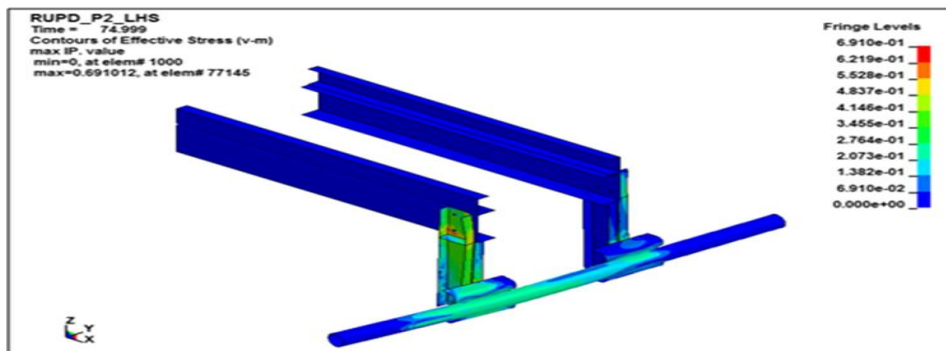
**Load case – P2 LHS – Iteration 2:**

Design Changes- A design modification is done on the C channel which is a part of the RUPD Model. The stiffener added back side of the C channel. The length of the clamp increased by 200mm. other side of the channel we added welding this all design changes shown in the fig.



