

APPENDIX "C"

CONSERVATION METHODOLOGY

Cleaning

Clean stones to remove biological growths, general soiling and dirt as required to complete the specified repairs to the stones. If the stone can be successfully treated without cleaning then cleaning is not required.

If cleaning is necessary the stone surfaces should be rinsed with a generous amount of water and brushed with a natural bristle brush. Repeat as necessary. If a stone has biological growth, it can be treated with an anti-biological solution. D2 Biological Solution (LimeWorks Products) is the recommended product for this application. D2 is a water soluble, non-toxic, anti-biological solution which does not react with the stone or leave soluble salts.

Removal of markers from the ground

Carefully dig on both sides of the marker without damaging or scraping the marker. If lifting equipment is required to lift the marker out of the hole, carefully place straps around marker so that the straps will not abrade or scratch the stone. For soft or friable stones such as deteriorated marble, stone should be consolidated before lifting straps are used. Store markers or component pieces of markers in a safe location. Cover markers when necessary to prevent damage or soiling.

Removal of failed repairs

Failed adhesives, mortars and pins require careful removal before proceeding with conservation treatment. Some temporary stabilization may be necessary as poorly attached fragments are disassembled. Stabilize all loose fragments of stone and friable areas of stone with tissue paper or cloth and Paraloid B-72 acrylate bitumen stone adhesive/stabilizer or water soluble adhesives or other means at the discretion of the conservator, prior to proceeding with any other treatments including removal and resetting of stones.

Removal of degraded structural resins may be particularly difficult and time-consuming.

Mechanical removal should be done with small hand tools, however, the cutting of pins and fasteners may require power tools. Ferrous metal pins are most often locked in place by corrosion expansion. Their removal is best done by careful drilling with a properly sized coring bit at low speeds and with water. Do not replace pins and fill voids with proper mortar fill material.

RESETTING

Eighteenth and early nineteenth century New England gravestones are typically stone tablets that were set directly in the ground. By the first half of the 19th century many headstones began to be set in bases. Stones were either mortared into slots or pinned to the base. In some cases older tablets were cut and reset with a base. Larger monuments are often made of several elements and can be both large and heavy. Specialized hoisting equipment is often required. Competent operation and structural engineering

considerations are required when performing this work.

Resetting in ground

Tilted stones set directly in the ground can be made plumb by careful excavation of the soil with hand tools, to permit re-setting in the proper position with good drainage. When excavating, all large stones should be removed as ice heaves can cause an underground stone to push on the gravestone. A typical tablet will have approximately 1/3 of its length buried in the ground. If there is not an adequate length of below grade material to support the marker a new cast concrete below grade base will be required.

Once the stone is carefully placed into the vertical position and at the proper depth, the stone is made plumb and level, and aligned with adjacent markers. Backfill with a mixture of coarse sand, pea gravel, and loam, wetted and compacted. Disturbed areas of the ground are re-graded with topsoil and seeded as required.

Some grave markers may be identified as fragments, or grave markers removed from the ground may turn out to be fragments of whole stones. The conservator should search for possible mates for all

fragments that are discovered lying on the ground or below grade. It is their responsibility to make every attempt to rejoin separated fragments.

Resetting on/in existing base

Unsecured stones in existing bases require re-setting. First, the base should be reset level and aligned with adjacent stones. Pins should be removed if present, then the stone can be re-set level and plumb in the existing slot. Re-set the stone in the slot with a full bed of modified lime (or hydraulic lime) mortar. Historically ratios of 1 part cement, 4 parts lime and 8 parts fine sand have been used with reasonable results. This mix is generally considered to be a soft mortar.

Some conservation recommendations have specified ratios as high as 3 parts cement, 2 parts lime and 8 parts sand. The increased cement and reduced lime content has the effect of increasing the strength and adhesion of the mortar. In theory this would tend to make the mortar last longer than the traditional mix. The negative aspect is that the higher cement ratio produces a harder joint which induces a compression stress on the stone as the stone swells with varying weather conditions.

Resetting into new cast concrete base

There are several situations where a new cast base will be required. Usually tablets which are broken near grade level or have been cut years earlier and set into bases that have failed are typical examples of when a new base is needed. Bases can be set above grade or below depending on the stone, aesthetics or other factors. Bases can be cast on site or pre-cast and set in place on a level bed of gravel and sand.

