5.0 OPINIONS AND CONCLUSIONS

5.1 FIELD CONDITIONS; RESTORATION LIMITS

The definition of restoration is to return the properties of the material being restored to something approximating its original properties. The tests documented in this paper demonstrate that the restoration of deteriorated wood can be accomplished by impregnating the damaged sections with Smith & Co.'s Professional Version Clear Penetrating Epoxy Sealer.

It is the opinion of the authors that the following guidelines or governing specification should apply to wood being treated with any wood restoration product, as a standard for the wood itself:

1. Restoration treatment must be correctly applied with a product appropriately formulated so that the impregnant can reach all microscopic rot channels.

2. The wood being treated must have a moisture content of less than 20% if full penetration is required. Moisture content above this limit will tend to deny full penetration. Open porosity will allow some penetration in any case. Site testing is required to define penetration percentages for moisture content above 20%. The foregoing is not a tested conclusion, but rather the opinion of the authors. It is included here because it is appropriate to do so.

3. If the treated wood has light damage that is largely contained in the summer growth areas, and if the undamaged portions of the member are adequate to carry loads defined in appropriate Building Codes for loading of the class in use for the portion of the member that is damaged, then the treated wood can be used for full loading.

4. If the damaged areas are primarily in the summer growth areas, and if the treated areas are required for structural loading, the members may be defined as structurally restored provided that full scale loading tests verify the loading capacity.

5. If the damaged wood has extended to winter growth areas but the wood is still intact and solid after treatment and is contained by solid or fully restored wood, the area may be strong enough to support bearing loads. Field testing should be performed to verify this.

6. If the wood has been heavily damaged with flaking or missing areas and if it is required for structural use, it should have additional treatment by techniques not covered in this paper. Alternatively, the wood should be replaced or supported by other means.

7. Appropriately treated wood of all classes can be assumed to be resistive to further rot damage. However, rot producing micro-organisms will continue to attack exposed wood if it is not protected from excess moisture.

8. The cedar shingle surrogate cannot possibly afford a conclusive test for the vast variety of field conditions. Therefore, any applications of this (or any) wood restoration technology in circumstances where the Uniform Building Code applies, should have a Special Inspection to oversee and sign off any applications.

5.2 FIELD PROCEDURE; APPLICATION TECHNIQUE

It is clear that if a restored piece of wood is a free-standing element painted for general weather protection and it serves no structural purpose whatsoever, then this impregnating product and its technology is perfectly adequate. It is also clear that if a large beam (6 x 12 for example) is eaten half way through by decay, then no amount of epoxy treatment can replace the 75% of beam strength lost. Somewhere in between the limits of "cosmetic restoration only" and "original wood remaining is adequate to carry any mechanical load" lies a region where this product and its technology have application validity.

Where any mechanical load is involved, the situation must be analyzed by an architect or structural engineer, since every piece of deteriorated wood is different. There can be no "hard-and-fast" rule as to which structural circumstances are appropriate for restoration and which are not. The analysis of structures and the calculation of stresses is the subject of an entire college education, and it is the firm position of the authors that any structural applications must be analyzed on a case-by-case basis by one professionally trained.

A limiting factor in the use of impregnants in buildings relates to application techniques. The material must be applied so that it effectively enters the rot-produced channels, and remains wet on the surface until the material reaches full penetration. Because of the complications of the many different building circumstances, and the fact that Smith & Co.'s Professional Version is capable of higher performance but is less tolerant of sloppy application technique than the commercial versions, it was decided by the manufacturer to limit its use to personnel trained in the use of this product.

As a logical consequence of all the foregoing, it follows that a standard application procedure for this product and this technology in the field would be:

a) calculate whether the remaining cross section of wood is sufficient to carry the applied mechanical load. If not, stop. If it is, got to step b).

b) apply the impregnating resin until by visual observation the rate of absorption has dropped to less than a tenth of the initial absorption rate. This is usually characterized by a gloss of free liquid standing on the surface instead of rapidly soaking in, or the virtual cessation of bubbles from immersed components.

c) allow the solvents to evaporate back out of the wood. This may take two weeks at 80°F for a 6 x 12; ten days at 80°F for a 4 x 12; five days at 80°F for a 2 x 12, assuming all the paint is removed from the wood. ***Much less time may be required.*** The actual solvent evaporation rate can easily be determined with the portable organic vapor detection units now commercially available.

d) any filling, painting or mechanical steps should follow routinely.

