U.S. General Services Administration

Limestone: Characteristics, Uses And Problem

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This procedure includes general information on the characteristics and common uses of limestone and identifies typical problems associated with the material. See also 04400-01-S for guidance on inspecting stone masonry failures.

Introduction

Limestone is a sedimentary rock composed principally of calcium carbonate (calcite) or the double carbonate of calcium and magnesium (dolomite). It is commonly composed of tiny fossils, shell fragments and other fossilized debris. These fossils are frequently visible to the unaided eye on close examination of the stone surface, however this is not always the case. Some varieties of limestone have an extremely fine grain.

Limestone is usually gray, but it may also be white, yellow or brown. It is a soft rock and is easily scratched. It will effervesce readily in any common acid.

Limestones may vary greatly in texture and porosity from coquina, which is a matrix of whole or pieces of sea shells loosely cemented by calcite, to oolitic limestones and microcrystalline limestones whose structures are so fine that they can be seen only under magnification.

Limestone deposits can undergo metamorphism during major geological events resulting in a recrystallizing as marble.

Oolitic limestone consists of substantial amounts of "oolites" or "ooliths." Oolites are small spherical or sub-spherical grains of concentric calcite.

The actual classification of limestones and marbles can be very confusing to the non-geologists.The same stone can be marketed one time as a limestone and, at another time and place, sold as marble. The subtleties which sometimes differentiate between grades and types of stones are frequently beyond the concern and expertise of maintenance workers, building

managers and historical architects with responsibility for maintenance of the resources. While this is understandable, it does not lessen or eliminate the need to accurately identify the materials which must be treated and maintained. Failure to accurately identify a material to be treated can result in the failure to consider important technical details which subsequently results in irreversible damage to the resource(s).

In an effort to improve accuracy in identifying the general categories of limestones at a 'macro' level, the following section contains descriptions of the most common types of limestone, however this information is no substitute for training and experience to correctly identify and catalog stone types. The following definitions are from the American Society for Testing and Materials (ASTM) document, "Standard Definition of Terms Relating to Natural Building Stones."

- Calcarenite: Calcarenite is composed of sand-sized grains of calcite, usually in the form of tiny fossils, shell fragments and fossil debris. Some calcarenites contain oolites and if the oolites are present in sufficient quantity, the stone is called oolite limestone. Oolite limestone is a sub-category of calcarenite.
- Coquina:Coquina consists of raw, unaltered shell fragments, often quite large, loosely cemented by calcite. It is generally very coarse and porous, frequently consisting of oyster and sea shells and fragments.
- Dolomite: Dolomite is a sedimentary carbonate rock composed of calcium and magnesium carbonate.Also called "magnesium limestone", it contains from 5 to 40% magnesium carbonate.
- Microcrystalline limestone: This is a limestone structure of crystals too small to be seen without magnification.
- Oolitic limestone: Oolitic limestone is a calcite cemented calcareous stone composed of shell fragments, practically non- crystalline in character. Generally without cleavage, and extremely uniform in composition and texture, oolitic limestone adjusts to temperature changes.
- Travertine:A calcium carbonate, usually light in color, travertine can be extremely porous or cellular. It is usually deposited from solids in groundwater.

Limestone coloration is generally a consistent pure white to off-white.Many varieties do not take a polish well, so that the surface is typically a matte finish, no-gloss surface.Limestones, like marble and other calcareous stones, are referred to as acid sensitive.Calcareous stones are readily dissolved in acid, therefore acidic products should not be used on limestones and marbles.

Typical Uses

Limestone is widely used in architectural applications for walls, decorative trim and veneer.It is less frequently used as a sculptural material, because of its porosity and softness, however, it is a common base material. It may be found in both bearing (structural) and veneer applications.

Problems and Deterioration

Weathering may have a degrading effect on the appearance and structural soundness of limestone. Factors include rain, snow, temperature, wind and atmospheric pollutants.Generally these factors act in combination with one another or with other agents of deterioration.

Rainwater, especially in combination with atmospheric gases often resulting in acid rain can result in dissolution of the limestone, causing higher levels of salt movement within the stone structure.Temperature can effect rates of deterioration and (in larger stones) movement of the pieces, as well as patterns of salt migration within the stone. Most of the natural or inherent problems which can occur with limestone require some degree of moisture to occur, however other problems such as wind erosion and vandalism may occur independently.

Natural or Inherent Limestone Problems

Weathering:

Limestone subjected to exterior exposures deteriorates due to weathering or the natural effects of wind, rain, and thermal change. Limestone is extremely durable. It does, however, absorb water and, since it is a carbonate rock, it is highly reactive when exposed to acids or even mildly acidic rain water, and it can suffer substantial deterioration. The most common effect of weathering and erosion is loss of precise detail.

Little can be done to restore edge detailing short of re-carving the stone which is usually infeasible.

