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TRANSMITTAL

TO: Jennifer Fitch, PE Project Manager Vermont Agency of Transportation	DATE	PROJECT NO.
	9/2/2014	Brookfield BRF FLBR (2)

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COPIES	NUMBER	DESCRIPTION	CODE
1		FRP Field Bonding Procedure - Rev 1	H
1		Trial Application Pictures	H

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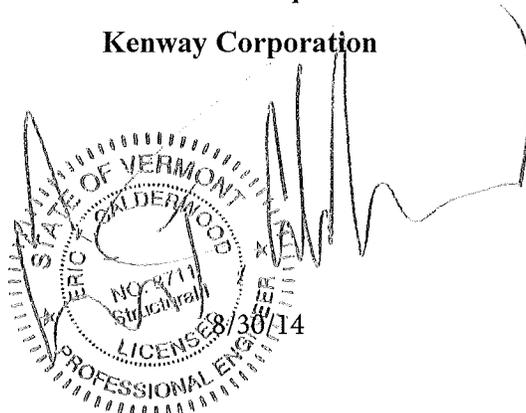
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| A FOR INITIAL APPROVAL | H FOR APPROVAL |
| B FOR FINAL APPROVAL | I AS REQUESTED OR REQUIRED |
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| D APPROVED AS NOTED-RESUBMISSION NOT REQUIRED | K LETTER FOLLOWS |
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BY: 

**Raft Field Bonding Procedure
Rev 1**

Prepared by:

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Kenway Corporation**



August 29, 2014

Raft Field Bonding Procedure

1.0 Purpose

This procedure documents the process for ensuring that mating pontoons are properly bonded together to resist operational loads and prevent ice buildup between the pontoons.

A Kenway staff member (Engineer and/or Technician) familiar with the adhesive and the bonding process shall be on site to assist with the procedure outlined below.

A pre-assembly meeting will be held on site for the first pontoon to walk through the entire procedure including mixing and application of adhesive to a test panel.

2.0 Safety

- 2.1 Follow approved lifting and handling procedures when moving and aligning pontoons.
- 2.2 Wear proper PPE when handling chemicals and working around suspended loads.

3.0 Execution

- 3.1 A minimum of 2 jacking assemblies is required (primary and a backup).
- 3.2 Complete dry fitting procedures at the manufacturing facility.
 - 3.2.1 Establish proper position of adjoining pontoons and apply reference marks indicating fore/aft and vertical alignment and spacing (parallel lines shall be placed on each side of the joint a known distance apart so that contact between the pontoons can be confirmed after bonding in the field).
 - 3.2.2 Determine if shims are required near threaded rod bulkheads to maintain desired alignment/gap (minimum 1/32 in.) when tension is applied to rods.
 - 3.2.3 Bond FRP shims as needed to the face of either pontoon and verify alignment.
- 3.3 After arriving on site, the bonding surfaces shall be cleaned and dried.
 - 3.3.1 One option is to spray with a pressure washer and wipe down with clean rags.
 - 3.3.2 Another option is to wash with sponges/rags then wipe dry with clean rags.
 - 3.3.3 For either method, the surface should be dry to the touch before proceeding. Actual wait time depends on environmental conditions in the field.
- 3.4 Ensure the pontoon supports (timber beams) are properly spaced and leveled in the on-site staging area per the lifting and handling procedure. Flat and level supports are essential to successful alignment.
- 3.5 Locate the first pontoon on the support beams by rigging per the lifting and handling procedure.
- 3.6 Locate the second pontoon on the support beams aligned with the first pontoon keeping the mating surfaces approximately 1 ft apart – leave rigging in place.

