TEST CASE DOCUMENTATION AND TESTING RESULTS

LSTC-QA-LS-DYNA-AWG-CI-3-3

TEST CASE ID AWG-CI-3

Seat Belt Stretch Test Simulation

Tested with LS-DYNA® R11.2 Revision 51-g7e1aee4

Friday 11th December, 2020

LSTC
Livermore Software Technology Corp.

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Contents

1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-CI-3. It provides general test case information like name and ID as well as information to the confidentiality, status, and classification of the test case.
A detailed description of the test case is given, the purpose of the test case is defined, and the tested features are named. The test case specifications also state the target measures for testing and the expected results, as well as their pass and fail criteria.
Testing results are provided in section 5 for the therein mentioned LS-DYNA® version and platforms.

2 Test Case Information

Test Case Summary	
Confidentiality	external use
Test Case Name	Seat Belt Stretch Test Simulation
Test Case ID	AWG-CI-3
Test Case Status	active
Test Case Classification	Verification
Test Case Source	Collins Aerospace
Tested Keyword	*MAT_FABRIC
Member of Test Suite	AWG CI SUITE
Metadata	AWG CI

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of Test Case ID AWG-CI-3 is the comparison of force-deflection results from quad and tria shell elements with tensile test data from a seat belt stretch test.

3.2 Test Case Description

Force-deflection data from a seat belt stretch test was used to define *MAT_FABRIC input. This material input was then used in a model of the test to compare the analytical cross-section forces at the center of the seat belt using both quad and tria shell elements with the test force-deflection data. In the analysis, the top belt is meshed with tria shell elements and the three meshes below use quad shell elements (See Figure 1). The tria and middle shell element meshes are stretched to the test deflection while the top and bottom shell element meshes are stretched to +30% and -30% of the test deflection, respectively.

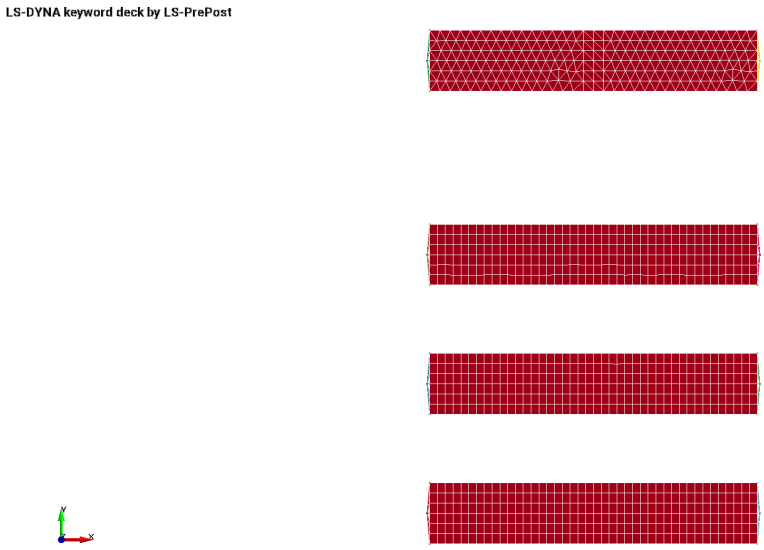

Figure 1: Seat Belt Model

3.3 Model Description

A seat belt with dimensions 254 mm long by 27 mm wide by 1.25 mm thick is modeled with tria and quad shell elements (See Figure 1). Using *BOUNDARY_PRESCRIBED_MOTION_NODE input, the tria and middle quad shell element models are stretched to the test deflection of 25.4 mm, while the top and bottom shell element meshes are stretched to 33 mm (+30%) and 17.8 mm (-30%) of the test deflection, respectively. The total deflection is determined from nodes on each end of the belt and the load is extracted from the cross-section force at the center of each belt. These results are compared to actual test data.
The model specifications can be found in Table 2. The material definitions and their parameters can be found in the input deck. The input deck name is listed in Table 3.

