Modeling an Adhesive Bondline Using WaveFEA

1. Introduction

Noran Engineering, Inc. was approached by The Membership & Strategic Initiatives of The Adhesive and Sealant Council, Inc. regarding creating an adhesive element that would be standard for all commercial FEA packages. The approach was to use a combination of rigid elements and 3-DOF springs to model the adhesive properties. An alternative was introduced by Noran Engineering, Inc., which is to use a single CBUSH element that would replace the rigid/DOF spring combination. In addition to this method, a third alternative was proposed which is to model the adhesive using 3D brick elements since WaveFEA can handle high aspect ratio brick elements without a loss in accuracy.

2. Verification

A lap shear test model was created as shown in Figure 1 below. This was modeled using laminate plate elements for the substrates with an element size of 0.1x0.1. Figure 2 shows the finite element mesh.

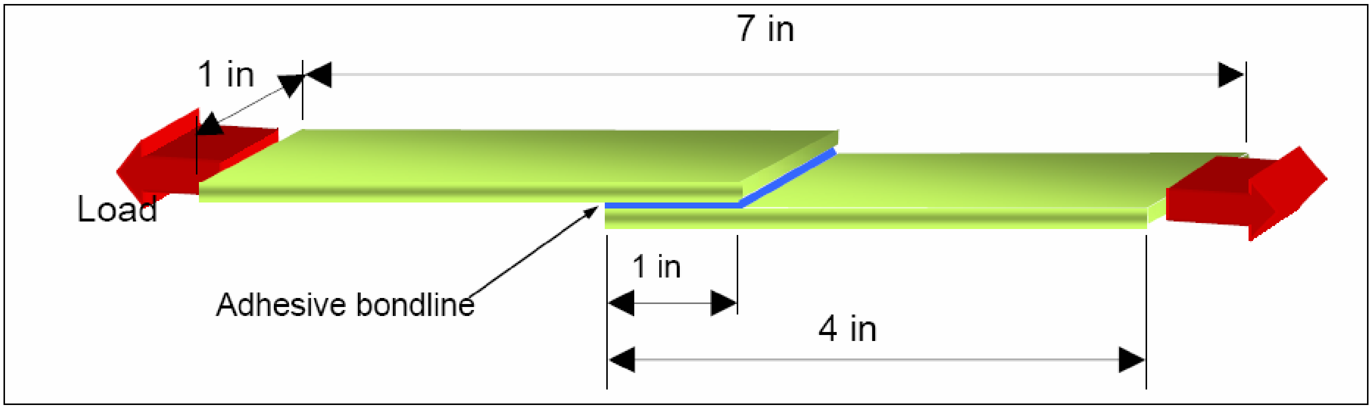

Figure 1. Test Case Setup

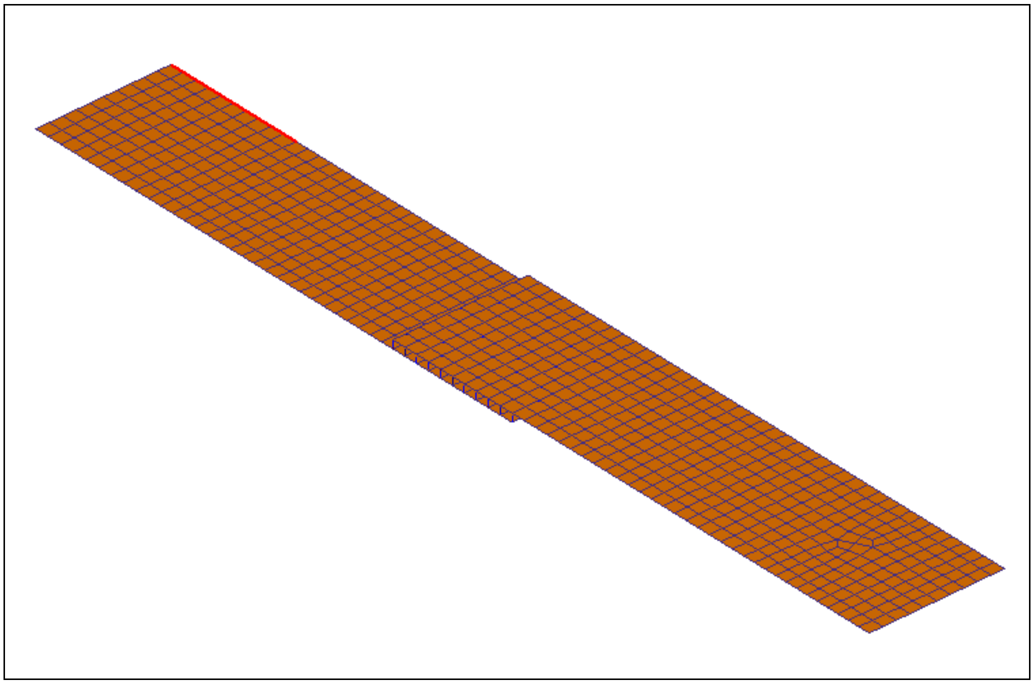

Figure 2. Finite Element Model

The detailed material properties and laminate lay-up can be found in the reference document Finite Element Tutorial: “Analysis of an Adhesively Bonded Joint” on our website www.nenastran.com.

Three different bond line thicknesses were analyzed using both the CBUSH and solid brick methods: t=0.01in, t=0.06in, and t=1.0in. A load was applied that is 10% of the ultimate load which was approximated as 167 lbs. Physical test results were available for the 0.06in bondline thickness and are shown in Table 1. Figures 1-6 show the T1 translation for the various model configurations.

Bond Thickness (in.)	Adhesive Element Type	WaveFEA max T1 Translations (in.)	Physical Testing Max T1 Translation (in.)
0.01	CBUSH	0.00367	N/A
0.01	TETRA	0.00367	N/A
0.06	CBUSH	0.00454	0.0045*
0.06	TETRA	0.00451	0.0045*
1.00	CBUSH	0.14200	N/A
1.00	TETRA	0.13300	N/A

* The physical testing results were estimated from the cross head displacement vs. shear stress graph.

