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TRANSMITTAL

TO: Jennifer Fitch, PE Project Manager Vermont Agency of Transportation	DATE	PROJECT NO.
	8/12/2014	Brookfield BRF FLBR (2)

XX WE ENCLOSE THE FOLLOWING: ______ UNDER SEPARATE COVER WE ARE SENDING THE FOLLOWING

COPIES	NUMBER	DESCRIPTION	CODE
1		FRP Fabrication NCR 7 - Pontoon 3 Dry Spots	H

CODE:

A FOR INITIAL APPROVAL
B FOR FINAL APPROVAL
C APPROVED AS NOTED-RESUBMISSION REQUIRED
D APPROVED AS NOTED-RESUBMISSION NOT REQUIRED
E DISAPPROVED-RESUBMIT
F QUOTATION REQUESTED
G APPROVED
H FOR APPROVAL
I AS REQUESTED OR REQUIRED
J FOR USE IN ERECTION
K LETTER FOLLOWS
L FOR FIELD CHECK
M FOR YOUR USE

BY: Paul J. Miller

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August 12, 2014

Mr. Paul Holloway
Miller Construction, Inc
PO Box 86
Windsor, VT 05089

Brookfield BRF FLBR (2)

Dear Mr. Holloway:

Nonconformance

After de-molding the hull for Pontoon 3, Kenway discovered 4 areas of dry fabric on the exterior (mold side). These regions are shown in Figures 1 – 4.

Root Cause

The dry fabric was caused by a slow leak in the rod bulkhead alignment sleeves through the hull mold. Kenway attempted to identify the source of a leak or leaks that was causing erratic drop test results over the course of an entire week. After exhausting every tool and trick, and more than 110 manhours, the decision was made on Friday, August 8 to infuse the hull and react to any observations during infusion.

Resolution

Further evaluation of these areas reveals that the dry fabric is predominantly limited to the C-veil layer with minimal isolated dry fiber on the outer surface of the mat only on the 4008 layer. The one exception is the East End, Radius Side where the dry fabric in the flange extends through the thickness. These areas are perfect candidates for reinfusion.

To resolve issues on Pontoon 3, Kenway recommends the following steps, which are consistent with established repair procedures.

1. Place a smooth caul plate (such as a sheet of HDPE) over the affected area having a series of small resin feed holes along the centerline of the dry area.
2. Place vacuum lines parallel to the line of feed holes on both sides of the caul.
3. Pull vacuum and establish the required drop test conditions.
4. Infuse the area, allow to cure, and inspect using visual and UT methods.

Note: The threaded rod holes were drilled prior to removing the hull for inspection so that the hull could be returned to the mold and proper alignment reestablished. Dry spots around these holes can be repaired using infusion by sealing vacuum bag from each side of the hole since the bulkheads have not yet been installed.

To resolve any potential issues going forward, Kenway is repairing and reinforcing the sleeves that pass through the hull on both sides of the mold to ensure vacuum integrity. A thorough inspection of the entire mold is being conducted for additional insurance and any areas of concern, including repaired areas, will be locally bagged and vacuum checked.

Please forward this nonconformance and the corrective action for review and approval.

