



LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-787458

Standard Operating Procedure (SOP)

Repair of Cracks and Spalls within the Concrete Façade Covering the Runit Island Waste Containment Structure_V2.0



Terry Hamilton

August 2019

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, Lawrence Livermore National Security, LLC.

Cover photo: View from atop of the Runit Island Radioactive Waste Containment Structure overlooking the Lacrosse nuclear test crater (40 kt, 05/04/1956 - DOE/NV-209-REV 15) (Photo Credit: Terry Hamilton, May 2013).

Standard Operating Procedure (SOP)

Repair of Cracks and Spalls within the Concrete Façade Covering the Runit Island Waste Containment Structure

Terry Hamilton¹, Steven Kehl¹ and Jim Powers²

¹Marshall Islands Dose Assessment and Radioecology Program

Lawrence Livermore National Laboratory

PO Box 808, L-397, Livermore, CA 94550

USA

(hamilton18@llnl.gov)

²CEL Consulting

An ATLAS Company

543 23rd Avenue, Oakland, CA 94606

USA

The concrete repair shall be performed using a combination of pre-packaged cement-based mortar (Structural Concrete[®] V/O) supplied by Five Star Products, Inc., and CRACKBOND[®] products from Adhesive Technology Corp., Pompano Beach, Florida.

Five Star Structural Concrete[®] V/O is a high strength, rapid setting, one component, permanent concrete repair material used primarily for vertical and overhead structural repairs. The material produces a repair which is dimensionally stable, develops an integral bond to existing concrete, and restores structural integrity within hours of placement (*Five Star DESIGN-A-SPEC[™] Guidelines*). The CRACKBOND[®] family of products are two component, high strength structural epoxy formulations specifically designed to repair cracks in concrete.

Recommended Materials

1. Concrete Spalls
 - a. Five Star Structural Concrete[®] V/O, 50 lb. pails
 - b. Fresh Water, 1 to 5-gallon plastic jugs
 - c. Burlap Concrete Curing Blankets or alternative
 - d. Chipping hammer
 - e. Bull Point Chisel
 - f. SDS Flat Chisel
 - g. Reciprocating Saw
 - h. Reciprocating Saw Nylon and Steel Brushes

- i. Perfect Trak Concrete Saw or equivalent with accessories including a diamond tipped saw blades
 - j. Spare concrete circular saw blades
 - k. DEWALT 8-gallon Gas Twin Stack Air Compressor with fittings
 - l. Plastic concrete mixing tub
 - m. Concrete finishing tools including a median size trowel, wooden float and edger
 - n. Short handled transfer shovel
 - o. 6-8 lb. head sledgehammer
 - p. 2-Kw generator (for chipping hammer and reciprocating saw)
 - q. Fuel for the generator contained in a 3 to 5-gallon outboard motor fuel tank
 - r. Plastic buckets with screw lids, 5-gallon
 - s. Wet-dry vacuum
 - t. Water pressure spray tank with nozzle, 3-gallon
 - u. Broom, stiff
 - v. Chalk line
 - w. Safety glasses
 - x. Ear plugs or earmuffs
 - y. Particle filter masks – 3M 8293 P100
 - z. Drill and paddle mixing
2. Concrete Cracks
- a. CRACKBOND® Epoxy Repair Paste, 21.2 fl. oz. cartridges, ADHESIVES TECH Item Number A22-ERP
 - b. DEWALT 8-gallon Gas Twin Stack Air Compressor with fittings
 - c. CC-100 Walk-Behind Crack Chaser, U.S. SAWS Item Number SX90102
 - d. Ultra-Vac 1250 with Honda Gas Engine with attachment hose for Crack Chaser
 - e. Finishing tools including a scrapper and putty knife(s)
 - f. Spare belts and drive shaft for the CC-100 Walk-Behind Crack Chaser
 - g. Battery operated sander/grinder

Standard Operating Procedure (SOP)

1. Concrete Spalls
- a. The FIVESTAR Structural Concrete® V/O mix shall be stored and handled in compliance with manufacturer recommendations.
 - b. Place the FIVESTAR Structural Concrete® V/O mix at the work site in a shaded area out of direct sunlight.
 - c. Immediately upon arrival at the site, saturate the spalled area of concrete with fresh water ... keep the area saturated while you prepare the site for repair.
 - d. Mark out a square or rectangular area around the outside of centrally positioned spalls or across the intersection of corner spalls with a chalk line.

- e. Set the Perfect Trak Concrete Saw (or equivalent) blade depth to 2-2 1/2 inches.
- f. Begin cutting the concrete along the chalk line. Keep the blade wet to aid cooling. If not using a Perfect Trak Concrete Saw (with a vacuum) then the water also helps reduce the dust loading in air. Follow along the saw blade with the dry-wet vacuum line to catch any drilling fluids or dust.
- g. Using the chipping hammer and chisels, chip-out the area of concrete inside the saw cut line to a depth of around 2 inches to generate a clean, structural sound, concrete surface. Roughen all concrete surfaces to a concrete surface profile of 6 or greater.
- h. Clean the remaining sides of the concrete area to be repaired using the reciprocating saw and a nylon or steel brush. Concentrate this effort on the spalled edge of concrete not along the inside of the adjoining concrete segments or panels.
- i. After surface preparation is complete, vacuum out any remaining rubble and/or concrete dust or dirt.
- j. Re-saturate with water, cover over the area with wet burlap and let stand for a minimum of 60 minutes (refer to considerations section). Continue to wet down the area as needed.
- k. FIVESTAR Structural Concrete® V/O: Add a 50 lb. unit of the concrete to the plastic tub and mix initially with a ½ gallon of cool, fresh water, mix for 2 to 3 minutes by constantly turning over the concrete. Add additional water as needed to obtain a uniform consistency ... continue to mix thoroughly for 3 to 4 minutes.
- l. Place material immediately after mixing in batches to full depth from one side of the repair job to the other.
- m. Work the material firmly into the substrate.
- n. As you add the concrete mix, use a float to smooth out the surface of the concrete to confirm with the surrounding concrete segments.
- o. Texture the surface of the concrete with a broom finish.
- p. On completion of the repair, use an edging trowel to score along the original joint lines of surrounding concrete segments.
- q. Cover the repaired section of concrete with wet burlap, add a layer of coconut fronds and sand.

