How to Avoid Small Area Stains and Blemishes

in the Design, Installation and Use of Indiana Limestone

by
W. H. McDonald

INDIANA LIMESTONE INSTITUTE
OF AMERICA, INC.

2ND EDITION

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Foreword

Indiana Limestone's weather endurance qualities are well-known and respected, and its resistance to damage from the common accretions of dirt and soil carried in urban atmospheres has been proved through more than a century of use in all types of buildings.

There are, however, a number of factors which may tend to create unsightly blemishes on the stone's visible surfaces. Most of the blemishes have no structural effect on the stone. They often will either disappear or become less objectionable through the natural process of weathering. Some will increase in intensity as the conditions causing them remain uncorrected, and a few present potential for increasing stone damage which is correctable ultimately only by replacement.

This publication is a guide to help architects, builders, masons, building owners and other interested persons examine the causes, prevention and removal of the most common blemishes. Specific conditions, which usually are local in occurrence, often may be treated by maintenance personnel. This booklet describes conditions that require treatment by experienced operators of specialized equipment.

Some building owners may prefer to solicit professional attention to blemish conditions on their Indiana Limestone buildings. Organizations, such as Sealant and Waterproofers Institute, Glenview, Illinois, can provide the name of companies competent to perform the work.

ILI will respond to inquiries about procedures and products mentioned herein. We solicit the comments of interested parties and will update this and related publications in response to improvements in materials used for treatment.

Comments on design and procedure throughout the book may apply equally to materials other than Indiana Limestone although no attempt has been made to include them.

Acknowledgments

Indiana Limestone Institute of America, Inc. is indebted to a number of persons and organizations whose knowledge of procedures and applications greatly expanded the scope of the publication. In the realization that any expression of thanks cannot give adequate credit to the many who contributed their time and knowledge, special thanks are extended to Harvey R. Beckman, Merle B. Booker, Raymond W. Casati, David M. Hall, Arthur Hockman, Lewis Jennings, Hugh F. Kluesner, Jr., Richard K. Leininger, Ernest E. Mills, John B. Patton, Edward D. Schmid, Jr., F. G. Summitt, Doyle Wilhite and Erhard Winkler.

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Handling and Storage Suggestions

This checklist will aid in avoiding stains and blemishes originating at the jobsite.

(1) NEVER STORE STONE ON MUD OR DIRT. Use sturdy wood skids or pallets covered with waterproof paper. Use non-absorbent pads as spacers. DO NOT USE SHIPPING PADS FOR THIS PURPOSE. Place skids at quarterpoints under stones. If stones are laid flat, make certain pads are placed one over another in a vertical line between stones.

(2) If stone must be stored overnight or longer, cover it carefully with waterproof paper or membrane, but allow air to circulate around the stones. DON'T WRAP STONE COMPLETELY.

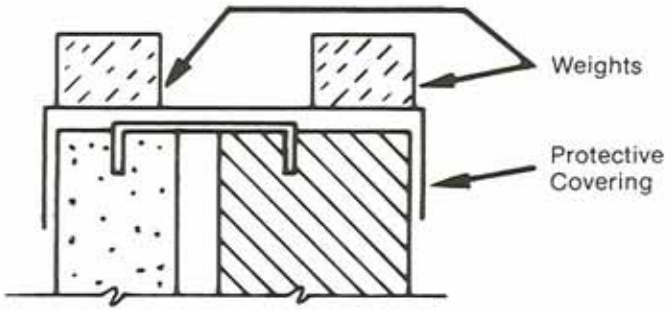
(3) DON'T SET DIRTY OR DUSTY STONE. Before setting stone, wash each piece on all sides with clear water and FIBER BRUSHES.

(4) DO NOT SET FROZEN STONE. Do not use salt to thaw ice on stone. Do not add retarding chemicals to mortars.

(5) Protect stone from sources of alkaline moisture such as concrete pours, below-grade moisture, rain-wet cavity construction, and the like. Do not pour or slug grout behind limestone which has not been protected by dampproofing.

(6) Oil and grease will stain stone—DON'T let them come in contact with it.

(7) COVER THE TOPS OF UNFINISHED WALLS AFTER WORK OR IN RAINSTORMS. Block unglazed windows. This procedure will reduce the accumulation of moisture in the cavity. Failure to observe this precaution can result in stained stone.



Natural Characteristics

Natural characteristics and variations normal to the stone are sometimes mistaken for blemishes. Typical of such conditions are the natural variegated material, rift or crossbedding, and certain types of seams or streaks.

VARIEGATED INDIANA LIMESTONE. This is in fact a grade of stone. The two colors, buff and gray, occur side by side in the deposit. Either color can be specified. When both colors are desired in a single project, they make up the variegated material, and will appear in an uncertain percentage in the wall.

