Edison Coatings, Inc.

GUIDE TO THE REPAIR OF NATURAL BUILDING STONE

Once considered unreliable and temporary in nature, composite repair systems for stone have become a mainstream component in Historic Restoration work. This evolution can be attributed to the development of effective, high quality specialty materials designed specifically for long-term compatibility with stone substrates.

With a history of more than 25 years of successful performance on thousands of architectural stone restoration projects, Edison Coatings offers the most complete, time-proven, compatible stone restoration systems. Edison's custom formulation capabilities provide the highest level of match and finish.

A completely integrated system, Edison's products include the following specialty materials designed specifically for use in stone restoration:

- **CONSOLIDATION:** ***System 95 Strengthener***
- **COMPOSITE PATCHING MORTARS:** ***Custom System 45***
- **CASTING MORTAR:** ***Custom System 45 w/ RL-2 Restoration Latex***
- **RE-PROFILING MORTAR:** ***Thin-Fill 55***
- **BONDING ADHESIVES:** ***Flexi-Weld 520T, Flexi-Fill 530***
- **CRACK REPAIR RESINS & GROUTS:** ***Flexi-Seal 510, Flexi-Weld 520, Flexi-Fill 530, PUMP-X 53-Series, Rosendale 11G***
- **REPOINTING & REBUILDING MORTARS:** ***Spec Joint 46, Rosendale 12M***
- **BREATHABLE COATINGS & STAINS:** ***EXPO 43, System 90-W-Color, Aquathane UA210, EverKote 300, Elastowall 351, ElastoTone 353***
- **AGING & DETAIL REPLICATION:** ***System 90-W-Color "Liquid Dirt", AquaSpex 220***

PHOTO: 25 years after repair with over 16,000 pounds of Custom System 45 Type SD, this 1855 historic sandstone building remains a testimonial to the product's long-term durability and compatibility.

The following is a brief guide to stone repair system options and preliminary selection criteria. Proper investigation and correction of the causes underlying the observed deterioration is prerequisite to repair, and repair plans and must consider the effects of sequencing on final results.

1: CONSOLIDATION

On substrates exhibiting limited cohesive integrity, application of an ethyl silicate stone strengthener can often stabilize marginal stone and reduce quantities of repair required. ***System 95*** consolidant can be applied either before or after repairs. Laboratory pre-testing is strongly recommended prior to application, however, as ethyl silicate performance varies based on the composition and condition of the substrate, and it may not be suitable for all applications.

2 : DEEP REPAIR

After proper surface preparation, repairs to spalls greater than 1/8" (3 mm) in depth are best achieved using ***Custom System 45.*** A two component cementitious system, ***Custom System 45*** provides higher bond strength, lower shrinkage and more efficient stress relief than competitive systems. This allows installation of large and deep repairs without cracking, extended curing regimens or distress to historic substrates.

Custom System 45 is produced in six different Natural Stone base formulations. Coefficient of thermal expansion is matched to each substrate to assure long term thermal compatibility with host stone, even in areas subject to rapid, wide swings in ambient temperatures.

TYPE	SUBSTRATE
BL	Bluestone
GR	Granite
LC	Limestone, Calcareous Cast Stone
MR	Marble
SD	Sandstone, Brownstone
SL	Slate

PHOTO: This entire brownstone façade was recreated by hand-carving Custom System 45 with Restoration Latex RL-1. The photograph was taken 10 years after restoration.

The standard liquid component is ***Restoration Latex RL-1*** which allows non-sag application for vertical and overhanging repairs. In cases involving very large and deep areas of loss, ***Restoration Latex RL-2*** (Superplasticized) may be used with ***Custom System 45*** to form and pour repairs in place or to cast replacement elements. ***Restoration Latex RL-3*** (Marine Grade) may be used for repairs subject to high constant moisture exposure, such as fountains and planters. In cases requiring exceptional levels of moisture and vapor permeability, such as retaining walls, ruins and other open structures ***Restoration Latex RL-4*** (Air Entraining) may be used to accommodate negative-side moisture and moisture vapor. For hot weather work at temperatures from 90 to 120^{0}F, ***Restoration Latex RL-5*** may be used to extend working times. For cold weather work at temperatures near the 50-degree minimum required for good color control, ***Restoration Latex RL-6*** can accelerate setting time.

GRADE	DESCRIPTION	RECOMMENDED USES
RL-1	Non-Sag Grade	General Use: Vertical, Horizontal and Overhanging Repairs
RL-2	Superplasticized	Castings and Poured Repairs
RL-3	Marine/Immersion	Fountains, Planters, High Constant Moisture
RL-4	High Permeability	Retaining walls, Ruined Masonry, for Highest Permeability Repairs
RL-5	High Temperature	For Repairs under Hot Weather Conditions up to 120^{0}F (50^{0}C)
RL-6	Low Temperature	For repairs in cold weather down to 40-50^{0}F (4-10^{0}C)

3: POLISHED STONE REPROFILING

As marble weathers it may "sugar" or erode and roughen. Granite may develop thin spalls, in which a section of surface delaminates from an otherwise sound stone element. Typically, spall thickness may be 1/8" or less (3 mm).

