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Framed Single Skin Laminate Transoms

by

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ABSTRACT

Outboard motors traditionally mount to the transom of a boat using "C" type clamps. These motors require a transom to be approximately 2 inches thick to accommodate the mount. This type of transom is still the most common style today. Modern outboard motors are bolted to the transom, thus the requirement for a thick transom is no longer appropriate. This study compares a traditional fiberglass over plywood transom to a framed single skin transom design. Both designs were analyzed using the finite element method to determine deflections and ply-by-ply stresses for identical load cases. The framed single skin transom has significantly lower deflections and stresses than the GRP plywood transom. It also weighs less, has a lower material cost, and requires less labor to build.

INTRODUCTION

Early outboard motors were relatively small with low power output. They were developed for use on small rowboats, which were open boats with flat wooden transoms. Early motor mounts were little more than "C" clamps that fit over the top of the transom and were tightened by hand. While there are still small outboard motors available today with this style of mount (mostly for dinghies and small sailboats), the vast majority of outboard motors, including all the moderate to high power models, bolt onto the transom.

The influence of the early wooden boat transoms is still seen today in most outboard motor powered GRP boats. The transoms are typically GRP skins over plywood or high- density foam, with a total thickness of about two inches. These transoms are manufactured by laminating the outer skin into the mold, then bonding the plywood or high-density foam into place, followed by laminating the inner skin. A number of ingenious clamping methods have been developed to hold the plywood or foam in place while the bonding materials cure. There have been many problems with transom plywood rotting in the past. While treated plywood will reduce or eliminate these problems, many builders have elected to build with high-density foam and market this as a better product. Treated plywood is more expensive than regular plywood, but high- density foam is even more expensive. The change to through bolted motor mounts eliminates the traditional transom thickness requirement, thus opening the door to alternative designs.

The development and popularity of high power four stroke motors has increased the structural requirements of transoms. Thickness limitations for plywood or foam core transoms (due to increased cost and weight) make framing the transom necessary to obtain the stiffness and strength required to accommodate these motors. It also leads to questioning the need for plywood or foam core if frames are also required. This study compares a traditional GRP plywood transom structure to a framed single skin laminate transom structure.

PROCEDURE

A generic boat transom was designed for both GRP plywood and framed single skin laminate. The geometry is identical, except for the thickness of the laminate and the additional framing required for the single skin transom. The materials were identical for both structures, and are presented in Table 1. The laminates for each transom are presented in Table 2.

Both designs were analyzed using finite element methods to obtain deflections and ply-by-ply stresses for identical loading scenarios. The finite element program, COSMOS/M, is a commercial adaptation of NASTRAN (NASA Structural Analysis), which has been widely used and accepted for several decades. The geometry was rendered into finite elements (Figure 1), material properties and laminates were specified, boundary constraints were specified (Figure 2), and loads were imposed (Figure 3). Two load scenarios were investigated for each design, one corresponding to a single outboard motor powered boat, and a second corresponding to a twin outboard motor powered boat.

RESULTS

The longitudinal (x direction) deflection of the transom was plotted for each of the four models, and presented in Figures 7 thru 10.

The von Mises stress (a method of combining all stress components into a single stress magnitude) was plotted for the first four layers of each of the four models, and is presented in Figures 11-26.

Figure 6. Boundary Conditions and Applied Forces for Twin Engine Framed Transom.

CONCLUSION

The framed single skin transom is stiffer and stronger than the GRP plywood transom. The number and type of layers of glass in the laminate is the same for both transoms. There is extra laminate in the frames on the framed transom, while there is plywood in the GRP plywood transom. The frame laminate is cheaper than the GRP plywood, requires less labor to install, and will weigh less. Thus the framed single skin transom is lighter, stiffer, stronger and cheaper than the GRP plywood transom.

Table 1. Materials

Gel Coat: NPG Iso
Resin: DCPD Blend Polyester

CSM	E: 8.0×10^5 psi	Tens. Strength: 1.0×10^4 psi	Comp. Strength: 1.8×10^4
3610	E: 2.0×10^6 psi	Tens. Strength: 4.0×10^4 psi	Comp. Strength: 3.6×10^4
Plywd	E: 1.5×10^6 psi	Tens. Strength: 5.0×10^3 psi	Comp. Strength: 6.0×10^3

Table 2. Transom Laminates.

Framed Transom Laminate

Material Type	Thickness (in)	Weight (oz/sqft)
Gel Coat	0.025	2.5
1.5 oz csm	0.042	4.5
3610	0.086	11
Plywood	1.5	576
3610	0.086	11
3610	0.086	11
3610	0.086	11
Total	**1.911**	**627**

Framed Transom Laminate

Material Type	Thickness (in)	Weight (oz/sqft)
Gel Coat	0.025	2.5
1.5 oz csm	0.042	4.5
3610	0.086	11
3610	0.086	11
3610	0.086	11
3610	0.086	11
Total	**0.411**	**51**

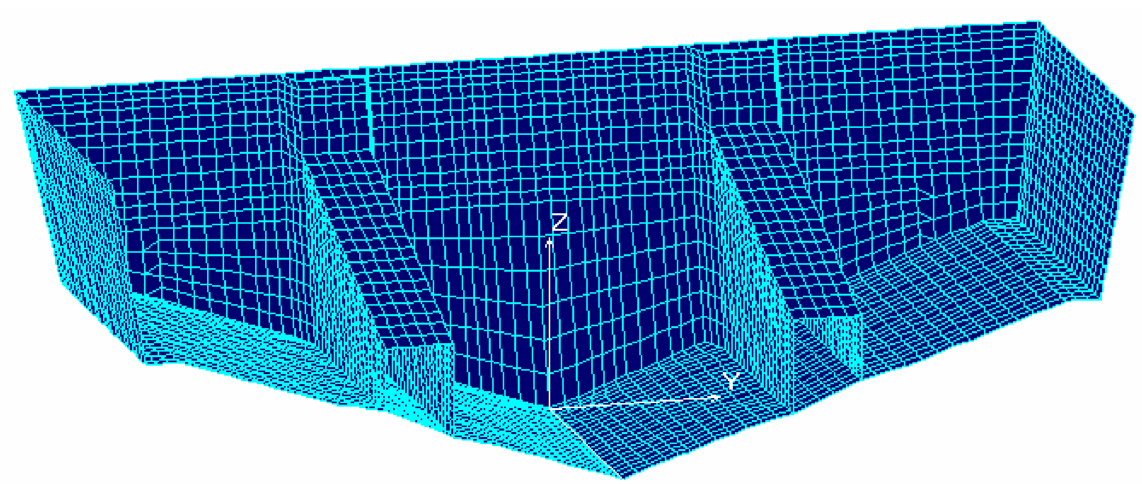

Figure 1. Finite Element Grid Representation of GRP Plywood Transom.

