REPAIRING *VIGAS* AND CORBELS

Before beginning a *viga* or corbel repair or replacement project, be sure to read the preceding chapter, *Inspecting Vigas and Corbels*, to determine if repair and/or replacement is actually required. Please also note that emergency shoring may be needed to support the existing roof structure while repairs are carried out if there has been extensive damage to either *vigas* or corbels (see Part Two, *Emergency Shoring*).

The methods described below were developed from the experience of conducting *viga* and corbel repairs at the Socorro Mission Preservation Project. The methods described in this chapter were summarized by US/ICOMOS intern, Jacobo Herdoiza, following a workshop on *viga* repair held at Acoma Pueblo in the Summer of 2003. Jake Barrow of the National Park Service developed the "splicing" technique described here. This technique applies only to buildings with rotted projecting and/or embedded *vigas* and to corbels that have sufficient sound wood near the interior face of the wall.

The intention of making repairs should be to restore the structural integrity of original *vigas* and corbels while preserving as much of their original fabric as possible. This is especially important if the originals are carved or pigmented. When *vigas* and corbels are repaired in place, the process is less expensive because there is no need to remove the roof. If possible, both assessment and repair should be supported by the expertise of an engineer in order to verify the structural stability of the roof system and to determine the specifications for any repair. The previous chapter on *viga* and corbel assessment provides additional information about the removal of decayed wood and determining the structural integrity of *vigas*.

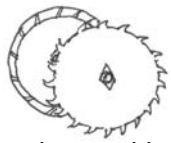
Before and after photos of deteriorated *vigas* repaired using the *viga* splicing method (Method D).

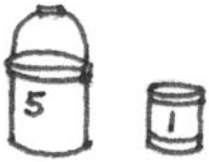
TOOLS AND MATERIALS REQUIRED


Axe


Chainsaw


Circular saw


Circular saw blade, diamond blade

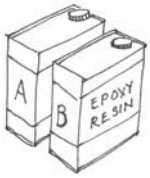


Containers


Drill

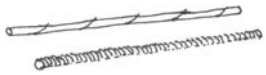

Drywall compound mixer


Dust mask



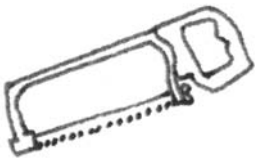
Epoxy resin

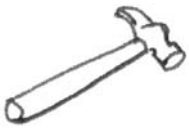

Funnel


Glass fiber rod (threaded and unthreaded) and nuts


Gloves


Goggles


Hacksaw


Hammer

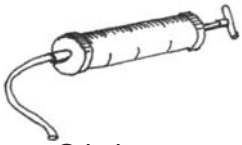

Handsaw


Hard hat


Ladder

Level


Measuring tape


Oil plunger

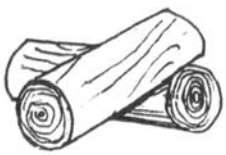

Plasterer's hawk


Plasterer's trowel


Plastic washers


Plumber's bit


Socket paring chisel


Vigas

<u>Additional materials:</u>
Bora-Care®
Modeling clay

Depending on the amount, location and characteristics of any decayed wood that is discovered, several repair options may be followed. There are four levels of decay. Each level requires a different method of repair:

METHOD A: SUPERFICIAL DECAY; APPLY BORA-CARE® TREATMENT

Bora-Care® is a chemical product used for prevention of termites, carpenter ants, wood-destroying beetles and fungi. It is preferable to many similar products because it serves as an insecticide and herbicide rather than one or the other. It is characterized by rapid, deep penetration and wide coverage. WARNING: Bora-Care® is harmful if absorbed through the skin. Avoid contact with skin, eyes or clothing. Cover plants and nearby soil to avoid contamination.

