1 Passive Safety Project

In this assignment you will work with experimental and with explicit finite element (FE) tools to solve a problem related to the front structure of a simulated vehicle represented by an empty paint can, Figure 1. The main focus of the project is to access finite element models of a simplified crash model, do a quality check of different finite element meshes, and predict the system performance. The model performance will be compared to data from the mini-sled device in Figure 1.

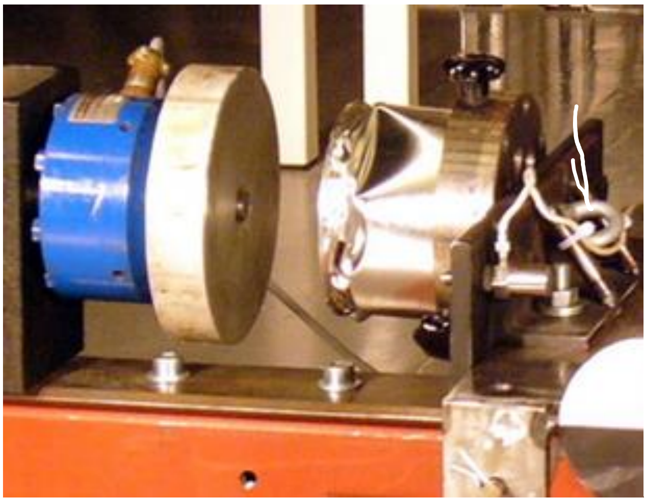
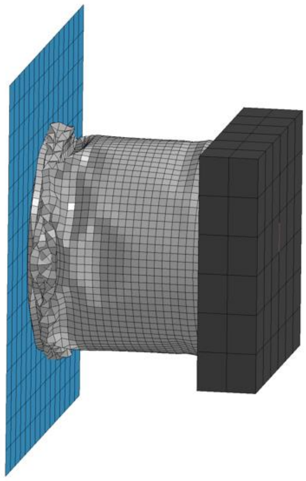



Figure 1. Crash lab (left) and finite element model (right) setups.

1.1 Learning outcomes:

After this assignment, students should be able to:

- Design an analysis approach to study an engineering challenge
- Post-process and analyze test data
- Demonstrate an understanding of the physical principles behind crash structures
- Post-process and analyze explicit finite element simulation data
- Assess the quality of an explicit finite element simulation
- Perform simulations
- Extrapolate simulation and test results to predict system performance under new conditions

2 Examination

There are 4 milestones and a final report that shall be completed to get credit for completing the assignment. You cannot get full credit for course if you have not successfully completed the assignment.

The 4 milestones are:

M1) Selection of appropriate test data to conduct you analysis
M2) Identification of a suitable FE model to conduct your simulation work
M3) Successful calibration of your model to experimental data
M4) Quality assurance review of a colleagues report

The final report will consist of results (chapters) from the first 3 milestones plus your answer to your assigned task.

The final report shall contain:

1) Short description of the objective of the project and selected test data (M1)
2) Experimental data properly processed and presented (Section 4)
3) A discussion of the Benchmark results and justification for the best model is presented. (M2)
4) Results of In-House simulations and compared to the experimental data validating the model performance (M3)
5) Analysis of the In-House and experimental data points to predict the design limits requested of your group. This prediction is simulated and the results discussed.

The results of points 1-5 above shall be provided in a report of **5–10 pages**. The report should include the simulation results, but does not need to extensively cover all the methods used for the simulation. **Deadlines for the milestones and the report are according to the course schedule in Canvas**. Everything is submitted through Canvas. If the report is not approved, it will be returned and the group must resubmit the report with the necessary changes.

3 Organization and Required Tasks

This assignment will be solved in student pairs. Different milestones must be met to achieve your project objectives. Each milestone contributes to the final report.

3.1 Assigned objective

Each pair will work with **one** of the following three tasks from the list below, assigned by the teaching staff

Task 1) You are working in a crash safety division at a small car company that produces cars for the upper market segment. Your product uses a car platform that is already developed for a budget car. Your car will be fitted with entertainment systems, extra noise insulation, better anti-whiplash seats etc. All this equipment will add mass to the car. ***What is the maximum car mass the existing design can support without encountering problems that the "car" front structure bottoms-out?***

Task 2: Safety engineers often use the concept of ΔV to assess crash severities. ***What is the maximum Δv for the simulated "car" front structure before the structure bottoms-out?***

Task 3: In order to design a safe car, the maximum acceleration in a full frontal collision should be limited. What is the minimum ***How light can a low cost "car" be with the existing "car" front structure?*** The maximum acceleration should be under 120 m/s^2.

Note that in the first 2 tasks the concept of "bottoming-out" is used. Bottoming-out is the term used to describe the maximum usable stroke of a vehicle structure. In these 2 tasks the student pairs will need to define their bottoming -condition.