Erosion:

Erosion can be the result of general weathering described above, or it can be a more localized phenomenon based upon handling or exposure. Wind driven airborne abrasives may selectively wear away detailing on certain elevations, based upon the direction of prevailing winds. One of the few effective ways to address this problem is by landscaping where plantings and/or grade can deflect the wind. Such landscaping and/or grading may range from the simple and inexpensive up to a major and expensive intervention. It would have to be consistent with appropriate policy for the management of cultural landscapes. It may, however, be cost effective when considering the extended life of the stone. The symptoms of erosion can be as simple as the loss of edge sharpness as described above, or it can be very localized, specific wear due to contact with landscaping and mowing equipment. Localized damage due to contact by mowing or other maintenance equipment is preventable.Where there is evidence of recurrent physical damage, steps should be taken to protect the resource(s).

Staining:

Discoloration of the limestone, whether general or localized, is staining. Staining, may be the result of exposure to a variety of exterior substances or to internal occlusions in the stone or structural elements.

Some of the most common types of staining and the causative agents are:

1. Oil/grease stains: These stains are usually the result of vandalism or use. A variety of organic or inorganic oils may be absorbed into the stone upon contact. The depth of penetration will depend upon the viscosity of the oil/grease, temperature, stone porosity, finish and dryness.

The appearance of grease/oil stains will usually consist of a darkening of the stone at the area of contact. The edges of the staining will generally be diffused, especially after an extended period.There are standard techniques for removing oil and grease stains.

For specific guidance on removing oil/grease stains from limestone, see 04455-10-R and 04455-11-R.

2. Dyes and inks: The staining could be any color depending on the type and source of the dye. This type of stain is likely to be extremely localized around the area of contact. The liquid containing the coloration may be absorbed into the stone and during the normal process of evaporation, the coloring pigment is deposited in the stone.

For specific guidance on removing ink and dye stains from limestone, see 04455-18-R.

3. Organic stains: Organic stains are caused by direct contact with decomposing organic matter, such as leaves, bird or animal droppings, flowers, tea or coffee. Regardless of the source these stains tend to be a slight reddish-brown in color. They also frequently disappear after the source has been removed. These stains may be left to weather and bleach or

oxidize out after the removal of the organic source, however a residue may still remain on the stone.

For specific guidance on removing organic stains from limestone, see 04455-14-R.

4. Metallic stains: Two major categories of metallic staining occur, they tend to be based on either iron or copper. The source of the staining may be internal structural components or elements. A major source is the water wash, or run-off, from adjacent metallic elements, especially bronze and copper.
    a. Rust stains: These stains are reddish-orange and are caused by the oxidation (rusting) of iron. The source of iron staining is usually the structural or connecting components. These components are usually hidden and protected; however, water penetration from bad joints or cracks can activate or accelerate rusting. The discoloration may be within the stone or it may be a deposit of rust on the surface of the stone. Surface deposits of rust may sometimes be removed by hand rubbing with a clean cloth. The examination of the stain should include such rubbing to determine if it is only a surface deposit.

    For specific guidance on removing rust stains from limestone, see 04400-06-R.

    b. Bronze and Copper stains: Stains from water run-off from bronze can range in color from a light green to a dark brown.The staining results from the dissolved copper salts (from copper or bronze) which wash onto the stone, then oxidize. The pattern of the staining is likely to be localized, streaked and in the path of the run-off from the metallic source.

    For specific guidance on removing bronze and copper stains from limestone, see 04400-07-R.

Crumbling:

This condition is indicative of a certain brittleness or tendency of the stone to break up or dissolve.It may be caused by an inherent weakness in the limestone or gradual breakdown of the binder, or it may be the result of external factors affecting the strength and durability of the limestone.

This condition may be caused by the use of de-icing salts, or any other source of salt migration, such as that which can occur when rising damp is present. There is currently little which can be done to repair the damage once this condition has developed, however the early detection of potential problems and elimination of sources of salts is critical to arresting the process.When this condition is severe and obviously caused by the heavy or inappropriate use of de-icing salts, it is sometimes called "Salt Fretting". Regular preservation maintenance may eliminate the causes promoting crumbling, however, once the condition has occurred, its correction or repair is beyond the level of a maintenance procedure. The Regional Historic Preservation Officer (RHPO) should be contacted for assistance.

Chipping:

The separation of small pieces or larger fragments from a masonry unit, frequently at the corners, edges or mortar joints is known as chipping. These fractures are generally caused by deterioration and repointing, especially due to the use of too hard a mortar, or by accident or vandalism.

Repairs include detachment repairs, patching and splicing. Repair of chipped stone requires a skilled mason and is not a maintenance procedure. If chipping is due to occasional impact from mowing or other landscape maintenance, steps should be taken to prevent future damage.

For specific guidance on repairing chips in limestone, see 04455-03-R.