Superficial wood decay means that erosion is not affecting the structural integrity of the *viga*. This decay is noticed when the surface of a *viga* is softened wood. In such cases, the adequate repair is to apply Bora-Care® treatment:

1. Scrape down decayed wood until solid wood is revealed.
2. Clean the surface thoroughly.
3. Apply Bora-Care® (refer to Bora-Care® directions for use).
4. Allow wood to completely dry for a minimum of 48 hours.

NOTE: It is problematic to use Bora-Care® in conjunction with other repair methods involving epoxies. The presence of Bora-Care® minimizes or even prevents adequate adhesion. Apply Bora-Care® to those areas that will not be directly epoxied. Let the epoxy, once it impregnates the wood, act as the insecticide and herbicide through encapsulation and the prevention of air flow.

METHOD B: UP TO 40% OF DECAY IN REGULARLY SHAPED AREAS; APPLY A DUTCHMAN

Once all decayed wood has been removed down to solid wood, it may appear that the damaged area has a shape appropriate for the insertion of a wood dutchman. A dutchman is a solid piece of wood that matches the missing or deteriorated piece in the existing wood element or *viga*.
NOTE: Repairs are only recommended if a minimum of 60% of the original wood is retained in the *viga* after the removal of all softened wood.

The application of a wooden dutchman has the advantage of repairing the *viga* with a compatible material (wood) and reducing the volume of epoxy employed for consolidation purposes. Epoxy is a chemical compound that forms hard, strong, and chemically-resistant adhesive bonds and enamel-like coatings.

1. Scrape down decayed wood to solid wood.
2. Clean surface thoroughly.
3. Carefully remove solid wood in order to create a shaped volume that will permit clear insertion of the dutchman. Try to remove as little of the original solid wood as possible.

4. Clear and clean the surfaces again.

5. Prepare the dutchman; verify that it exactly matches with the area removed from the *viga*. Try to use the same kind of wood, and whenever possible recycle solid pieces of original wood.

6. Clear and clean the surfaces again.

7. Apply Bora-Care® (please refer to Bora-Care® directions for use) and allow wood to completely dry (at least 48 hours).

8. If the *viga* is rectangular or square in section, cut and install temporary plywood forms around the *viga*. The form will serve to cover the *viga* and the dutchman joints.

9. Apply paste wax to the inside of the plywood form to facilitate its removal when the process is complete.

10. Fill joints in the plywood forms and any cracks in the *viga* undergoing repair with moldable clay to prevent the epoxy from failing to properly infiltrate the wood.

11. Prepare epoxy (please see ConservEpoxy® or comparable brand instructions for application). Note that epoxy should be prepared and applied in a shaded place.

12. Apply epoxy to the area of the *viga* that will receive the dutchman.

13. Fix the dutchman firmly to the *viga* using diagonally driven screws. Wooden dowels installed using epoxy can also be used with a combination of screws to hold the dutchman down.

14. Remove forms when the epoxy is completely dry.

15. Repeat the same procedure if multiple dutchmen need to be applied.

METHOD C: UP TO 40% OF DECAY IN IRREGULARLY SHAPED AREAS; USE EPOXY CONSOLIDATION

Once the decayed wood has been removed down to solid wood, it may appear that damaged areas do not permit application of a dutchman. In such cases, the consolidation process will employ an epoxy resin as a structural infill to restore the stability of the *viga*.

The conditions for structural epoxy repairs are the same as those for dutchmen. Use this method if a minimum of 60% of the original wood is retained after the removal of softened wood. Take into account that applying epoxy is an expensive and very delicate procedure that may severely affect the breathability of the air in the work area.

Finally, note that epoxy consolidation should be considered a last ditch effort before proceeding to the splice method for repairing an inoperable *viga* section.

1. Scrape down decayed wood to solid wood.

2. Clean the surface thoroughly.

3. Apply Bora-Care® (please refer to Bora-Care® directions for use) and allow wood to completely dry (at least 48 hours). Apply Bora-Care® only to those areas that will not be epoxied. The epoxy itself will

minimize threats from insects or fungus by blocking airflow once it cures.