5.3 CONCLUSIONS

These qualified conclusions were determined by testing rot infested wood for penetration characteristics, observing the mechanical characteristics of treated cedar shingles, a surrogate for lightly rotted wood, and by a parallel analysis of field conditions at a heavy-timber structure (to be discussed in a separate paper). The results of a very specific treatment procedure showed a clearly defined improvement of the mechanical properties of the wood.

It is well documented that fungal decay of the cellulosic portion of wood happens first and most extensively before delignification and rapid loss of mechanical strength. The results of the tests clearly demonstrate that this early deterioration creates microscopic porosity in and between the cellulosic tubes of the summer growth rings which effectively allows penetration by the impregnant. Using a blue dye, the investigators found that the impregnant rapidly penetrates wood with this initial deterioration. In effect, the absorption of Smith & Co.'s Professional Version Clear Penetrating Epoxy Sealer was shown to be an indicator of the volume of rot present in the wood.

Macroscopic and microscopic photographs show that the penetration patterns of wood with this initial deterioration and prepared cedar shingle specimens are very similar. The use of cedar shingles was found to be an effective surrogate to represent deteriorated wood, and to measure the properties of products intended to restore deteriorated wood.

8.0 APPENDIX

these will be found on the following pages:

8.1 Test fixture description

8.2 Test specimen fabrication

8.3 Preparation of test specimens

8.4 Test specimen tip adapter

8.5 Test procedure

The mechanical test procedure is given in section 4.2. It is so simple that further description is deemed unnecessary.

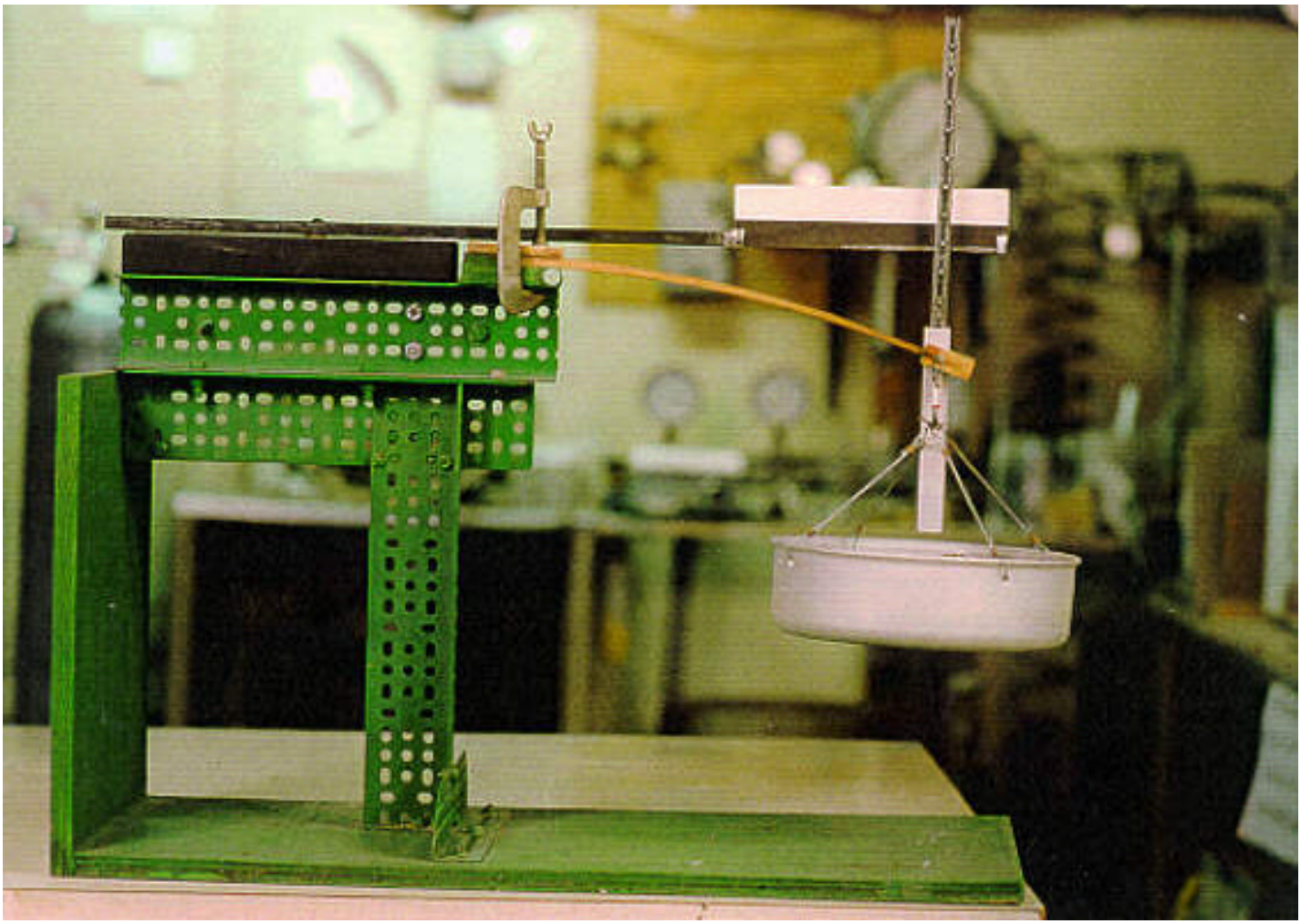
8.6 Product description from the manufacturer

