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Standard Guide for Assessment and Maintenance of Exterior Dimension Stone Masonry Walls and Facades[1]

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1. Scope

1.1 This guide outlines how to visually assess exterior stone masonry walls and facades to determine their general condition. Examining key features of the construction can help identify and diagnose problems which require repairs or corrective action. Such an examination can expose conditions which may be addressed with maintenance and minor repairs, or may require expert assistance. This guide is not intended to be used for buildings requiring major exterior rehabilitation or structural repairs.

1.1.1 This guide applies to walls of solid stone or dimension stone used as a cladding. Stone cladding is typically connected to a backup material with a variety of anchoring methods, including traditional hand-set masonry anchors such as straps, dowels, cramps, hook-and-eyes, dove-tails, wire ties, and the like. Joints between stones in these types of buildings are usually filled with mortar or sealant. Sealant-filled joints are usually designed to accommodate structural and thermal movements.

1.2 This guide specifically excludes dimension stone used in interior building surfaces, flooring or paving, slate dimension stone used as roofing. Though they share some similar assessment and maintenance concerns, thin stone (less than 2 inches nominal thickness) exterior cladding, and stone cladding attached to metal flames are also excluded due to their unique design characteristics and performance requirements. Although procedures and cautions listed herein may apply to walls and facades containing semi-dimension, or partially sized, stone in the form of split-face, or rubble and to stone-facade concrete panels, the guide is not specifically directed to such stone use. It does not address removal of small-area stains.

2. Referenced Documents

2.1 *ASTM Standards:*

C 119 Terminology Relating to Dimension Stone[2]

3. Terminology

3.1 Terms used in this guide are defined in Terminology C 119.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *crack monitor*—any of the several two-part devices that can be attached to stone masonry in such a way that they can span cracks in order to periodically measure changes in crack width thereby indicating movement.

3.2.2 *dutchman*—repair used to patch stone masonry with a section of new stone. The damaged area within a particular stone element is removed. The remaining void is trimmed to a regular shape. A new piece of stone, or "dutchman," is cut from matching stone cut slightly smaller than the area to be filled. It is installed using dowels or some other mechanical attachment, then adhered, or mortared into place.

3.2.3 *exfoliation*—deterioration or loss of stone in the form of flakes, scales, and layers.

3.2.4 *professional assistance*—independent opinions and recommendations provided by persons having expertise in the assessment and repair of stone masonry. Such professionals may include independent consultants such as architects, engineers, material scientists such as mineralogist or geologists, or stone masonry contractors.

3.2.5 *thick*—stones with a nominal bed-depth of 2 in. (5 cm.) or more.

4. Significance and Use

4.1 This guide attempts to provide information to assist building owners and managers with limited knowledge of stone construction to recognize basic problems with performance of facades, and to keep them in good condition through periodic inspections and maintenance. Increased awareness of the behavior of stone masonry facades and associated materials can reduce maintenance and replacement costs by addressing problems and deterioration early.

4.2 The objective of all maintenance should be to limit deterioration through early intervention. When it appears damage to stone support elements has occurred, professionals should be consulted to evaluate the support conditions, as well

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

as recommend methods to restore the building's integrity and preserve public safety.

5. Introduction

5.1 An effective maintenance program for exterior stone masonry should incorporate preventive maintenance among its key elements. Early attention to problems, and simple measures to remedy them, will often avoid costly renovation later. This guide is intended to help interested personnel locate such problem areas, better understand potential causes of stone deterioration, and identify appropriate corrective measures for the observed deficiencies.

5.2 Maintenance supervisors should understand how their building is constructed to apply this guide and better maintain their buildings. Employing a professional to assist them in interpreting pertinent drawings and documents, and initially inspecting conditions should help them become effective observers of stone performance.

5.3 This guide lists many typical problems that can affect stone masonry, facades. It describes likely causes, and discusses common repair methods. All initial attempts at repairs should be done under the observation of a professional to ensure the use of proper materials and techniques.

5.4 Personnel responsible for stone facade maintenance should be familiar with the systems used in the construction of their buildings on at least an elementary level. Prior to inspections, they should be briefed by personnel knowledgeable about the building and its construction, particularly the stone wall system. This background should help in determining when the engagement of a professional should be considered.

6. Guidelines for Inspections

6.1 *Schedule Inspections*—Schedule and perform semi-annual inspections of stone wall elements. Inspect all elevations of the building. A walk-around visual survey with a camera and binoculars should be a minimum procedure. Use adjacent buildings' roofs and windows to gain same-level access, to examine building facades and associated elements. Use building windows and set-backs where possible for additional vantage points. If the available access is not sufficient to perform the inspections, then consider methods, as outlined in 6.3. Photograph any observed distress or problem areas for later reference in determining appropriate repairs.

