SALINAS–Verification Notes

Garth Reese[*] Dan Segalman[†] Manoj K. Bhardwaj[‡]
Kenneth Alvin[§] Brian Driessen Kendall Pierson[¶]
Timothy Walsh[‖]

Sandia National Laboratories
Albuquerque, NM 87185-0847

June 10, 2003

Revision: 1.5

Date: 2003/06/05 17:56:00

[*]Phone: 845-8640
[†]Phone: 844-0972
[‡]Phone: 844-3041
[§]Phone: 844-9329
[¶]Phone: 284-5894
[‖]Phone: 284-5374

Contents

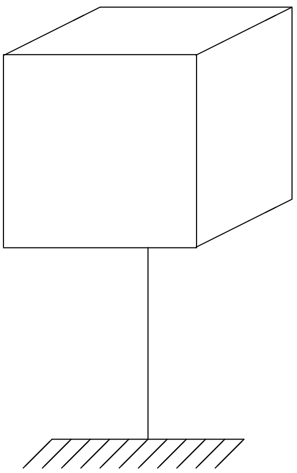

Figure 1: Box on a Bar test object

Salinas - Verification Notes

1 RBE3 - comparison with Nastran

A very simple model was constructed for evaluation of an RBE3 link. The structure consisted of a cube placed on the end of a beam. The beam terminates in the center of the cube, and is connected to the eight corners of the cube with an RBE3 as illustrated in Figure 1. The model is named "BoxOnBarRbe3.inp".

There are slight differences in the beam models used by Nastran and by Salinas. A summary of the modes is included in the table. As can be seen in the table, the agreement is quite good. All the modes of the structure are preserved by the RBE3.

#	Nastran Frequency	Salinas Frequency	Description
1	2354.8	2354.4	1st bending
2	2354.8	2354.4	1st bending
3	6833	6832.7	pogo stick, axial mode
4	9942	9939.4	2nd bending
5	9942	9939.4	2nd bending
6	13697	13335	torsion
7	22367	22365	hex deformations
	$> 20,000$	$> 20,000$	hex deformations

2 Verification of hexshells

In this section we list the results of several verification examples for hexshell elements. These verification examples were taken from Carlos Felippa, the developer of the element, (see reference 1). The goal here was to reproduce the results obtained in that report.

2.1 Example 1

This example corresponds to section 9.5 in the report 1, and consists of a circular ring subjected to equal and opposite forces acting along the vertical direction. The exact solution for this problem is given in both reference 2 and reference 3 as

$$\frac{\pi^2 - 8}{4\pi} \frac{PR^3}{EI} \tag{1}$$

We note that this solution is the total change in diameter for the ring.

For modeling purposes, we only model a quarter of the ring, and we apply appropriate boundary conditions on the symmetry planes. We note three details for comparing the results to the exact solution. First, the exact solution as given is for the total change in diameter for the ring. Since we are only modeling a quarter ring, this result must be divided by 2. Second, since the ring is cut at the top surface and we are applying a point load on the symmetry plane, the applied load P will produce twice the deflection in a quarter ring as in the full ring. This is explained in more detail in reference 3. However, since there is a need to both divide by two and multiply by two, these factors effectively cancel one another out, and thus equation 1 is the solution for comparison in the case of a quarter ring.

The results obtain by Salinas are compared with those of Carlos in Table 1.

Table 1: Normalized Deflections for the Pinched Composite Ring

N_e	$\frac{R}{h} = 20$ Carlos	$\frac{R}{h} = 20$ Salinas	$\frac{R}{h} = 100$ Carlos	$\frac{R}{h} = 100$ Salinas
4	.5746	.5771	.0062	.062
6			.4322	.4376
8	.9582	.9631	.7813	.7971
16	.9896	.9947	.9659	.9886
32	.9955	1.00072	.9753	.9981

For this example, Carlos also reported results for a two-ply case. Since we do not have an analytical solution to compare with, and since the reported results are normalized by the exact solution, we have no reference point and thus we did not run the two-ply case. We did, however, run a two-ply example where the modulus and poissons ratio were the same in both plies. The results were the same as running a single ply with those same material properties, and so this provided some verification of the multiply implementation.

2.2 Example II

This was the pinched cylindrical shell example (section 9.6). Only one eighth of the shell was considered. The computed results were divided by four to account for the fact that the load was only applied to a quarter section. The results are shown in Table 2.

Table 2: Normalized Deflections for the Pinched Cylindrical Shell

mesh	Carlos	Salinas
4x4	.0762	.1
8x8	.2809	.45
16x16	.5366	.81
32x32	.8029	.87
128x128		.897

2.3 Example III

The Scordelis-Lo Roof example. We note that, although in this example only a quarter of the roof is modeled, there is no need for dividing the answer by any multiple(as in previous examples) since the applied load is a gravity load rather than a point load. We note that the boundary conditions at the rigid diaphrams were incorrectly reported in Carlos's writeup. The correct ones are $u_x = u_z = 0$. With these conditions, the results as shown in Table 3 agree well with the expected values.

2.4 Example IV

This is the twisted beam model. The normalized results, compared with those of Carlos, are given in Table 4.

Table 3: Normalized Deflections for Scordelis-Lo Roof example

mesh	Carlos	Salinas
2x2	1.2928	1.29
4x4	1.0069	1.011
8x8	.9844	.984
16x16	.9772	.979

Table 4: Normalized Deflections pretwisted beam example

mesh	Carlos, in plane	Carlos, out of plane	Salinas in plane	Salinas out of plane
1x6	1.0257	.9778	1.014	.929
2x12	1.0041	.9930	.985	.975

References

[1] Felippa, C. A., "The SS8 Solid-Shell Element: Formulation and a Mathematica Implementation," Tech. Rep. CU-CAS-02-03, Univ. Colo. at Boulder, 2002.

[2] Young, W. C., *Roark's Formulas for Stress & Strain*, McGraw-Hill Book Company, 6th edn., 1989.

[3] Timoshenko, S., *Strength of Materials*, D. Van Nostrand Company, Inc., third edn., 1955.