RIFT OR CROSSBEDDING. Rift is normal in sedimentary stones. It appears in the wall as faint, roughly parallel lines similar to marbling. Sometimes grain-size changes occur with this condition. Rift is an accepted characteristic.

SEAMS. Glass seams are narrow fractures or partings in the stone that have been recemented by transparent calcite. Like calcite streaks (wider white streaks, without transparent infill), they are structurally sound but are eliminated or controlled in the finer grades.

QUARRY SAP. When quarried, limestone contains ground water. This can appear as a brown or gray glaze on the stone. It is a temporary phenomenon which disappears with time and weathering. This condition is more prevalent in gray stone than in buff. It can be controlled by seasoning blocks and slabs prior to fabrication, although ILI standards do not require it.

Some natural characteristics are not allowed in any but quarry-run material. They include the following:

MISCELLANEOUS. Pyrite, a mineral of iron sulfide, occasionally occurs in sufficient size to be visible to the eye. Stone containing visible crystals is not allowed in finished work other than quarry run and splitface. **Stylolites,** known in the trade as crow-foot seams, appear as dark jagged lines in stone sawed cross-grain. Stylolites may form planes of weakness in bending or tension: hence, they are allowed only in quarry run materials and in coursed ashlar, such as splitface.

Notes on New Construction

Limestone is wet when quarried, and water is used in most production processes. Therefore, the material often arrives at the job saturated with moisture. Construction adds more water in the form of mortar, concrete, blown fireproofing and the like. As the building is closed, humidity and moisture which cannot otherwise escape tend to be released through the walls and joints of the building.

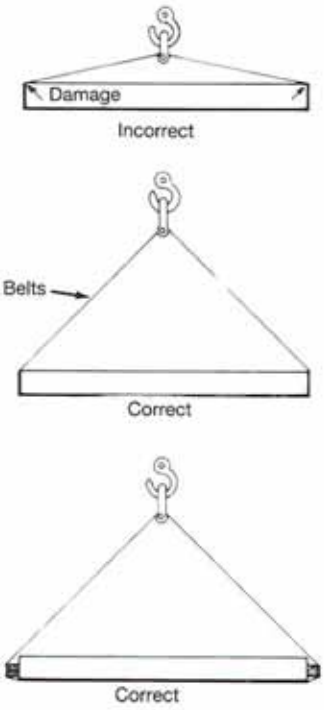
These factors may create an appearance of wetness or moisture on stone surfaces. This condition is temporary and will be naturally eliminated as the mois-

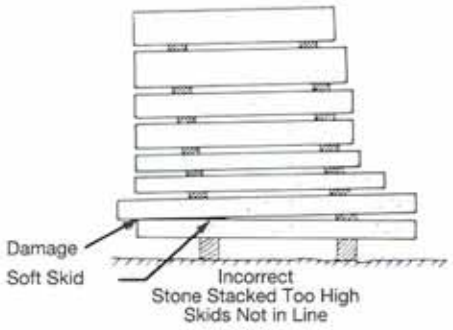
Handling and Storage

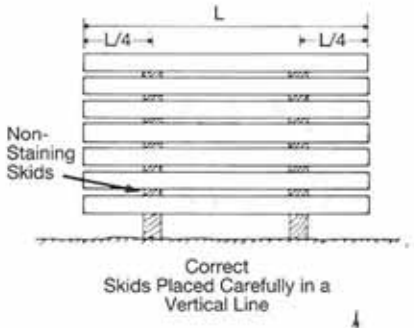
All Indiana Limestone should be carefully unloaded at the storage or building site by competent workmen. The stone should be handled by such methods as will guard against soiling, mutilating or chipping. Pliable sling belts of 3" or more in width should be used, and the belts should be of sufficient length so that the edges of stone will not be under pressure great enough to cause chipping. All stone should be stacked on pallets or skids, clear of ground to provide protection from dirt stains. The stone should be covered with a clean tarpaulin, strong, nonstaining waterproof paper, or polyethylene plastic, during extended periods of storage or when necessary to protect from damage.

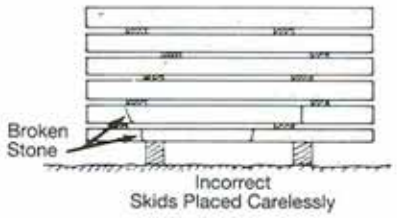
When stone is stacked, the faces should be separated by nonstaining skids. Only two skids per stone should be used and they should be placed one-fourth of the length of the stone from each end. To prevent breakage, make sure the skids are placed directly above each other. Use wood skids made from cypress, white pine, poplar, or yellow pine that does not contain excessive amounts of resin. Do not use chestnut, walnut, oak, or other woods containing tannin.