6.2 *Condition Documentation/Monitoring*—Keep accurate and cumulative records of inspection findings. Buildings constructed of thick dimension stone with mortar or sealant-filled joints react slowly to environmental forces. Knowledge of the timing of a condition's onset and understanding its progress aid in assessing the distressed condition. Monitor critical or deteriorated areas between scheduled inspections. Use measurements or crack monitors to measure changes in cracks, increasing lippage between stones (stones projecting or retreating in plane from the adjacent stones), or other changes and displacements in stone position. Well-kept records will aid in the diagnosis of the specific causes of the conditions observed, should more experienced professionals be required.

6.3 *Tall Buildings*—Inspections of buildings with heights that exceed those readily observable with binoculars, or with limited vantage points require more detailed planning. It will be necessary to view representative areas of the facades from suspended or fixed scaffolding, mobile work platforms, or personnel lifts to adequately observe existing conditions.

7. Procedure for Evaluation of Stone Conditions

7.1 At a minimum, the following procedure should be used as a guide to decide an appropriate course of action for observed deficiencies as part of an inspection and maintenance program for stone masonry facades.

7.1.1 Identify and document the defects.

7.1.2 Note the extent of the defects, patterns or concentrations of distress.

7.1.3 Postulate the likely causes.

7.1.4 Perform necessary maintenance or obtain assistance with repairs:

7.1.4.1 If the condition is stable and does not appear to be progressive, perform appropriate maintenance, and simple or temporary repairs.

7.1.4.2 If the cause is not apparent, and the condition appears stable and not progressive, monitor the condition and consult with professionals to determine the cause and appropriate repairs.

7.1.4.3 If the observed conditions are considered dangerous or progressive, obtain professional assistance immediately.

8. Maintenance

8.1 *Routine Maintenance*—Many problems can begin or worsen due to neglect of routine maintenance. Stone masonry itself, when used in an exterior application, requires periodic joint repairs, such as sealant replacement, tuck pointing, and cleaning. Stone facade components can also be affected by a lack of maintenance of other building systems, such as roofs, parapets, windows, and flashing.

8.2 *Cleaning*—Regular cleaning is also critical to the long term durability of natural stone facades, as well as their appearance. Cleaning methods should be selected that do not damage the stone. Cleaning methods and materials should be first tested, from the least to the most aggressive, to determine the mildest treatment that provides satisfactory results. Prior to implementing a cleaning technique building-wide, test areas should be cleaned using the proposed methods. The areas should be evaluated for a minimum period of six weeks to assess the results. Improper selection of cleaning chemicals and procedures will produce unsightly and irreversible damage to the appearance, and potentially the structural integrity, of the stone facade components.

9. Areas of Focus for Inspection

9.1 *Moisture or Water Staining*—Look for signs of moisture entrance on interior and exterior surfaces, as well as throughout the stone wall system. Water penetration can lead not only to deterioration of interior finishes, but also to stone and joint material degradation and corrosion of anchor system components if the water is trapped behind or within the wall or facade system for prolonged periods. Water absorbed into stone and joint materials can cause dimensional changes, potentially reducing clearances and creating stress concentrations. Trapped water can freeze and expand, causing the stone to

weaken, and eventually spall or crack. Joint materials may also deteriorate as a result.

9.1.1 Water can also carry minerals, chemicals, or other contaminants that can be deposited on or within the stone and joints, causing discoloration, staining, or deterioration.

9.1.2 Wetness, staining, or darkening may be due to trapped moisture. Discoloration or deposition of efflorescence (a powdery white or gray accretion on stone faces) may also be evidence of moisture entry, or "rising damp." Rising damp is a condition in which the stones appear darker due to water wicking into the stone by capillary action from a water source along one or more edges of the stone, such as at the base of a building.

9.2 *Joints*—Every inspection should include a review of each joint between stones. Document anomalous and suspect conditions photographically, especially in areas of accelerated deterioration. Where a problem is suspected, it is useful to compare photographs taken at various times to establish the progression and rate of deterioration.

9.2.1 Look for missing mortar and sealant, for cracks in mortar, for partings between mortar or sealant and the stone, for non-uniform joint sizes due to tight, closed or opening joints, and for lipped stones. Connections between stones and non-stone materials such as windows and other openings are often particularly susceptible to racking and eccentric movement. Check for plugged weep holes throughout the wall system. Compare the width of expansion, control, and construction joints. Look for wider or narrower tops and bottoms of such joints.

