TEST CASE DOCUMENTATION AND TESTING RESULTS

ANSYS-QA-LS-DYNA-AWG-CI-8-8

TEST CASE ID AWG-CI-7

Compression Member - Forward Leg, Leg Spreader Bar

Tested with LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8

Thursday 4th July, 2024

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Document Information	
Confidentiality	**external use**
Document Identifier	ANSYS-QA-LS-DYNA-AWG-CI-8-8
Author(s)	Prepared by LS-DYNA® Aerospace Working Group
Number of pages	18
Date created	Thursday 4th July, 2024
Distribution	LS-DYNA® Aerospace Working Group / internal ANSYS QA

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1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-CI-7. 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	Compression Member - Forward Leg, Leg Spreader Bar
Test Case ID	AWG-CI-7
Test Case Status	active
Test Case Classification	Application Benchmark
Test Case Source	Boeing
Tested Keyword	*ELEMENT_SOLID *MAT_ELASTC *LOAD_NODE
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-7 is twofold: to simulate a compressive load on a rod that is representative of a forward leg, leg spreader bar or a portion of an actuator that is subjected to tensile, compressive, and bending loads; and to simulate a buckling test with a transverse load applied along with the compressive load.

3.2 Test Case Description

This test case has two subcases. In the first subcase, a compression test scenario is simulated with a prescribed displacement of 0.4 mm/s applied to the free end of a rod that has the other end fixed in all degrees of freedom. In the second subcase, a buckling test scenario is simulated with a prescribed displacement of 0.2 mm/s applied to the free end of a rod that has the other end fixed in all degrees of freedom while a transverse load of 0.004 kN/ms is applied in the center section of the rod. See Figure 1.

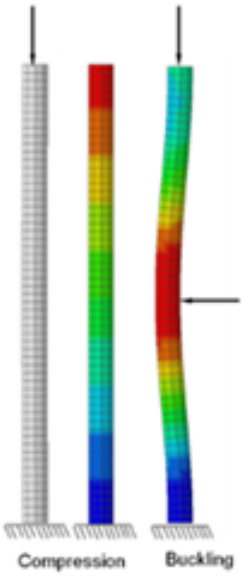

Figure 1: Compression and Buckling Member.

3.3 Model Description

An aluminum (2024-T351) rod with a 228.6 mm (9 inch) length and 12.7 mm (0.5 inch) diameter is fixed at one end in all degrees of freedom as shown in Figure 1. The Finite Element Model is shown in Figure 2. Two subcases are evaluated. In Subcase 1, the free end of the rod has a prescribed displacement of 0.4 mm/s applied and the displacement of a node on the free end is monitored along with the internal energy of the rod. In Subcase 2, the free end of the rod has a prescribed displacement of 0.4 mm/s applied and the center section has a transverse load of 0.0004 kN/ms applied. The transverse displacement of a node at the center of the rod is monitored along with the internal energy of the rod.

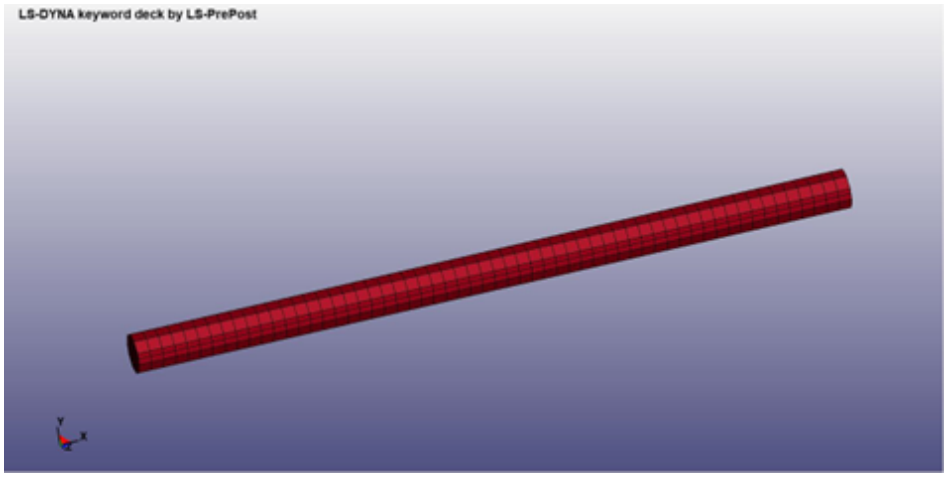

Figure 2: Rod Finite Element Model.