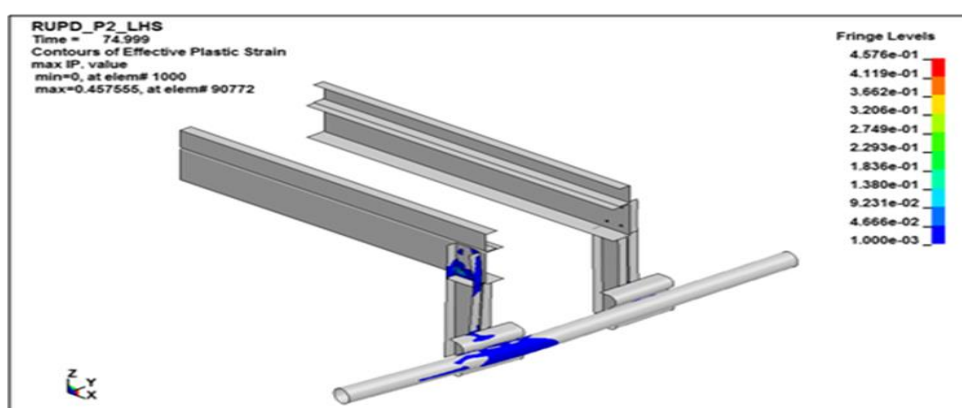
**Overall Plots:**

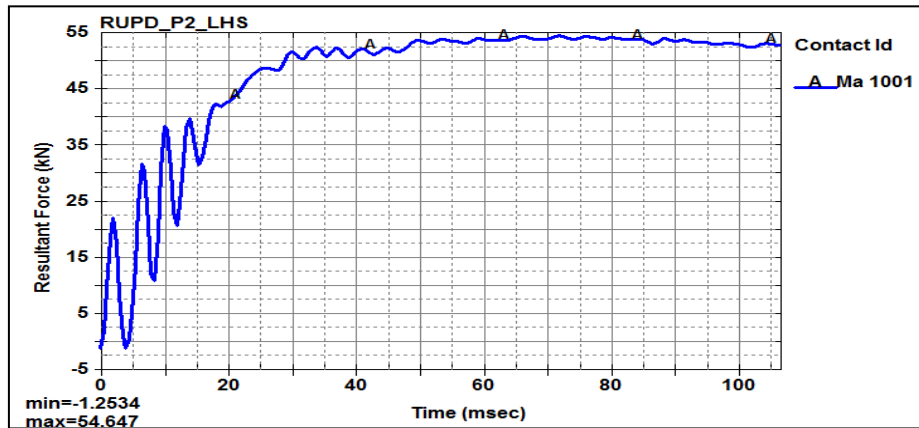
**Stress**



Stress in GPa

**Strain**

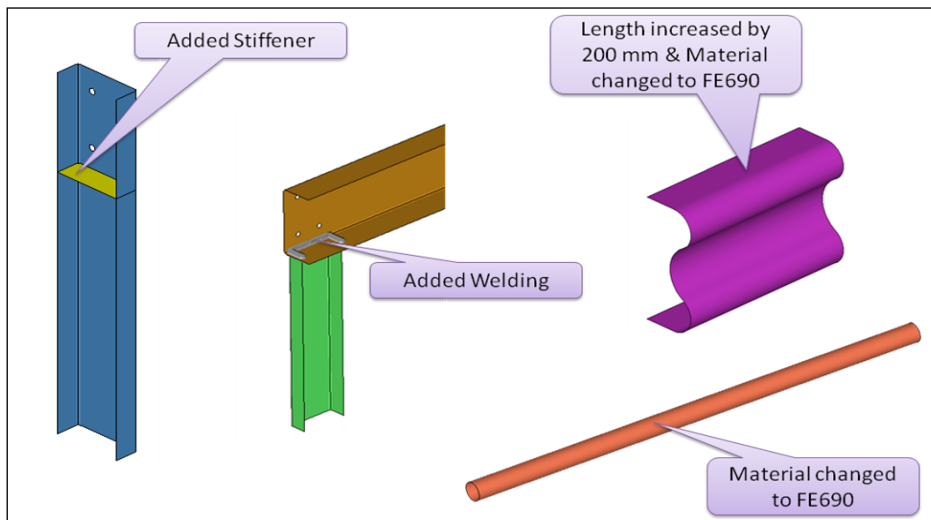




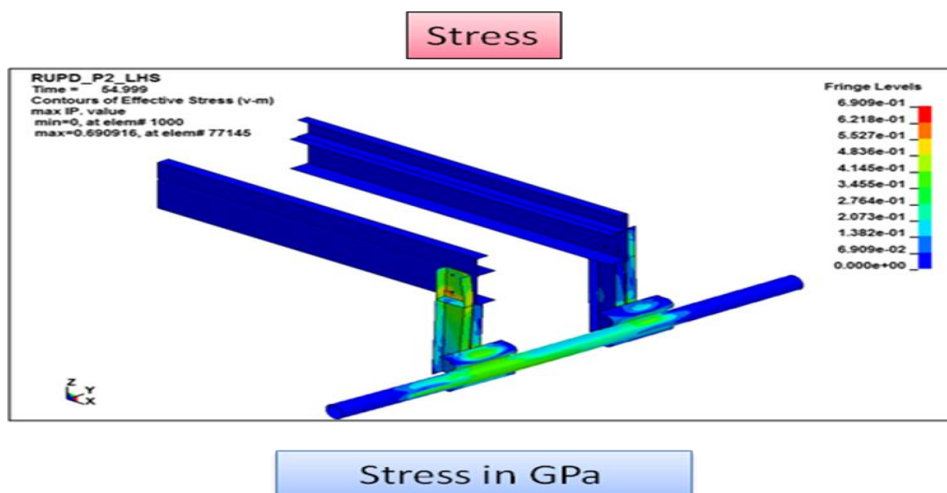
Observation & Conclusion - The maximum load carrying capacity of RUPD observed is 54.647 kN. Hence **does not** meet regulatory requirement of 73.575kN. Higher grade material for attachment bracket & pipe is recommended to increase load carrying capacity of RUPD.

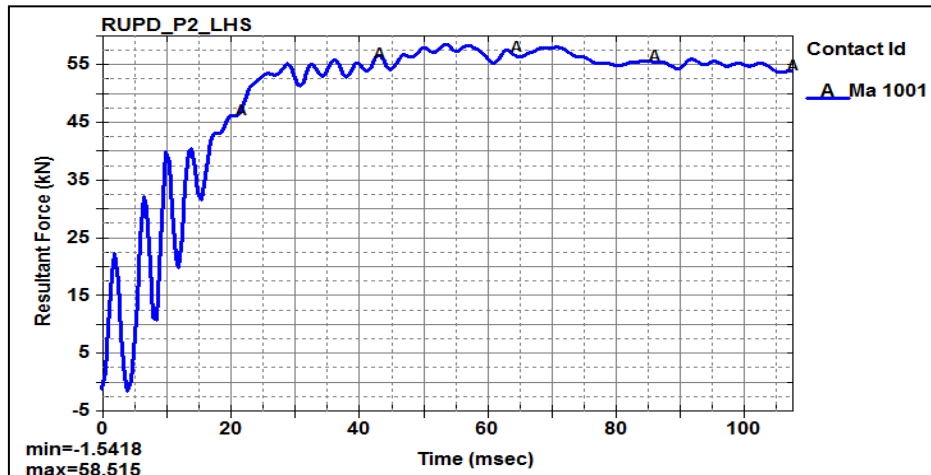
**Design Changes for Iteration 3:**

The length of the clamp increased by 200mm and material changed to FE690. Other side of the channel we added welding. The material of pipe changed to FE690 this all design changes shown in the fig.