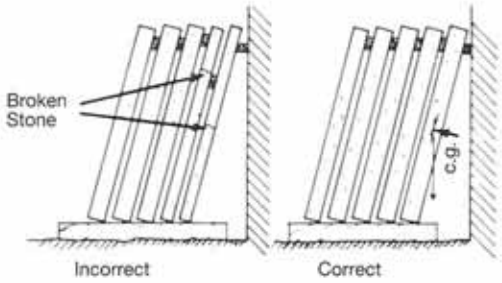
Do not stack stones to excessive height, so that the weight of the stone compresses the spacers and increases the possibility of damage to edges.

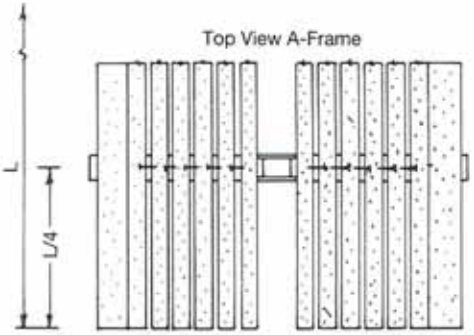


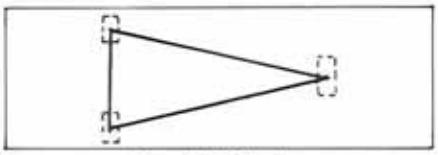


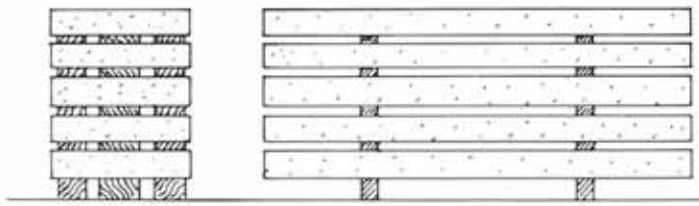


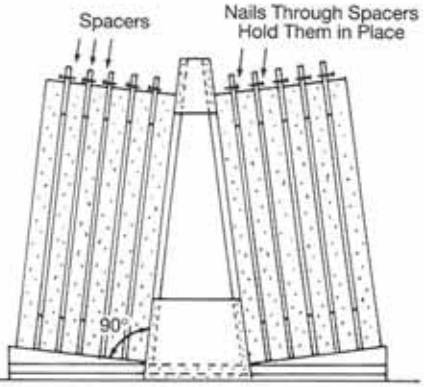












ture is breathed away by the stone. The time required for complete clearing of internal moisture varies with building type and shape, types of joints, number of weep holes or wicks, weather conditions and a number of other factors. But the refractive changes in the stone's surface caused by wetness will eventually disappear.

As mentioned elsewhere, wall tops and window openings should be protected until closed, and in general all potential entrances of water eliminated during the construction process.

Blemishes Caused in Handling and Storage

Repair of actual breakage, such as chips and scratches, is covered more fully in another publication, *Repairing Damage to Indiana Limestone*. Copies are available from ILI or its member companies. Minor scratches will be self-healing, and resultant white lines will disappear in time. The process can be helped, however, by brushing with wet fiber brushes. Minor chips usually are best left alone.

ILI strongly recommends that no transport padding materials be used as separators in the jobsite stacking yard. Celotex and other fibrous materials may create "pad marks" which can have a relatively long life. They may collapse and allow stones to touch and chip. Soft wood spacers such as white pine are preferable; plastic half-ball pads may be used as well.

Avoid storage conditions where pallets may settle unevenly; this can cause breakage and stains from soil. Where large panels are stored on A frames or otherwise set on edge, protect bearing surfaces with padding and secure panels to avoid overturning or tipping.

Abused stone with many chips and scratches should be set only when approved by the architectural authority. Stone which has fallen in handling or suffered collision in transportation should be examined carefully for cracks and other structural defects.

General Comments on Major Cleaning Procedures

Probably more damage to fine older buildings is done by inept building cleaners than by years of exposure to corrosive atmospheres. Unfortunately, many decisions to clean buildings are made without adequate preparatory steps and without investigation of alternate methods, their costs and results.

Consideration should be given first to the easiest and cleanest method which will produce desired results. In some cases, for instance, a low-pressure hosing will remove enough accumulated dirt to expose the basic color of the building materials and to reveal long-hidden architectural detail.

Not all buildings will clean up so easily, and different areas of the same building may require different treatments. A general rule should be to use the most conservative treatment or material which will achieve the required degree of cleanliness.

The contractor should have adequate insurance to protect both himself and his client against damage to neighboring structures, to materials on the building which are not in his contract, adjacent foliage and landscaping, and passersby.

Cleaning methods are categorized as wet, dry and chemical. Each has its place, and sometimes all must be used to achieve desired results. Architects and clients should decide how clean the building should be and what degree of mess they are willing to allow to achieve it. Preliminary talks with building cleaning personnel and demonstrations on test patches on the building will aid immeasurably in the decisions.