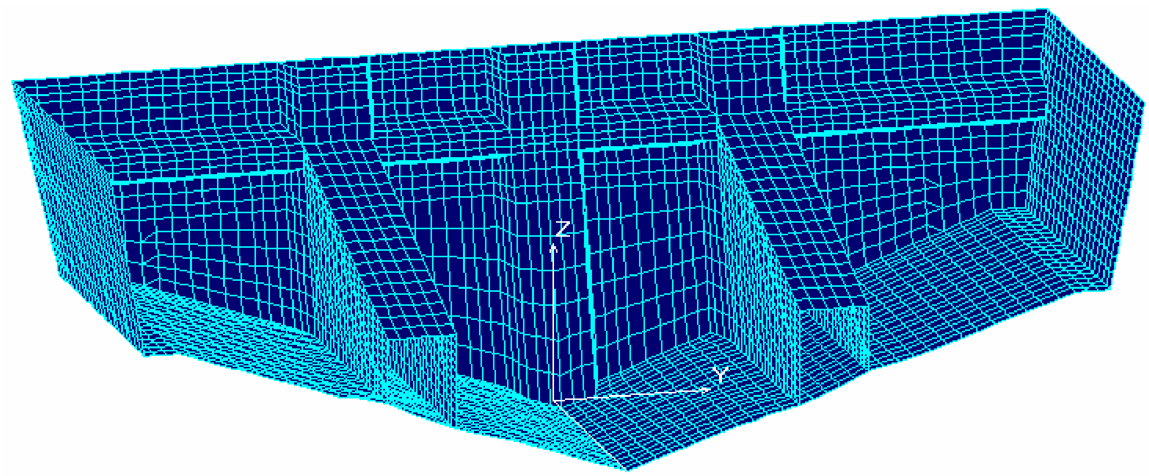

Figure 2. Finite Element Grid Representation of Framed Transom.

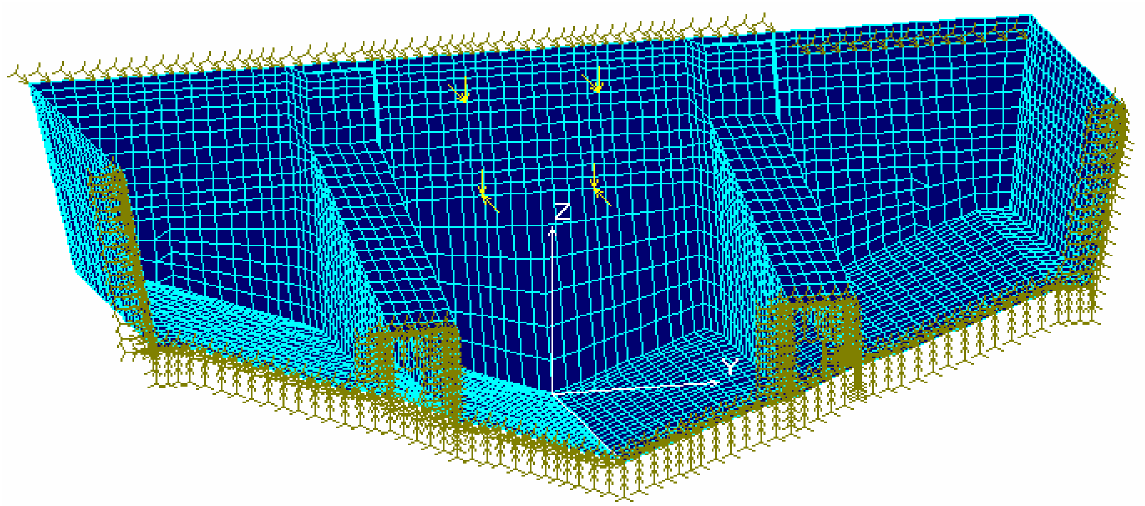

Figure 3. Boundary Conditions and Applied Forces for Single Engine Plywood Transom.

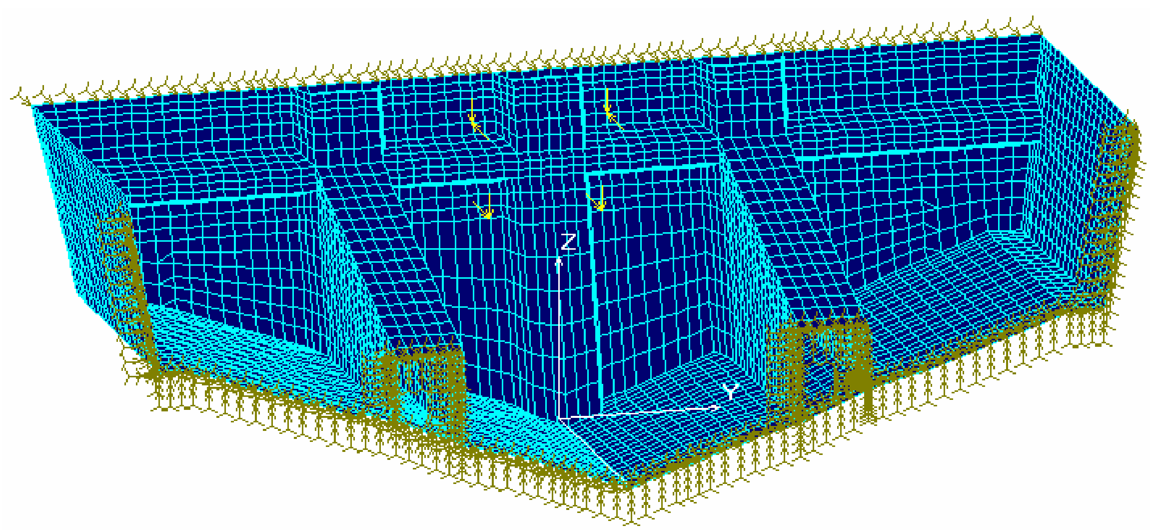

Figure 4. Boundary Conditions and Applied Forces for Single Engine Framed Transom.