4. Prepare a wood form to contain the epoxy, preferably with plywood, if the *viga* undergoing repair is square or rectangular.

5. Check the plywood form for fit and then remove it from the *viga*.

6. Coat the inside of the form with paste wax for ease of removal later.

7. Fill cracks in the form and its corners with moldable clay and fix the wood form firmly to the viga with screws.

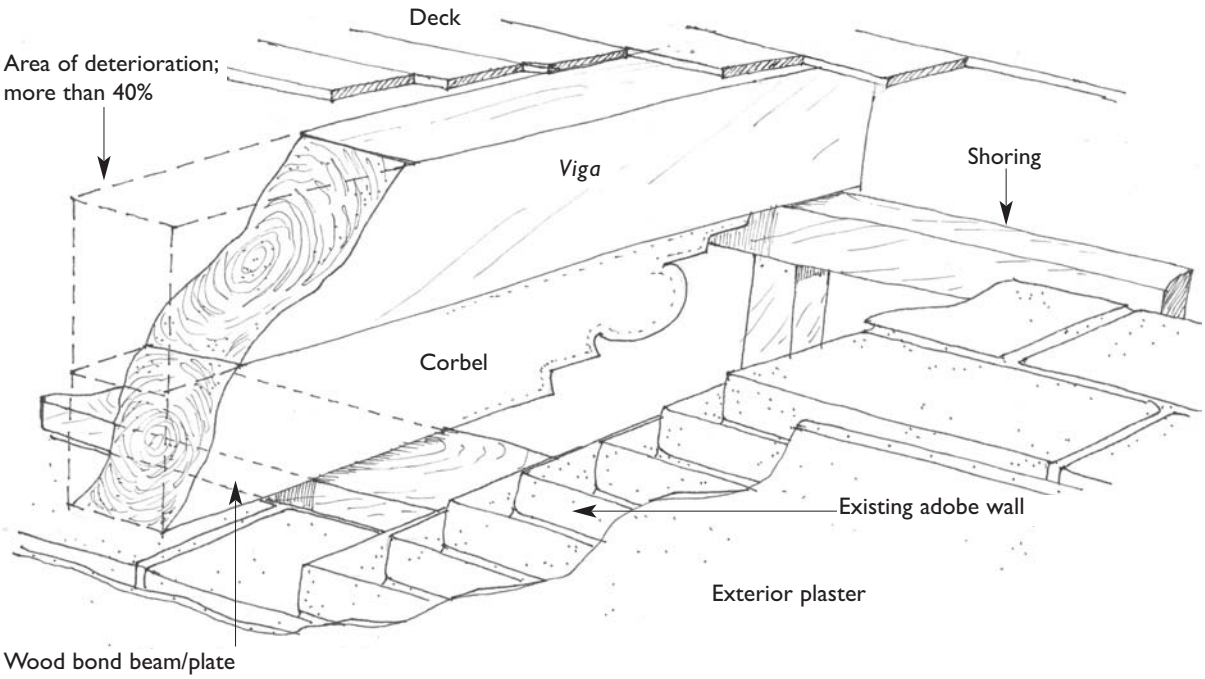
8. Prepare the epoxy according to the manufacturer's directions (see ConservEpoxy® or comparable product instructions) and augment it with a consolidation recipe of two parts sand and one part fine aggregate. NOTE: Epoxy should be prepared and applied in a shaded place to obtain optimum results.

9. Apply epoxy mix carefully and slowly to avoid any risk of damage (fire) to the *viga*. (The chemical reaction of epoxy creates intense heat and could cause wood to catch fire.)