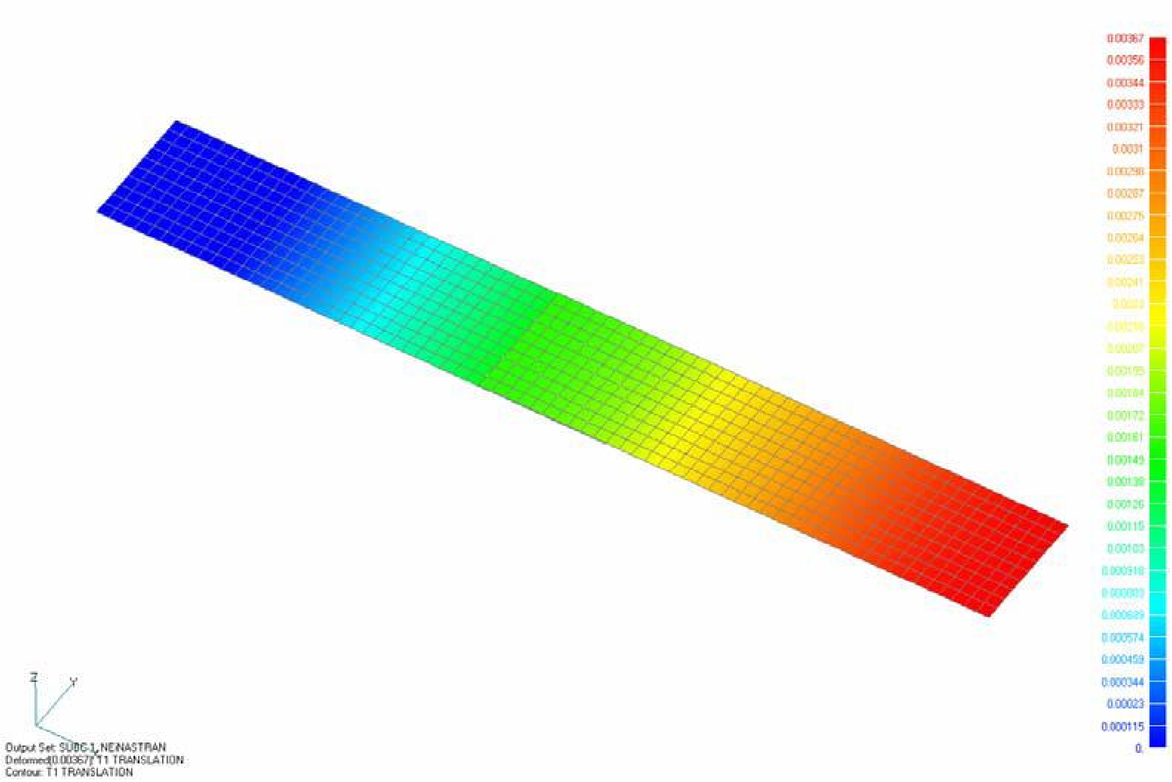

Figure 3. The t = 0.01in Bondline Modeled Using CBUSH Elements. Max T1 = 0.00367in.

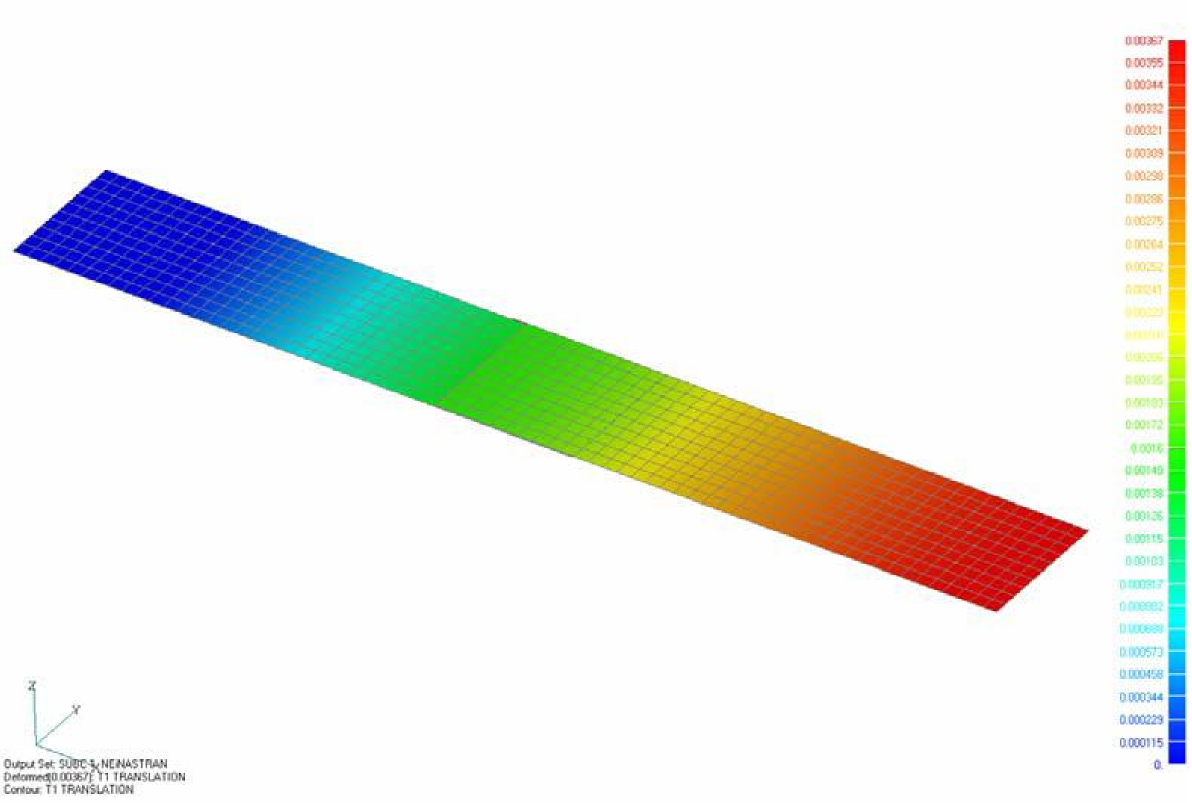

Figure 4. The t = 0.01in Bondline Modeled Using Solid Tetra Elements. Max T1 = 0.00367in.

