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Ship Structure Committee Case Study

This case study has been prepared by the Ship Structure Committee (SSC) as an educational tool to advance the study of ship structures. The SSC is a maritime industry and allied agency partnership that supports, the active pursuit of research and development to identify gaps in knowledge for marine structures. The Committee was formed in 1943 to study Liberty Ship structural failures and now is comprised of 8 Principal Member Agencies. The Committee has established itself as a world recognized leader in marine structures with hundreds of technical reports, a global membership of over 900 volunteer subject matter experts, and a dynamic website to disseminate past, current, and future work of the Committee. We encourage you to review other case studies, reports, and material on ship structures available to the public online at **www.shipistructure.org**.

*Double Hull Tank Barges:*Two Fleets, Two Approaches to OPA90 Phase-Out

Date:

Summary

As mandated by the Oil Pollution Act of 1990, all single hull tank vessels, including barges will be phased out by 2015. According to MARAD, as of the end of 2005, there are over 200 coastal tank barges operating in the US, accounting for 2.5M DWT of cargo. Approximately 100 of them are double hull, 1.6M DWT – 50% by number but 64% by volume. Because complete replacement of the fleet with new barges is clearly not feasible, many operators are opting to retrofit their single hull barges to double hull. This case describes two approaches to this retrofit – wrapping a second hull outside the existing, and plating in new cargo tanks within the existing hull.

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Design 1: Reinauer Transportation

Reinauer Transportation Company (RTC) is a tug and barge operator based in Staten Island, NY. They own and operate a fleet of 36 barges. Their barges range is size from 19,000 to 150,000 bbls. 12 of RTC's barges are double hull, including two that are wrapped. (Of the remaining single hull barges, nearly all are less than 5,000 gross tons and therefore not due for retirement until 2015.)

RTC's double hull refit barges were engineered by Guarino and Cox and built at Bollinger Shipyards. The approach is simple – a double hull, in the form of ballast J-tanks, is fit around the existing vessel. The existing hull becomes the new inner bottom and wing bulkhead. This maintains the existing cargo capacity, arrangement, and piping. The beam and depth of the barge are increased accordingly. The vessel's draft is less than the original because the additional steel weight is offset by the larger waterplane area.