Considerations:

- All concrete repairs shall be conducted under the supervision of a licensed engineer.
- Any rooting vines in or around any concrete spalls should be removed prior to commencement of the repair.
- Working time for placement of batches of concrete will be around 15 to 20 minutes (using cold water to mix with the concrete will help extend work time of the material).

- Consider performing the placement of concrete in the mid to late afternoon allowing as much time as possible to pre-soak (condition) the concrete.
- The concrete should be saturated but free of standing water at time of placement of concrete.
- Do not exceed maximum water content as stated on the concrete packaging.
- Wherever possible, place FIVESTAR Structural Concrete V/O full depth from one side of the repair to the other.
- To ensure optimal bond development, firmly work materials into substrate.
- An ample source of potable water should be available for preconditioning, mixing, cleaning and curing the concrete.
- Knee pads will markedly increase comfort of workers when kneeling.
- Wash off accumulated dust from your body as soon as the job is done.
- Recommend wetting down the repair site with Burlap, coconut leaves and overlying soil over a period of several days to allow proper curing of the concrete.
- After 7 days or more, return to the site and remove the dirt, coconut fronds and Burlap from the repaired sections of concrete, sweep the area clean of any debris, and take post-repair photos of each spall repair.
- Recommend that the work area be shaded from direct sunlight with a shade or popup canopy.
- Document the work performed using digital photography or video.

Caution: Always wear proper personal protective equipment, such as safety goggles, particle dust mask and gloves, especially while sanding, sawing, chipping or grinding concrete.

2. Concrete Cracks

Crack Preparation

- a. CRACKBOND® products shall be stored and handled in compliance with manufacturer recommendations.
- b. Attach the Ultra-Vac system to the Crack Chaser and position cutting blade over the crack.
- c. Adjust the saw blade cut depth to $\frac{3}{4}$ " per pass.
- d. Perform a test saw cut along the crack. Ensure the width of the blade (nominally 0.25 to 0.5 inches) is sufficient to remove any feathered edges along the crack. Ensure that the dust collection Ultra Vac system is functioning properly.
- e. Saw cut along the crack using a maximum speed of approximately 6 feet per minute.
- f. Where appropriate, extend length of the saw cut to about 10-15 cm (about 4-6 inches) beyond the visual end of the crack.

Crack Cleanup

- g. Use a wire brush or a reciprocating saw with a nylon or steel brush to abrade along the interior of the crack.
- h. Blow out the crack with compressed air. Ensure that the crack is free from debris, dust, wax and/or grease.

Cartridge Preparation

CRACKBOND® Epoxy Repair Paste (refer Adhesive Technology website; <http://atcepoxy.com/wp-content/uploads/TDS-CRACKBOND-EPOXY-REPAIR-PASTE-v1.0.pdf>)

CRACKBOND® Epoxy Repair Paste is a two component, moisture insensitive, high modulus, high strength, structural epoxy adhesive pastes available in cartridge and bulk systems. It may also be used to repair spalls and as a capping paste for structural crack injection.

- n. Check the expiration date on the cartridge to ensure it is not expired.
- o. Remove the protective cap from the adhesive cartridge and insert the cartridge into the dispensing tool.
- p. Dispensing a small amount of material in a disposable container until both components are flowing evenly.
- q. After the cartridge has been balanced, confirm the internal mixing element is in place and screw on the proper Adhesives Technology mixing nozzle to the cartridge. Do not modify mixing nozzle prior to dispensing adhesive.
- r. Dispense an initial amount of material from the mixing nozzle into a disposable container and discard. The product should be a uniform light gray color with no streaks.
- s. For crack repair, work CRACKBOND® Epoxy Repair Paste into the crack and smooth out with a trowel.

Considerations:

- All concrete repairs shall be conducted under the supervision of a licensed engineer.
- Use all equipment and crack repair products according to manufacturers' instructions.
- The Crack-Chaser should not be operated at speeds of more than 2 meters (app. 6 feet) per minute
- Any rooting vines in or around any concrete cracks should be removed prior to commencement of the repair.
- If possible, schedule dispensing to consume an entire CRACKBOND® cartridge at one time with no interruption of epoxy flow.
- If you have any problems in dispensing product, replace the nozzle and repeat the cartridge balancing steps described in the SOP section above.

- Never reuse a cartridge nozzle as any cured product inside the nozzle will affect the mix ratio.
- Knee pads will markedly increase comfort of workers when kneeling.
- Recommend that the work area be shaded from direct sunlight using a shade or popup canopy.
- Document the work performed using digital photography and/or video.