10. Let the *viga* completely dry before removing the forms and reinstalling it in the building.

METHOD D: MORE THAN 40% OF DECAY; USE *VIGA* SPLICING AND GLASS FIBER ROD REPAIR

If more than 40% of the original section of the *viga* appears to be decayed after the softened wood has been scraped away, consider complete removal of the decayed section and splicing new wood to the original *viga*. The possibility of reusing most of the original *viga* justifies this type of intervention. NOTE: Splicing should only occur at the *viga* end for best structural stability. The good end of the original *viga* must extend at least four inches into the wall, and rest, preferably, on the existing or new wood bond beam or plate.



Splicing the *viga* and introducing glass fiber rods and epoxy repair is a non-reversible process. Before proceeding, be sure that the preservation team unanimously agrees to this type of intervention and that all other possible repair procedures have been investigated.

This method is recommended when decay is noticed in load-bearing sections that rest on adobe walls. If vertical cracks or deep deterioration is noticed in the middle of the load-bearing areas of a *viga*, consider complete removal of the *viga* and replacement in kind.

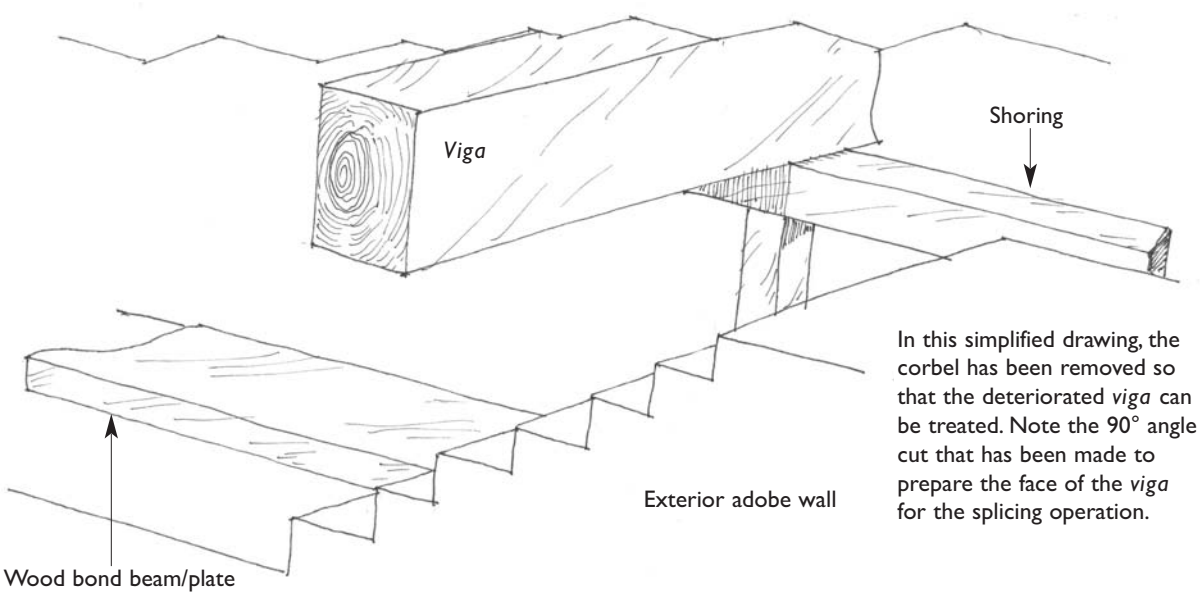
NOTE: Cornerstones has had success obtaining threaded glass fiber rods from:
Harrington Industrial Plastics
5312 Pan American Freeway NE
Albuquerque, NM 87109 Phone: 505-884-0295 Fax: 505-881-2464

1. Scrape down decayed wood to solid wood.

2. Estimate the volume of decay within the *viga*. If the remaining solid section of the *viga* is less than 60% of its original volume, proceed to repair, using glass fiber rods and epoxy.

3. Document the *viga* (especially the area to be spliced) with drawings and photos.

4. Measure the length and the section of the portion to be spliced, but verify that the remaining solid *viga* is long enough to cover the bearing distance between the adobe walls, as mentioned above. Note that glass fiber rods will operate as part of the main structural component and need to be located in the load bearing portion of the *viga* that rests on the adobe walls or the wood bond beam or plate.