FEA Model information	
Nodes	1180
Solid elements	0
Shell elements	1152
Beam elements	0
Material type list	MAT_34
Parts	1
Units	mm (length), ms (time), kg (mass), kn (force)

Table 2: FEA Model Information

Input Deck Name
Seat_Belt_Test.k

Table 3: Specification of the test cases

4 Test Specifications

4.1 Test Case Targets

Table 4 displays the test case targets. The test case targets specify values or a series of values taken from the finite element analysis solution of the test case. The test case targets are x force at the sections 1-4 (sections 1-4 are defined as the middle planes of the bottom-top belts in figure 1) .

Test Case Targets				
Target number	output	component type	components id	retrieved from
1	secforc	x force	1	binout/secforc file
2	secforc	x force	2	binout/secforc file
3	secforc	x force	3	binout/secforc file
4	secforc	x force	4	binout/secforc file

Table 4: Test Case targets for Test Case ID AWG-CI-3

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Test Case ID AWG-CI-3.

The test case passes if the test case target data falls within the corridor bounds. Otherwise the test fails.

The test case corridors are upper and lower bounds for the test case targets. They were defined based on the test target data obtained with LS-DYNA® R10.2 Revision 134743 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R10.2 Revision 134743) combinations, so that the time domain is the same.
- Calculate the upper and lower bounds by:

$$bound_{up}(i) = max(i) + 0.2 \times [max(i) - min(i)] + 0.05 \times peak$$
$$bound_{low}(i) = min(i) - 0.2 \times [max(i) - min(i)] - 0.05 \times peak$$

  where $max(i)$, $min(i)$ are the maximum and minimum values at the i_{th} time step across all platforms and executable (R10.2 Revision 134743) combinations the test case was calculated with, $peak$ is the maximum absolute y value across the whole time domain, $bound_{up}(i)$ and $bound_{low}(i)$ are the upper and lower bounds for the i_{th} time step.

5 Test Case Results

5.1 Software and Hardware Specifications

In order to ensure cross-platform consistency, the herein mentioned sub test cases are run on platforms specified in table 5 and the results are calculated with software versions defined in table 6.

Platform Name	Operating system	CPU type	MPI-Protocol	Number of cpu's [1]
mars	CentOS 6.5	Intel® Xeon® E5- 2640 @ 2.50GHz	Platform MPI 8.2.0.0	4
dinar3b	SUSE LES 11	AMD® Opteron ® 6276 @ 2300MHz	Platform MPI 8.2.0.0	4

[1] Number of cpu's used for calculation of the test case

Table 5: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type [1]	Precision [2]	executable
LS-DYNA®	971	R11.2	51-g7e1aee4	SMP	SP	ls971.51-g7e1aee4.R11.2
LS-DYNA®	971	R11.2	51-g7e1aee4	SMP	DP	ld971.51-g7e1aee4.R11.2
LS-DYNA®	971	R11.2	51-g7e1aee4	MPP	SP	mpp971.51-g7e1aee4.R11.2
LS-DYNA®	971	R11.2	51-g7e1aee4	MPP	DP	mpd971.51-g7e1aee4.R11.2

[1] MPP = Massively Parallel Processing, SMP = Symmetric Multiprocessing

[2] SP = single precision, DP = double precision

Table 6: Tested LS-DYNA® version

5.2 Results Summary

Table 7 contains the results of the Test Case ID AWG-CI-3 completed with all combinations of software and hardware defined in section 5.1 (4 * 2 total cases).
Details on the test results can be found in the section 5.3.

The table 7 validation summary is:

- **PASS** - Pass criteria in section 4.2 is attained.
- **FAILED** - Pass criteria in section 4.2 is not attained.
- **ERROR** - sub test case terminates due to error.
- **N/A** - sub test case was not calculated.

