

Front Under Run Protection Device Strength Test Certification Through FE Simulations

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ABSTRACT

Passive safety regulations specify minimum safety performance requirements of vehicle in terms of protecting its occupants and other road users in accident scenarios. Currently for majority cases, the compliance of vehicle design to passive safety regulations is assessed through physical testing.

With increased number of products and more comprehensive passive safety requirements, the complexity of certification is getting challenged due to high cost involved in prototype parts and the market pressures for early product introduction through reduced product development timelines. One of the ways for addressing this challenge is to promote CAE based certification of vehicle designs for regulatory compliance. Since accuracy of CAE predictions have improved over a period of time, such an approach is accepted for few regulations like ECE-R 66/01, AIS069 etc which involves only loadings of the structures. In this approach use of numerical tools like Finite element simulation technique is allowed for certification purpose.

This paper describes the experience in use of CAE tools for certification of commercial vehicles for FUPD (front under run protection device) strength requirements as per AIS069 regulatory requirements. Paper explains about the CAE & test correlation process, CAE methodology adopted and the approach used for certifying FUPD models through FE simulations. Using this approach almost fifteen different

commercial vehicles were certified for FUPD strength requirements saving substantial amount of cost and time involved in physical prototype tests.

INTRODUCTION

Today, certification of components, aggregates and vehicles for safety requirements is done through physical testing for most of the load cases. But such is not the case during vehicle development stages. Currently with the advancement in the numerical methods, processing speed and software capability, vehicle development is mainly done in virtual environment. Numerical models are extensively used to evaluate design alternatives with significant reduction in engineering and development time. Decisions regarding the design modifications and solutions to the problems are taken based on simulation results. As a result, reduction in the component, sub-system and full vehicle prototype builds are possible. Such confidence on the simulation results have been built over the period of time through proper modeling techniques, quality measures, correlation and validation criteria's on both full vehicle and component level models which are subjected to static loads and dynamic impacts (crash).

Even with such current advancement in CAE, validation and certification tests are still required to be done through physical tests which are also cost and time intensive.

With Regulatory authority showing confidence in the virtual testing, the new sets of regulations which are being drafted

and implemented are taking CAE capability in consideration. This would help in reducing the costly prototypes and reduce the vehicle development time. The aim of the virtual testing in regulation is to extend the same confidence on CAE as in vehicle development phase. Currently for safety regulations, CAE based certification is allowed for few load cases. For example strength of bus superstructure (ECE-R 66/01 & AIS031)^[1, 2], Rear under run protection device - RUPD (ECE -R58)^[3], lateral protection device - SUPD (ECE -R73)^[7] and Front under run protection device - RUPD (ECE R93 & AIS069)^[5, 6] can be certified through CAE (calculations).

Front under run protection device (FUPD) (fig 1) is a structural member provided on the front of commercial vehicles to protect smaller vehicles against under ride. These FUPD structural members are required to meet regulatory quasi static strength requirement within certain allowable displacement based on tonnage capacity of the vehicle for N2 and N3 class vehicles.

This paper discusses the process followed in developing CAE methodology and validation criteria for CAE based certification of FUPD as per AIS069. The process once developed and approved by regulatory authority was then used for all front under run protection device (FUPD) certification. Same method can also then be implemented for RUPD and SUPD certification in the future.

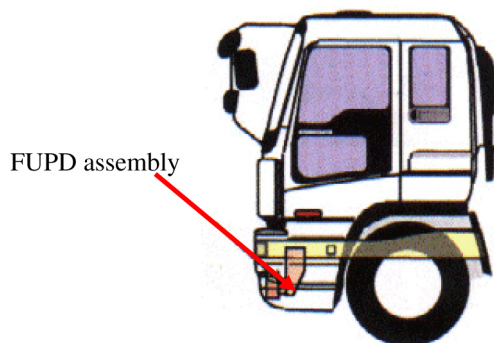


Fig 1. FUPD member connected to front end of commercial vehicle

FUPD STRENGTH REQUIREMENT

To evaluate FUPD strength requirements as per ECE R93 & AIS069, quasi static load through loading device (Ram) is applied on FUPD at defined locations (refer fig 2). In order to meet the regulatory requirement, FUPD should be able to withstand the applied load within specified amount of deformation. Summary of the FUPD requirement is tabulated below in table 1. As per ECER93 & AIS069 test can be done on the full vehicle or on the rigid bench (see fig 4)^[5, 6]. To avoid any variation from one vehicle to other because of suspension and vehicle movement during test and to have a common CAE process and loading condition it was decided to perform FUPD correlations exercise on rigid fixture.

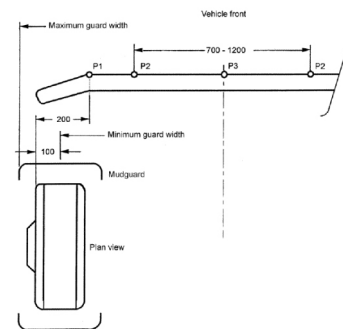


Fig 2. FUPD loading locations for P1, P2 and P3 (dimension in mm)

VALIDATION OF FINITE ELEMENT MODEL (FE) SIMULATIONS FOR CERTIFICATION

Before use of FE model in FUPD certification, the models have to be validated for.

- Reliability and accuracy of results
- Confidence level on FE solvers
- Validation and quality parameters used in FE model.