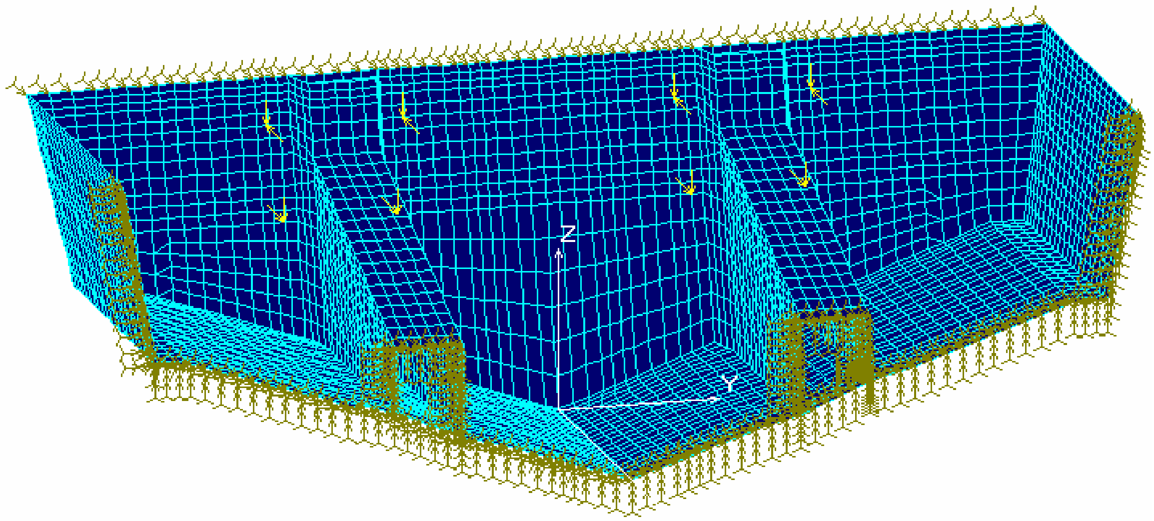

Figure 5. Boundary Conditions and Applied Forces for Twin Engine Plywood Transom.

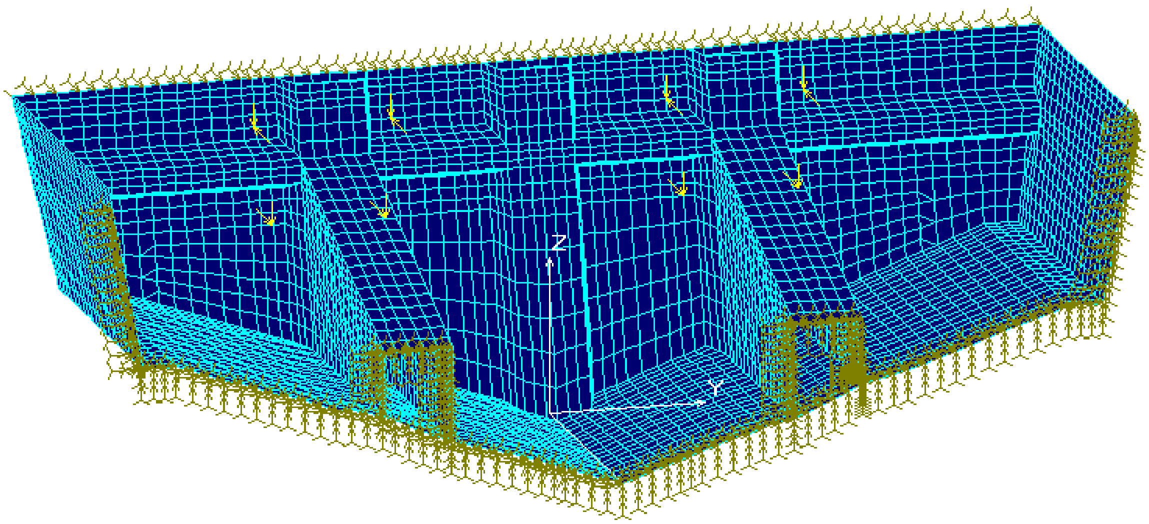

Figure 6. Boundary Conditions and Applied Forces for Twin Engine Framed Transom

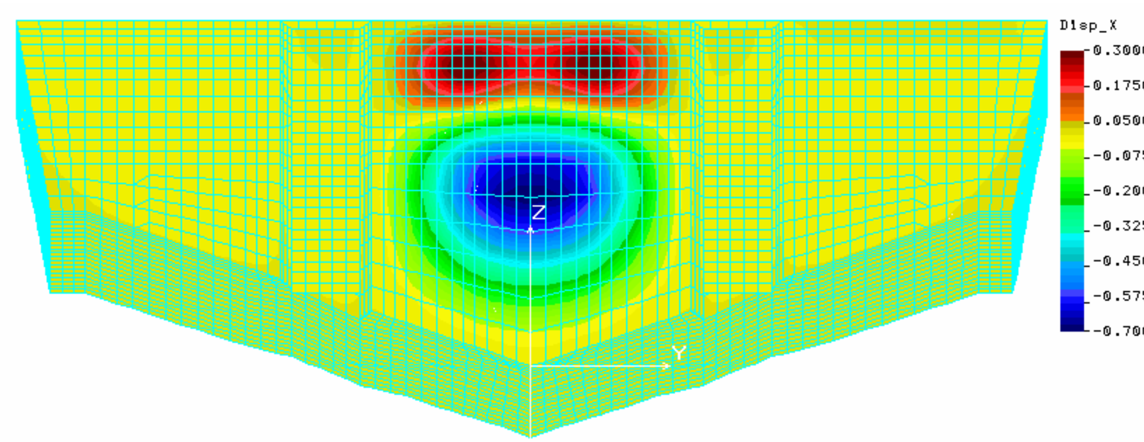

Figure 7. Deflection of GRP Plywood Transom with Single Engine Loading.

