Repair Of Stone

by Susan D. Turner

Stone is a hard, naturally occurring material that is found in the earth. Each type of stone has a different appearance, strength, porosity and structure. Stones can be metamorphic, sedimentary or igneous. Igneous rocks are those caused by volcanic action and are very hard, such as granite. Sedimentary rocks are formed by the deposits of rivers and bodies of water. Over time, layers and layers of sediment build up and with pressure and chemical reaction, form rock. Two common types of architectural sedimentary stone are limestone and sandstone. Metamorphic rocks are sedimentary rocks that have been acted upon by great pressure deep within the earth. Examples of architectural metamorphic rock are marble and slate.

Stone is quarried from the earth and cut and shaped to form building blocks. As a natural material, it is not necessarily perfect or homogeneous. The type of stone and where it is quarried dictates the strength of the stone. The way in which the stone is cut and finished, and the direction in which the grain lies once the stone is laid dictates its susceptibility to weathering.

Deterioration

Weathering of the stone has many names, depending on the cause or the resultant appearance, but weathering is, by definition, the deterioration of stone by physical, chemical or biological causes. Physical causes include movement, including structural differential movement, frost/ice jacking, salt crystallization, and thermal expansion and contraction. These movements exert forces on the stone, causing them to crack or spall or dissolve or blister. Chemical processes that deteriorate stone include rusting of iron fasteners that stain the stone and acid rain that dissolves it. Biological factors include fungi and plants or vines which retain moisture or acid rain near the stone and aggravate ice-jacking conditions.

Stone can also deteriorate through inherent conditions in the stone or wall. There are many examples of these weaknesses:

- Sedimentary stone is inherently weak between the bedding planes. If the bedding plane does not lie horizontally, water can get between layers and fracture away the face of the stone incrementally through freeze/thaw action. Stone porosity contributes to ease of deterioration.
- Porous stone, when thoroughly wetted, absorbs water. When subjected to very cold temperatures, water in the pores turns to ice and expands, causing the stone to fracture.
- Lack of strength, such as exists in marble, contributes to a more rapid deterioration due to poor resistance to impact, freeze/thaw cycles, and acid rain.
- Design errors in the wall may allow water infiltration or result in water condensation of exfiltrated warm moist air causing deterioration from ice damming.
- Hard mortar will cause a softer stone to crack if subjected to differential movement.
- Sand blasting, prevalent in the 1970's as a way to clean stone, irrevocably removes the surface detail and accelerates physical factors of deterioration.

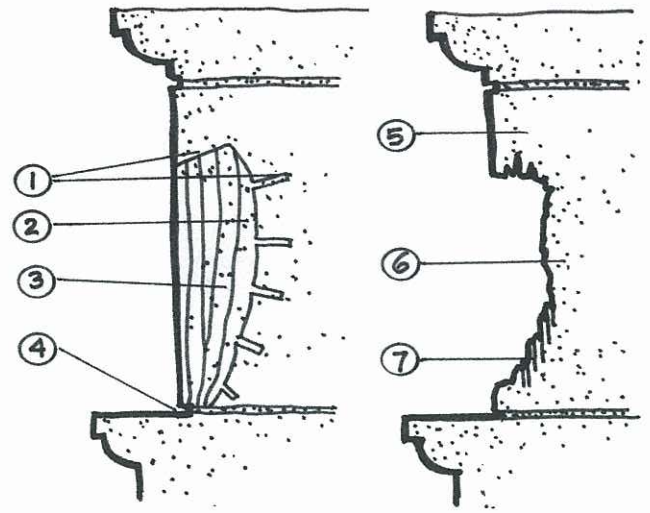

ILLUSTRATION: SUSAN D. TURNER

Figure 1: Plastic repair proceedure; 1) mechanical key; 2) slurry coat; 3) build up layers; 4) retain joints; 5) sound stone; 6) stone weathered away; and 7) friable stone.

Repairs

Unlike brick, where a single unit can be relatively easily replaced, stone should not be replaced as the first act of repair. As always in restoration, the approach that results in the least intervention in the building should always be attempted first.

First and foremost, a broken piece should be reattached. If missing, it should be replicated, based on details elsewhere on the building or from accurate documentation. To reattach a piece, use a stainless steel pin as a dowel to provide mechanical attachment between the two and use epoxy

on the pin and surfaces to provide a chemical bond. Ensure that the epoxy does not squeeze out over the stone by using masking materials.

A more aggressive repair is a dutchman, which is a procedure whereby a piece of stone is bonded into the existing stone to repair damage. Unsound stone is cut away, leaving a geometric space which is to be filled by the new piece . The new stone should match the type, grain and colour of the existing stone and then be pinned and epoxied into place. It is usually oversized and then tooled to match the profile and texture. This repair should be barely discernable.