Raft Field Bonding Procedure

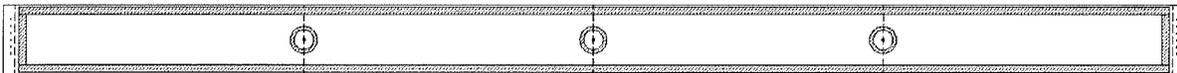
- 3.7 Pass the threaded rods through the first pontoon and adjust placement of the second pontoon until all three rods can be inserted leaving approximately 2 ft extending beyond the first pontoon.
- 3.8 Dry fit the two pontoons confirming that reference marks can be realigned and the geometric tolerances are met.
 - 3.8.1 Slide the second pontoon to within 6 in. of the first pontoon using the crane then remove the straps.
 - 3.8.2 Use a center hole jack on the middle threaded rod to pull the pontoons together until contact is made.
 - 3.8.3 Pay attention to alignment of the reference marks established at the manufacturing facility.
 - 3.8.4 Once reference marks are aligned, determine if adjustments to supports are needed to meet the remaining geometric tolerances and install as needed.
- 3.9 Remove the center hole jack and the threaded rods.
- 3.10 Lift one end of the second pontoon and separate the pontoons a few inches to allow the lifting straps to be installed.
 - 3.10.1 Install one 3/4 in. or 7/8 in. hoist ring or lifting eye through a bolt hole in the longitudinal bulkhead (web). Lifting devices shall be rated for 5,000 lb.
 - 3.10.2 Lifting device shall have a USS washer between the nut and FRP plate.
 - 3.10.3 Once a sufficient gap is established, reset the basket lifting configuration.
- 3.11 Locate the second pontoon on the support beams aligned with the first pontoon with the mating surfaces approximately 3 ft apart – leave rigging in place.
- 3.12 Pass the threaded rods through the first pontoon and adjust placement of the second pontoon until all three rods can be mostly inserted leaving approximately 2 ft extending beyond the first pontoon.
- 3.13 Prepare the MA590 adhesive for mixing in 2-1/2 gal containers.
 - 3.13.1 Have an equal amount of Parts A and B (about 5 lb each) ready to mix.
 - 3.13.2 Total amount required is approximately 27 lb or 3 buckets at 10 lb each.
 - 3.13.3 Use cordless drills and paddle mixers to thoroughly mix each batch.
 - 3.13.4 Do not mix adhesive until all preparations have been made to ensure maximum working time – about 100 min. at 74°F and 200 minutes at 55°F.
Note: Cooler temperatures will significantly increase working time while warmer temperatures will decrease working time.
 - 3.13.5 Temperature of the parts and air shall be a minimum of 55°F. Tenting the area with plastic or tarps, using 2x4s to keep the sheeting above the pontoon near the joint, and running an indirect heater can be used to achieve and maintain minimum temperature, if needed, for 2 hr. If warm temperatures are expected, perform the operation in the morning when air and part are below 74°F.

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Note: Monitor the surface temperature along the length of the bond area. Heat should be positioned and adjusted (e.g. thermostat control and/or adjusting venting of tent) to avoid hot spots exceeding 80 °F in the bond area.

- 3.14 Once all preparations have been made, mix the 3 batches of adhesive at the same time and apply to the perimeter of the mating surface on the first pontoon as shown below.
- 3.14.1 Use the short side of a 1/4 in. V-notch trowel to spread a *continuous* band of adhesive approximately 4 in. wide along all four edges of the pontoon with the objective of completely sealing the space between pontoons. Stay 4 in. away from the bolt holes on each end of the pontoon.
- 3.14.2 Apply a 4± in. ring of adhesive using the V-notch trowel at mid-height approximately a 1 ft radius away from the threaded rods.
- 3.14.3 The goal is to have all adhesive in place within 15 minutes of mixing.

Note: Test applications show about 6 ft of adhesive can be applied in less than 30 seconds. Therefore, 3 men could apply 106 ft in less than 3 minutes.



Note: This results in 5,200 in² of adhesive prior to clamping. After clamping (squeeze out), the anticipated coverage area is about 2X or 10,400 in².

- 3.15 Lift the second pontoon enough to slide it closer to the first pontoon leaving just enough room to remove the lifting straps without disturbing the adhesive.
- 3.16 Pass the threaded rods entirely through the second pontoon and prepare for clamping.
- 3.16.1 Secure a bearing plate, washer, and nut on each end.
- 3.16.2 Mount a center hole jack on the middle threaded rod.
- 3.16.3 The goal is to have the jack in place within 35 minutes of mixing.
- 3.17 Slowly apply tension to the threaded rod drawing the two pontoons together.
- 3.17.1 Pay attention to alignment of the reference marks established at the manufacturing facility.
- 3.17.2 Once desired alignment is achieved, continue loading the jack until a value of 15,000 lb is reached then snug the nut under the jacking chair.
- 3.17.3 Repeat the tensioning process on the two outer threaded rods to 15,000 lb.
- 3.17.4 The goal is to have the pontoons joined within 60 minutes of mixing.
- 3.18 Allow the adhesive to spread under pressure for 2-5 minutes.
- 3.18.1 While waiting, scrape off squeeze out from the perimeter and reapply this adhesive to sections that are missing enough adhesive to cause squeeze out.