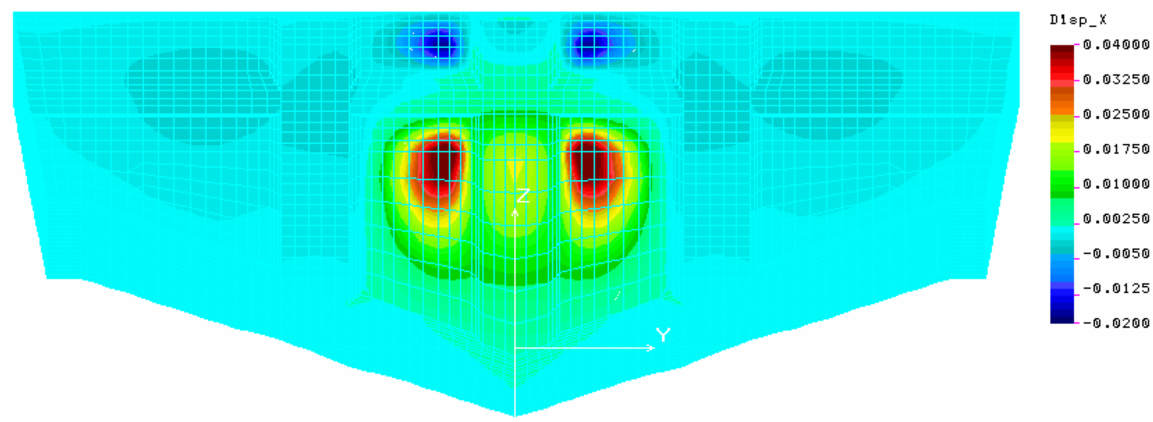

Figure 8. Deflection of Framed Transom with Single Engine Loading.

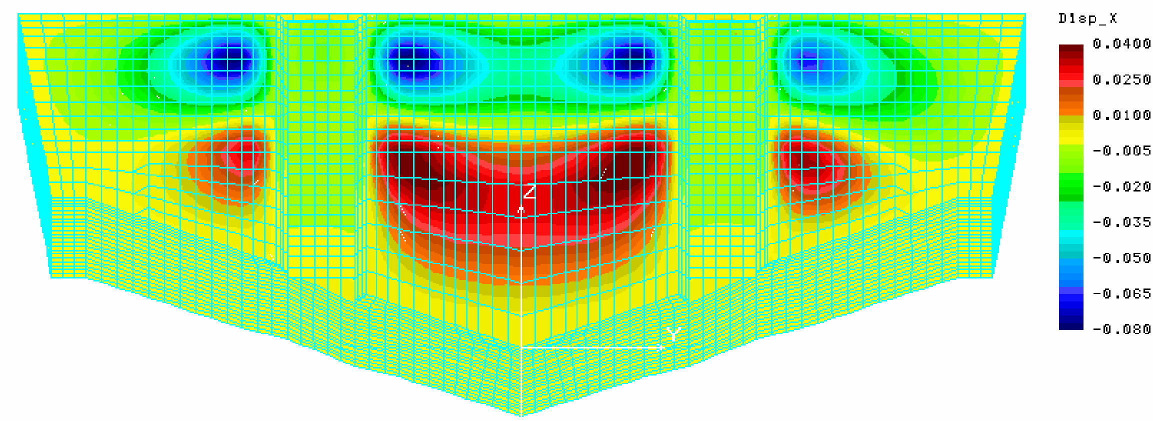

Figure 9. Deflection of GRP Plywood Transom with Twin Engine Loading.

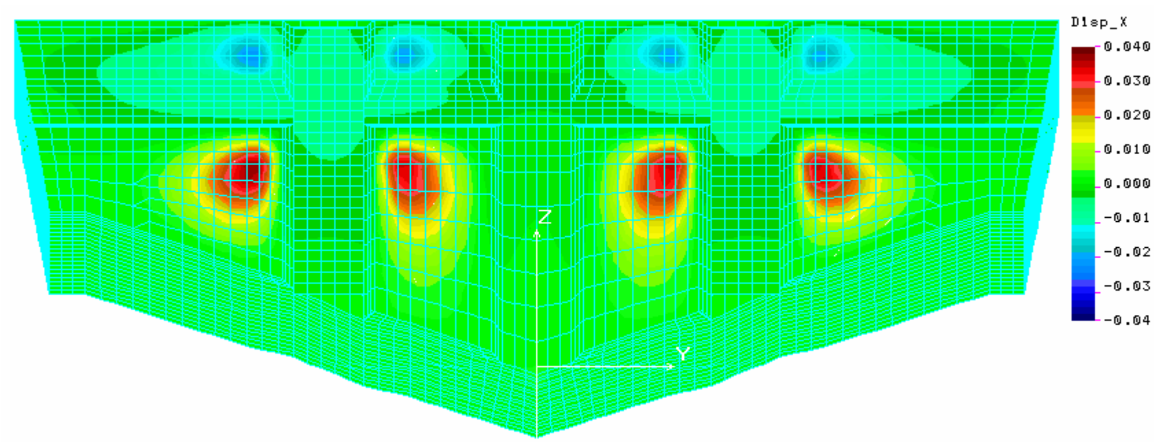

Figure 10. Deflection of Framed Transom with Twin Engine Loading.

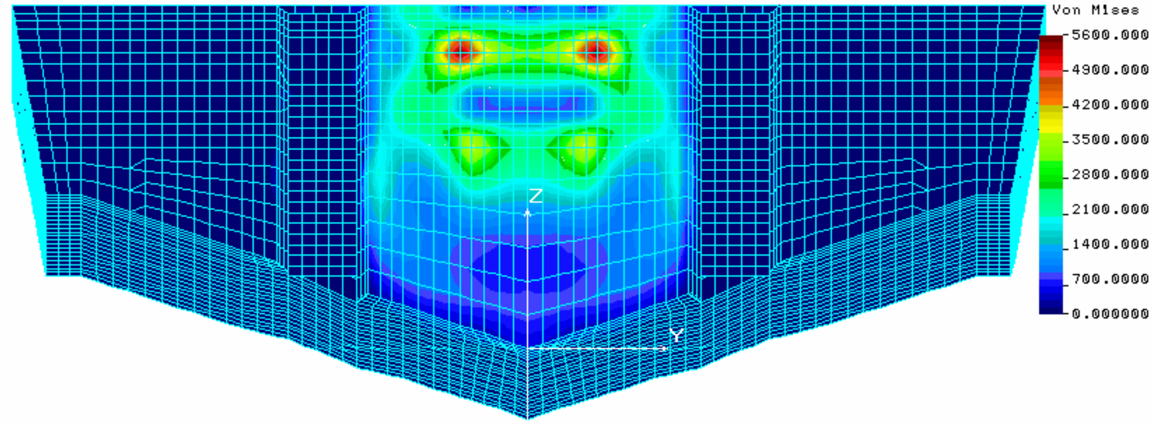

Figure 11. Stress in Mat Layer 1 for Single Engine GRP Plywood Transom.

