TEST CASE DOCUMENTATION AND TESTING RESULTS

LSTC-QA-LS-DYNA-AWG-CI-1-4

TEST CASE ID AWG-CI-1

Arbitrary Energy Absorber (EA) Model using *MAT_GENERAL_SPRING_DISCRETE_BEAM

Tested with LS-DYNA® R9.3 Revision 126955

Thursday 31st May, 2018

Warranty Disclaimer:

Document Information	
Confidentiality	**external use**
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Contents

1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-CI-1. 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	Arbitrary Energy Absorber (EA) Model using *MAT_GENERAL_SPRING_DISCRETE_BEAM
Test Case ID	AWG-CI-1
Test Case Status	active
Test Case Classification	Validation
Test Case Source	NASA Langley Research Center
Tested Keyword	*MAT_GENERAL_SPRING_DISCRETE_BEAM
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-1 is the comparison of results from different cpu architectures for an arbitrary EA model using *MAT_GENERAL_SPRING_DISCRETE_BEAM.
The reliability and consistency of LS-DYNA® as a finite element solver for this test cases is evaluated by performing analyses on different cpu architecture platforms.

3.2 Test Case Description

In this Test Case, *MAT_GENERAL_SPRING_DISCRETE_BEAM is chosen to represent the arbitrary EA (see figure 1). A drop test scenario is simulated with a 200 lb mass at node 2 traveling at 240 in/s loading through an energy absorber (EA) produces a 2000 lb constant EA force.

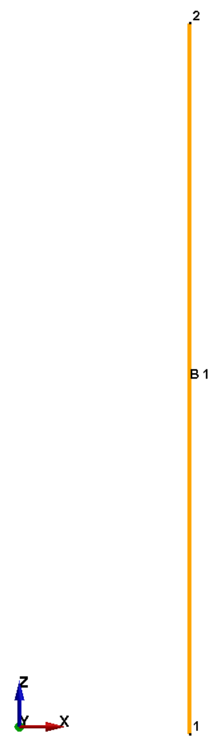

Figure 1: Simple EA Model

3.3 Model Description

This model consists of one beam element and one mass element at node 2. *MAT_GENERAL_SPRING_DISCRETE_BEAM is used to model the arbitrary EA. In the *MAT_GENERAL_SPRING_DISCRETE_BEAM card, type is set to 1 for inelastic behavior, degree of freedom is set to 1, and the parameter SCOOR in PID=104 is changed to -2.0 to keep motion along node 2 to 1 as defined in *ELEMENT_BEAM. Gravity is active in z direction using *LOAD_BODY_Z. *DEFINE_CURVE ID=29 is used to apply load, starting with "largest" negative to zero, and then to positive for unload. The model specifications can be found in table 2. The material definitions and their parameters can be found in the input deck.

Model information	
Nodes	3
Beam elements	1
Material type list	MAT_196, MAT_020
Mass elements	1
Parts	1
Units	in (length), s (time), lbf-s^2/in (mass), lbf (force)

Table 2: FEA Model Information

4 Test Specifications

4.1 Test Case Targets

Table 3 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. They are chosen in a way that they can be directly or indirectly compared to the experimentally determined values or observations.

Test Case Targets				
Target number	output	component type	component id	retrieved from
1	z-displacement	node	2	binout/nodout file
2	z-velocity	node	2	binout/nodout file
3	z-acceleration	node	2	binout/nodout file
4	axial force resultant	beam	1	binout/elout file

Table 3: Test Case targets for Test Case ID AWG-CI-1

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Validation of the Test Case ID AWG-CI-1.

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® R9.0 Revision 117338 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R9.0 Revision 117338) 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 (R9.0 Revision 117338) 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 4 and the results are calculated with software versions defined in table 5.

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	1
dinar3b	SUSE LES 11	AMD® Opteron ® 6276 @ 2300MHz	Platform MPI 8.2.0.0	1

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

Table 4: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type [1]	Precision [2]	executable
LS-DYNA®	971	R9.3	126955	SMP	SP	ls971.126955.R9.3
LS-DYNA®	971	R9.3	126955	SMP	DP	ld971.126955.R9.3
LS-DYNA®	971	R9.3	126955	MPP	SP	mpp971.126955.R9.3
LS-DYNA®	971	R9.3	126955	MPP	DP	mpd971.126955.R9.3

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

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

Table 5: Tested LS-DYNA® version

5.2 Results Summary

Table 6 contains the results of the Test Case ID AWG-CI-1 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 6 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
1	**PASS**

Table 6: Results summary for Test Case ID AWG-CI-1

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-CI-1 for LS-DYNA® R9.3 Revision 126955.