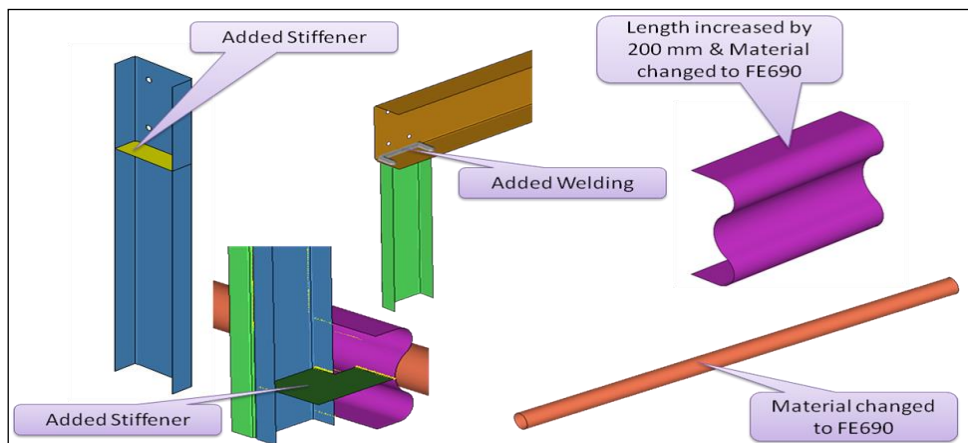
**Overall Plots:**





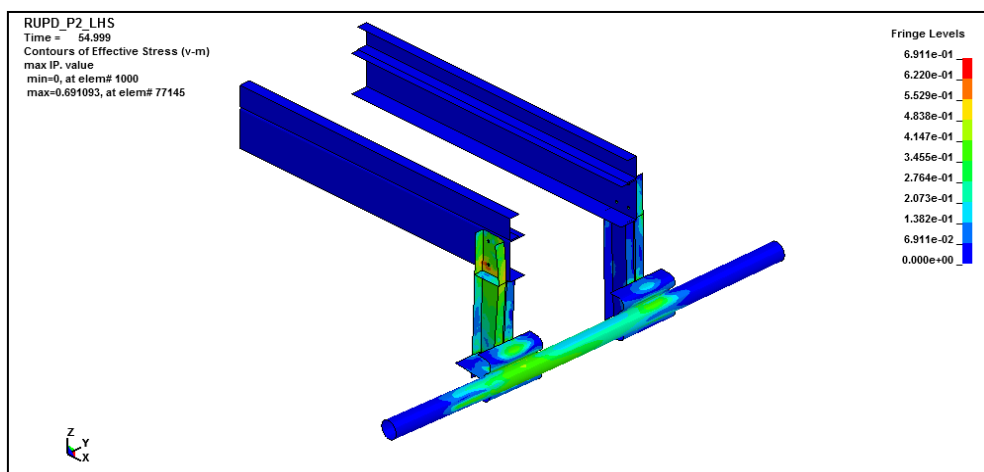
Observation & Conclusion-The maximum load carrying capacity of RUPD observed is 58.515kN. Hence **does not** meet regulatory. Additional stiffening bracket to be welded between C Channel & attachment bracket to increase strength requirement of 73.575kN.