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- 3.19 Starting at the middle threaded rod, load the jack until a value of 15,000 lb is restored then snug the nut under the jacking chair. Repeat for the other two rods.
- 3.20 The goal is to have the second tensioning complete within 80 minutes of mixing.
- 3.21 Confirm that hard contact has been made between the pontoons by verifying the pre-established distance exists between the gap reference marks.
- 3.21.1 If the gap has not been closed, apply an additional 10,000 lb to each jack until the desired gap is achieved up to a load of 55,000 lb.
- 3.21.2 The goal is to have the raft in final clamped position within 95 minutes of mixing. See 3.13.4 for typical working times depending on temperature.
- 3.22 Scrape clean any additional squeeze out that occurs.
- 3.23 Leave the bonded raft in place for at least 12 hours. Maintain a minimum temperature of 55°F for at least 7 hours after the adhesive was mixed.

Note: Monitor the surface temperature along the length of the bond area. Heat should be positioned and adjusted (e.g. thermostat control and/or adjust venting of tent) to avoid hot spots exceeding 100 °F in the bond area.

4.0 Supporting Calculations

The special provision specification requires that a shear key be designed for a distributed, factored shear force of 0.75 kip/ft. The following calculation demonstrates that the adhesive applied as described above will provide the required shear strength.

$$\begin{aligned} V_u &= 0.75 \text{ kip/ft} & V_n &= F_s h \\ F_s &= 1.60 \text{ ksi} & h &= 8 \text{ in. (uncompressed}^1 \text{ height of adhesive = 4" + 4")} \\ \lambda &= 0.9 & \phi &= 0.5 & C_m &= 0.85 \\ C_m F_s h \lambda \phi &= 58.75 \text{ kip/ft} & & \gg & 0.75 \text{ kip/ft} \end{aligned}$$

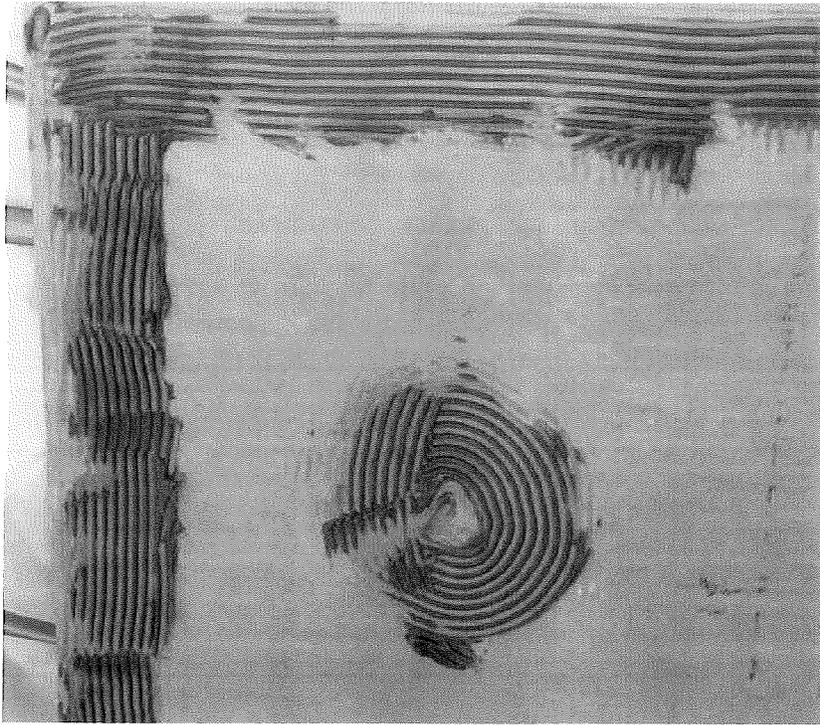
As noted in the previously submitted technical data sheet, Plexus MA 590 is commonly used to bond fiberglass material used in marine construction. It is resistant to water and solvents and has excellent impact resistance and flexibility even at low temperatures.