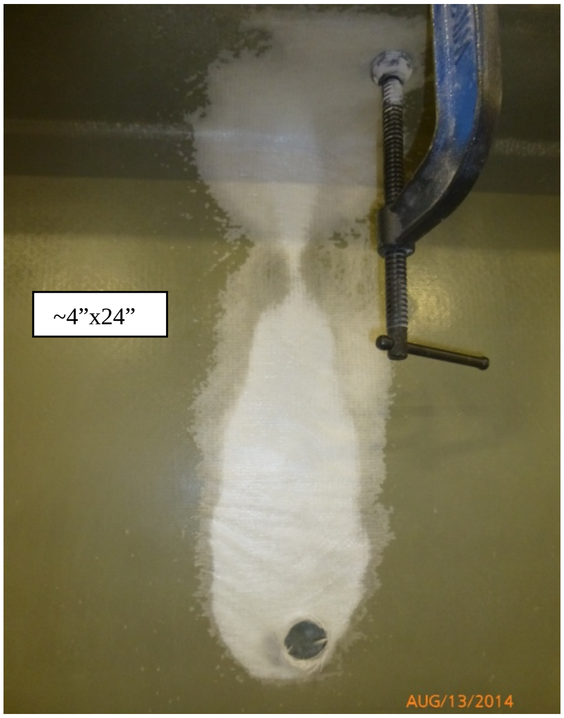

Figure 1 – West End, Radius Side

Figure 2 – Middle, Radius Side

Figure 3 – East End, Radius Side

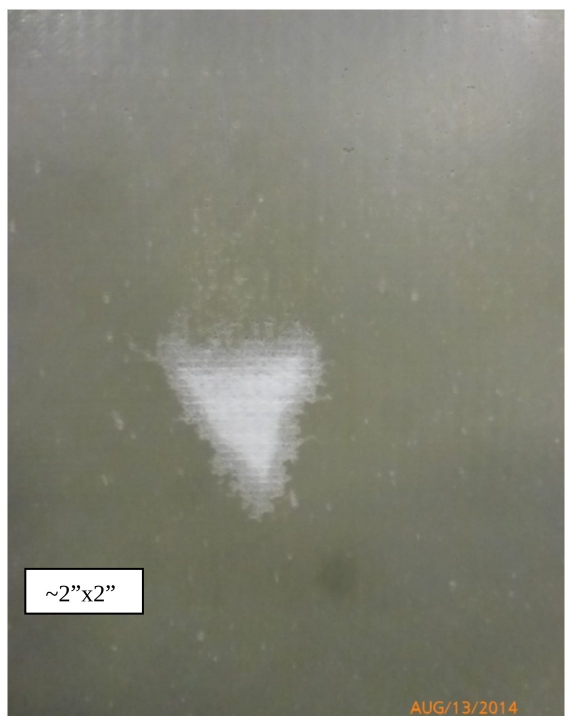

Figure 4 – West-Middle, Radius Side

Sincerely,

Jacob Marquis, P.E.
Senior Project Engineer

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August 13, 2014

Mr. Paul Holloway
Miller Construction, Inc
PO Box 86
Windsor, VT 05089

Brookfield BRF FLBR (2)

Dear Mr. Holloway:

Background

In a letter dated August 12, Kenway identified four areas of dry fabric on the exterior (mold side) of Pontoon 3. The cause and proposed resolution were also discussed. Based on comments and concerns raised by T. Y. Lin in a letter dated August 12, Kenway is forwarding additional information further quantifying the areas of dry fabric and justifying the validity of the proposed re-infusion repairs.

Defect Characterization

A measurement method was developed and used to quantify the depth of dry fabric in poorly infused areas as shown in Figures 1 and 2. A compass point is lightly tapped into the dry side of the laminate until it stops against cured resin. The point is clamped to a steel straight edge and the distance from the tip to the straight edge is measured with digital calipers. These values are transposed to a photo of each defect.

Figure 1 – Dry Fabric Measurement Tool

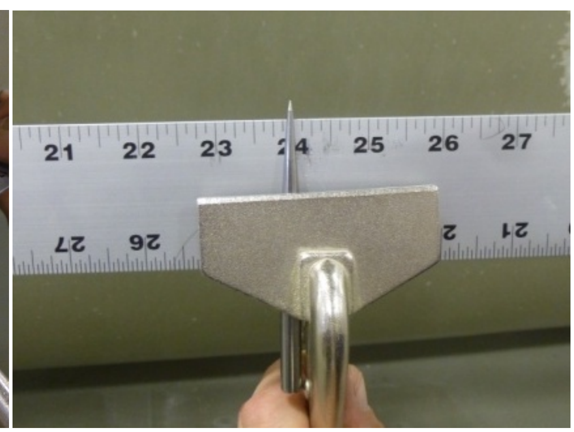

Figure 2 – Tip Offset from Straight Edge

The average thickness of the fully infused hull laminate in the vicinity of the defects, as measured using a UT thickness gauge, is 0.607 in. (Thickness is greater than 1 in. due to the existence of ply overlaps throughout the radius and above.) This value is used in conjunction with the dry fabric thickness to provide the approximate thickness of properly wet out laminate.