4 Experimental Data

The test lab has provided 7 datasets with different test masses and test speed configurations. The test lab has limited capabilities and cannot experimentally determine the limits requested in the tasks. Not all 7 tests are suitable for each task. All experimental data is provided to the students in the format directly recorded by the equipment. The student teams must identify the test data suitable for their task (3-4 tests depending on the task) in Milestone 1. Each report must include an analysis of your relevant test results and provide the following parameters as a minimum:

- Initial test velocity should be determined from *two different* sources of data
- Test Δv should be determined from *two different* sources of data
- Deformation should be defined and presented for all test conditions (both in percentage and absolute deformation)
- Contact force determined from *two different* data sources
- Calculation of absorbed energy and kinetic energy

All test data should be *properly scaled, filtered, adjusted for offset etc*. Filters for Excel or Matlab are available on the course homepage. See Section 4!

Note that you will need to determine the test speeds for all tests before you can make an informed decision about the data to select.

5 Simulation Task

The student groups will simulate the experimental setup using the finite element code LS-DYNA. The software that you are going to use are LS-PrePost and LS-DYNA. See the canvas page for the LS-Dyna resources.

5.1 Tasks

The are 3 main simulation subtasks, the benchmark task, in-house simulation task, and project objective simulation.

5.1.1 Benchmark Task (Milestone 2)

The first objective of this task is to identify a model that you trust to support and *to verify the answers of your project task*. Imagine that you are working at an automotive OEM and that you are responsible for selecting the consultant company that will perform a larger simulation contract for your firm. In order to do so, you have received five different result files from different consulting companies. All these consulting companies have received the same information and simulated the same test. Which company provided the best model? Download the result files from the course home page. Look at the meshes, the energy balance, deformed shape, force, acceleration, etc. **Based on these observations you will need to choose the model that you consider the most appropriate to simulate this test. The decision must be described in a short report and submitted your report with tables and/or graphs motivating your decision.**

5.1.2 In-House Simulation Task (Milestone 3)

Imagine that you are working at a consulting company and you are responsible for validating a model for an automotive OEM customer. You will take a mesh that your colleagues from the

CAD department have generated and **add all necessary** information to simulate the experiments. Download and choose an input file from the course home page, based on the benchmark task. **Simulate the same conditions as your experiments and compare the experimental and the simulation results.** You will have to tune (we will discuss this in class) the model to properly predict the experimental data. Validate that your simulation model correlates with the experiment and present the validation results confirming your model captures the physics of the test.

5.1.3 Project objective simulation

Based on the benchmark and in-house simulations, you are required to apply the chosen and validated model to fulfill the objective assigned to your group (Section 1.3). You should add a "*virtual data point"* to complement your experimental data beyond the experimental limits. Use your model to predict the system performance at the design limit required. This predicted point is an extrapolation of the experimental data and should be presented appropriately.

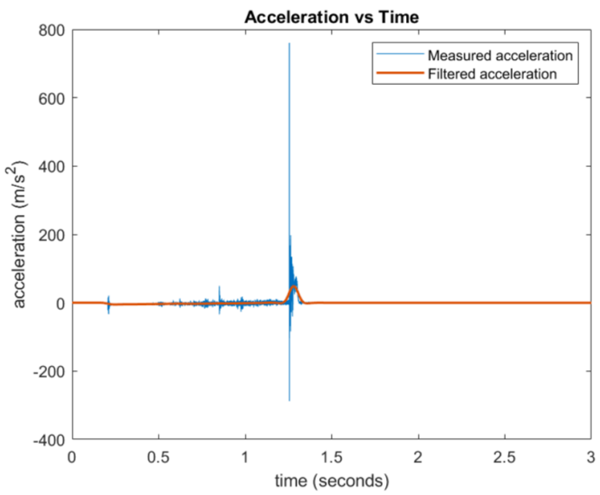
5.2 Supervision

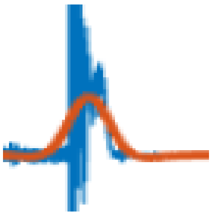
Sessions in the computer rooms are held according to the course schedule.

Report Dos and Don’ts

- Provide concise overview of objectives and methods – we don’t need a history lesson on vehicle design!
- Provide the filter cutoffs used for processing the data. The measurement lecture has an overview of recommended filter characteristics
- Make sure the measurement data has been offset adjusted and scaled appropriately. Use an appropriate reference window, just because there are 10000 datapoints doesn’t mean all points are relevant for plotting.
- Any plots of comparing simulation and measurement curves must be plotted on the same plot, not in separate plots. Think about how you want to compare the curves and the best way to present this
- Make sure you plot your predicted design limits are presented on the same graph used for the prediction.
- No LS-Dyna plots (screen dumps) will be accepted.