The best way to validate FE model is to compare its results with the physical tests. The same is demanded in ECE R66 / AIS031 on bus rollover. "The validity of the calculation method shall have been established by comparison with the results of physical tests"^[1, 2]. This would mean physical tests

Table 1. FUPD load requirements for AIS069 & ECE R93

P1	80 KN or 50 % of the maximum mass of the vehicle(which ever lesser)
P2	160 KN or 100 % of the maximum mass of the vehicle(which ever lesser)
P3	80 KN or 50 % of the maximum mass of the vehicle(which ever lesser) – optional if FUPD is symmetric
Max Allowable deformation	Horizontal distance from front extremity of the vehicle is 400 mm (After test). Height between the bottom surface of the FUPD and the flat ground surface is 500 mm (450mm as per ECE R93 regulation) (After test)



cannot be fully replaced by virtual tests. However the modeling methods and quality parameters once validated can be used to verify multiple models saving a lot of physical tests.

The same approach used in certification of bus rollover is also considered for FUPD certification. In view of this, one of the current design intent FUPD structure was physically tested and correlated with CAE. This validated the CAE process & method was used for building the confidence in the CAE model. The same methodology was then agreed with certifying agency for all future FUPD certification.

Methodology followed for CAE based certification of FUPD strength test is detailed below through flow chart (fig 3). An essential step of this methodology is to prove the validity of simulation result with commonly accepted methods.

In conventional approach use of CAE stops with initial FUPD structural development and certification is done through physical tests. With the further use of physical test to correlate with FE model and updating the FE model based on deviation identified and learning, the confidence in the CAE model was built. The learning like making the CAE rig model compliance match with the test rig, material confirmation as per specification and worst case FUPD model selection were also considered. This helped in accurate and reliable FE predictions of FUPD structure comparable with physical test.

Once such a good level of correlation between the physical test and simulation was achieved, evaluation of CAE model based on different pass / fail criteria was set and checked against. These learning's from CAE correlation was then carried over for all future FUPD development and certification. This helped in avoiding costly physical prototypes and reduced development time for FUPD.

FE MODEL

FE model was built as similar to test set up with following considerations (see fig 5).

- FUPD cross beam and its connecting bracket to the chassis frame was considered for simulation.
- Fixture and ram as representation of the test set up was also modeled in CAE. Pin joint for ram was also modeled as in physical test set up.
- Industry standard quality requirements for FE model were considered and followed to build FE model.
- All the FUPD members including fixture and ram were modeled with shell element.

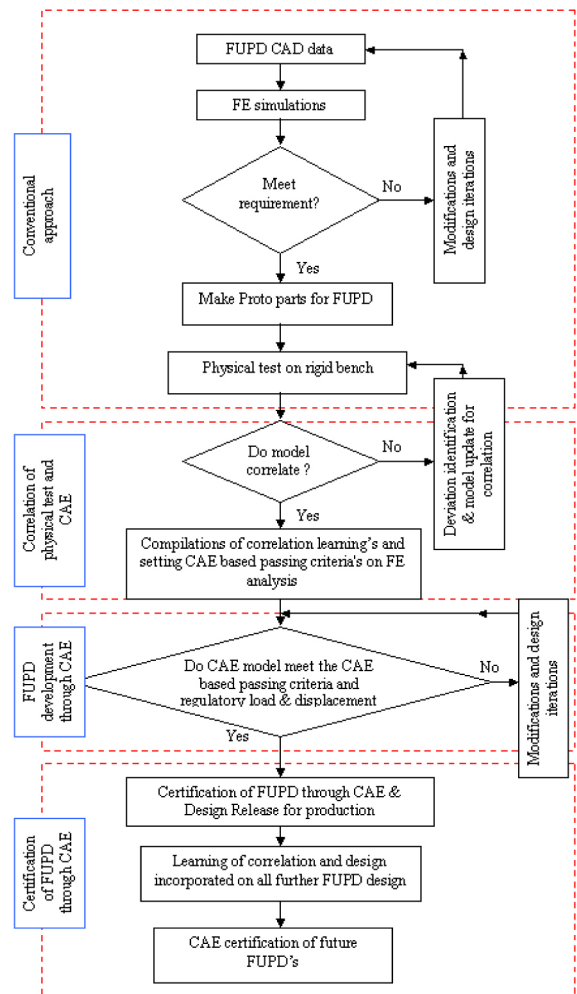


Fig 3. CAE based FUPD certification approach for structural strength

- Seam welds in FUPD were represented with rigid links in CAE.
- Bolts (only shank part) were modeled with solid element as beam representation of the bolts was not seen to be capture stresses and loads properly. Also it was assumed that mating parts connected through bolts will not have relative motion and so was connected with rigid links in CAE.

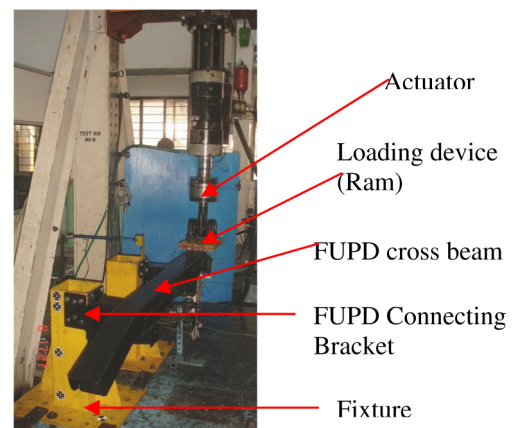


Fig 4. FUPD physical test set up on rigid bench