Wet cleaning methods include scrubbing, either manually or by machine; high- and low-pressure hosing with water at various temperatures; slow soaking with pierced hose; and steam. A combination of grit blast and aerated water called "wet-aggregate" often is used.

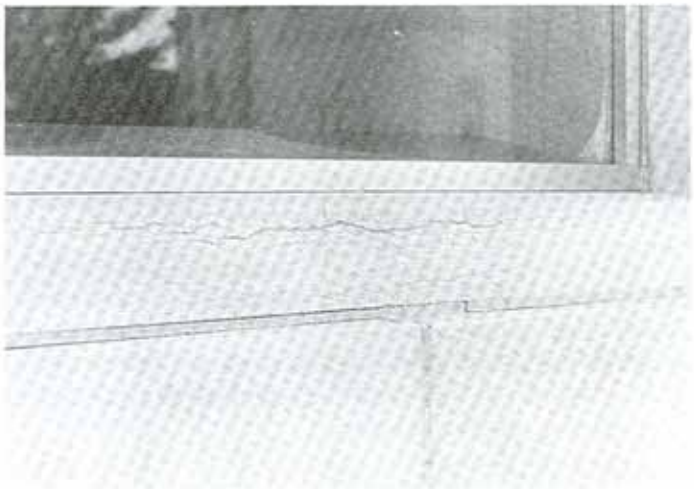
Dry cleaning methods include ordinary sandblast, and grinding or sanding both by hand and with various handheld sanders. Sandblasting should be used only as a last resort.

The chemical agents used to clean buildings are usually acidic. Improper dilutions of these materials can cause damage to limestone. Manufacturers' instructions should be carefully noted and used when chemicals are used to clean limestone. Generic acid cleaners such as muriatic acid should not be used in strengths which cause discoloration of the stone.

In general, when wet or chemical cleaning methods are used, ILI recommends that jointwork be done prior to cleaning. Many building cleaning contractors prefer to tuckpoint or seal joints after cleaning; however, unsound joints may admit water, especially under pressure, and stain may result.

Dry cleaning methods should be used sparingly. Many cities have prohibitions against sandblast; it should be done only on covered scaffold by personnel skilled in building cleaning with that method. Grinding produces a fine dust which must be controlled and uneven grinding pressure may pattern the stone in uneven swirls or streaks. Grinding may be

used on flat surfaces; ornament or enrichment may be cleaned with handheld sandpaper.



This is a typical example of the damage caused by unskilled workers using sandblast to clean Indiana Limestone.

Cleaning new construction of Indiana Limestone should require no more aggressive methods than low- to medium-pressure cleaning, with occasional scrubbing. DO NOT apply brick cleaners or acids to new Indiana Limestone. Protect the stone from the wash of acid-based cleaners used to wash brick adjacent to stone; the stone should be thoroughly wetted prior to cleaning.

Comments on the use of water repellent treatments apply as well to newly cleaned buildings as to new construction. See p. 12.

Stains and Blemishes Produced by Manner of Stone Use in the Building

DESIGN CONSIDERATIONS. Specific comments throughout this section deal with design aids to avoid conditions which lead to stain. In general, avoid details which produce traps for dirt and water or provide roosting areas for birds. Select materials for use adjacent to and in contact with limestone which will not bleed when oxidizing or provide pooling areas for rainwater. **Provide adequate dampproofing for back faces and undergrade areas.** Provide adequate subgrade drainage, and slope grade, walks and deck areas to assure runoff. The ILI Handbook contains good details and recommendations for designers, specifiers and draftsmen. Copies of the Handbook are available from ILI or any member company.

MOISTURE WITHIN THE WALL. Water penetration in all its forms causes more damage in buildings than any other single factor. Well-made mortar or sealant joints exclude moisture for years, but may ultimately begin to leak. Sometimes, "equal" materials or systems are installed as moisture barriers where conditions require other materials or systems. Failures are also caused by improper specifications and details and by poor workmanship in the construction phase. This section addresses both causes of problems with limestone.

Efflorescence and Exfoliation. Efflorescence is a white or gray powdery substance on building walls, and is a symptom of deeper problems of leakage or seepage—unwanted water is entering the building.

Water—whether from joint or other leakage in the roof or wall, condensation, leaking pipes or other causes—picks up salts of aluminum, calcium, magnesium, potassium and other elements, usually as sulfates, nitrates, chlorides and carbonates. These combinations are variously soluble; their sources are other construction materials, including mortar and cement, block, brick, trash and debris; in some cases the salts are present in the rain or in the atmosphere.

Water moving through the walls transports the salts to or immediately under the exterior surface where the moisture is released as vapor, leaving the salts on and under the surface layers. Continuing action of this nature produces efflorescence, otherwise known as "bloom," "scum," or "saltpeter."