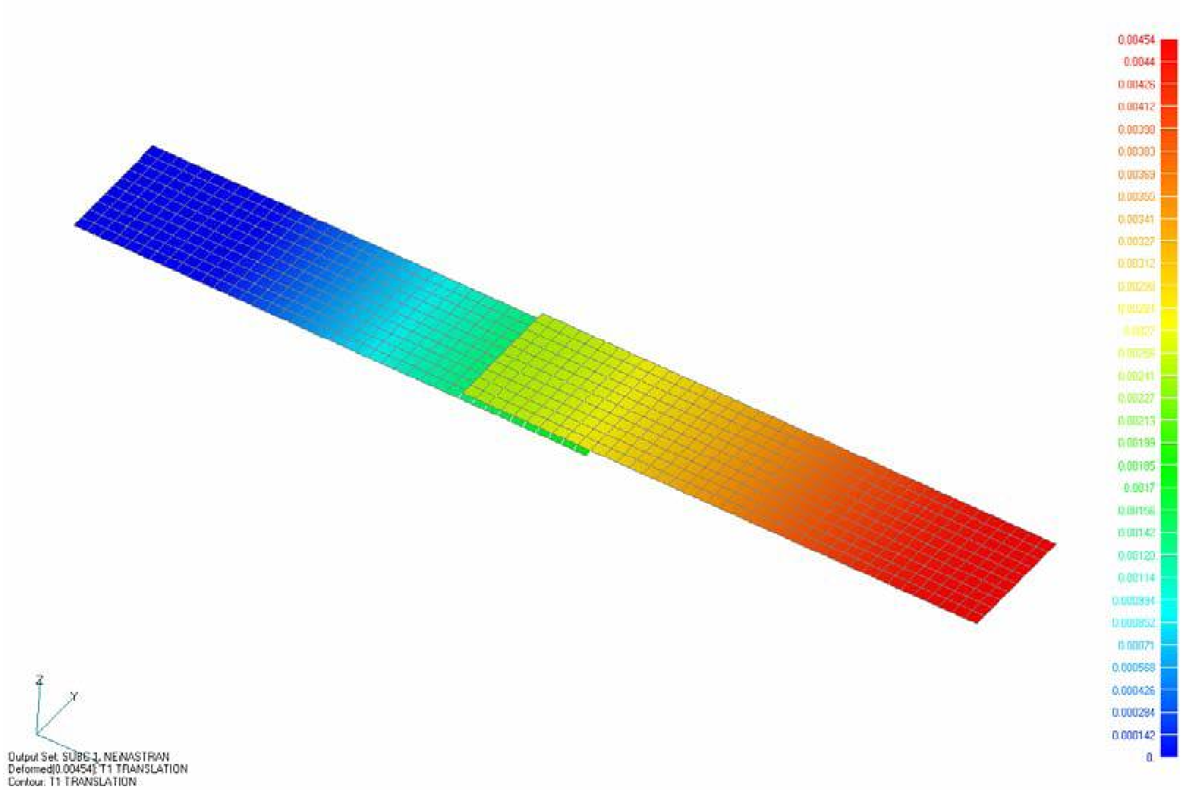

Figure 5. The t = 0.06in Bondline Modeled Using CBUSH Elements. Max T1 = 0.00454in.