Unobtrusive, smooth repairs in depths up to ¼" (6 mm) are achieved by using ***Thin-Fill 55*** Reprofiling Mortar. There is no ***minimum*** depth and the mortar is designed for easy sanding or polishing to achieve perfectly smooth surfaces, when required to replicate existing polished stone profiles. The product is also easily tooled after initial set to produce fluted profiles, when required to match existing stone.

A cementitious mortar with low coefficient of thermal expansion, high bond strength, low Modulus for efficient stress relief and positive moisture and moisture vapor permeability, ***Thin Fill 55*** facilitates achievement of excellent aesthetic finishes for

repairs to smooth architectural stone. It is fully compatible with ***Custom System 45***, and may be applied over deeper patches to achieve special surface finishes when required.

Thin Fill 55 is frequently matched to the predominant color of the existing stone, to facilitate subsequent special finish application.

4: CRACK REPAIR

A variety of potential causes of cracking in stone mandates that a variety of repair alternatives be available. Crack repair material selections and methods are best specified by a design professional experienced in the properties, assembly details and deterioration mechanisms of stone. Crack width monitoring can assist in determining the movement capacity required, if any, for the repair system.

The following systems are used in the repair of cracks in stone:

▸ ***Custom System 45*** or ***Thin Fill 55*** are often used to repair cracks determined to be stationery, or non-working. The crack is typically grooved out to approximately 1/4" width x ½" depth, and is then filled with a matching ***Custom 45*** or ***Thin Fill 55*** repair mortar.

PHOTOS: Color-matched Flexi-Fill 530 was used for crack repair to this marble on the South Carolina State House.

▸ ***Flexi-Fill 530,*** a 2-component flexibilized acrylate epoxy paste filler allows less invasive repairs with higher tensile strength and elongation, for cracks exhibiting some limited movement. A Dremel tool may be used to slightly open the face of the crack to a nominal 1/16" x ¼"depth, and the narrow opening is then filled with the color-matched ***Flexi-Fill 530*** paste grade filler. At initial cure stage (typically 30 – 90 minutes) the product cures to a soft rubber which is easily trimmed with a razor or utility knife..

▸ ***Pump-X53-Series*** cement and lime-based injection mortars are also used in certain repair situations as they are more compatible than epoxy resins and can be used to fill voids and cracks without risk of staining the stone. A variety of grades is available, including ***Pump-X53 Grout*** for filling large voids and cracks (>1/4"), ***Pump-X53i Microinjection Grout*** for fine cracks down to 1/16" (1.5 mm), ***Pump-X53iE Expanding Microinjection Grout*** for filling cracks where slight grout expansion is desired (+2%) and ***Pump-X53iL Hydraulic Lime Injection Grout*** where a softer, self-healing grout is desired.

▸ ***Rosendale 11G*** natural cement-based grouts are used in historic masonry buildings and structures originally built with natural cement. Natural cement was the predominant hydraulic binder used in the United States and Canada in the 19th Century. Use of natural cement injection grouts assures compatibility with original binders and provides the benefits of the unique combination of high bond strength/low modulus associated with Rosendale natural cement.

▸ ***Flexi-Seal 510*** flexible epoxy and ***Flexi-Weld 520*** semi-rigid epoxy are used where the deepest penetration and highest tensile bond strengths are required.

5: REBONDING MASONRY UNITS

Fractured stone elements can often be salvaged and repaired rather than replaced. The use of ***Flexi-Weld 520T*** masonry adhesive permits cleanly broken pieces to be quickly and cleanly rebonded, without creating a gap between the broken surfaces. When a narrow gap between the pieces must be filled by the adhesive, ***Flexi-Fill 530*** is used. Both adhesives are available in custom color-matched formulations, often used in cases where a "glue line" may remain visible.

Both two component, 100% solids acrylate-epoxy adhesives can be used under a wide range of temperatures to quickly grab and re-bond all types of broken masonry elements. ***Flexi-Weld 520T*** can also be used to affix metal anchors and for bonding Dutchman repairs using small sections of new stone.

PHOTOS: Stone column base, before and after rebonding with Flexi-Weld 520T.

6: MASONRY COATINGS

Polished Stone

Once repairs have been made and surface profiles restored, specialty coatings are sometimes used to replicate the reflectance and depth of the original finish of polished hard stones like marble and granite.

▸ ***Aquathane UA210 Type E*** clear coats may be used to provide gloss and depth of finish. It is a highly durable waterborne aliphatic polyurethane capable of withstanding decades of weathering with minimal effect. It is generally combined with ***Type G Bonding Additive*** to assure tenacious adhesion to smooth, non-porous existing surfaces.