Model information	
Nodes	1593
Solid elements	1160
Materials	1
Parts	1
Units	mm (length), ms (time), kg (mass), kN (force,) GPa (stress)

Table 2: FEA Model Information

Model information	
Test Case ID	Input Deck Name
1	compression_bar_forward_seat_leg.key
2	buckling_bar_forward_seat_leg.key

Table 3: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Test Case Targets				
Target number	Output	component type	component id	retrieved from
1	X-component Displacement	Node	1301	binout/nodout file
2	Internal Energy	Part	1	binout/glstat file
3	CPU Time	-	-	d3hsp file

Table 4: Test Case Targets Subcase 1 - Compression

Test Case Targets				
Target number	Output	component type	component id	retrieved from
4	Z-component Displacement	Node	1448	binout/nodout file
5	Internal Energy	Part	1	binout/glstat file
6	CPU Time	-	-	d3hsp file

Table 5: Test Case Targets Subcase 2 - Buckling

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Validation of the Test Case ID AWG-CI-7.

The sub 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® R14.0 Revision 114 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R14.0 Revision 114) 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 (R14.0 Revision 114) 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.

For CPU Time target, it holds:

$$bound_{up}^{CPU\,Time} = 2 \times Max + 1$$
$$bound_{low}^{CPU\,Time} = 0$$

where Max is the maximum CPU Time (in seconds) across all platforms and executable (R14.0 Revision 114) combinations the test case was calculated with and $bound_{up}^{CPU\,Time}$ and $bound_{low}^{CPU\,Time}$ are the upper and lower bounds.

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 6 and the results are calculated with software versions defined in table 7.

Platform Name	Operating system	CPU type	MPI-Protocol	Number of cpu's [1]
cdcvdce7mbu01	CentOS 7.9	Intel® Xeon® Gold 6238R @ 2.20GHz	Platform MPI 08.3.0.2	4

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

Table 6: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type [1]	Precision [2]	executable
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	SP	ls971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	DP	ld971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	SP	mpp971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	DP	mpd971.4-gaf1eb871e8.R14.1.1

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

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

Table 7: Tested LS-DYNA® version

5.2 Results Summary

Table 8 contains the results of the Test Case ID AWG-CI-7 completed with all combinations of software and hardware defined in section 5.1 (1 * 2 * 4 total calculation runs).
Details on the test results can be found in the section 5.3.

The table 8 cross cpu architecture consistency 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.

Sub Test Case ID	PASS/FAILED
1	**PASS**
2	**PASS**

Table 8: Results summary for Test Case ID AWG-CI-7

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-CI-7 for LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8.

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 type, branch and the revision of the executable.