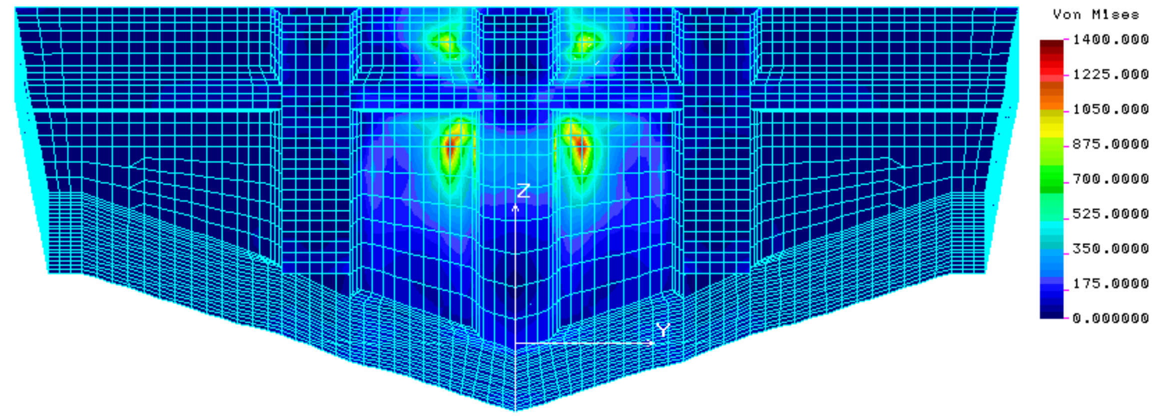

Figure 12. Stress in Mat Layer 1 for Single Engine Framed Transom.

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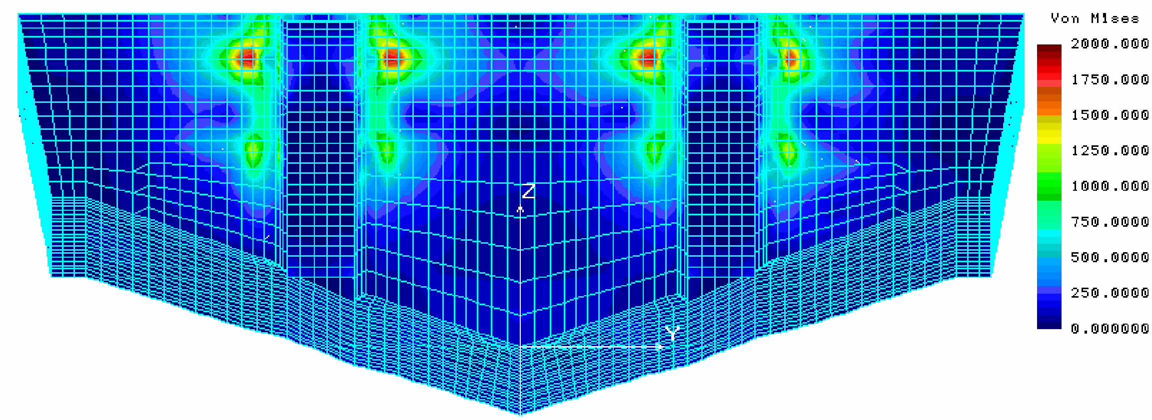

Figure 13. Stress in Mat Layer 1 for Twin Engine GRP Plywood Transom

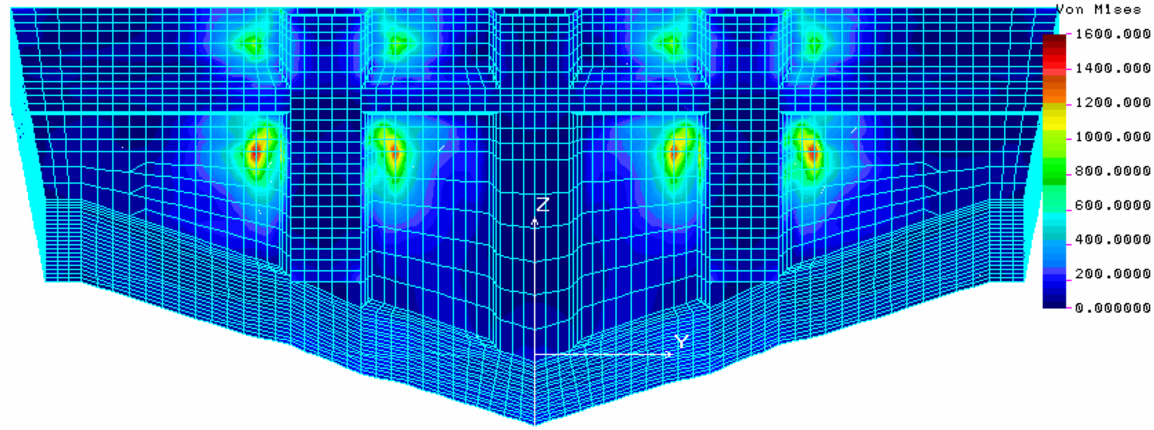

Figure 14. Stress in Mat Layer 1 for Twin Engine Framed Transom.

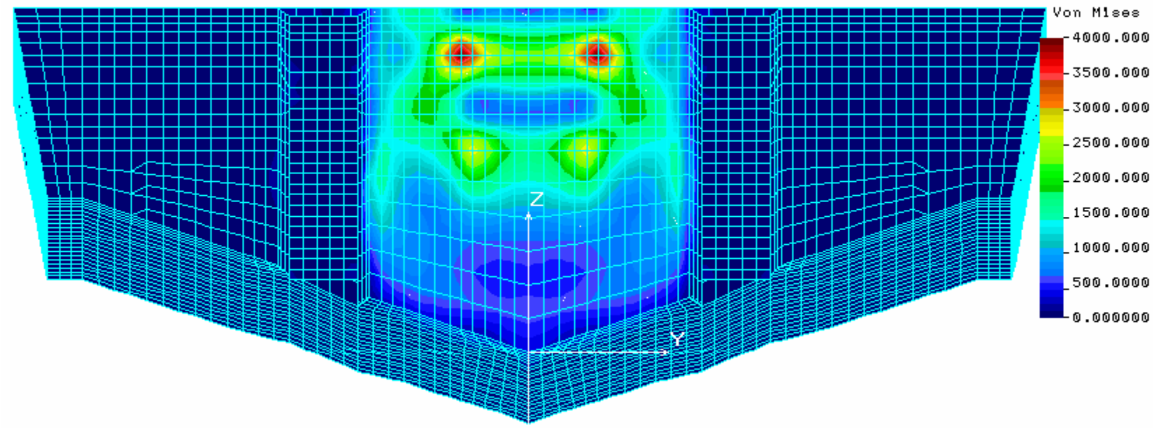

Figure 15. Stress in Mat Layer 2 for Single Engine GRP Plywood Transom.