The following calculation evaluates stresses in the hoist ring/lifting eye placed in the web bolt holes for separating the pontoons after dry fit.

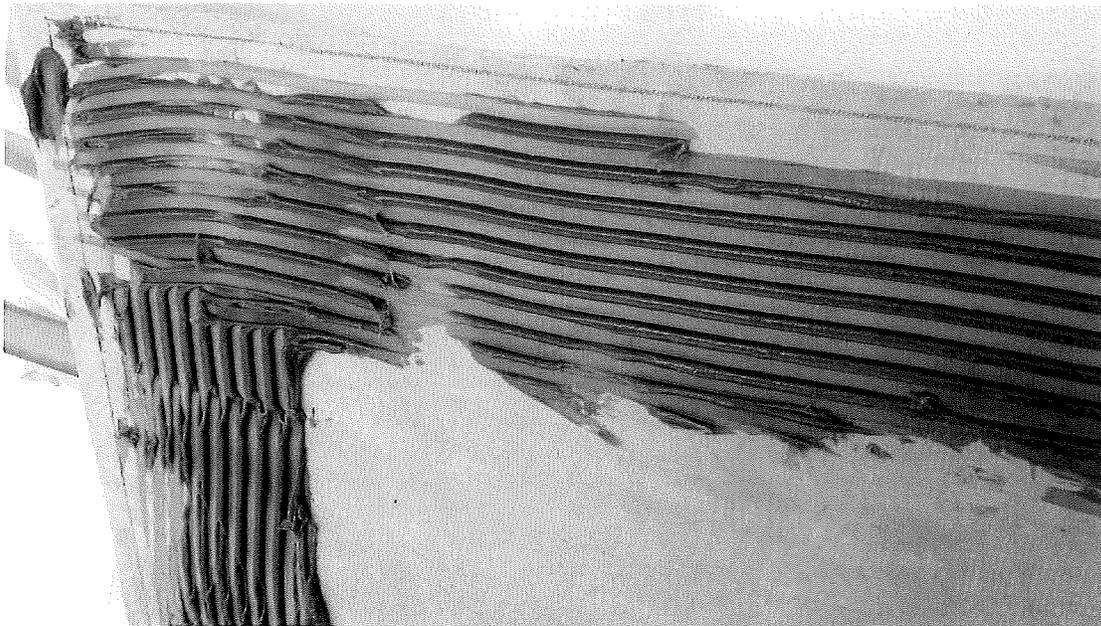
$$\begin{aligned} W_p &= 13,500 \text{ lb} & & \text{(weight of pontoon)} \\ R_u &= 1.4W_p = 9,450 \text{ lb} & & \text{(factored load on hoist ring)} \end{aligned}$$

Since vertical web bolt loads were evaluated in the design calculation submittal for pin bearing, shear-out, net tension at 0-5°, net tension at 5-90°, and cleavage using a factored bolt load of 14,800 lb, the hoist ring will pass all the same calculations with the lesser load of 9,450 lb.