5.3.1 Subcase 1, Test Target 1: X-component Displacement

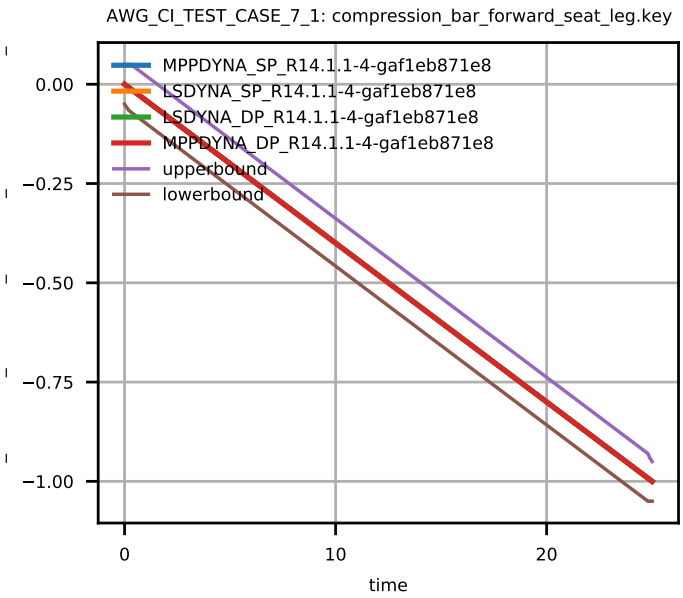

Figure 3: X-component Displacement of Node 1301.

5.3.2 Subcase 1, Test Target 2: Internal Energy

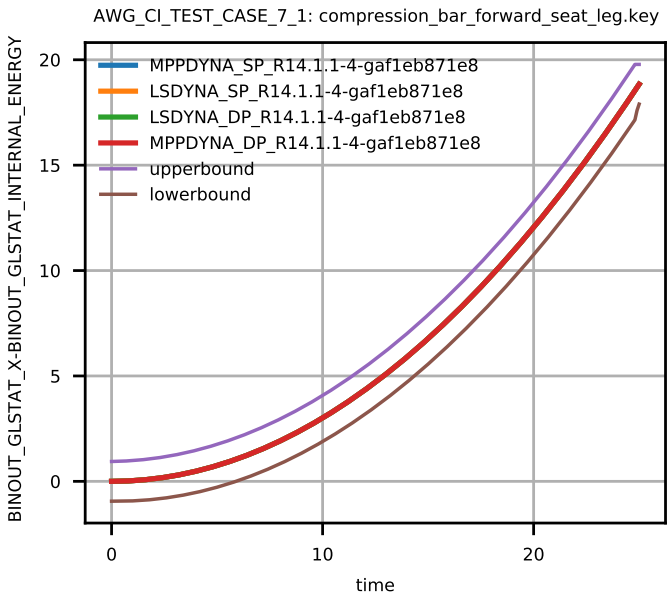

Figure 4: Internal Energy of Part 1.

5.3.3 Subcase 1, Test Target 3: CPU time

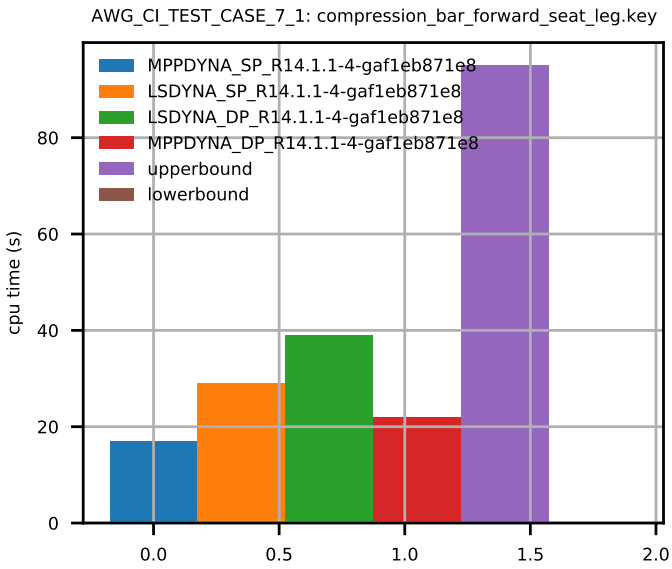

Figure 5: CPU Time Comparison.