A badly leaking roof caused this eyesore. When the leaks were repaired, the efflorescence cleared up within a few months.

Efflorescence is not itself responsible for damage to masonry substrates. However, when pitting, flaking or other evidence of deterioration appears in the immediate area of the efflorescence, the condition can lead to severe damage if it remains uncorrected.

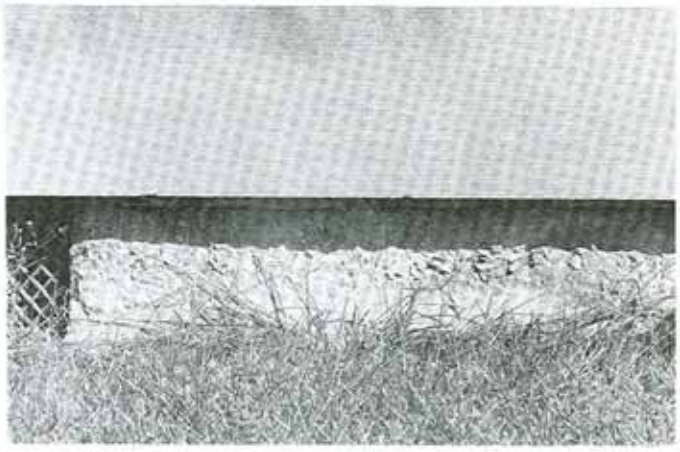
In its mildest form, efflorescence is a purely visual and temporary problem; it will wash away in rain. But concentrated flows of water, such as leaks in gutters

or window-wall systems, or accumulated water on decks and patios, present ideal conditions for a sufficient buildup of salts below the wall surfaces to separate the surface layers from the main body of material. This process, known as exfoliation, ultimately can destroy the affected material.

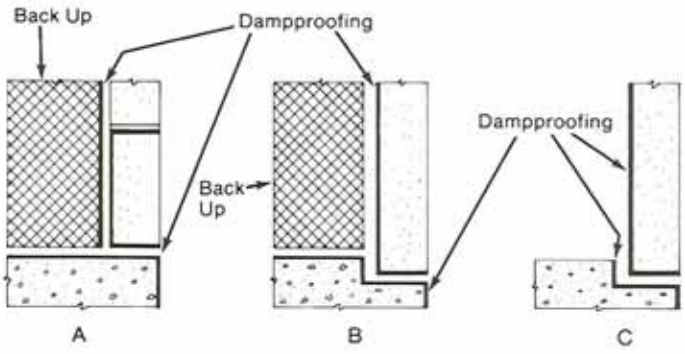
Typical sheeting in exfoliating limestone at the base course of a retaining wall (ca. 1880). The stone is sluffed off in thin layers. Compare to exfoliation in concrete shown in the following photograph.

Three conditions are required for exfoliation or efflorescence: a supply of moisture, a supply of the materials described and an evaporation surface. To control efflorescence or exfoliation, the source of water must be located and stopped, or its route through the exterior material must be blocked.

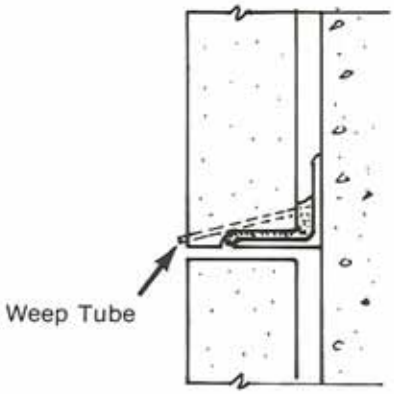
In construction design, dampproofers, either asphaltic or cementitious, should be placed both at grade and other potential watertraps. Continuous angles, floor slabs and clip angles are the most susceptible areas. The dampproofers usually are applied to the backs of stone in the immediate area where water may collect. Such moisture must be wept off.



This limestone basecourse has been protected from water absorption by a setting bed of waterproofed mortar between it and the concrete foundation. (ca. 1930)



Clogged weep holes often may be opened or new weeps installed where none previously existed to relieve the problem. Felt wicks serve the same purpose and may be more effective, in that they cannot be closed by dirt accretion or insects. By whatever procedures, the source of water should be eliminated, and the dampproofing materials applied where stone backs can be reached.



Exfoliation and major efflorescence are evidence of problems which may require specialized diagnosis and treatment.