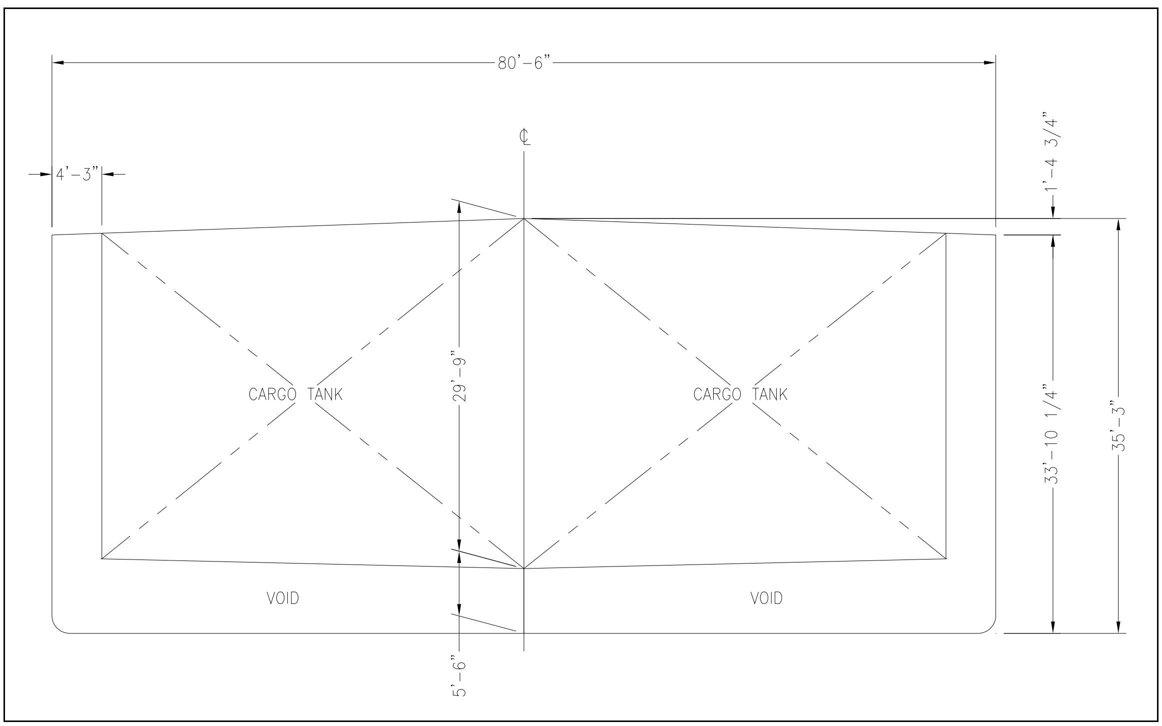

Figure 1. Midship Section – RTC-120 Double Hull

The following table summarizes the modification to the RTC-120.

Table 1. RTC-120 Modification

	Original Design	Double Hull
Length	405'-0"	405'-0"
Beam	72'-0"	80'-6"
Depth	28'-6"	33'-10 ¼" at side
Capacity	119,459 bbls	119,459 bbls
Draft 100%	25.04'	23.92'
Lightship	2,200 LT	3,470 LT

Scantlings were designed based on ABS rule requirements for a new oil barge for ocean service as shown in Figure 2. Ultrasonic thickness testing was done on the existing vessel to ensure that the original steel was still sufficient.

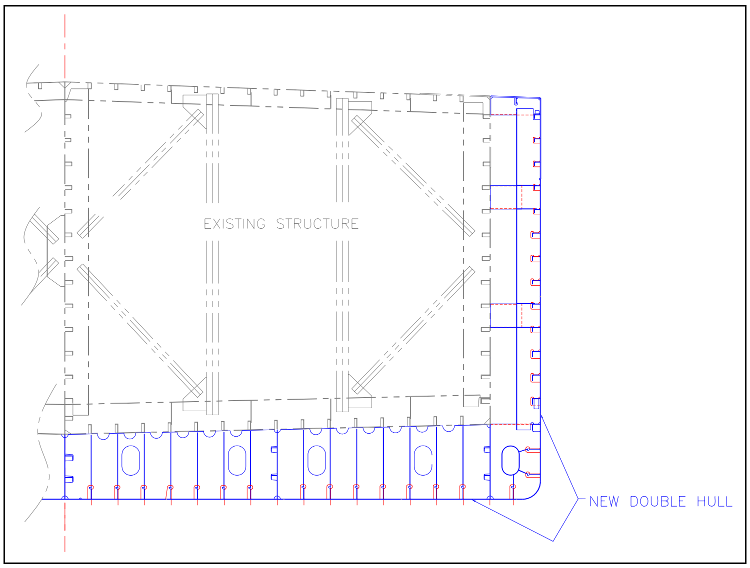

Figure 2. Double Hull Structure – RTC-120

As shown in Figure 3, rather than attempting to fair in the new cargo block dimensions to the existing bow and stern, the new side and bottom were carried over the length of the barge. Although no special analysis was done to predict the impact of the modified lines on hull performance, RTC reports no adverse effects. The only modification necessary was an adjustment to the notch to account for the lower draft.