9.3 *Stone*—Cracks and spalled areas at or near joints may indicate excessive compression loading, anchor failure, and environmental deterioration, among other things. Misalignment of stone across a series of joints may indicate local or structural building movements.

9.3.1 Surface deterioration may take the form of exfoliation (where the surface is lost in thin layers), spalling, powdering, or chipping. These conditions can be particularly prevalent where chloride-based de-icing products used on paving systems aggravate the effects of freeze-thaw cycling Both calcium chloride ($CaCl_2$) and sodium chloride (NaCl) are commonly used. Both will cause damage to stone surfaces.

9.4 *Facades*—Sight along walls for bulging areas, particularly in those containing smaller stones. Look for areas of different, or changing, colors. Compare colors before and after rains; a continuing damp appearance for some time after a rain may suggest a leak. Cracks across stones, or diagonally along mortar joints, may suggest unaccommodated expansion and contraction or structural movements.

9.5 *Unique Details and Fenestration of the Building*—Look particularly at parapets, copings, building returns and corners, and projecting or corbeled courses, for dampness and misalignment. Check all facades at their bases for the appearance of rising damp. Compare the appearance of joints and stones at and near openings. Due to the typical uniqueness of their installation, soffit stones deserve special attention to their alignment, color retention, and joint conditions.

9.6 *Building Components Not Fabricated from Stone*—Many problems on buildings occur in the roof/parapet areas, near openings, and at grade. Look carefully at the inside surfaces of parapets; check the flashing and counter-flashing; the cant-strip and blocking; the mortar of masonry, back-up or under the coping; the coping head joints; expansion joints; and the roof membrane. Inspect roof valleys, particularly at their ends, where they terminate into drams and down spouts. Check for functioning dram leaders and down spouts. Also note any cracks and open joints at and near windows and doors.

10. Common Problems and Typically Recommended Repairs

10.1 The following section lists a number of common problems that can occur with exterior stone wall construction which can be identified and addressed, at least in early stages, by a maintenance staff with some specific training. The conditions are listed from least to most serious. Table 1 is a brief summary of common stone problems, their repairs, and the consequences of delaying corrective action. However, complex distressed conditions and advanced stages of any stone masonry problem may need the attention of experienced professionals.

10.1.1 *Rising Damp*—Stone masonry at or extending below grade, will absorb moisture from its surrounding environment, transfer that moisture upwards, and release it at evaporative surfaces. Any chemicals or minerals dissolved in the water will remain within the stone during this process.

10.1.1.1 Water repellents and clear sealers are sometimes inappropriately recommended to limit water entry into the stone. Application of a sealer above grade will usually not prevent water entry, but will serve to reduce the ability, of the water to evaporate from the stone elements. A more appropriate repair would be to expose the below-grade stone areas, allow them to dry. out, and apply damp proofing before recovering the stone. Where this stone condition exists adjacent to concrete at grade, professional help is recommended. Where rising damp occurs, especially in frost zones. surface loss in the form of chips or exfoliation may also occur due to freezing of the trapped water or accumulation of water-borne crystalline minerals within the body of the stone. This condition can ultimately cause structural damage.

10.1.2 *Mortar Distress*—Minor cracks and hairline partings in mortar joints can often be repaired successfully by tuck pointing. Deteriorated mortar should be completely removed from the joint to an appropriate depth given the joint conditions. The new mortar is then installed in lifts or layers, to achieve good and complete compaction. Missing mortar sections can be replaced in similar fashion, and the mortar must be placed so that it does not fall into the cavity behind the stone. Stone edges should be masked for protection against mortar smears.

10.1.2.1 Cracked mortar joints and missing mortar allows increased amounts of water into the exterior wall system and potentially into the building interior. This condition should receive prompt attention and repair to prevent further damage to the stone as well as interior finishes. Monitor repaired areas carefully.

10.1.3 *Surface Loss*—Sanding and dusting of stone surfaces may be evidence of crystal growth, breakdown of natural stone