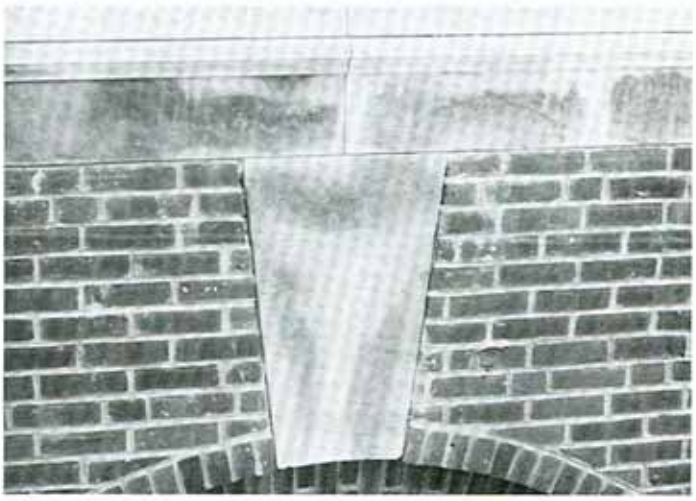
Stain Due to Alkali Solutions. The phenomenon of alkali stain is characterized by a brown, rusty color on buff stone and a gray-brown color on gray stone. Stain usually appears during and shortly after construction. Its cause is closely related to that of efflorescence, which sometimes develops on or near affected areas.

Alkali stain usually occurs in small areas on the building, although the conditions causing it may exist broadly as a result of defective design, poor workmanship or unavoidable circumstances. Alkali stain is easy to avoid and in most cases disappears in a relatively short time after the causes are eliminated.

Soluble alkalis, generally potassium and sodium compounds, are natural elements of all cement. If ground or rain water has opportunity to dissolve these alkalis and subsequently pass through limestone, stain may result. In some cases, water ab-

sorbed by the stone from the mortar or tuckpointing will produce stain.

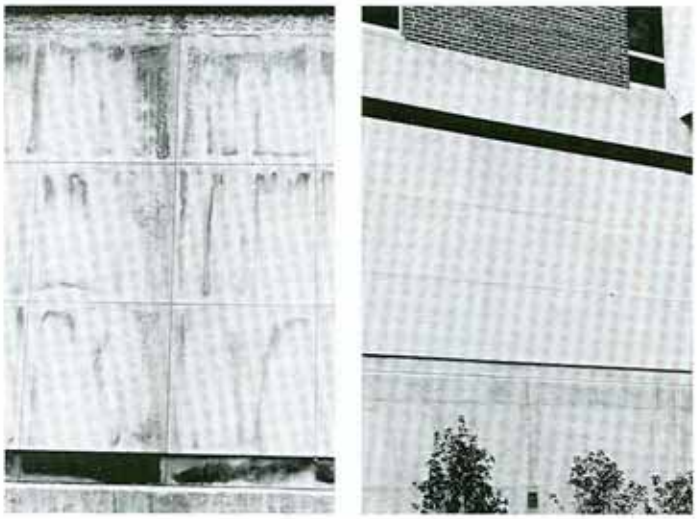
This phenomenon requires comparatively large amounts of water to become a significant problem, and even then it is purely a matter of appearance. Conditions such as untopped, uncovered walls, unglazed window openings, wash from concrete pours and moisture absorption from mortar will produce stain. The available water from mortar is slight,



Alkali stain. An overnight rain produced this condition in an untopped, uncovered wall. The stain disappeared in a few months.

and the resultant stain is light in color. Conditions which supply large amounts of water will produce stain of greater intensity and longer life.

For instance, heavy rains over a weekend may thoroughly soak a freshly set cavity wall with unglazed



Before & After photos of an intense alkali stain condition. Note the extremely dark stones above the floor spandrel. This stain cleared to the "After" condition within 18 months.

windows and unset coping. The resultant alkali stain may require several months to disappear.

Older buildings can develop leaks in joints and connections. Mortar and sealant joints may fail with age; leaks in in-wall piping systems, or condensation in cavity construction, can produce stains on exterior walls. Such sources may be quite difficult to locate.

Ordinarily, the best way to deal with alkali stain is to leave it alone after correcting the causative factors. If exposed to sun and rain, the natural process of weathering is most effective in its elimination.

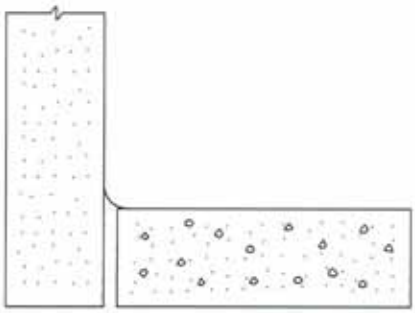
Occasionally, prompt removal of alkali stains may be necessary. Often, mild stains can be relieved by washing with tri-sodium phosphate, followed by medium-pressure rinse (up to 800 psi). Make sure that all possible leaks are stopped. Darker stains may require other procedures. ILI publishes a Technote on Stain Removal containing additional suggestions. It may be obtained from ILI or from any member company.