Cast concrete bases are typically made with a slot that is $\frac{1}{2}$ " wider and thicker than the stone and is recessed 3"-4". Depending on the size of the stone the base is usually 8"-12" deep, 8"-12" greater thickness and 6"-8" wider than the stone. Drainage holes in the cast base are required in order to remove moisture from the mortar pocket. This method is fine when resetting stones with a square bottom.

Some conservation specifications recommend squaring the bottom of the stone by cutting the stone with a saw. This should never be done as the use of power tools on old stones can cause damage to the stone. In addition valuable history including inscriptions and initial stone integrity will be lost. If the

bottom of the stone is not square a base with the same dimensions as above should be made but the slot should go completely through the base. This allows the excess stone to extend under the base level if needed and provides for better support. This also allows broken fragments, belonging to the stone, to be either attached to or buried beneath the stone. The stone would then be mortared into the base with a high lime mortar as described above.

Resetting of two and three part markers

Re-level lowest unit of multi-part markers using gravel and/or shim stones prior to setting

additional units on top. Depending on the existing conditions, provide six inches of gravel beneath the lowest unit if the existing is sitting on soil. Set units of two and three piece markers and monuments on full mortar beds. Use wood wedges placed in the joints to control thickness of setting beds. Do not use shims that will remain as part of the setting bed. Maintain existing joint thicknesses. Do not set historic markers in joint compound.

Compress setting mortar to a depth 2.5 times the joint height in order to prepare for the final pointing. Point joints using specified mortars. Use white mortar for white marble and tinted mortars for colored stones such as granite or sandstone. Tint the mortar to match the base color of the stone.

Extensions to slab markers that are too short to be reset

Stone extensions: Markers that are too short to be reset in the ground without covering the existing lettering and carvings can be extended with natural stone in the same manner that fragments of broken markers are reattached.

The new piece of stone must be of the same width and thickness as the original and from the same geological class of stone. i.e. marble with marble and slate with slate. The new piece of stone must be coped out to mate with existing piece of stone without removing any of the historic material that contains carving or lettering.

STRUCTURAL REATTACHMENTS

Broken stones to be bonded should be carefully cleaned and dry fitted to insure proper fit. The area around the stone should be probed for any missing pieces which may belong to the stone.

Traditional method of two part epoxy (Aboweld 55-22, Abatron) is the common way of bonding stones that require structural integrity. Epoxy is very strong, although it also is moisture insensitive. This has the effect of creating a moisture barrier at the repair joint. For marble and slate stones this can cause a

small amount of stone degradation over time due to the inability of the moisture to wick away from the area. Field observations have shown that failures usually occur adjacent to the repair joint which has been attributed to the strength of the epoxy being stronger than the marble. Closer observations have shown that the stone at the new break is usually degraded. Epoxy should be reserved for conditions where high shear forces are acting on the stone. Several factors such as angle of break, thickness of the stone, weight and bonding surface area need to be considered when deciding to use epoxy.

For most bonding applications, a non polymer, cement based restoration mortar (Jahn Restoration Mortars, Cathedral Stone) should be used. The specific bonding method should conform to the manufacturer's specifications for the specific stone and should be performed by a certified Jahn Products Technician. Bonding with restoration mortars is preferable since the mortars are permeable to moisture and allow the stones to breath. Over time the stone integrity is maintained and should last longer than the epoxy. Restoration mortars should be tinted to match the stone color and texture after cleaning. Tinting can be achieved through appropriate pigments (alkali stable oxides) which are available through Cathedral Stone or mason supply.

Reinforcement

The routine use of pins has been the traditional way of reinforcing broken stones. This method is in debate and controversial. The use of pins should be avoided except in some very extreme situations where it is unavoidable. Generally, the use of pins is to provide extra support to keep two pieces together. If the stone begins to lean and the adhesion joint fails between the stones, then the pins are carrying the full weight of the stone. The pin extends the moment arm which can cause a large blow out on the face of the stone next to the pin. **Do not replace pins.**

REPAIR MORTARS/ CRACK FILLERS

Pre consolidation/stabilization prior to treatments

The goal of pre-consolidation shall be to secure all loose, semi-detached or friable areas against loss during other conservation treatments including pointing and cleaning. Contractor will be held responsible for losses on the stone that take place during conservation treatments therefore the extent of pre-consolidation shall be that which is in the contractor's judgment sufficient to secure against losses. Submittal shall be for materials and methodology not extent of pre-consolidation.

Acrylic Resin B-72 dissolved in a solvent such as acetone approximately 5% solids shall be applied with a brush to areas requiring pre-consolidation. Japanese tissue paper shall be applied to wetted areas.