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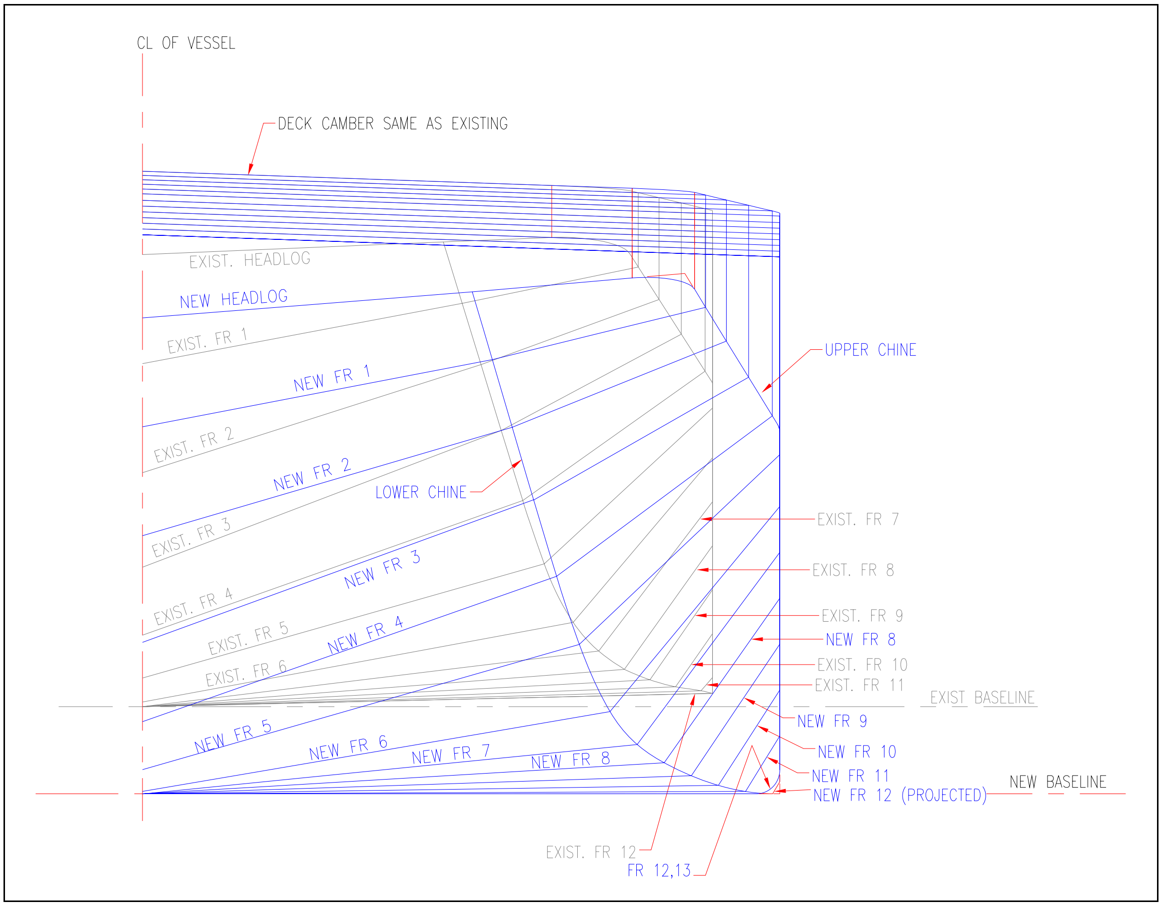

Figure 3. Revised Bow Lines – RTC-120

Design 2: Maritrans

At the time of its merger with Overseas Shipping Group (OSG) in 2006, Maritrans owned and operated 11 coastal ATBs, ranging in size from 175,000 to 420,000 bbls. These barges were built in the 1980s to be equivalent to a product tanker.

Because of the size of these vessels, Maritrans felt that increasing the beam and depth by wrapping the hull was not a viable option. Factors in choosing an internal design are as follows:

- Cargo is protected by new steel.
- Existing underwater hull form and thus existing speed/power relationship is maintained.
- Raised trunk design recaptures lost volume as well as permitting a design loadline to accommodate the weight of the extra structure.
- Barge can continue to be maintained in the same repair facilities where beam limitation is an issue.
- Tug/barge tie-up and connection arrangements are unchanged. This is especially important for the Intercon ATB's in Maritrans' fleet.

Together with Schuller and Allan, Maritrans developed their patented approach to double hulling a barge. This approach involves cutting the deck inboard of the side shell and the centerline bulkhead above the bottom shell and lifting this as one section to a height above the deck chosen to maintain cargo volume. Wing bulkheads and inner bottom are then fitted inside of the existing web frame structure.

Table 2. M-214 Modification

	Original Design	Double Hull
Length	536'-0"	536'-0"
Beam	84'-0"	84'-0"
Depth	35'-0"	35'-0" at side 48'-3" at trunk
Capacity	188,017 bbls	214,625 bbls
Draft 100%	28.37'	29.39'
Lightship	3,397 LT	5,443 LT

Figure 4 shows a typical midship section for one of the two classes of Maritrans' single hull barges. These barges are built much like tankers with longitudinal stiffeners and heavy transverse frames. (Three of Maritrans' single hull barges were originally built similar to the smaller RTC barges with columns and diagonal beams providing some transverse stiffening. However, the rebuild process was similar for these barges.) Figure 5 shows the modified section. Existing structure is depicted in pink, while new structure is depicted in green.