In this simplified drawing, the corbel has been removed so that the deteriorated *viga* can be treated. Note the 90° angle cut that has been made to prepare the face of the *viga* for the splicing operation.

5. Mark the edges of the section to be spliced. NOTE: For the best results cuts should always be made at a clean 90° angle.

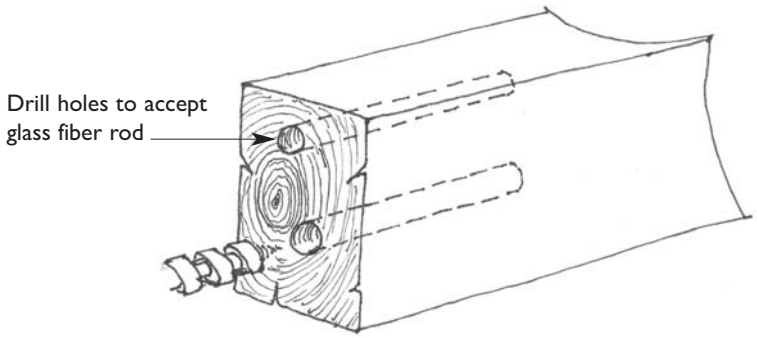
6. Select the piece of wood for the splice. Choose a piece of wood that has similar characteristics as the section being removed; i.e. same type of wood and equal dimensions. Whenever possible, try to use a splice that is created from a solid fragment of a recycled original *viga*. The splice should be cut at a 90° angle to match the cut in the face of the existing *viga*.

7. Match as precisely as possible the facing side of the replacement piece with the existing *viga*. Level and fix the splice to the existing *viga* using screws driven diagonally into both pieces. Verify that there is full contact between both pieces.

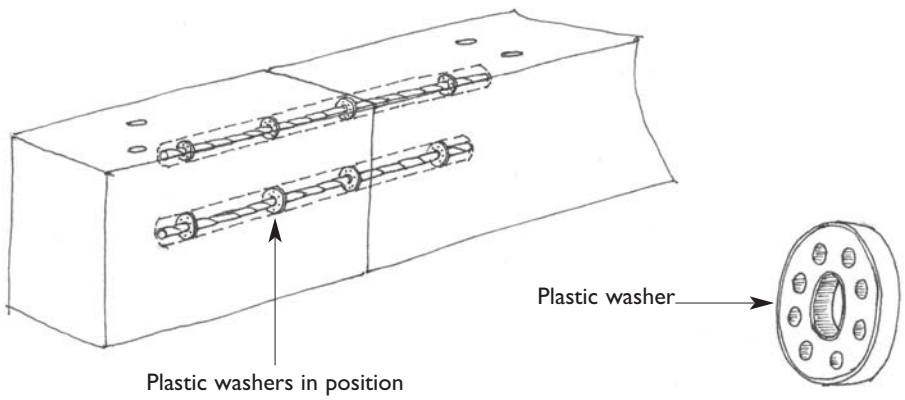
8. Analyze the sectioned *viga* and identify adequate locations on the cut end where holes for the glass fiber rods can be drilled. Note that each glass fiber rod must be located at least one and a half inches away from any crack or from the edges of the *viga* face.

9. Mark the locations of the holes on the *viga* ends and transfer the locations accurately to the section of the replacement piece.

10. Select the diameter of the glass fiber rods (1/2 or 3/4 inches in diameter) based upon the structural stress to be loaded and the area available in the section of the *viga* that is to be drilled. You may need an engineer to verify the amount of weight each glass fiber rod can hold.