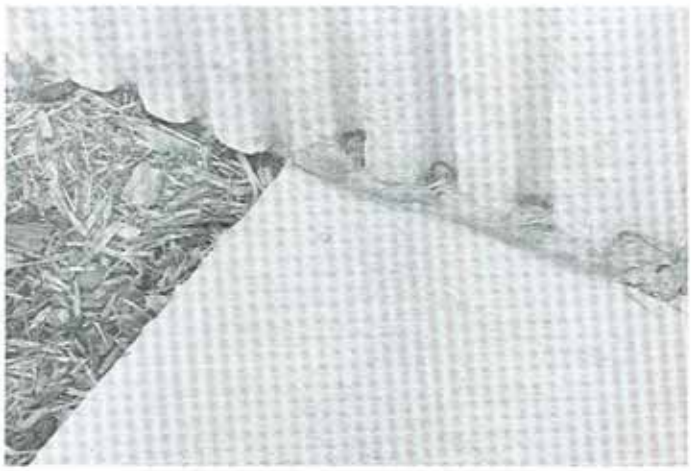
Improperly designed or constructed decks produce conditions leading to stain, efflorescence and exfoliation in any fascia material at their perimeters. In such extreme situations, dampproofing as discussed in the text may fail, and physical isolation of the lower fascia from resultant leaks will be the only way to avoid problems.

ABSORPTION FROM GRADE. Stain in base courses or ashlar at grade may be associated with either interior or exterior moisture. Omitted, poorly applied or deteriorating dampproofing occasionally is found to cause stain at grade. Equally often, puddling at grade, especially where concrete paving is adjacent to the stone, is the causative factor. The latter condition may be readily identified in damp weather, although its solution is involved with the difficulties of grade and slope changes.

Where esthetics permit, in existing conditions, a cove of properly colored joint sealant may be applied in

areas affected by puddling to break contact between moisture pools and stones' lower surfaces. (See figure below.)



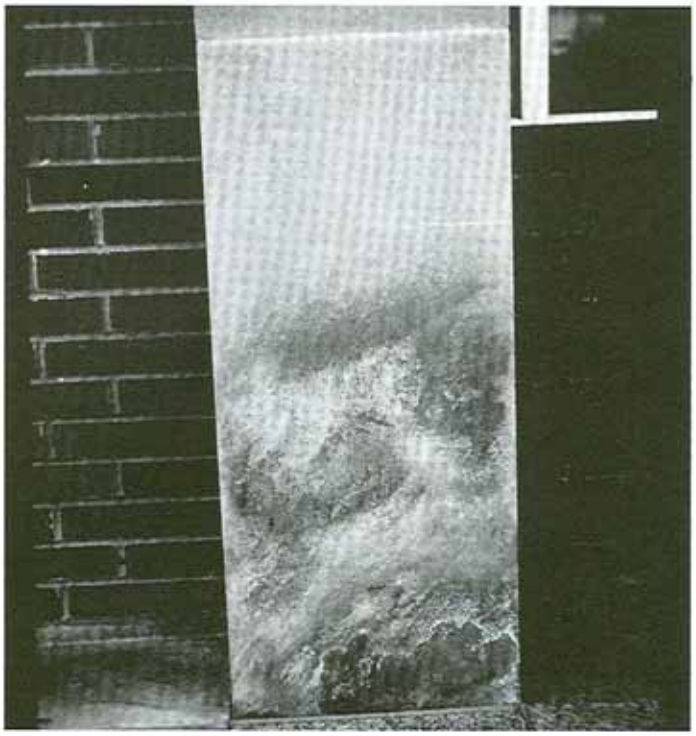


Although poorly tooled, this sealant "cove" between paving and stone face is an effective barrier to moisture absorption.

Treatment of improperly dampproofed areas within the wall is much more difficult and usually requires skilled treatment. Stain accompanied by exfoliation should be corrected promptly to avoid potential structural damage. Interior moisture sometimes can be wept off by inserting plastic weep tubes into the lower areas of vertical joints; existing weep holes can be cleared of debris. In some cases, no treatment short of removal of lower courses and placement of adequate dampproofing materials will solve the problem.

Moisture and its attendant stain in landscaping applications such as paving, benches, curbing, steps, signs, and the like present a continuing problem if original design and dampproofing procedure are faulty. Although high alkalinity is common in these areas, materials from other sources can contribute to stain at grade, and these stains present their own unique problems. (See Salt, Fertilizers, Soil Organic Fractions.)

Salt. The use of chloride compounds for snow and ice removal near limestone should be avoided. Common table salt (NaCl) and related chemicals recrystallize under the stones' surfaces as discussed elsewhere (p. 8) and cause efflorescence, especially around lower courses and below the first mortar or sealant joints. If exfoliation and efflorescence are prevalent in walkway areas, the building's winter maintenance program should be reviewed.