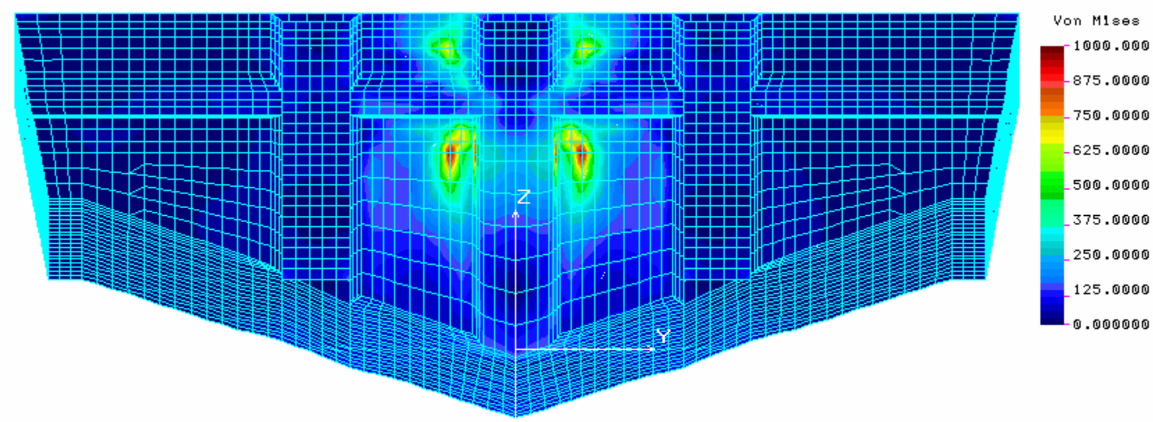

Figure 16. Stress in Mat Layer 2 for Single Engine Framed Transom.

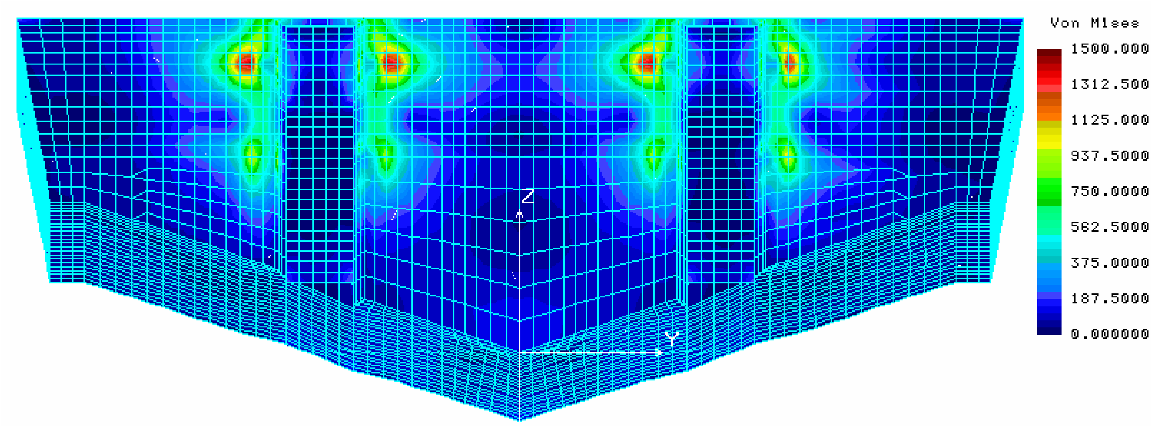

Figure 17. Stress in Mat Layer 2 for Twin Engine GRP Plywood Transom.

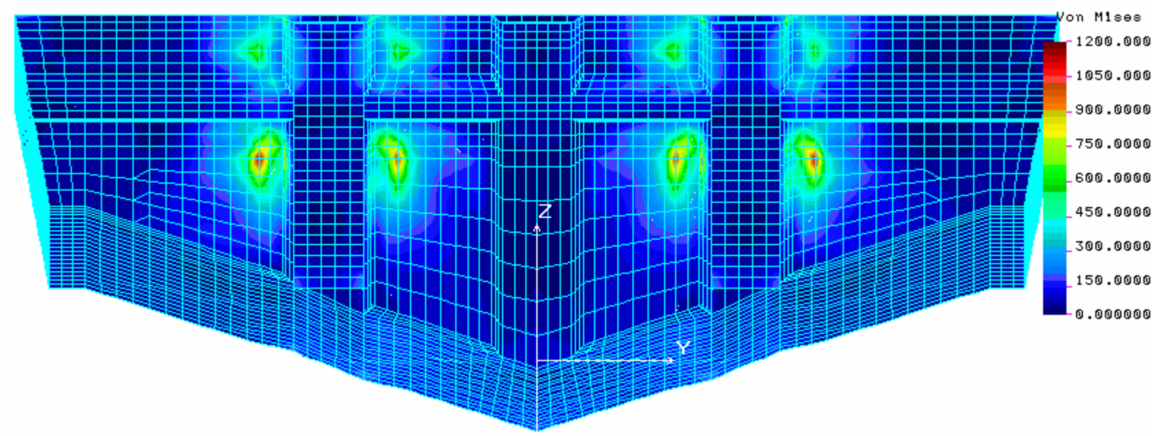

Figure 18. Stress in Mat Layer 2 for Twin Engine Framed Transom.

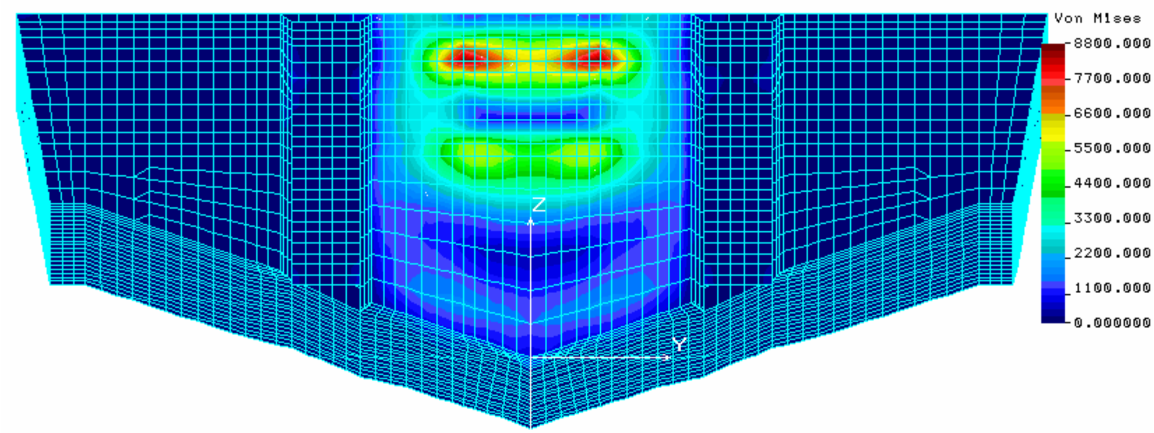

Figure 19. Stress in Transverse (90^o) Layer 3 for Single Engine GRP Plywood Transom.