8.7 To contact the authors

Appendix
Section 8.1
Test fixture description

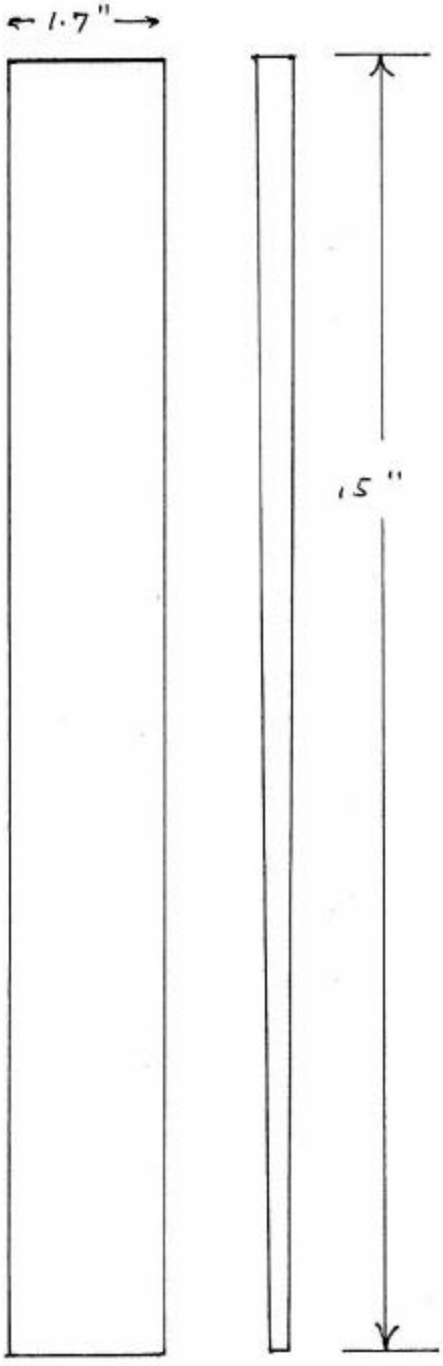
The design of the fixture is extremely simple. Construction materials of steel angle with holes (Dexion™) and plywood were used. A piece of ½" electrical conduit was used as a fulcrum, so that the cedar test specimens would have a radius somewhat larger than their thickness over which to bend. This turned out to be adequate, because only five of the 31 unimpregnated specimens and twelve of the 53 impregnated specimens failed at the fulcrum. This percentage (about 15-25%) was not deemed unusual considering the scatter of other data parameters for these wood specimens.

Weights were placed in a pan, the pan suspended from the steel pin in the tip fixture glued on each specimen, and a counterweighted ruler placed on one side of that steel pin. As the specimen bent further, the ruler could be read against a fixed black/white line behind the ruler. Deflection of the specimens could thus be recorded as a function of force applied. When the specimen failed the pan fell to the table top. A foam rubber cushion (not shown in the picture) was placed beneath the pan to reduce the noise.



Appendix
Section 8.2
Cedar shingle test specimens

Saw trim original shingle to remove .03" minimum.
Saw trimmed end to show clean wood.



Specimens to be stabilized at 50 % R.H. 15°C 48 Hr to daily weight gain/loss ≤ 0.15 grams.

Specimen weight = 40 grams ± 4 grams after saw trim.

Appendix
Section 8.3
Preparation of cedar shingle test specimens

1. Equilibrate1 week at 15°C, 50% R.H.

2. Trim ≥ .03″ off of wide end. Trim narrow end to 15″ length overall.

3. Cut test specimens 1.70″ wide.

4. Weigh to nearest 0.1 grams. Discard those weighing above 44.0 grams or below 36.0 grams. Stamp weight on wide end with 3/16″ metal stamps.