TABLE 1 Summary of Common Stone Distress and Repairs

Stone Problem	Common Minor Repair Or Maintenance	Consequence To Delaying Repairs
Cracked/missing mortar, separations between mortar and stone.	Monitor joints for continued movement. Remove mortar in joints to a minimum depth of 2 times the joint width. Tuck point the cracks with mortar compatible to the original material.	Cracks progress and widen, resulting in water infiltration through wall system.
Compressed or split sealant in stone joints; sealant not bonded to substrate.	Remove existing sealant and bond break material, clean and prime joint, install new bond break and sealant. Match original sealant material (i.e. use silicone with silicone, polyurethane with polyurethane). Monitor joints for excessive movement.	Water infiltration, stone anchorage damage, stone deterioration, interior wall damage, increase sealant failure.
Continual Dampness at grade level, even in dry weather (rising damp).	Expose stones' lower surfaces, allow to dry; damp proof and provide additional drainage.	Potential stone and joint deterioration; structural instability, water infiltration.
Dampness or efflorescence in upper building areas.	Reseal flashings, roof, clean out gutters drain leaders, and down spouts; check parapets, window sills, and flashings; examine all stone and other types of masonry for cracks.	Water infiltration, interior leakage, deterioration of stone anchorage.
Surface loss by powdering, "sugaring," or exfoliation.	Limit surface deterioration and water infiltration into stone. Check for leaks; eliminate chloride based chemicals from snow-removal procedures.	Continuing surface loss, structural instability.
Cracked, broken stones.	Seek assistance with stone replacement; if fragments are stable and secure, tuck point or caulk crack with sealant; monitor closely for additional cracking or movement.	Water infiltration, deterioration of stone anchorage, structural instability.
Numerous cracked, missing, or spalling stones.	Monitor condition closely and seek professional assistance.	Deterioration of stone anchorage; structural instability, water infiltration; safety concern.
Failed expansion joint material, stone spalling adjacent to expansion joints, or non-moving expansion joints.	Monitor expansion joint movement. Obtain professional assistance.	Water infiltration, structural instability, damage to stone anchorage, excessive building movements, inability to accommodate stone or structure movements.

binders due to environmental exposure, or mechanical abrasion. In certain sedimentary stones this condition is normal, and diagnosis may require professional evaluation. Flaking or exfoliation can indicate a condition such as freeze/thaw distress, which should be addressed. Depending on the amount of stone deterioration, the final repairs may require stone replacement. It is important to first correct the cause of the deterioration before replacing the stone elements.

10.1.4 *Cracks*—To develop appropriate repairs, it is critical to understand the causes of cracking. In many situations cracks indicate relief of built-up stresses within the stone. Cracks can indicate stress concentrations within the wall system due to external causes or improper installation. Sometimes cracks are simply caused by mechanical impact. The number of cracked stones and their locations is critical in determining the muse of the cracking and developing the appropriate level and type of repairs.

10.1.4.1 Cracked stones do not always have to be replaced. If the fragments are stable, they can be anchored with supplemental fasteners, and the crack surface treated to limit water infiltration. If cracked stones are repaired, they should be carefully monitored. Widening or lengthening of existing cracks or the formation of new cracks in adjacent stones, can be indicators of more severe problems If these conditions exist professional assistance should be sought.

10.1.5 *Displacement, Bowing, or Bulges*—When stone is observed to be out of alignment with adjacent stones or out of plumb with other building elements, it may reflect several conditions. These can include misalignment during original construction, deterioration of the stone, failure or deterioration of the stone anchors, disruption/deterioration of the stone back-up structure, in-service displacement due to overloading or strength loss after installation, or inadequate initial material strength.

10.1.5.1 It is important to determine whether the displacements have occurred during the service life of the stone, or if the stone was installed with a misalignment. Examination of the joints can sometimes offer clues as to the cause of the observed displacements. If the joints are cracked and separated, this can indicate the movement has occurred since the joint material was installed. If the joints are in good condition, then the displacement may have been present when the joint material was installed.

10.1.5.2 Bulges in stone masonry or stone panels are typically caused by a lack of lateral reinforcement or anchorage and resulting in over-stress of the stone from compressive, flexural, or thermal loading. Bulges can be serious and may indicate stone instability. These should be reported and addressed immediately.

10.1.5.3 Appropriate repairs for bulging, displaced, or bowed stone can include installing supplementary. anchors, externally stabilizing the stone masonry, or rebuilding the bulged area with new material and appropriate anchors and reinforcement. A structural analysis may be required to confirm stone stability.

10.1.6 *Spalls, Fragments*—Stones that have cracked and created unstable fragments require immediate attention. This condition may indicate a local or building-wide problem. In older buildings such as those constructed with mild steel or red iron anchors, spalls may occur as the embedded steel elements or back-up structure corrodes. The corrosive by-product is larger in volume than the original material, thus exerting a pressure on the stone and causing a spall. Spalls can also be caused by localized stresses or objects embedded in joints that cause stress concentrations that lead to failure of the stone.

10.1.6.1 The most important, step towards addressing spalls is to remove the fragments that are loose, unstable, and in danger of falling. The removal of a spall will temporarily expose the stone interior to increased damage; however, it is more important to remove the hazard that can result from a falling object.