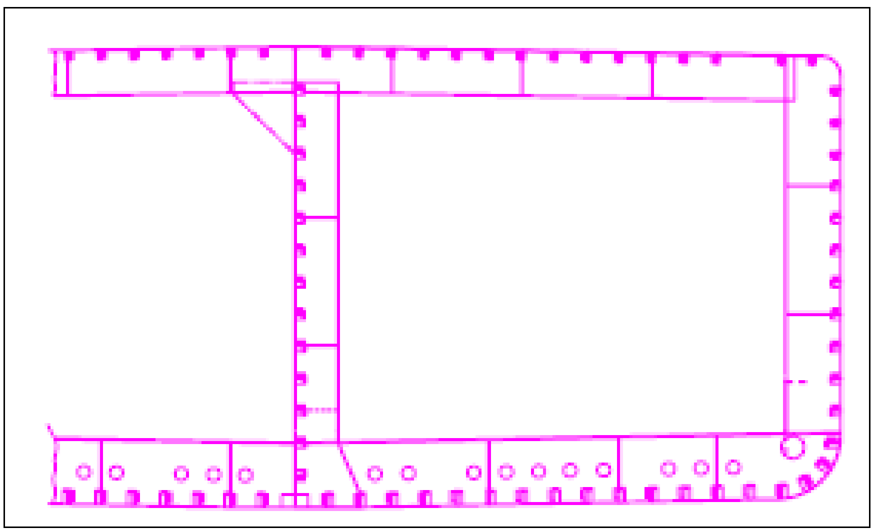

Figure 4. Pre-Mod Midship Section – M-214

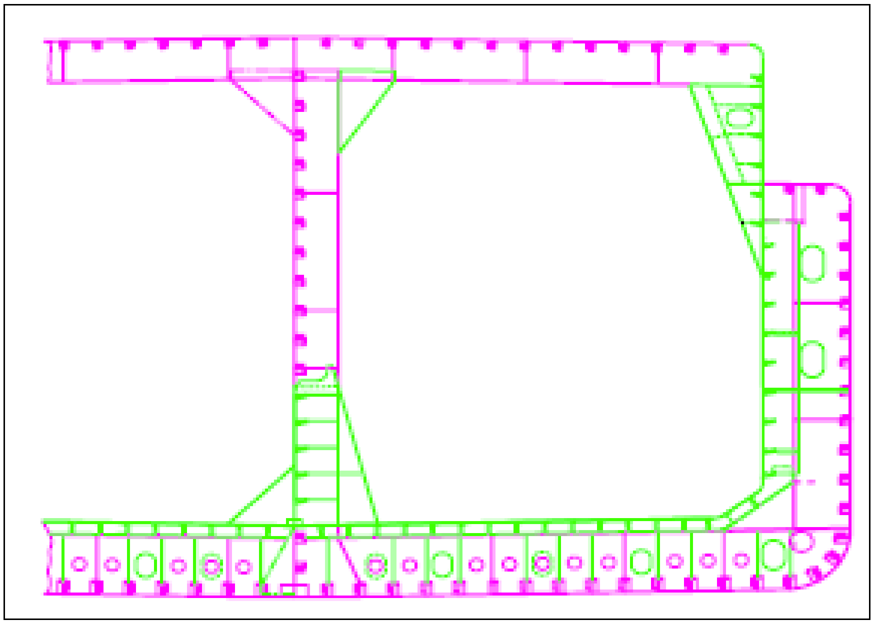

Figure 5. Post-Mod Midship Section – M-214

The height of the existing transverse frame is not as high as required by OPA-90 for the double bottom of the barge (B/15), so filler plates are added to get the proper depth. The filler plates are fabricated to be two inches deeper than the new inner bottom longitudinal, creating a gap that leads to a simplified and innovative fit-up. In the ballast tank there is a similar filler plate structure, except that the existing frame is a flanged plate and the new structure laps on it. (See Figure 6.)

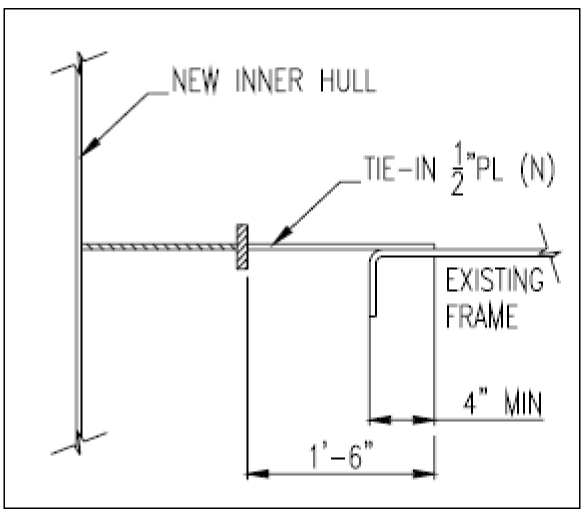

Figure 6. Inner Side Construction – M-214

Because of the novelty of their concept, Maritrans undertook a process of advanced analysis to confirm the feasibility of their design. This analysis included finite element analysis (FEA) to identify and mitigate areas of elevated stress.