Another lower level intervention, plastic repair, can be used in circumstances where an irregular deterioration has occurred (Fig. 1). The "plastic" is a cementitious, breathable mortar-like mix that can be trowelled on to replace the missing material. It comes in a variety of colours and textures to provide a perfect match. First, remove any unstable stone and loose dirt and dust. Undercut the edges and drill deep holes into the sound stone at the back of the patch to provide a mechanical 'key' into the remaining stone. Apply the mortar in thin coats, scarifying the last surface to provide a mechanical bond with a subsequent coat. Keep the plastic patch damp for a sufficient period of curing. Render the surface to match the existing.

A large problem occurs when stone, such as face-bedded sandstone or limestone, is delaminating (splitting away in vertical layers). A procedure called blind exfoliation repair can save the stone. This entails drilling holes through the unsound layers and injecting grout into the holes to fill the spaces between the layers. Pins are inserted into the holes and the exposed ends of the holes filled with plastic repair material. While this is a non-reversible repair, it could be used where the stone would be lost in any event. This procedure attempts to retain the most historic material and is a lower level of intervention than replacing the stone.

Another problem may be cracks appearing in the masonry due to structural differential movement. Once the movement is stabilized, crack repair can be undertaken. In rubble foundations, epoxies should not be the first choice for repairs since they are non-reversible. Rather, fill the crack by placing formwork at the face of the crack and then pour a thin cement grout into the form(Fig. 2). As the grout sets, the formwork is removed and the process repeated for the parts of the crack higher up. Epoxies can be used by a qualified craftsman using an injection technique in situations where the consultant requires strength for the stone. This is not a reversible intervention, but it is desirable when there is danger of losing the entire original stone.

The worst problem occurs when stones, which have particles held together by a cementitious material, deteriorate due to weathering, resulting in a crumbling or sugaring of the stone. Consolidation, a chemical process, will reverse the process of deterioration. The stone is soaked with a solution that chemically bonds the stone particles back together as it evaporates. Consolidation techniques are non-reversible. Extreme caution should be used due to many side effects. Moreover, consolidants can photo-degrade, losing strength or colour. If the consolidant has a lower porosity then the original stone, problems with condensation and freeze/thaw action can occur or be aggravated.

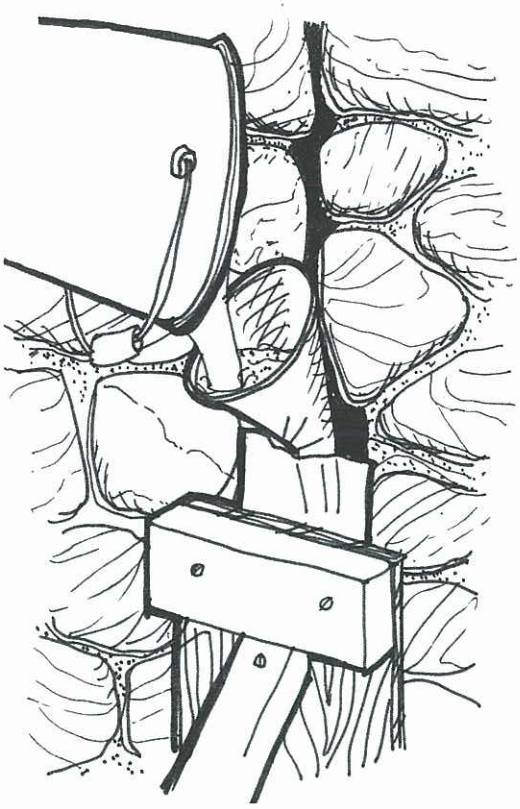

ILLUSTRATION: SUSAN D. TURNER

Figure 2: Crack repair proceedure.

Conclusion

The focus of this article is to address small repairs of stone. Where damage is extensive or widespread, a professional should be consulted for an overall assessment of the wall system, analysis and action plan. Whenever repairs are undertaken, craftsmen skilled in the work should be used. While qualified workers can be expensive, no amount of money can "undo" the damage of unqualified workers.

Works Consulted:

Ching, Francis D.K. *A Visual Dictionary of Architecture*. New York: Van Nostrand Reinhold, 1995.

Weber, Dr. Helmut, Dr. Klaus and Zinsmeister. *Conservation of Natural Stone—Guidelines to consolidation, Restoration and Preservation*. Ehnigen, Germany, expert verlag, 1991.

London, Mark. *Respectful Rehabilitation Series: Masonry—How to Care for Old and Historic Brick and Stone.* Washington D.C.: National Trust for Historic Preservation in the United States, 1988.

Susan Turner is a restoration architect living in Winnipeg. She can be reached at susan_rktect@hotmail.com