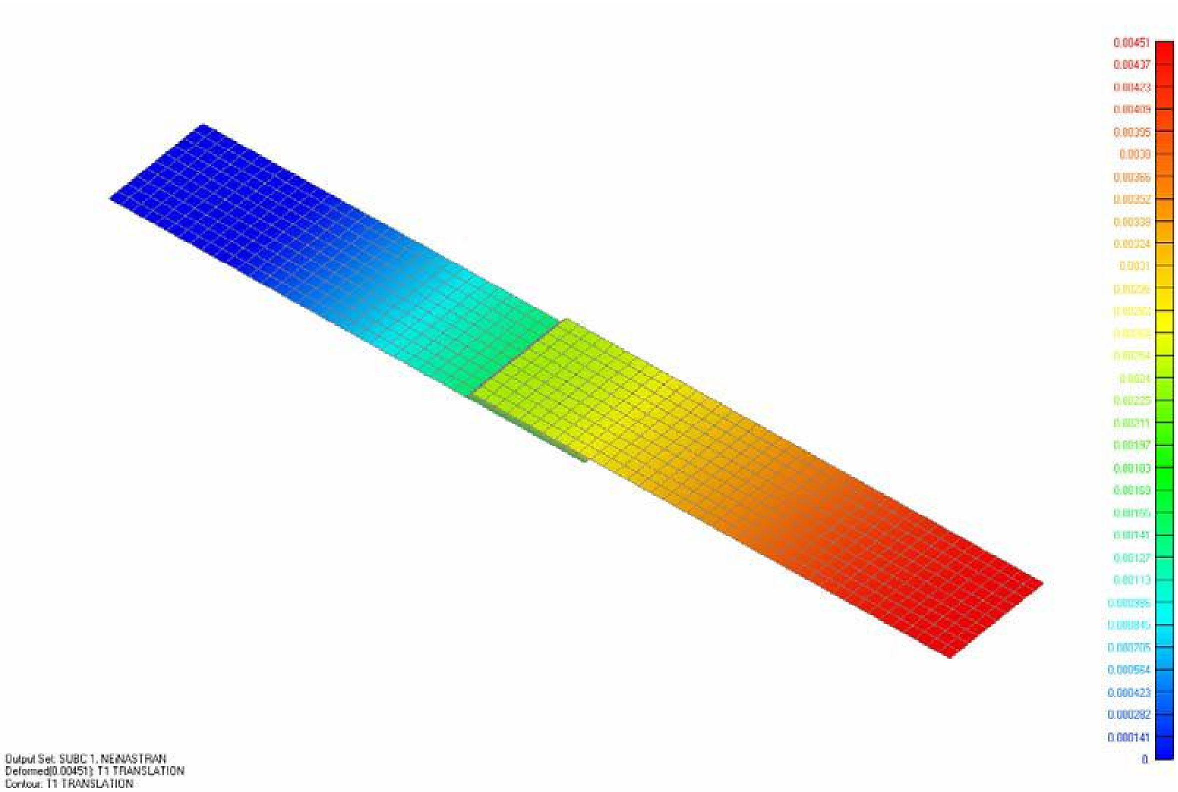

Figure 6. The t = 0.06in Bondline Modeled Using Solid Tetra Elements. Max T1 = 0.00451in.