Additional solution of B-72 may be applied over tissue paper. Where conditions permit, water soluble adhesives may be substituted for B-72.

Removal of prior mortar fills and composite mortar repairs Pre-consolidation as described above shall precede all raking out of joints, removal of mortar caps and prior composite mortar or adhesive repairs. It is the conservator's responsibility to

pre-consolidate all loose and friable areas of stone prior to starting other treatments.

Surface tension and bond of prior repairs may be broken using power tools such as small diamond cutting wheels, Dremmel Tools and small pneumatic chisels. All other removal is to be performed by skilled craftsmen using hand tools. Use of hand held grinders or other power tools shall be only after demonstrated proficiency by each craftsman/conservation technician on selected control areas. Cutting wheel shall not be brought in proximity with stone surface or edges. Cutting wheels shall be used only to break the bonds to create entry points for hand tools. Every precaution shall be taken not to damage, nick, scar or abrade the stone.

Areas of missing stone can be filled using commercially available restoration mortars (Jahn Restoration Mortars, Cathedral Stone) tinted to match the stone. Tinting can be accomplished in the same way as described above in bonding mortars. Large cracks can also be filled using the same mortars. Mortar repairs should not be performed if there is a risk of freezing temperatures within two weeks after performing work.

Filling of delaminating stones

De-lamination occurs in many stones typically slate and sandstone. Repair of delaminated stones is designed to reattach the separated layers and prevent water penetration. The first step is to thoroughly clean the interior surfaces of the crack to remove debris. Depending on the nature of the crack, hand tools and compressed air can be used to clean out the area. Interior surfaces should then be wetted with water or a solution of water and isopropanol. For cracks larger than a 1/8" commercially available M40 flowable grout (Cathedral Stone) can also be used. For smaller cracks M32 is better suited due to smaller grain size. Grouts should be tinted to match the stone after cleaning. Flowable grouts should be applied using manufacturers recommendations.

Mortar fills and mortar caps –General

The goal of mortar fills and caps is to create the maximum water shedding fill, joint or seam for each particular configuration of stone. Surface of fill shall be tooled and slicked to conform to the contours of the edge of the stone in order to achieve maximum water shedding.

Mix mortar to specified proportions and in conformance with the color and texture of approved samples. Apply mortar to stone that has been properly prepared and is free of dirt, soiling and any loose or friable material or surface accretions that may have a detrimental effect on the bond. Wet stone must avoid excess absorption of moisture from mortar.

Apply mortar in consecutive lifts where required to avoid excessive shrinkage. Cure moist mortar for a minimum of seven days or until mortar is properly cured. When mortar has cured, tint the surface of the mortar with approved product.

Mortar application for fills and mortar caps

First layer must create a uniform depth for later applications and be thoroughly compacted into cavities. Apply mortar to a maximum thickness of $3/8"$. After voids have been filled to a uniform depth, apply remaining mortar in successive thick layers. Fully compact each layer and allow it to dry to thumbprint hardness before applying next layer. When the final layer is thumbprint hard, tool to match the approved sample. Avoid feather-edging of mortar joint.

If existing stonework has rounded edges from wear, recess slightly the mortar from face of stone surface. Immediately after completion, remove excess mortar by light brushing with a natural bristle brush. Do not leave encrusted matter.

Keep mortar damp for 48 hours after pointing to permit proper hardening of mortar. Cover masonry temporarily with burlap, which must be moistened periodically. Temporarily cover wall with plastic sheets to prevent evaporation. Continue to moisten for up to seven (7) days, if required due to high temperatures or high winds. Protect mortar from overnight rain. For proprietary mortars; follow manufacturer's directions for applying and curing mortars.

Cleaning after mortar fills or patching or grouting

The face of all stonework shall be thoroughly cleaned after completion of the pointing and other work liable to soil the stone. The stonework shall be gone over and any mortar splashes or smears shall be carefully removed from the surface with scrapers.

The cleaning shall be done with clean water applied vigorously with natural bristle brushes. After cleaning with brushes the stone shall be thoroughly rinsed with clear water. Proprietary cleaning compounds containing caustic agents, intended for removing mortar smears shall not be used. The goal is to remove all smears before they set so that caustic agents are not required.

Reattachment of small fragments

Small stone fragments or friable areas are typically reattached with a solution of Acryloid B-72 in solution of acetone. This method is mainly for non structural applications where a zero thickness bonding joint is desired. Care should be taken as the B-72 forms moisture impermeable layers at the joint similar to epoxy. Depending on the geometry of the break it is possible to create a moisture trap which can cause deterioration over time. Clean all excess B-72 from the stone surface with acetone.