Color Finishes

Breathable masonry coatings and stains are often used to blend mismatched previous repairs, to unify texture and/or color, to provide details and highlights, and to protect repaired stone from weathering.

▸ ***Elastowall 351*** and ***ElastoTone 353*** are internally plasticized 100% acrylic coatings which have been used for decades to both provide an aesthetic matte finish and to aid in exclusion of water from stone exhibiting small working cracks. They are favored by some Conservators for their high rates of moisture vapor transmission, their ability to bond to less aggressively prepared surfaces and to a wide variety of existing materials, and their ability to be removed/reversed if so desired at some later date. Both products are formulated with the same basic chemistry, with ***Elastowall 351*** providing higher film build and greater crack-bridging capabilities than ***ElastoTone 353.***

▸ ***EverKote 300*** is an inorganic potassium silicate based mineral coating system which provides a hard, natural surface with exceptional permeability and durability. It is a reactive treatment which should be considered permanent, and must be applied to bare masonry, stone or metal surfaces only. It is available in two grades: ***Patinar*** coating and ***Penetral*** stains.

The above products are available in over 900 standard colors. Fan decks are available upon request. Custom color matching service is also available from Edison Coatings, Inc.

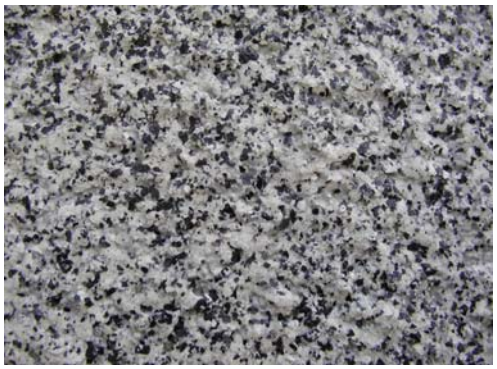
PHOTO: This previously-painted 375,000 sq. ft. historic landmark limestone facade was coated with Elastowall 351 in 1988.

▸ ***EXPO 43*** is a two component cement-based coating which can be used in conjunction with ***Custom System 45*** to impart texture and color to stone and masonry surfaces. It is available in colors

to match ***Custom System 45*** stone patches, and is a useful adjunct for large-scale repair projects.

7: DETAIL REPLICATION

A particular challenge in stone restoration work is the replication of special details frequently found in multi-colored, coarse-grained granites. These special finishes can often be recreated using ***AquaSpex 220*** special effects coatings. ***AquaSpex 220*** incorporates color-matched flakes in a clear binder, permitting close control of speckle color, density and size.



AquaSpex 220, incorporating 1500 micron Charcoal Grey, Black and White flakes, provides a final finish to repaired granite which closely matches the original material.

With less aggressive cleaning methods often being adopted in order to reduce cleaning-related surface damages, new patches which are uniform in color may appear too clean to properly match adjacent surfaces. To better blend patches with weathered stone, a semi-transparent ***System 90-W-Color*** stain can be selectively applied. Often, the color of the stain may be matched to natural dirt deposits, providing a means of instantly weathering or aging the new repairs. In such applications, the product is popularly referred to as ***"Liquid Dirt"*.**

8: REPOINTING

Repointing may be done at various points in the work sequence, depending on the overall scope. Generally, repointing is best undertaken with mortars of the same composition as the original mortar, provided that the original mortar performed well. Petrographic analysis is required to determine composition of original mortars.

For most 20th Century buildings, original mortars were based on portland cement (ASTM C150), either in combination with lime (ASTM C207) or in a proprietary blend as masonry cement (ASTM C91). ASTM C270 specifies masonry mortars based on portland cement, and ***Spec JOINT 46*** is offered in each of the various types included in the specification (M, S, N, O and K) in order to meet specification requirements.

In the 19th Century, natural cement (ASTM C10) was the predominant hydraulic binder used in masonry mortars. ***Rosendale 12M*** is a series of authentic natural cement-based mortars, as used in the construction of thousands of 19th Century buildings and structures. Unlike portland-based mortars, which tend to embrittle with age and may require 100% repointing after 50-75 years of service, natural cement mortars may have an unlimited life span. Only damaged mortars need to be removed and repointing is then undertaken on a localized basis.

PHOTO: 150-year old natural cement mortar remains in good condition despite severe coastal exposures.

Prior to the rise of cementitious mortars, lime mortar was the predominant technology. While European tradition included use of lime putty that was slaked and then aged for prolonged periods of time, differences in natural limestone deposits in the US led to different practices for using lime mortars. Because North American lime is most often dolomitic (high in magnesium carbonate) as opposed to high-calcium European limes, American lime has better water retention immediately after slaking and does not require aging in putty form. Many American lime mortars were simply "hot-mixed", or slaked in a mixture with sand, and then were used almost immediately. ***Spec Joint 46 Type L*** dolomitic lime mortars provide ready-to-use historic mortar compatible with traditional American practices.

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