5. Place five specimens in a 1000 mL laboratory graduate. Place a 360 gram weight on top of the specimens.

6. Add impregnant to fully immerse.

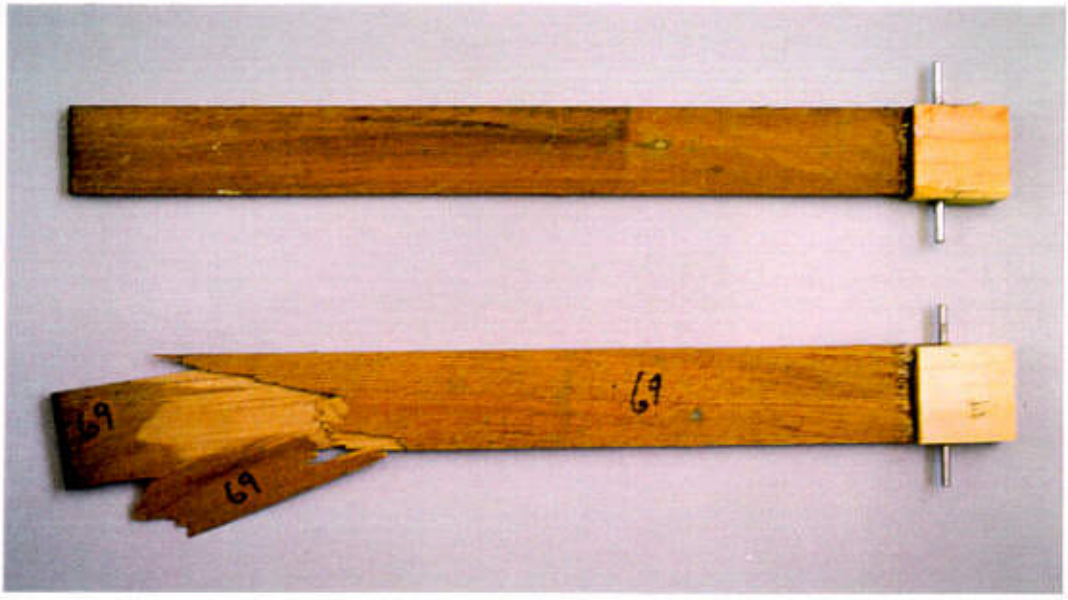
7. Allow specimens to remain immersed for 20 minutes.

8. Remove weight. Remove wet specimens and place on a 1/4″ wire cloth screen in a well ventilated area and allow to dry and cure for manufacturer's stated cure time, and until weight is constant within ± 0.1 grams.

9. Note final weight for each specimen.

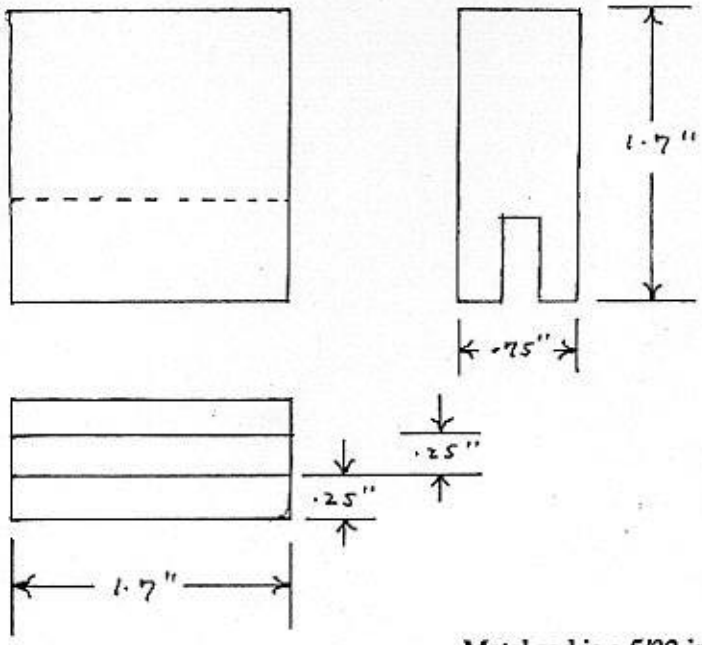
10. Affix tip fixture with Smith & Co. All Wood Glue™ or equivalent. Allow to cure at least 24 hrs at 15°C.

11. Place specimen in test fixture. Apply force and measure deflection in increments per test program. Test to failure in all cases.