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 [**?**] for details on this option).

Example for title and legend:

Title:
'AWG_CI_TEST_CASE_1: EA_Discrete_Beam.k' states the test case ID 1 and name of the input deck.
Legend:
'nodout_zdisp2,mars,ls971.126955.R9.3,1' states that the graph shows the z-displacement of node 2 derived from the 'nodout' output file for an input deck which was calculated on the 'mars' platform with a LS-DYNA® R9.3 Revision 126955 binary (SMP, single precision) on one processor.

5.3.1 Test Target 1

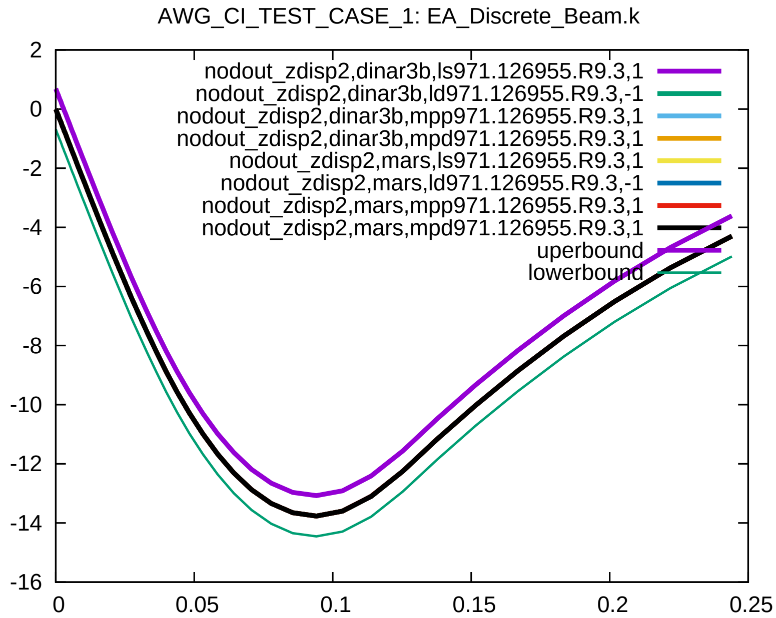

Figure 2: Cross platform results, nodal z displacement node 2

5.3.2 Test Target 2

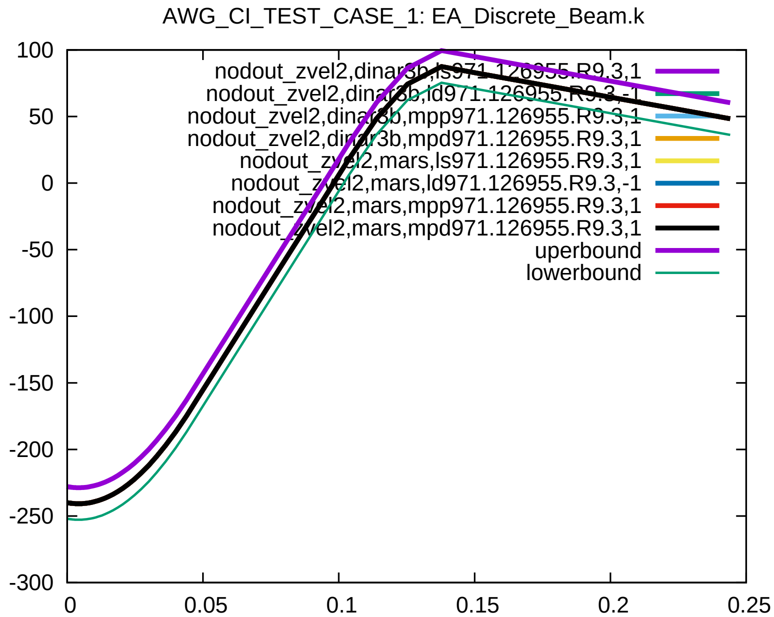

Figure 3: Cross platform results, nodal z velocity node 2

5.3.3 Test Target 3

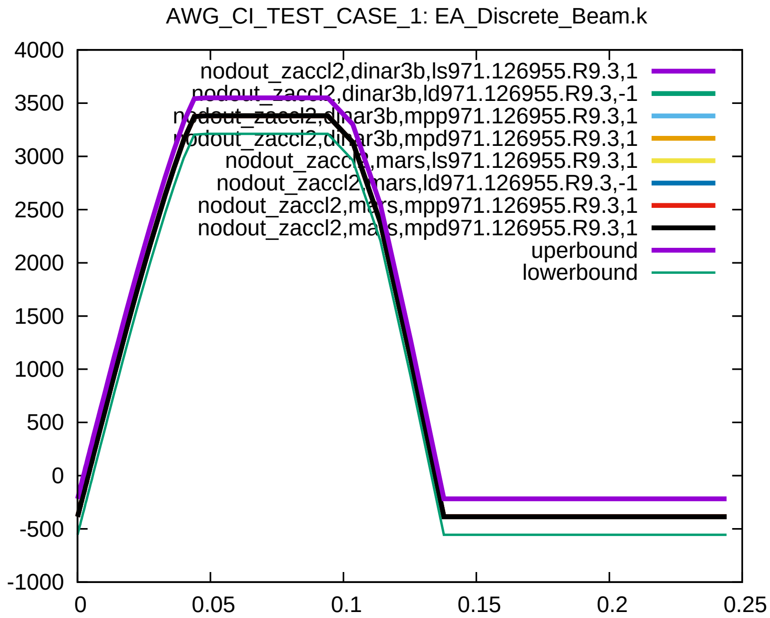

Figure 4: Cross platform results, nodal z acceleration node 2

5.3.4 Test Target 4

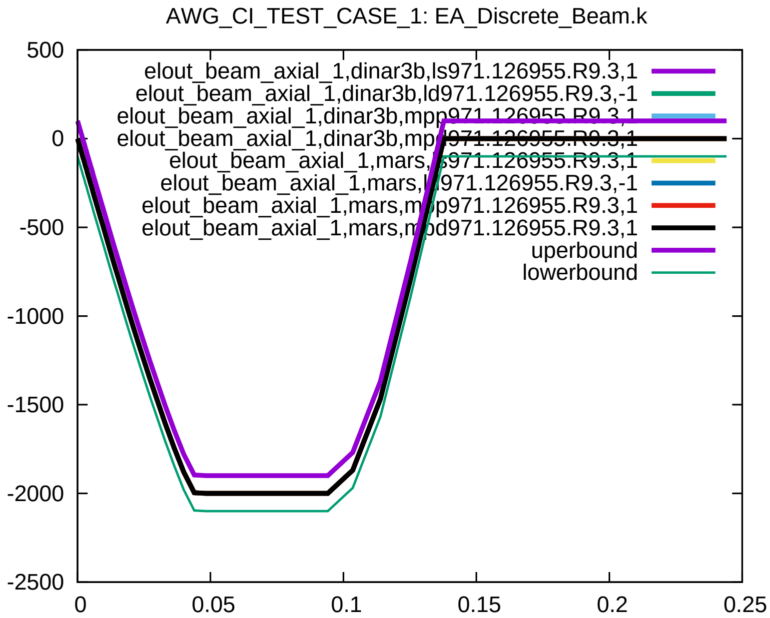

Figure 5: Cross platform results, axial force resultant beam 1

5.3.5 CPU time

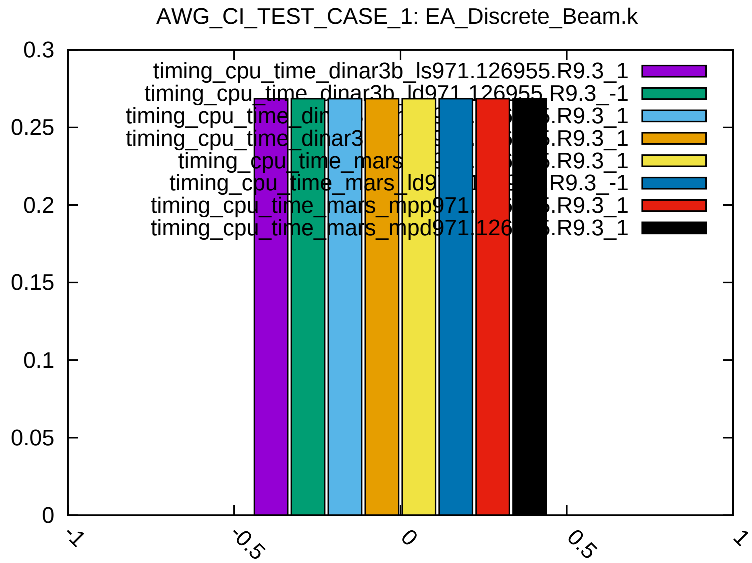

Figure 6: Cross platform results, CPU time