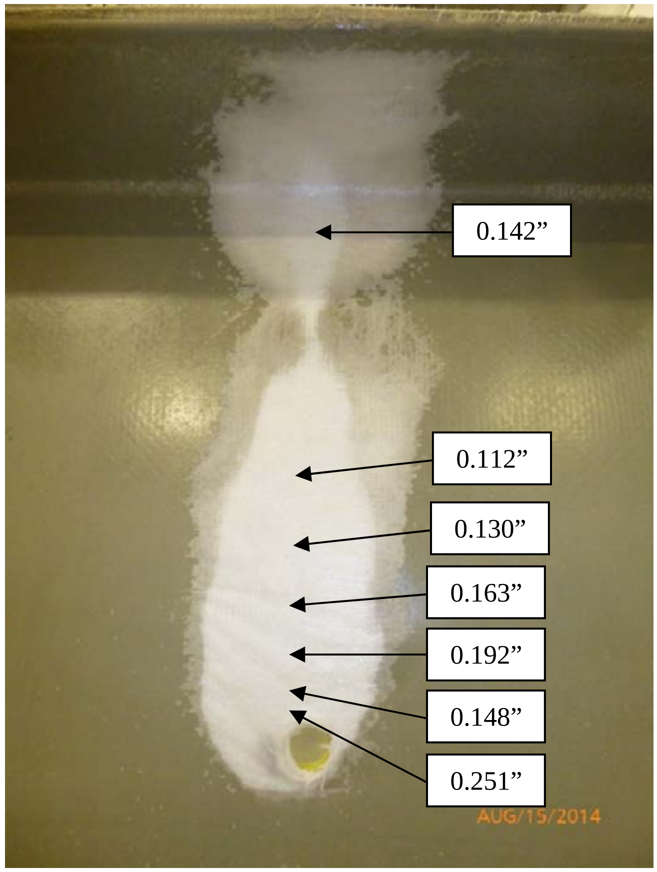

Figure 3 – West End, Radius Side: Dry Fabric Depth

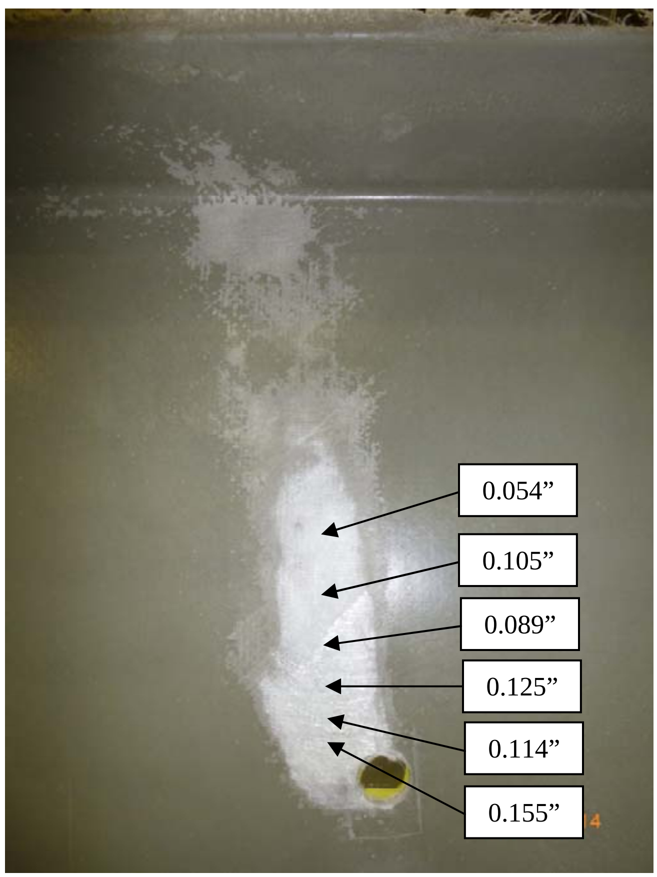

Figure 4 – Middle, Radius Side: Dry Fabric Depth

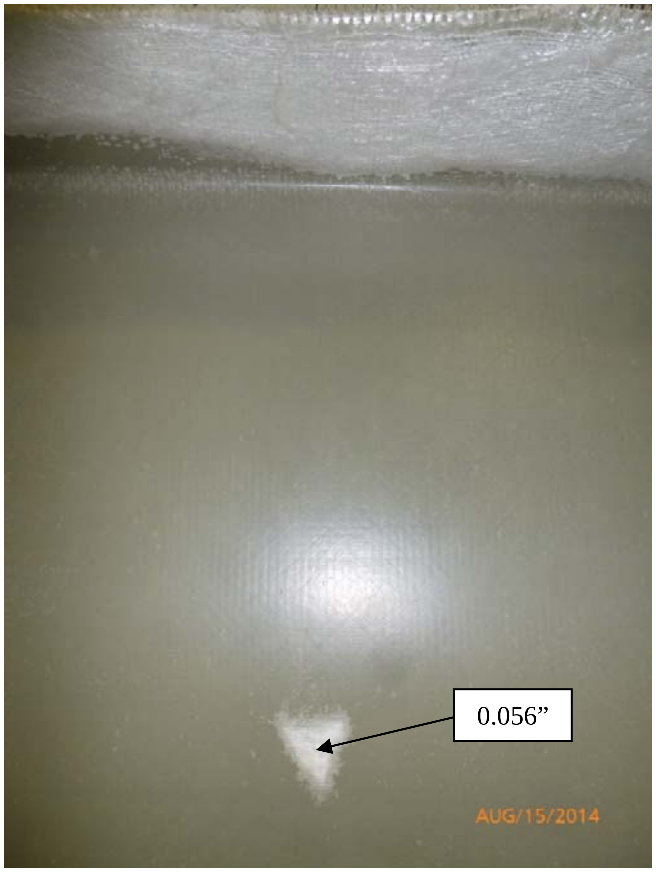

Figure 5 – Between Middle and East End, Radius Side: Dry Fabric Depth

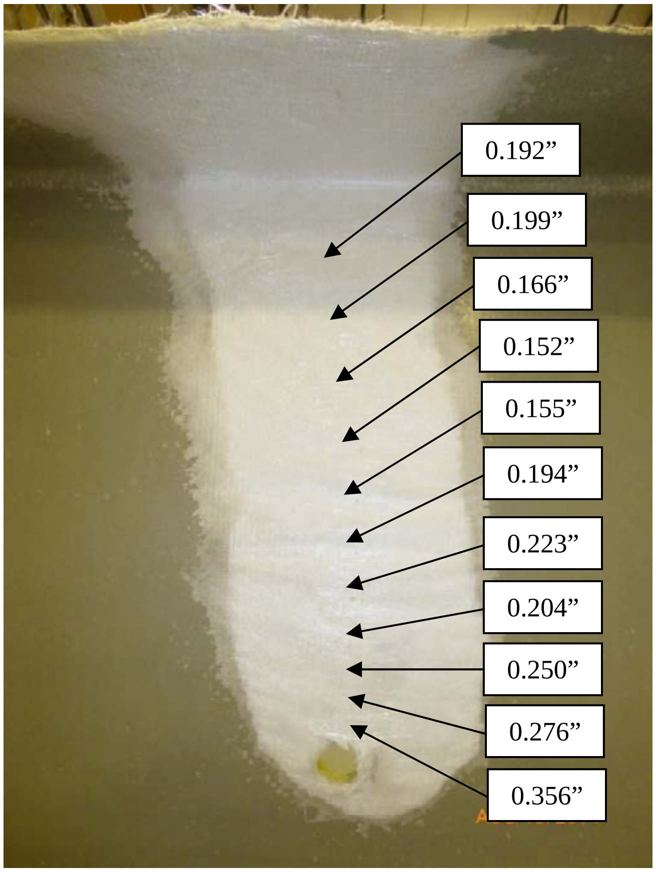

Figure 6 – East End, Radius Side: Dry Fabric Depth

Figure 7 – East End, Vertical Side: Dry Fabric Depth

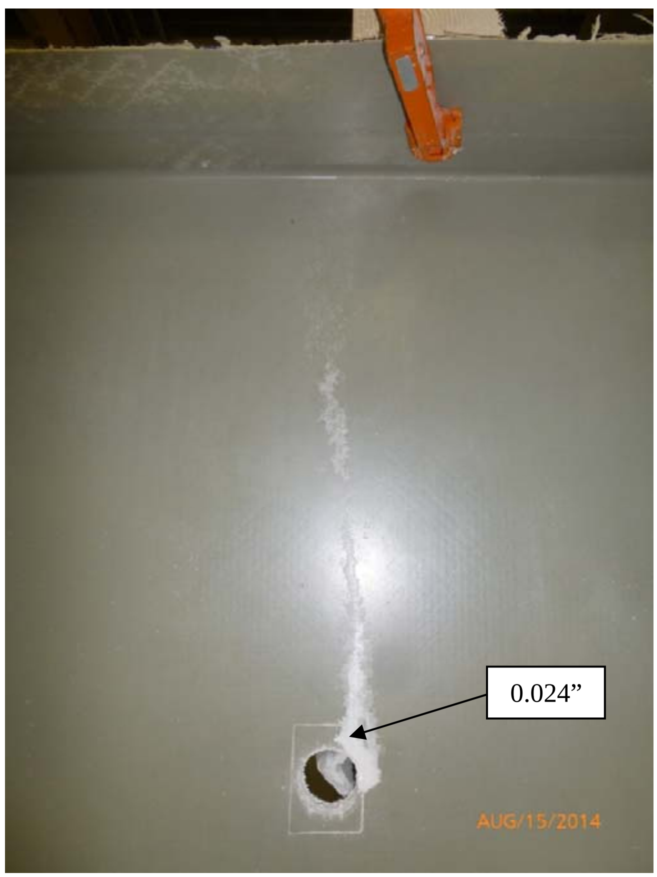

Figure 8 – Middle, Vertical Side: Dry Fabric Depth

Figure 9 – West End, Vertical Side: Dry Fabric Depth

Table 1 lists the maximum and mean depth of dry fabric measured along a vertical centerline at each defect location and the corresponding minimum and mean thickness of solid laminate based on an average hull thickness of 0.607 in.

Table 1 – Dry Fabric and Wet Laminate Thickness

Location	Max Dry Depth	Mean Dry Depth	Min Resin Thick	Mean Resin Thick
West, Radius	0.251	0.163	0.356	0.444
Middle, Radius	0.155	0.107	0.452	0.500
Mid/East, Radius	0.056	0.056	0.551	0.551
East, Radius	0.356	0.215	0.251	0.392
East, Vertical	0.012	0.012	0.595	0.595
Middle, Vertical	0.024	0.024	0.583	0.583
West, Vertical	0.034	0.034	0.573	0.573

Discussion

Visual inspection of the hull interior indicates the entire inner surface is fully wet out and well infused. Analysis of the dry fiber depth data shows the average laminate thickness along the centerline of each defect area (worst case) is typically greater than 1/2 in. and