**Load case – P2 LHS – Iteration 4:**

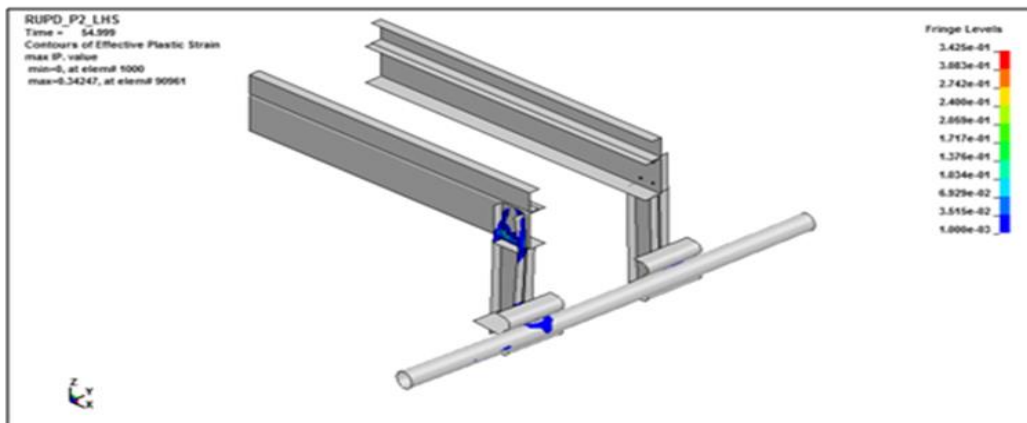


**Design Changes-** A design modification is done on the C channel which is a part of the RUPD Model. The stiffener added back side of the C channel. The length of the clamp increased by 200mm and material changed to FE690. Other side of the channel we added welding. The material of pipe changed to FE690 this all design changes shown in the fig

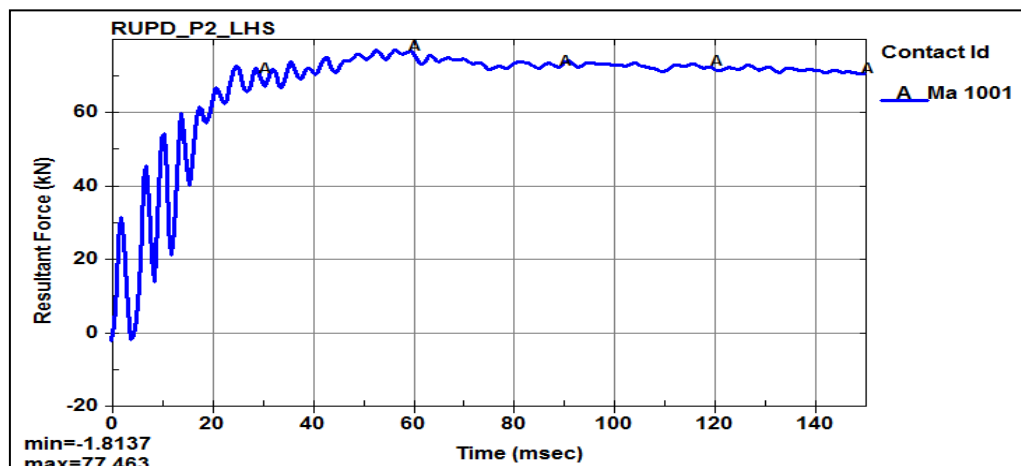
**Overall Plots:**



## Strain



### RUPD Load Carrying Capacity:



Observation & Conclusion - The maximum load carrying capacity of RUPD observed is 77.463 kN. Hence meets regulatory requirement of 73.575 kN. All parts show localized high plastic strains hence structural integrity is assumed safe.

## 5. CONCLUSION

- The various iterations done for design enhancement of RUPD shows incremental improvement in load carrying capacity from 48.55 kN to 77.463 kN. Hence meets the required regulatory requirement.
- The RUPD design thus achieved through incremental design changes is close to optimum design.
- Basic shaped design parts like C- Channels, pipe & stiffener plates were used to meet regulatory requirements. Thus the cost of RUPD is kept low.

## 6. FUTURE SCOPE

- Further use of mechanisms like spring damper systems, crushable aluminum section etc can be verified to achieve long life for RUPD and improved crashworthiness characteristics.
- Use of alternate materials like carbon fiber, foams, plastics etc can be studied to lower the RUPD mass.

- Intelligent RUPD design can be thought of which can retract while reversing of vehicle & operating normally when truck cruises in forward direction.
- FEA prediction of tests can be further improved by using finer mesh size, accurate modeling of welds, prediction of weld failure, consideration to material etc.

#### ACKNOWLEDGMENT

I would like to take this opportunity to express my respect, deep gratitude & regards to my guide **Prof. Shinde.V.B.** Without whose help this work would not have been successful. I express my sincere thanks to **Prof. Borkar. B.R.** for giving me all his support & cooperation for my project work.

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