The FEA evaluated four loading conditions, ballast and cargo loading for both stillwater and wave conditions. To accentuate the stillwater bending, the ballast condition was given a hogging wave and the loaded condition a sagging wave. In addition, weights are reduced in the wave ballast case and increased in the wave loaded case to account for dynamic effects.

Stillwater conditions are representative of vessel operation in harbor and mild seas for either the loaded ballast or cargo draft. These two conditions yield stress levels well within the elastic range, and the vessel has a safety factor greater than SF =2, based on yield. Wave conditions approximate the vessel loaded and underway in roughly 25-foot seas, which is expected to be an extreme condition. When the stress levels in these two load cases are compared to yield, the safety factor is approximately SF=1.4. It is worth noting that the stress levels related to longitudinal bending are significantly reduced due to the additional double hull structure and the resulting increase in vessel section modulus.

More detailed FEA concentrated on the most extreme of the loading conditions, i.e. full load cargo with a sagging wave amplitude equal to 1/40th the vessel's length (13.4 feet), or a wave height of (26.8 feet), with a multiplier of 125% to account for additional dynamic loading.

As displayed in Figure 7, the majority of the structure is below 20 ksi with only two "hotspots" above. The first "hot-spot" is located at the upper intersection of the bracket structure between the transverse bottom framing and the transverse side framing. The second "hot-spot" is located near the intersection of the upper trunk deck transverse framing and the vertical framing on the new longitudinal wing bulkhead. After further investigation and mesh refinement, it was decided that in the upper area, the levels of stress are reported inappropriately high due to model geometry.

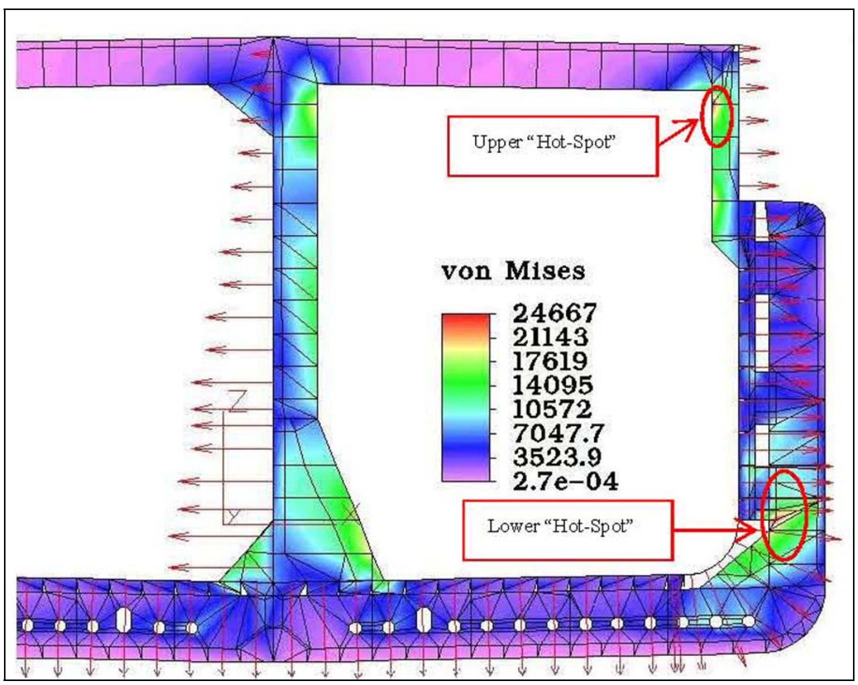

Figure 7. Areas for Elevated Stress

The lower "hot-spot" occurs at a sharp corner and from what is known about the way the vessel deflects, this location is a prime area for high shear and bending moment-related stresses. In addition, the original design for this corner bracket was a bent flange toe-ing to one side. FEA showed that this asymmetrical section was causing out of plane bending. In order to mitigate this, flat bars pictured in Figure 8 have been added to balance the flanges and create a symmetrical section.