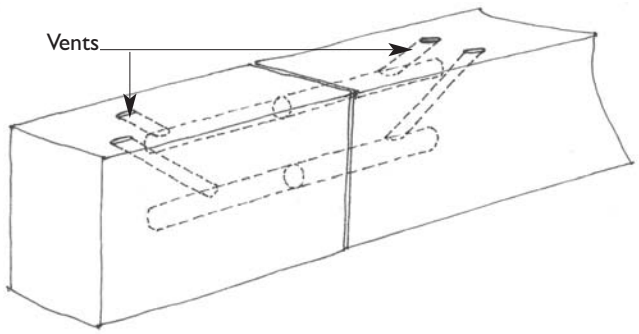
11. Drill holes 12-inches deep (long) into the marked locations in each section of the existing *viga* and the replacement splice. Make sure that the holes are drilled level and are thoroughly cleaned of sawdust and debris.



12. Purchase or fabricate plastic washers to slip the rod through. The washers will slide over the rod, and should fit snugly into the drilled portion of the *viga* and the tail splice. Place two washers in the original *viga*, and place two in the new tail. The washers serve to center the rod. They keep the rod from floating to the bottom of the drilled channel once the epoxy is introduced. Small holes will be drilled in the washers to permit epoxy to flow through and around the rods and the washers. Always do a dry run before pouring the epoxy to make sure everything fits properly.

13. Firmly and precisely match the replacement splice with the *viga*, making sure that there is full contact between all facing cuts. If the faces of the cuts do not precisely align, clean and level them again.

14. After successfully performing a dry run (no epoxy), separate the tail and *viga* and remove the glass fiber rods and washers.



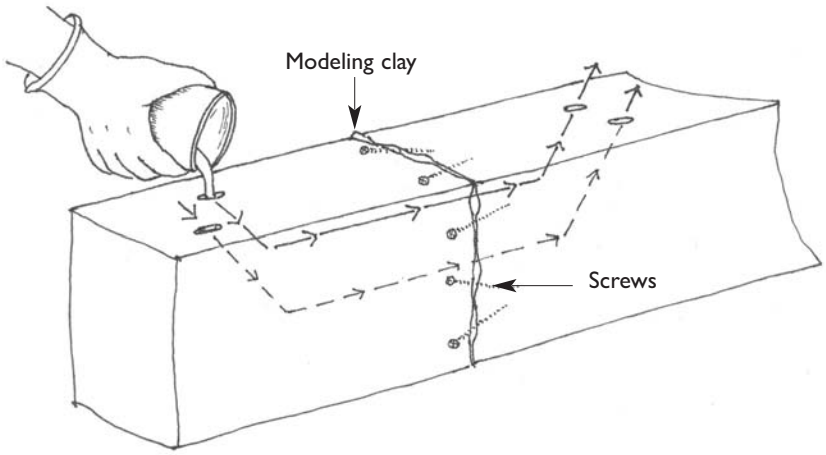
15. Drill several 7/8-inch-wide holes at a 45° angle down from the top of the *viga* and down from the top of the replacement splice until they intersect with the rod holes. These will be used as air vents and as conduits for the fluid epoxy.

16. Place the 45° vent and application holes so that each is within one and a half inches of the end of the rod holes.

17. Reinsert the glass fiber rods and washers and then rematch the *viga* with the replacement splice. Fix them firmly together using screws.

18. Prepare the epoxy (see ConservEpoxy® or comparable product instructions). NOTE: Epoxy should be prepared and applied in a shaded place to obtain optimum results.

19. Cover all the joints between the *viga* and the replacement splice with modeling clay. Be sure to also cover any possible conduits for leaks, such as cracks in the wood, at least three feet in each direction.



20. Slowly pour the epoxy into the vent holes in the top of the replacement splice. It is important to do this slowly to avoid loss or damage to the *viga*. Ensure that the epoxy penetrates adequately into the *viga*. Epoxy application is complete when the epoxy appears level in the vent and application holes that are in both the replacement splice and in the original portion of the *viga*.

21. Let the epoxy dry completely before reinstalling the *viga* in the roof. Make sure that you always follow the epoxy manufacturer's specific instructions.