Cracking:

This condition is manifested by the appearance of narrow fissures ranging from less than 1/16 to 1/2 inch wide or more in the stone. It results from a variety of causes, such as structural overloading due to settlement, the use of too hard a mortar mix or a flaw in the material. Minor cracking may be no problem, in and of itself, but it can be an indication of structural problems and the cracks can be a point of entry of water into the interior of the stone, promoting salt migration. Cracking, which allows water or salts to enter the stone, increases the possibility of failure along the limestone and may result in subsequent spalling. Repairs include patching and replacement.

For specific guidance on repairing cracks in limestone, see 04455-03-R.

Detachment:

This is not a failure of the material per se but a failure of the construction system, i.e. the connectors and/or joints. The definition implies that the failed component survives intact and may be re-installed using appropriate mechanical techniques.

The failure of anchors or metal connectors which lead to detachment may be caused and/or accelerated by the penetration of water into the structure behind the stone, causing rust and corrosion. Adequate pointing and caulking can prevent leakage and penetration of water into the system.

For specific guidance on resecurring detached limestone blocks, see 04460-07-R and 04460-13-R.

Efflorescence:

The appearance of a whitish deposit locally or uniformly over the surface may be efflorescence, the surface deposition of soluble salts. There are numerous sources for the soluble salts which create the hazy appearance; salts can come from mortar, improper cleaning agents, rising damp, de-icing salts, chemical landscaping treatments and air pollution.

Efflorescence can be a salt residue resulting from improper chemical cleaning, i.e. too strong a chemical cleaner or inadequate rinsing. It can also be an indication of water problems.Salt migration and/or sub-florescence and efflorescence should be considered a symptom which should be investigated to identify the source of the soluble salts and/or the source of moisture. Corrective action should then be taken to eliminate the source of the problem once it is identified.

Some efflorescence may occur naturally with new stones, mortar and installation materials.Normally, this efflorescence will be removed by natural rain and weathering processes and/or by regular washing. The new or continued appearance of efflorescence is a stronger indicator of problems like rising damp or inappropriate cleaning methods, all of which should be referred to the Regional Historic Preservation Officer (RHPO).

For specific guidance on removing efflorescence from limestone, see 04500-02-R.

Erosion:

Erosion is the wearing away of the material surface by the natural action of wind, windblown particles and water. It can occur with limestone as well as any exposed materials. Inspections should include examination for any apparent loss of detail and edge sharpness which could be due to erosion.

Erosion may be less of a problem on rock-faced or quarry-faced marble, but may be a more serious problem on stone with more

precise detail. Little can be done to correct this problem once it occurs, other than to protect the surface from further exposure. This may stop or at least retard the erosion process.

Flaking:

This is an early stage of peeling, exfoliation, delamination or spalling evidenced by the detachment of small flat thin pieces of the outer layers of stone from a larger piece of stone. Flaking is usually caused by capillary moisture or freeze-thaw cycles which occur within the masonry.

The problem can also occur due to sub-florescence, so that if flaking occurs, the area should be examined to determine if salt crystallization is occurring in the flaked areas.

Peeling:

Peeling is the flaking away of the stone surface from the substrate in strips or layers. It may result from the improper application of masonry coatings which result in failure of the coating and/or stone surface. It may also result from a defect in the stone, or from weathering.

Encrustations of the surface caused by chemical reactions with environmental elements may also peel or flake along the bedding plane.

Rising Damp:

Rising damp is the suction of ground water into the base of masonry through capillary action. Moisture is drawn up into the stone and may rise and fall due to conditions of temperature; humidity; site grading; absence or failure of damp courses, and/or treatments to the masonry surfaces which affect evaporation.

During active wet periods, rising damp may be visible as a darkening of the stone along the base at ground level.Due to the continuous changing of the moisture level due to varying exposure conditions, staining or efflorescence may be visible at a range of several feet up from the ground. Continuation of the problem can lead to more severe problems of flaking, peeling and/or spalling, but the correction of the problem requires the elimination of the source of water or the interruption of its path into the stone by physical or chemical damp-proofing.

Spalling:

Spalling is the separation and breaking away of pieces of stone due to sub-florescence, freeze-thaw, improper repointing withtoo hard a mortar mixcontaining too much portland cement, or structural overloading of the stone.

Spalling is less frequent with limestone than with sedimentary stones which are also less hard. Limestone is hard enough to resist internal forces which would cause spalling in other natural stones or fabricated masonry.

For specific guidance on repairing spalling limestone, see 04400- 03-R and 04455-03-R.

Sub-florescence:

This is a potentially harmful internal accumulation of soluble salts deposited under or just beneath the masonry surface as moisture in the wall evaporates.

The build-up of salts and their crystallization can create substantial pressures within the masonry, causing pieces to break off along the planes of deposition. Efflorescence at the surface is an indication that sub-florescence is possible. Techniques for mitigating the problem include poulticing, removal of identified salt sources, elimination of moisture in the stone and damp-proofing.

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