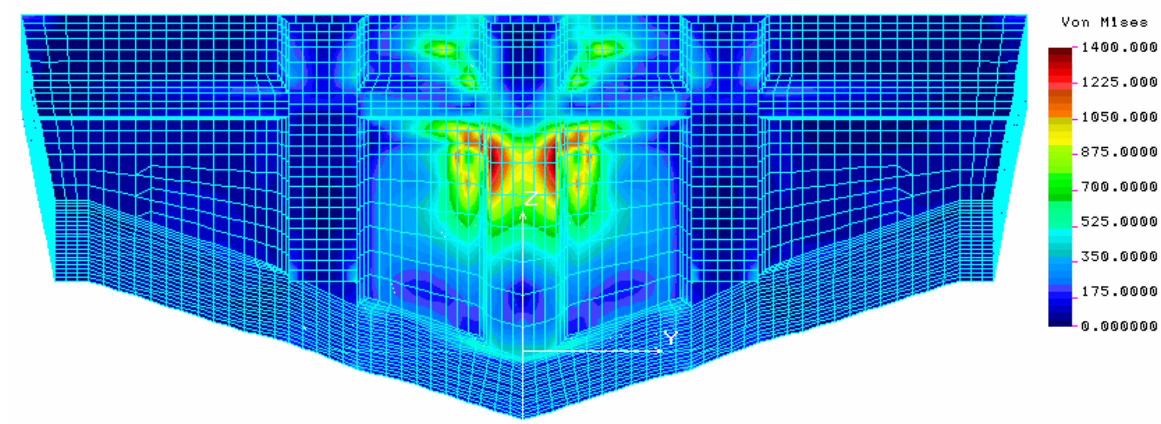

Figure 20. Stress in Transverse (90^o) Layer 3 for Single Engine Framed Transom

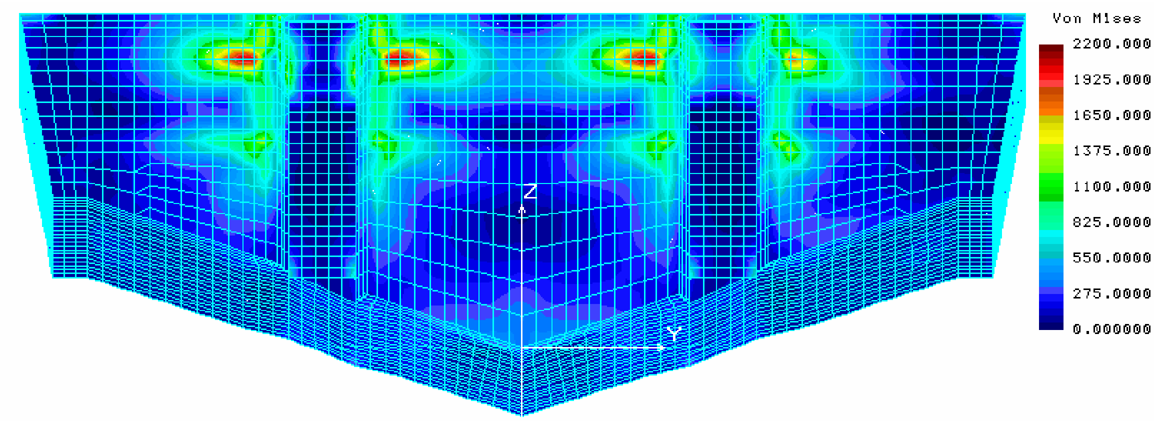

Figure 21. Stress in Transverse (90^o) Layer 3 for Twin Engine GRP Plywood Transom.

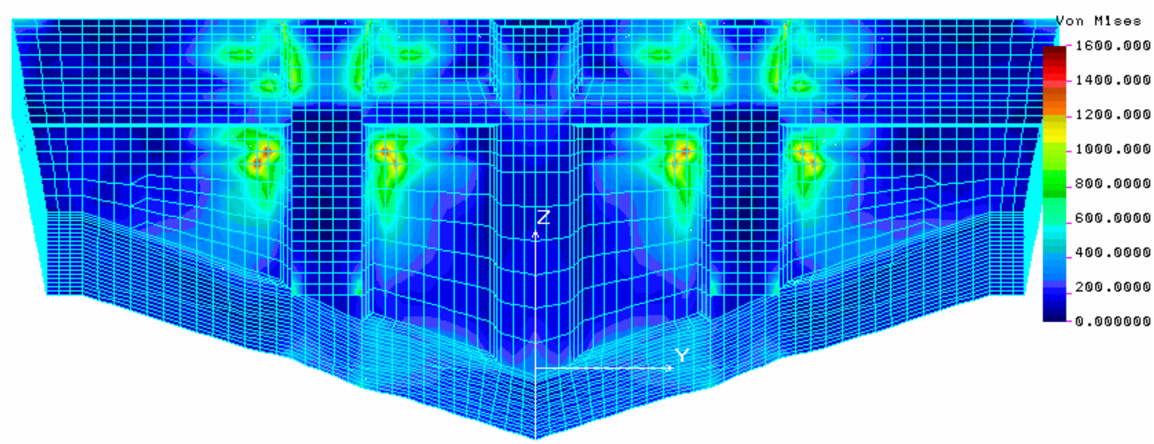

Figure 22. Stress in Transverse (90^o) Layer 3 for Twin Engine Framed Transom.