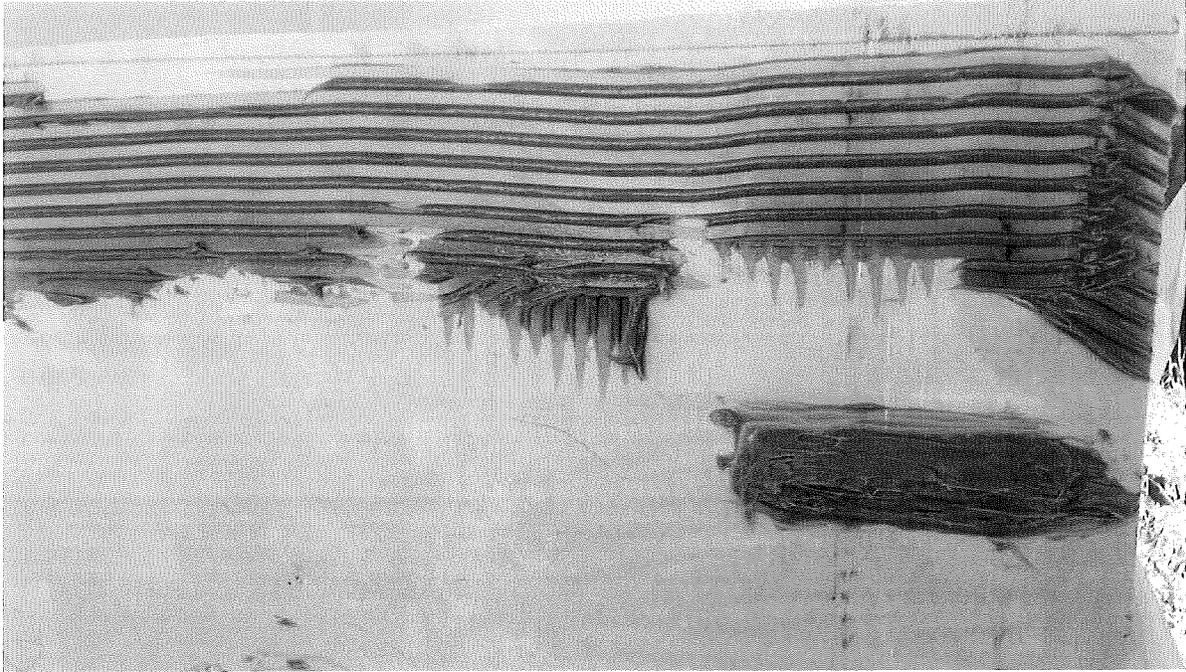
¹ Actual height of adhesive after it's compressed between the pontoons is greater than 8 in! Therefore, use of the uncompressed height is conservative.



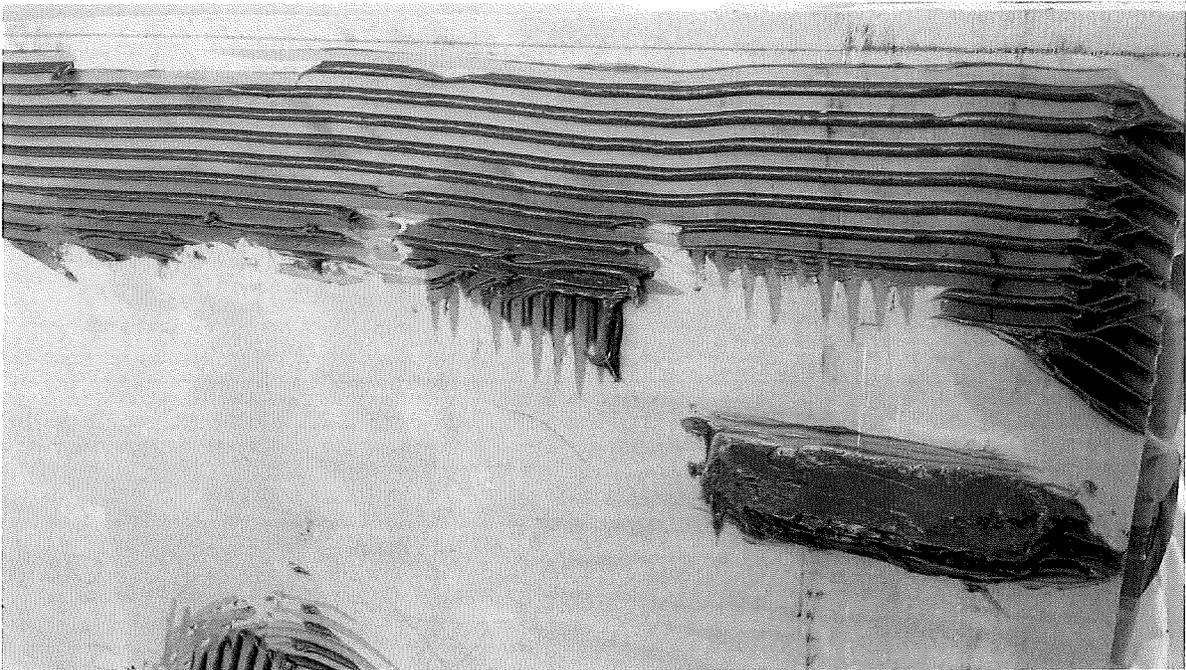
2 minutes after application and repeated impact/jarring of panel. No sag.



28 minutes after application and repeated impact/jarring of panel. No sag.



75 min. after application and more impact/jarring – 1-1/2" high triangular bead applied. No sag.



161 min. after application and more impact/jarring. No sage to 1/4" beads or 1-1/2" wedge.