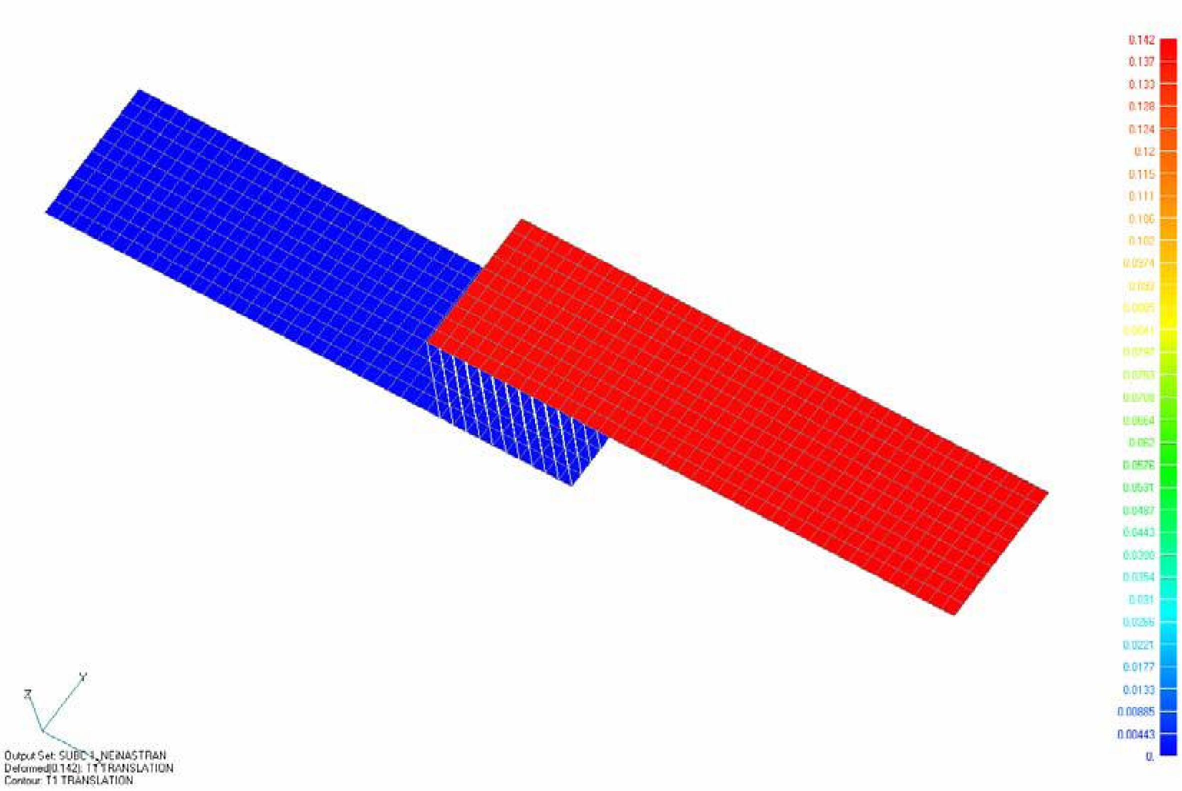

Figure 7. The t = 1.0in Bondline Modeled Using CBUSH Elements. Max T1 = 0.142in.

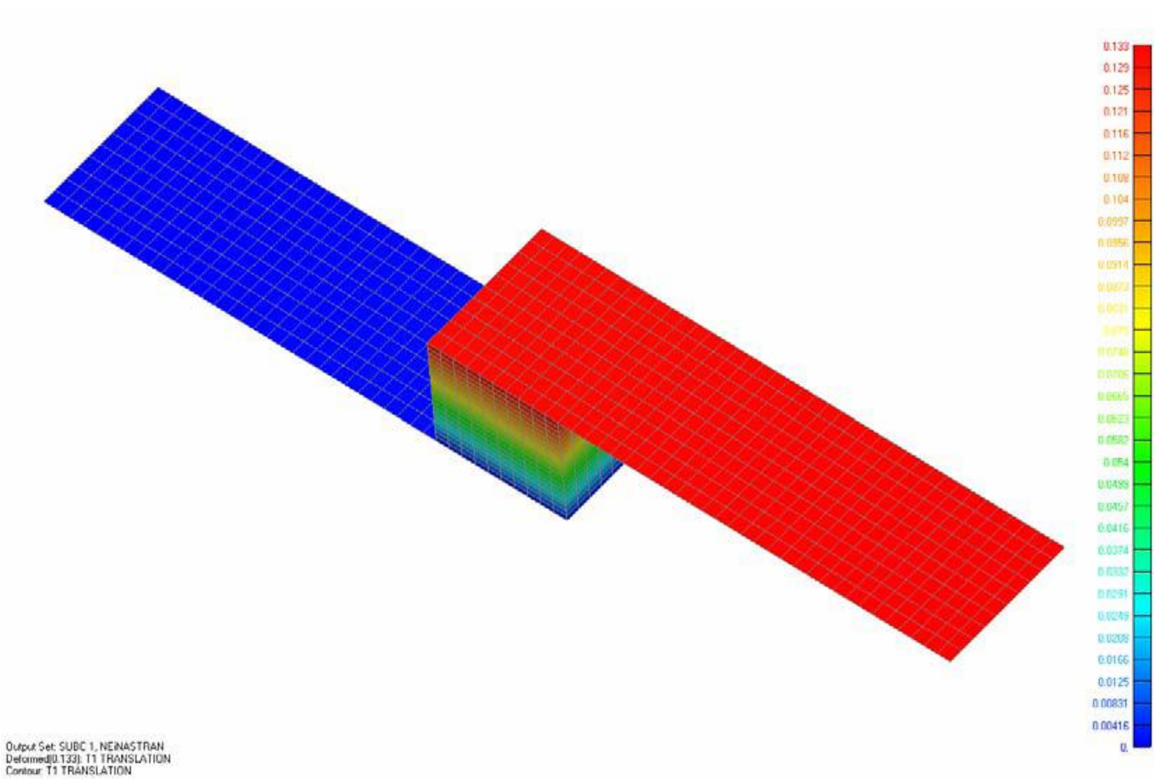

Figure 8. The t = 1.0in Bondline Modeled Using Solid Tetra Elements. Max T1 = 0.133in.

3. Conclusion

The results show that both the CBUSH and solid tetra adhesive element types give very close results, and both agree with physical test results.