Test Case ID	PASS/FAILED
3	**PASS**

Table 7: Results summary for Test Case ID AWG-CI-3

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-CI-3 for LS-DYNA® R11.2 Revision 51-g7e1aee4.

For each sub test case defined in section 3.3 there is a graph displaying the time history of the result target defined in section 4.1 for the platform and software version combinations defined in section 5.1.

The title of the graph states the test case ID and the name of input deck. The legend contains the result file name, output, platform, executable and number of cpu's separated by comma. A minus sign before the number of cpu's refers to the compatibility option for SMP calculations (see [1] for details on this option).

Example for title and legend:

Title:
'AWG_CI_TEST_CASE_3: Seat_Belt_Test.k' states the test case ID 3 and name of the input deck.
Legend:
'secforc_xforc1,mars,ls971.51-g7e1aee4.R11.2,4' states that the graph shows the x force at section 1 derived from the 'secforc' output file for an input deck which was calculated on the 'mars' platform with a LS-DYNA® R11.2 Revision 51-g7e1aee4 binary (SMP, single precision) on four processor.

5.3.1 Test Target 1

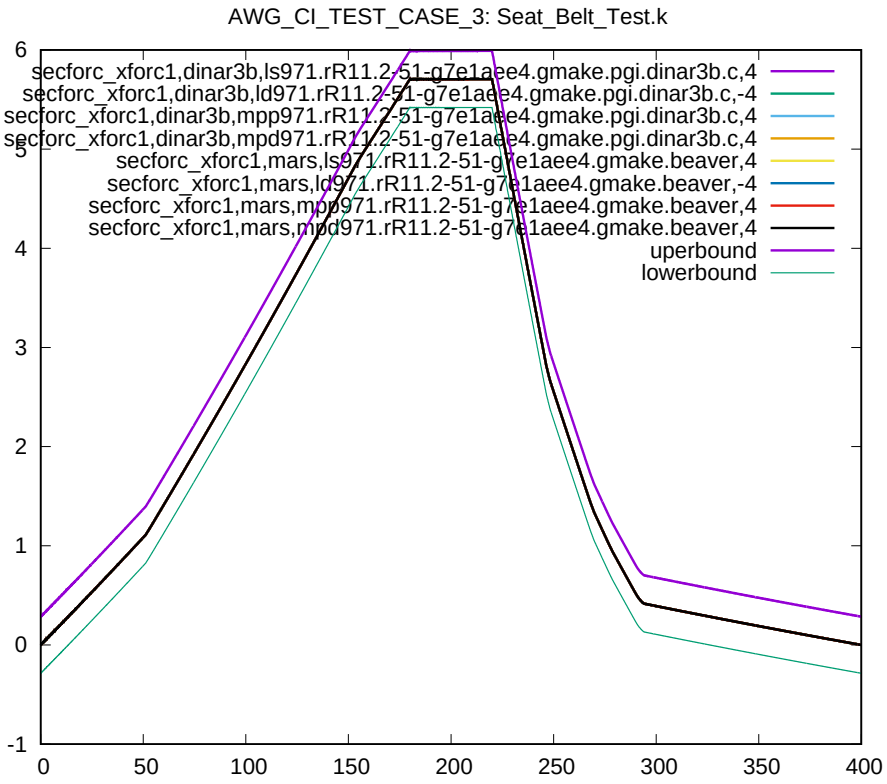

Figure 2: Cross platform results, x force at the section 1