Figure 8. Structural Reinforcement – Bilge Bracket

Figures 9 and 10 compare the FEA results of the as-designed bracket and the reinforced bracket.

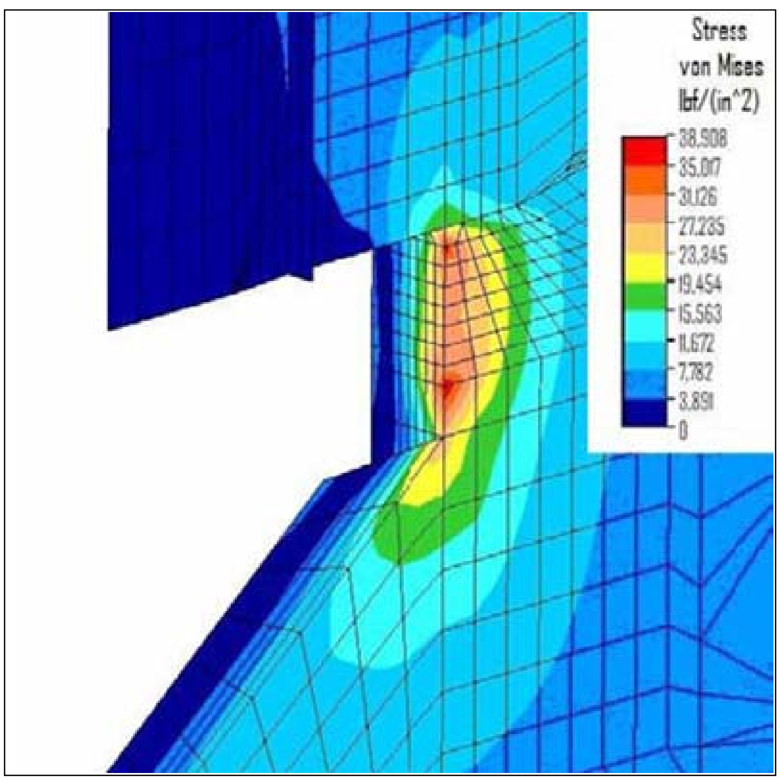

Figure 9. Detail of As-Designed Bracket

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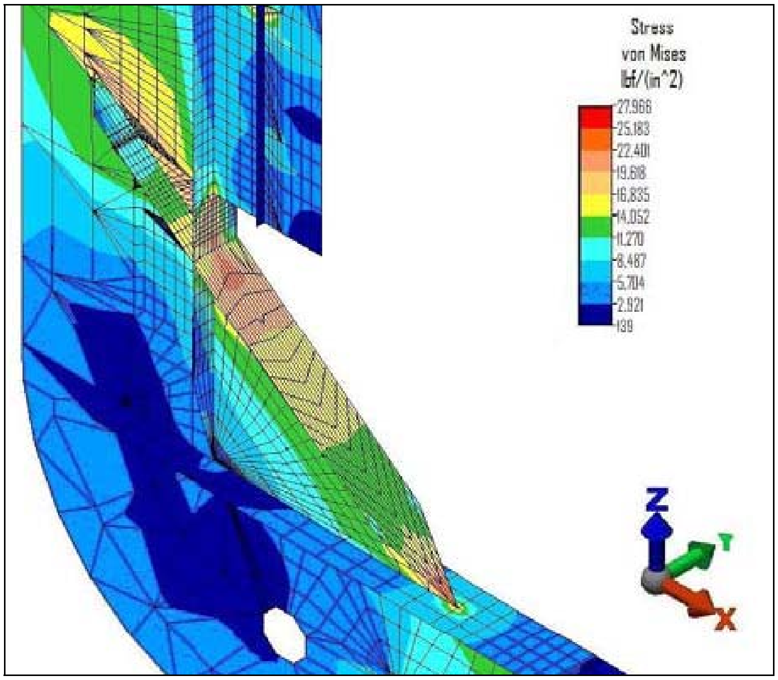

Figure 10. Stress Results of Reinforced Bracket

End Result

Both RTC and Maritrans have been satisfied with their approach to double hulling a single hulled barge. RTC has converted two vessels in this manner, and Maritrans, ten.

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Acknowledgements
The staff of Reinauer Transportation, Guarino & Cox, and Overseas Shipping Group, contributed substantially to this case study.

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