5.3.4 Subcase 2, Test Target 1: Z-component Displacement

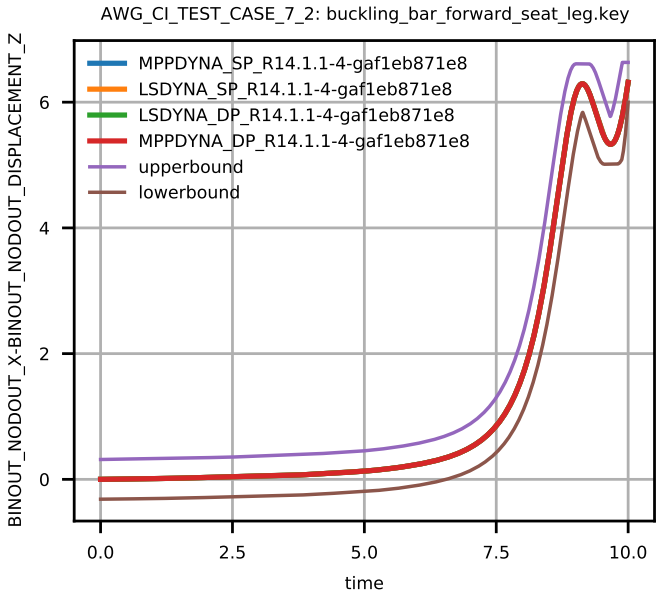

Figure 6: Z-component Displacement of Node 1448.

5.3.5 Subcase 2, Test Target 2: Internal Energy

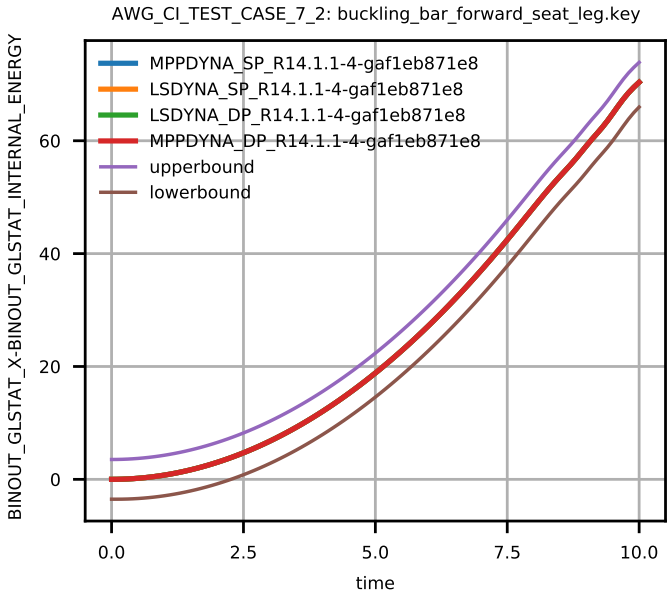

Figure 7: Internal Energy of Part 1.

5.3.6 Subcase 2, Test Target 3: CPU time

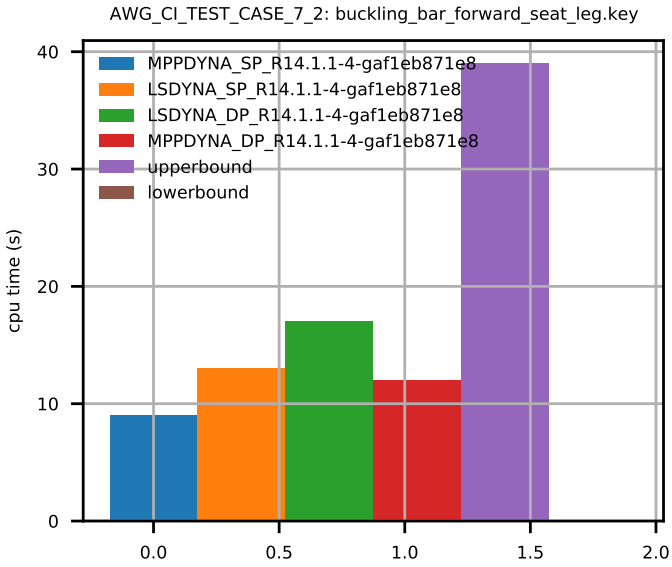

Figure 8: CPU Time Comparison.

References