Examples of plots:

<table>
<tr><th>Plot</th><th>Comment</th></tr>
<tr><td>


</td><td>X and Y ranges are too large. The only region of interest is shown below.

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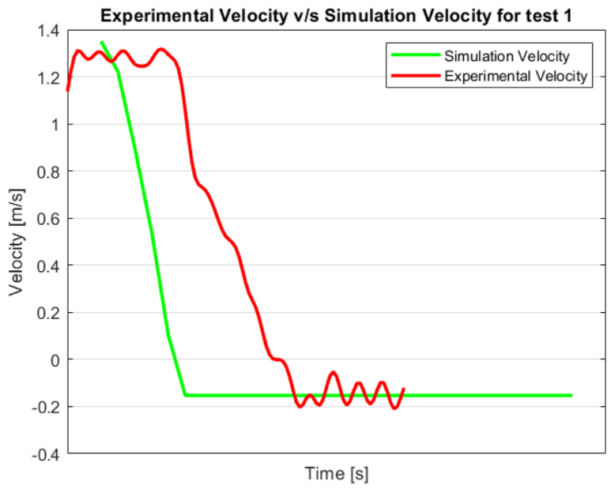
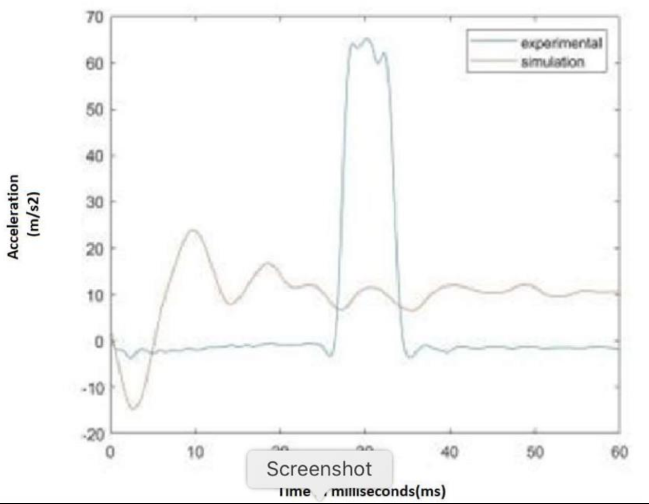
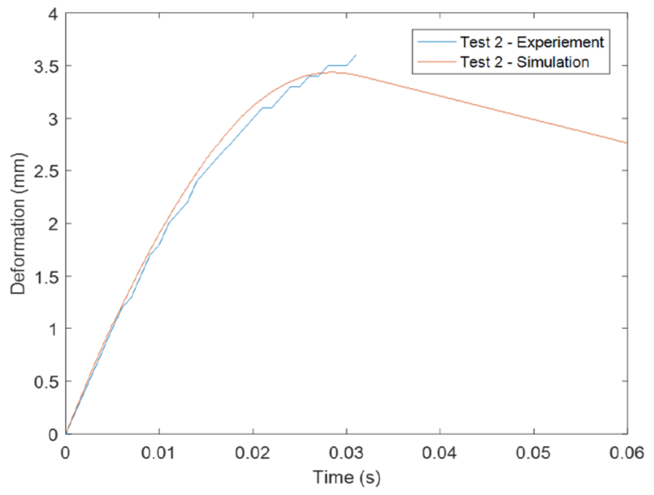
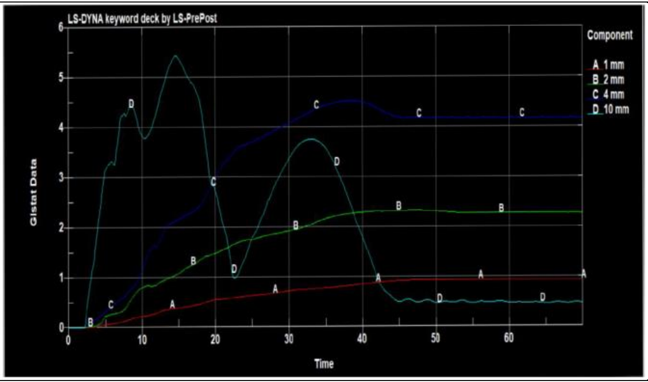


</td><td>The 2 curves do not start at the same time. They need to be aligned so the data at each time point are comparable.</td></tr>
</table>

<table>
<tr><td>
</td><td>There are 2 different scales for the X axis for the different data sets.</td></tr>
<tr><td>
</td><td>Experimental and simulation data scaled on same axis. The data at each point are directly comparable.</td></tr>
<tr><td>
</td><td>LS-Dyna Pre-Post plot. Not good for comparing to simulation data. Black background makes it difficult to see the information.</td></tr>
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