5.3.2 Test Target 2

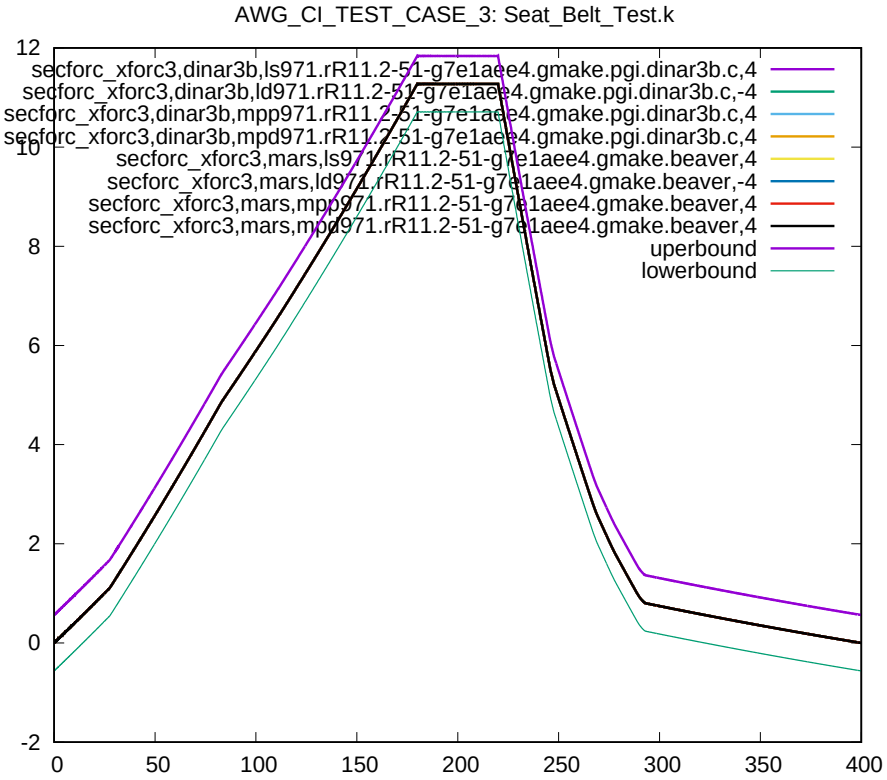

Figure 3: Cross platform results, x force at the section 2

5.3.3 Test Target 3

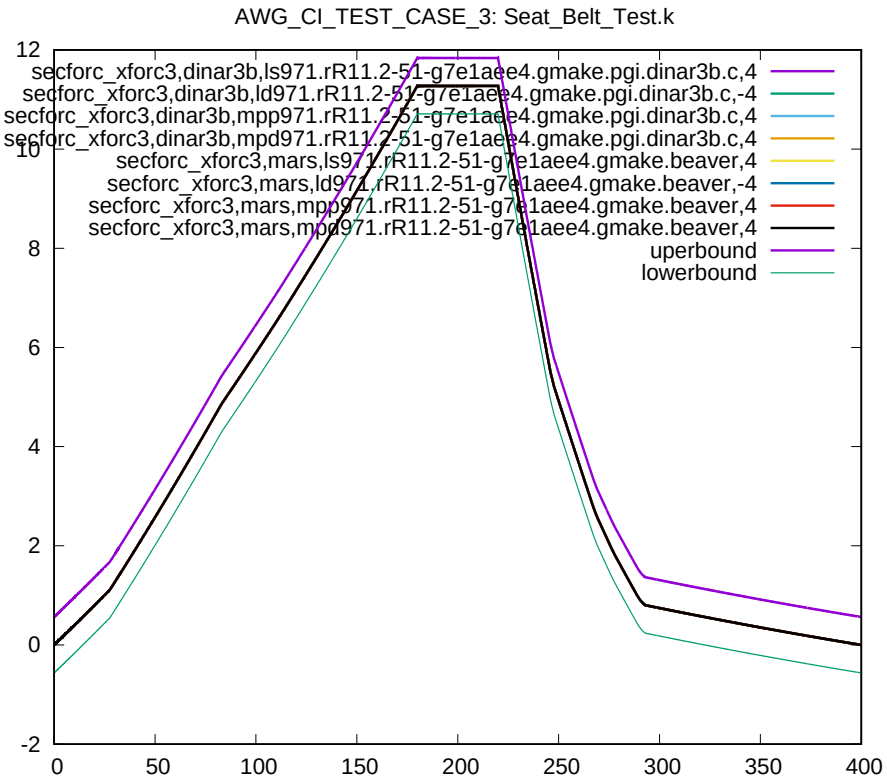

Figure 4: Cross platform results, x force at the section 3

5.3.4 Test Target 4

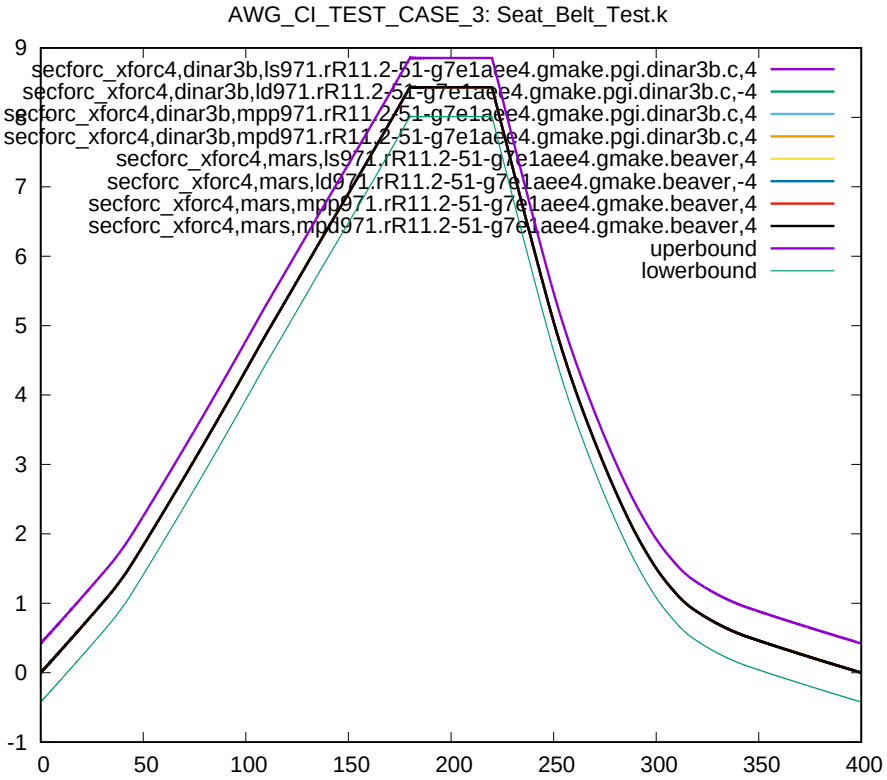

Figure 5: Cross platform results, x force at the section 4

5.3.5 CPU time

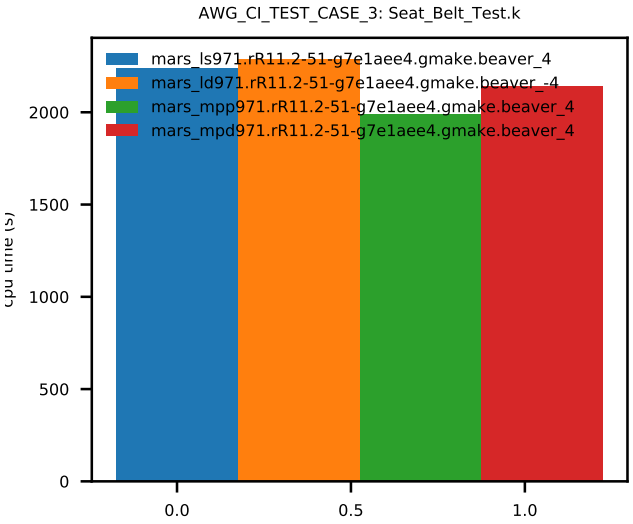

Figure 6: Cross platform results, CPU time (s)

References

[1] LSTC, *LS-DYNA KEYWORD USER MANUAL*, 7374 Las Positas Road, Livermore, CA, 94551, USA, version 971 ed., May 2007.