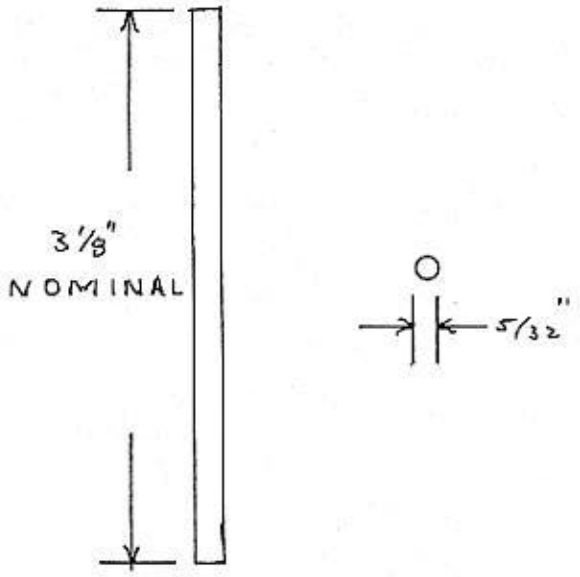


Appendix
Section 8.4
Test specimen tip adapter

Fabricate from Fir or other equivalent wood.



Metal rod is a 5/32 inch drill blank or equivalent.



8.6 Product description from the manufacturer

The Professional Version of Clear Penetrating Epoxy Sealer is designed to dissolve not only the saps and oils in the wood but also the natural water, and to keep the impregnating resin dissolved ("in solution") in the presence of those saps, oils and moisture of the wood. This permits the solvent-resin mix to efficiently penetrate the natural porosity of the wood. Fungi and bacteria produce an additional porosity that is especially penetrable by this product.

The resin system is formulated primarily with resins derived from wood and therefore the resin system is compatible with the chemistry of wood in a way that no other resin system is. The resin system is very hydrophobic to inhibit liquid water accumulation in impregnated regions while allowing (via the designed porosity remaining in the wood) the diffusion of water vapor through the impregnated region as well as the natural porosity of the wood. Wood impregnated with this system has a toughness and flexibility comparable to the original wood, because the resin system itself has a toughness and a flexibility comparable to the original wood.

When fungi and bacteria eat their way into wood, they destroy the material and create porosity on a gradient between the sound wood, the slightly porous wood with fungal spores in that region but the wood apparently sound, and then more obviously deteriorated wood, until at the extreme there is wood so porous and so obviously deteriorated you could stick your finger into it.

When wood is impregnated with this material, the penetration extends all the way through the zone of deteriorated wood containing bacterial and fungal spores, and on into any available porosity of the sound wood. This impregnation helps the wood resist further deterioration such as might be caused by fungi or bacteria.

Because the primary purpose of the product is not to kill fungi or bacteria or encapsulate fungal spores in epoxy, thus possibly stopping them from hatching, (even though it might do that) the Federal EPA and the California EPA (Environmental Protection Agency) do not allow such claims to be made unless the product is registered as a pesticide. Since the primary purpose of the product is the mechanical restoration of deteriorated wood, the product is not registered as a pesticide. Consequently no such claims are made by the manufacturer and others are discouraged from making such claims.

The sole claim for this product is that it can improve the physical properties of wood in some circumstances, and that it can help the wood resist further deterioration such as might be caused by fungi, bacteria, etc. Contributing to this claim is the fact that varnish, oil-base enamel paint and most latex paints stick better and last longer when applied to wood that has been treated first with Smith & Co. Clear Penetrating Epoxy Sealer. This has been a consistent observation by thousands of Smith & Co. customers, since 1972. Improving coating adhesion directly helps the wood resist decay.

The Professional Version of Clear Penetrating Epoxy Sealer and a compatible family of fillers are used by factory-trained technicians under the registered trademark LIGNU® to effect restoration of architectural structures. This trademark is owned by Steve Smith.

Regulatory matters

Under the California State Structural Pest Control Act, Business and Professions Code, Division 3, Chapter 14, Section 8510, this product is not a pesticide. It is not formulated to protect wood surfaces from deterioration caused by insects, fungi, etc. It is formulated to restore useful mechanical properties to wood and to improve the adhesion of paints or fillers to wood. Restoration work may be conducted under section 8556 of this act.

Restoration work may be conducted under Title 16 of the Professional and Vocational Regulations, division 19, Section 1991 (5).

When doing restoration work on older structures, one should ensure that the result has adequate ventilation, as specified in the 1991 Uniform Building Code, Section 2516 (c)6.

Under the National Volatile Organic Content Emission Standard for Architectural Coatings, 40 CFR 59, this product is classified as a Waterproofing Sealer. It meets the specified limit of 600 g/l VOC.

Local Air Quality Management Districts may have regulations which affect the use of this product.

8.7 The Authors

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