minimum laminate thickness is generally greater than 3/8 in. with the exception of one point on the east end radius side, which is just over 1/4 in.. (Note: the 8 in. square FRP blister will be bonded over this region and the bulkhead flange provides additional support.) Even if the current dry fiber was not re-infused, the hull would be watertight.

Concerns have been raised regarding the adequacy of re-infusing dry fabric resulting from incomplete wet out during infusion. Specifically, T. Y. Lin is questioning the long-term structural performance and watertight integrity of a “cold joint” after repeated ice and vehicle loading. Kenway has researched the proposed repair approach and provides the following information to validate the use of re-infusion as a repair technique.

1. The DDG-1000 Program Composite Repair Procedure allows the repair of dry reinforcement by re-infusing the laminate (secondary infusion). The feed line is placed where the most dry plies are concentrated (typically defect centerline) and the vacuum line is placed at the edge of primary infused laminate. Vacuum is maintained at or below 20 in. Hg.
    a. The DDG-1000 composite components are exposed to high sea state repetitive loading and designed to resist severe shock loads.
    b. The repair procedures were reviewed and approved by the American Bureau of Shipping (ABS) and the U.S. Navy.
2. The ABS Guide for Building and Classing Naval Vessels, Part 8: Materials and Welding, Chapter 3: Welding and Fabrication, Section 8: Fabrication, Inspection and Repair of Composite Ship Hull Structure allows the re-infusion “of local dry areas with resin using base process methodology” – meaning standard VARTM methods.
    a. Vessels manufactured following this code are designed to resist repetitive high impact loading from wave slamming and cyclic sag/haunch loading.
    b. Hull structure is intended to remain watertight and structurally sound, even accounting for repairs performed during fabrication or as a result of subsequent damage.
3. Both repair guides mentioned above, as well as the ABS Guide for Building and Classing High Speed Craft, also permit the repair of damaged areas allowing the removal of solid laminate through the entire thickness, the inclusion of a 12:1 taper, and subsequent hand lamination of a secondary laminate of equal thickness to the original infused laminate as shown in Figure 10.
    a. This is significant since the approved repair process on composite hull structure demonstrates confidence in watertight and structural integrity of primary ship structure when no continuous fiber exists across the joint and only a secondary resin bond exists.
    b. Local damage repair is specified with hand lamination, having higher resin content than infusion, which is why a few extra ply are shown in Figure 10.
    c. In the case of pontoon re-infusion, the same resin bond exists but there is also continuous fiber across the joint – similar to rebar ties in concrete slab construction joints.