Consolidation of friable stone

Consolidation should be performed before any other treatments are done. Consolidation should be performed using Conservaire OH100 (Prosoco) following manufacturers specifications for proper application. OH100 should be applied a minimum of 6 applications to promote deep penetration. Failure to perform this task can cause a hard skin to form and cause a layer of stone to delaminate. OH100 binds the grains of the stone without filling the voids between the grains. This allows the stone to continue to breath and expel water from the interior of the stone. Any stone that is consolidated should not have further conservation work for 30 days to allow all the solvent

to evaporate. Structural bonding applications will be degraded if there is solvent still present at the adhesive joint.

MATERIALS

Comply with referenced standards and other requirements indicated applicable to each type of material required. Reference in the specifications to materials by trade name is to establish a standard

of quality. It is not intended to exclude other manufacturers whose materials are, in the judgment of the project manager with the conservator and based on sample panels, equivalent to those named.

Materials for cleaning and removing soiling prior to repairs

Water, all water should be clean portable water.

Detergents or soap, should be Vulpex soap from Talas, 568 Broadway, New York, NY 10012 (212)219-0770 or Orvus WA Paste also available from Talas.

Biological growths should be treated with D-2 available from LimeWorks.us (215)536-6706 or Revive from Prosoco.com or approved equal.

Materials for flushing cracks and fissures prior to adhesive or infill

Clean water or solvents such as Acetone or Ethanol D6 Anhydrous.

Materials for stabilization of loose fragments prior to removal or other treatments

Paraloid acrylic resin B-72 and Japanese tissue paper or fine cloth such as silk Crepeline applied to the surface of the friable or loose stone. B-72 should be dissolved in solvent such as acetone and the percentage of solids to solvent to be field tested. B-72 is available from Talas, 330 Morgan Ave, Brooklyn, NY 11211 (212) 219-0770 www.talasonline.com or other conservation supply companies.

Material for non-structural repairs and laying down stone flakes

Paraloid acrylic resin B-72 (100%) dissolved in solvent such as acetone and the percentage of solids to solvent to be field tested. Tubes of 10% paraloid B-72 in acetone can be obtained from Talas, 330 Morgan Ave, Brooklyn, NY 11211 (212) 219-0770 www.talasonline.com or other conservation supply companies.

Material for adhesive structural repairs

Exterior grade flowable and paste epoxies that are moisture tolerant and specifically manufactured for the structural repair of stone and masonry. Akemi Akepox 2000, 2010, 2030,

5000, and 5010 available from Akemi North America, Stone Boss Industries, 26-04 Borough Place, Woodside, NY 11377 (718)278-2677 or approved equal.

Material for mortar fills, rebuilding areas of loss and caps

Composite repair mortars should be non-polymer modified composite repair mortar specifically for slate, sandstone or marble and should be used for fills, rebuilding areas of loss and capping delaminating stones. These can be obtained from Cathedral Stone Products, 8332 Bristol Court, #107, Jessup, Maryland 20794 (800)6840901 and www.limeworks.us (215)536-6706.

For smaller voids use Acryloid B-72 dissolved in solvent. Concentrations will vary depending on the depth and width of the crack or void to be filled. Large voids to be filled with B-72 bulked with an inert material such as fine grain stone material. Exact proportions to be determined by the conservator in the field based on the size of the area to be filled and other requirements such as ability of the mix to flow evenly through the area.

Replacement stone (for extending broken stones)

1. Marble: Vermont Marble available from Vermont Quarries, 88 Church Street, Rutland, Vermont 05701, (802) 775-1065 or approved equal.

2. Slate: New or Salvaged slate to match color and texture of historic material. Portland Munson Slate available from Sheldon Slate Products, 38 Farm Quarry Road, Monson, ME 04464, (207)-997-3615, or approved equal.

Soil materials

1. Structural Fill: Provide gravel, sandy gravel, or gravelly sand free from organic material; foam, trash, snow, ice, frozen soil and other objectionable materials and well graded within the following limits:

Sieve Size Passing Through

6 inches

No.4

No. 40

No. 200

Percent Finer by Weight

100

30-90

10-50

0-8

2. Crushed Stone: Provide clean, washed crushed stone free of fine materials and graded within the following limits:

Sieve Size Passing Through

6 inches

3/4 inch

1/2 inch

No. 4

No. 40

No. 200

23

Percent Finer by Weight

100

90-100

20-30

0-5

0-5

0-5