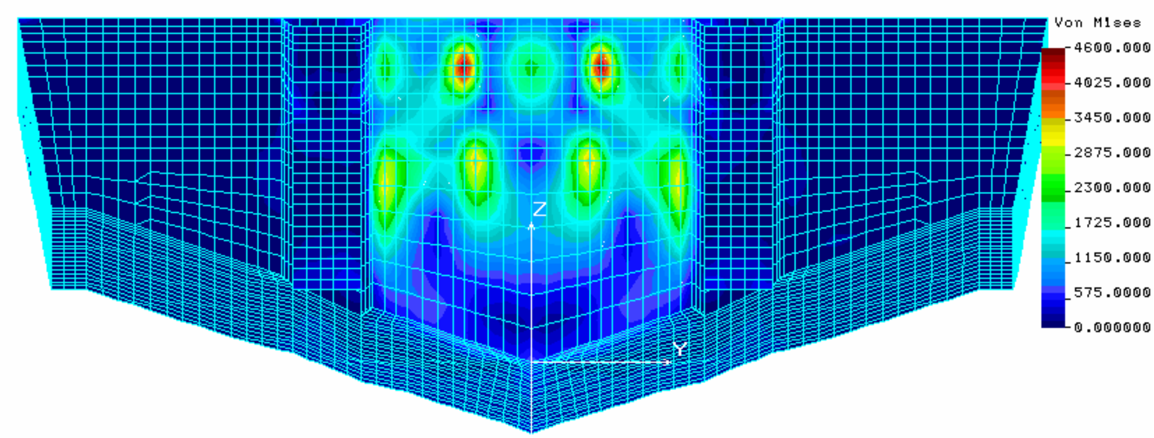

Figure 23. Stress in Vertical (0^o) Layer 4 for Single Engine GRP Plywood Transom.

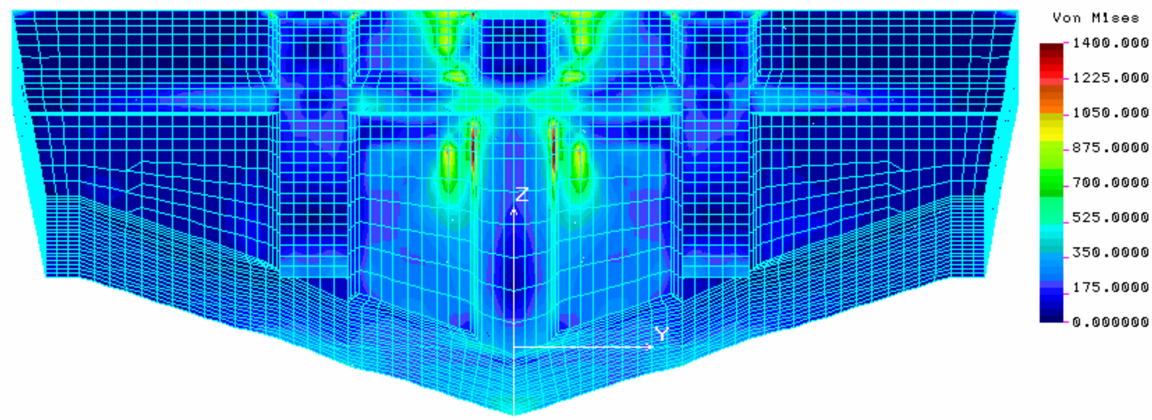

Figure 24. Stress in Vertical (0^o) Layer 4 for Single Engine Framed Transom.

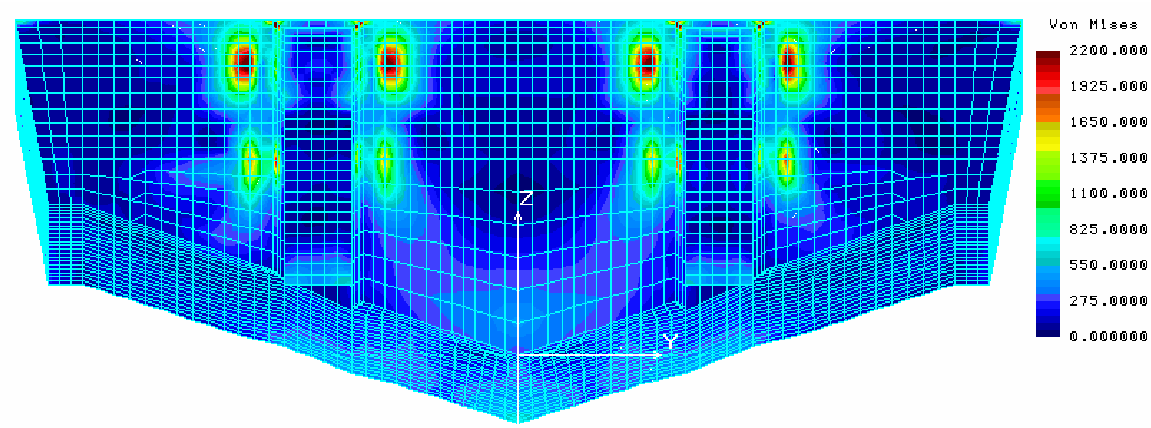

Figure 25. Stress in Vertical (0^o) Layer 4 for Twin Engine GRP Plywood Transom.

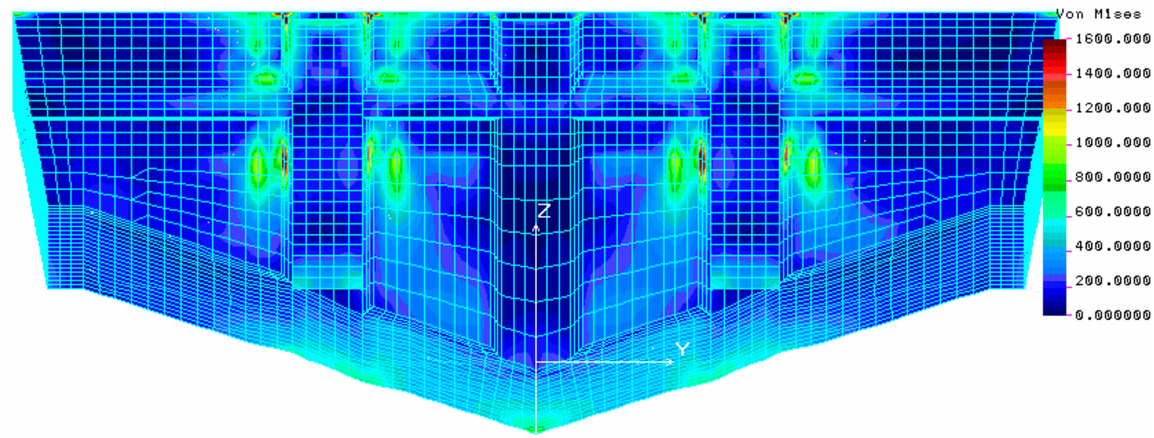

Figure 26. Stress in Vertical (0^o) Layer 4 for Twin Engine Framed Transom.