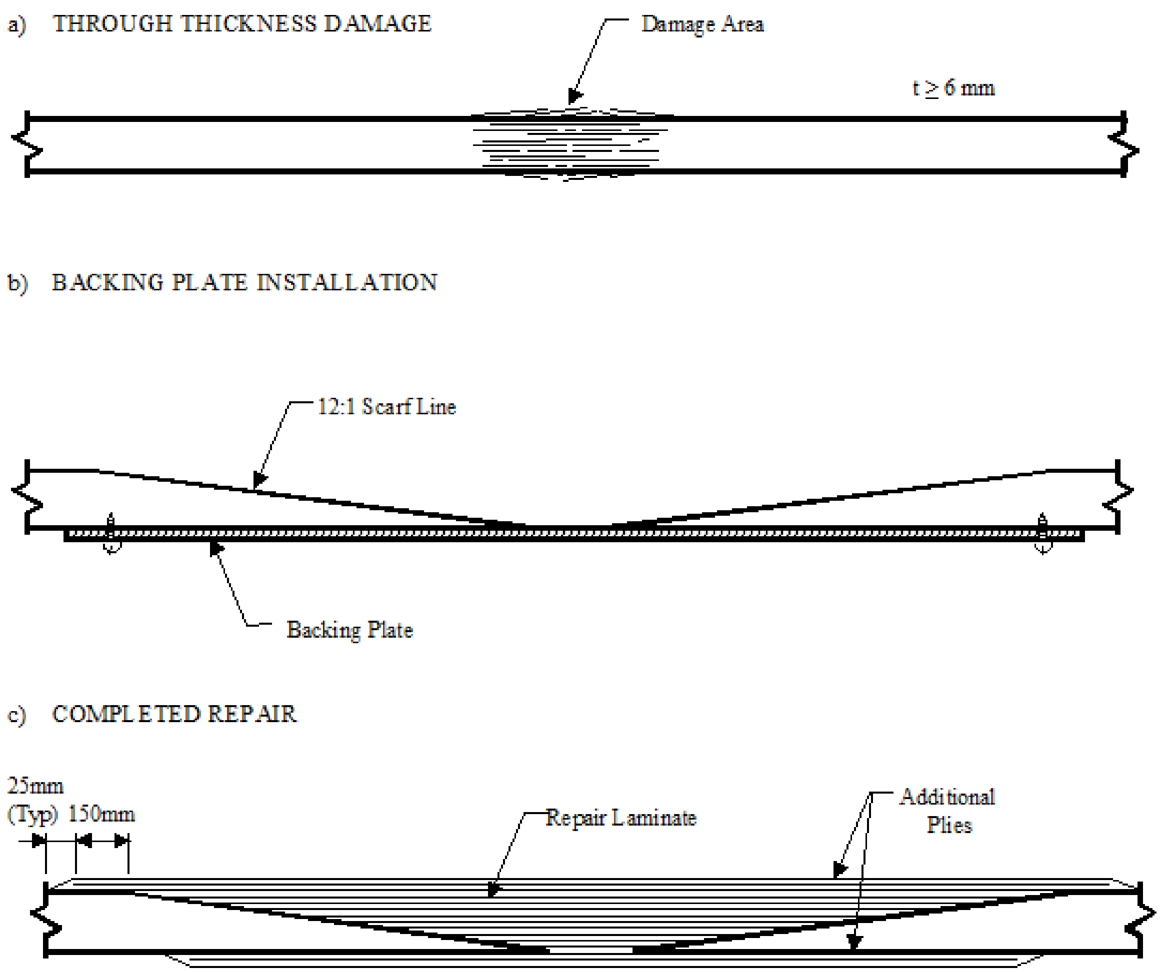

Figure 10 – ABS Through Thickness Damage Repair Example

<u>Summary</u>

Based on the existence of continuous solid laminate throughout the entire length and width of the pontoon hull, the relative area and shallow depth of the dry regions, and the well documented use of re-infusion as a valid repair technique during fabrication of marine structures (as approved by ABS, the U.S. Navy, Ingalls Shipyard and Bath Iron Works), Kenway requests that Pontoon 3 be accepted once successful re-infusion of the dry areas has been performed and inspected.

The bulkhead alignment sleeves that pass through the hull, which were the source of vacuum leaks and associated dry spots, have all been repaired using a robust solution to avoid any future leaks.

Sincerely,

Jacob Marquis, P.E.
Senior Project Engineer