10.1.6.2 Depending on the size and shape of the fragment, it may be possible to reinstall the piece using supplemental anchors and materials to seal the crack. If the fragment cannot be reinstalled, the spalled area can be filled with a patching material. A patching material must be carefully selected to be compatible with the surrounding stone. The patch should also include mechanical anchors, such as dowels or pins, to ensure the patch will remain stable and relatively watertight for its useful service life.

10.1.6.3 A patch may not be aesthetically acceptable, so often a dutchman repair is used. The dutchman repair is more expensive, but offers an improved appearance and longer service life than a conventional repair with a patching material.

11. Assessment and Maintenance Checklist for Stone Facades

11.1 Fig. 1 is an example of a checklist that can be used when surveying an exterior stone facade. Every building is different and may possess unique conditions not addressed by this form. It may be useful to include general areas that require greater attention or increased maintenance.

Evaluate all of the following groups of inspection items. Inspect to insure that they are functioning properly.

I. Building Components/Conditions: Condition of the stone facade can depend on the condition of other building components. The following items should be in good condition and functioning properly. Check any item that is not functioning as designed, or any deficient conditions that may exist.

_____	ROOF MEMBRANE	2 PTS
_____	ROOF FLASHING	2 PTS
_____	COPING	2 PTS
_____	COLLECTORS AND GUTTERS	2 PTS
_____	INTERNAL DRAIN SYSTEM	2 PTS
_____	ACTIVE ROOF WATER LEAKAGE	6 PTS
_____	ACTIVE WALL WATER LEAKAGE	6 PTS
	TOTAL - BUILDING COMPONENTS	____ **PTS**

II. Elevated Facade Elements/Walls: Includes stone masonry, panels, copings, and all other exposed facade elements above grade level. Check all conditions observed .

_____	SOUND, CLEAN, AND DRY	0 PTS
_____	SOILED	2 PTS
_____	DAMP	2 PTS
_____	EFFLORESCENCE	2 PTS
_____	BLOCKED/NONFUNCTINONG WEEP HOLES	2 PTS
_____	SCALING, POWDERING, EROSION	4 PTS
_____	SPALLING OR CRACKING	8 PTS
	TOTAL - ELEVATED FACADE ELEMENTS/WALLS:	____ **PTS**

III. Ground Level Facade Elements/Walls: Includes stone masonry, panels, copings, and all other exposed facade elements at grade. Or in contact with ground Check all conditions observed .

_____	SOUND, CLEAN, AND DRY	0 PTS
_____	SOILED	2 PTS
_____	DAMP	2 PTS
_____	EFFLORESCENCE	2 PTS
_____	BLOCKED/NONFUNCTINONG WEEP HOLES	2 PTS
_____	SCALING, POWDERING, EROSION	4 PTS
_____	SPALLING OR CRACKING	8 PTS
	TOTAL - GROUND LEVEL FACADE ELEMENTS/WALLS:	____ **PTS**

FIG. 1 Example Assessment and Maintenance Checklist for Stone Facades

IV. Stone Facade Joints: Includes all stone masonry or panel joints, moving and non-moving, mortar-filled, or sealant-filled. Check all conditions observed .

_____	SOUND AND WATER TIGHT	0 PTS
_____	MORTAR LOOSE, JOINTS OPEN	2 PTS
_____	SEALANT SURFACE DETERIORATED	2 PTS
_____	SEALANT JOINTS OPEN OR BREACHED	4 PTS
	TOTAL - STONE FACADE JOINTS:	____ **PTS**

V. Window/Window, Sill/Window, Perimeter Joints: Includes all joints between stone and other facade elements, including windows, doors, copings, belt courses, curtain walls, and roofing. Check all conditions observed.

_____	SOUND AND WATER TIGHT	0 PTS
_____	MORTAR LOOSE, JOINTS OPEN	2 PTS
_____	SEALANT SURFACE DETERIORATED	2 PTS
_____	SEALANT JOINTS OPEN OR BREACHED	4 PTS
	TOTAL - WINDOW/WINDOW, SILL/WINDOW, PERIMETER JOINTS:	____ **PTS**

Total the points in each category associated with the checked items and compare with the ranges and recommendations provided below for each category total:

Less than 2 points:	Continue to perform routine maintenance.
2 to 4 points:	Increase maintenance to address problem areas.
5 to 7 points:	Perform maintenance and minor repairs as required, monitor level of deterioration. Contact a professional for consultation.
8 points or more:	Stabilize if possible, monitor condition, seek professional consultation immediately.

FIG. 1 Example Assessment and Maintenance Checklist for Stone Facades *(continued)*