METHOD E: AN ALTERNATE SPLICING METHOD FOR *VIGA* TAILS

The following method may be used for splicing *vigas* in place. If using this method for *vigas* that are square or rectangular in section, accuracy is extremely important.

1. With a 1/4x16-inch auger bit, drill into the *viga* at a 30° to 45° angle to check it for rot (see instructions above).

2. If the *viga* tail is deteriorated, one remedy is to splice a new tail onto the body of the original *viga* without removing it.

3. Remove six to eight inches of plaster and adobe around the *viga* to expose the rotted wood.

4. Accurately measure the rotted *viga* tail to determine the correct dimensions of the replacement tail.

5. Using a chain saw and other tools, remove all the rotted wood and leave the exposed cut as smooth and as close to 90° as possible.

6. Match the replacement tail with the existing *viga*. Take note of the square, flat faces of both pieces.

7. Determine the location and size of the drill hole based upon overall dimensionsof the *viga*, cracking in the timber, and ease of access. Always try to minimize the amount of original material that is removed, and seek to maximize structural strength. The hole will need to accomodate the glass fiber nut to be used. Make sure the hole and the nut match in size as closely as possible.

8. With a socket-paring chisel, transform the round circumference of the drilled hole in the *viga* into a square. This will allow a square glass fiber nut to be inserted.

9. Attach the square glass fiber nut with epoxy resin into the square hole in the *viga*.

10. Once the replacement tail has been cut to match the diameter of the existing *viga* and length of the section being removed, measure and cut a threaded glass fiber rod to a length of two feet. Drill the appropriately sized hole to match the first hole. Fit the rod with plastic washers to help center the rod in the hole. Drill small holes in the plastic washer to allow the epoxy to squeeze in and around the washer.

11. Mix epoxy according to the manufacturer's specific instructions.

12. Stand the replacement piece vertically. Fill the hole in the tail half full of epoxy resin and insert the glass fiber rod.

13. Before the epoxy sets, adjust the rod so that it projects accurately from the face of the tail at a 90° angle. Then allow the epoxy to set.

14. Drill two 7/8-inch holes at a 45° angle a couple of inches above the center hole of the *viga* so that they intersect with the rod hole. One hole will serve to pour in the epoxy resin and the other will serve as a vent.

15. Coat the threaded glass fiber rod with heavy motor oil or Vaseline®. Screw it into the square nut in the face of the *viga* the entire depth of the hole. Pour the epoxy resin into one of the 3/4-inch holes using a funnel or an oil plunger. The center hole will be full when the epoxy runs out the vent. Allow the resin to settle by tapping the *viga* with a mallet and make sure the threaded rod remains at a 90° angle to the face of the *viga*. Before the resin completely hardens, completely unscrew the threaded glass fiber rod from the hole and the nut. The rod will have formed a threaded shaft. In order to calculate how fast the epoxy resin dries, test by using a sample of the epoxy resin before inserting the rod back into the *viga*. Make sure the timing is correct so that the threaded shaft maintains its integrity.

16. Allow the epoxy to harden completely. Screw the new *viga* tail that has the threaded glass fiber rod protruding from it into the square glass fiber nut in the existing *viga* and tighten securely.

17. After the new *viga* tail is in place, fill the cavities between the wall and the *viga* with adobes laid in mud mortar. Infill any crevice or hole with mud mortar and it to dry. Apply a plaster on the outside that matches the existing plaster.

GENERAL RECOMMENDATIONS

Systematically document each *viga* before repairing. Make drawings, take photos, and collect samples of rotted wood for lab analysis if necessary.

Bora-Care® and epoxy are extremely toxic materials. Follow all the safety procedures before preparing and applying.

Bora-Care® and epoxy have specific directions for use. Carefully read the instructions before using. Especially consider the conditions needed to apply each material and to let them dry.

Do not hesitate to consult technical experts to assess *vigas* and to determine the appropriate repair procedure.

FIELD NOTES