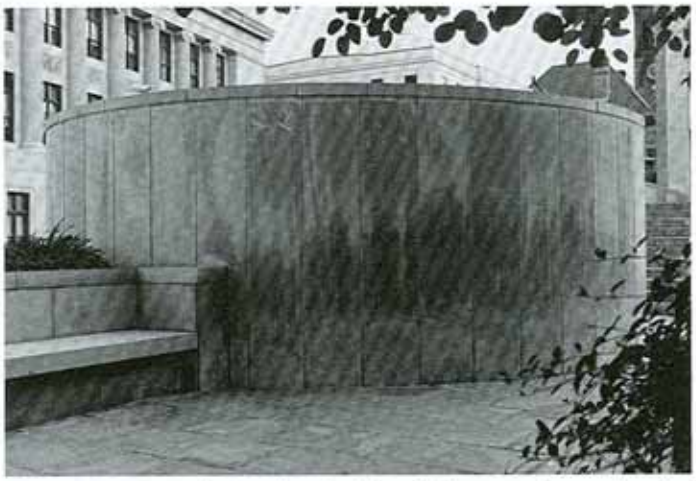


A typical efflorescence pattern on Indiana Limestone. Here it is shown superimposed on an alkali stain.

Although absorbed salt will not cause stains *per se*, the darkening effect of its moisture vehicle and the occasional resultant efflorescence are characteristics to watch for in assessing the potential for future problems. Salt absorbed from salted walkways may creep up stone faces three or four feet due to capillarity. One sign of this phenomenon is a continuous damp, blotchy look, even in dry weather, caused by

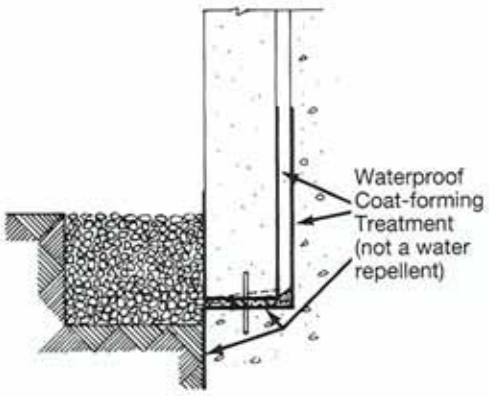
Over relatively few years, a snow-removal program using salt produced this deterioration on walkway paving.

the attraction of atmospheric moisture to absorbed salt.



A combination of absorbed salt solutions and unprotected stone backs in a planter area produced this discoloration.

Most clear water repellent treatments are minimally helpful in this area of preventive maintenance. Dampproofers used on stone backs can be applied to the affected face areas. Usually, the area absorbing the moisture is limited to two or three inches in height, although an occasional puddling condition may exceed that height, as may salted snow drifts.



Clear water repellents should not be used on stone backs or under grade.

Either asphaltic or cementitious dampproofing will protect against puddling. Asphaltic materials become a design consideration due to their color. Cementitious materials are of more neutral colors, but coatings are subject to wear, abrasion and breakage. Causative factors should be identified as external prior to the application of face treatments.

Fertilizers. Where stone is used at landscape grade, fertilizer-rich moisture presents metallic salts to the stone faces at or under grade. Such stone often is placed on slabs, grade beams or other structures of cement, making two types of deleterious materials available to the stone through capillarity.

Dampproofers should be specified in new construction, or added to existing when the problems occur. Underground concrete used as support for stone should itself be dampproofed. Cementitious material may be applied to the unexposed surfaces of the stone and up to or slightly above planned finished grade on exposed surfaces. It may also be used as dampproofing on underground concrete.

Where stone has been set unprotected in these conditions, it will help to expose the covered portions of it and to treat them with dampproofing, including the joint between stone and structure. This procedure will help isolate the stone from soil and fertilizer moisture. For proper protection against alkali stain, the full joint area between stone and concrete should be treated, although dampproofing the structure as far below the stone as possible will reduce the surface available to moisture.

Soil Organic Fractions. Stain from construction soil and ordinary dirt or clay is usually the result of contact by those materials with exposed surfaces; the coloring matter from soil normally will not travel through to the face of the stone. Therefore, proper handling will prevent problems of this sort. (See p. 6 on handling and storage.)

Avoiding dirt-splash on stone installed at grade involves simple preventive measures. A shallow trench filled with gravel around installed lower courses will reduce the incident of splash. During construction, membrane sheeting, scrap plywood or used scaffold boards will provide protection. Generally, any protective material spread from the wall line to two or three feet away will prevent splash.

To remove most types of dirt, wash with fiber brushes and cleansing powder. Occasionally, more drastic cleaning methods will be required, and in these cases high-pressure water or steam-cleaning may be effective.

EXTERIOR MOISTURE. ***Water Repellents.*** Exterior water repellents intended for application to vertical, above-grade, masonry walls are, generally, clear liquids of low viscosity. Their chemical makeup allows them to be absorbed by masonry substrates, leaving the surface essentially unchanged in color or texture. The active ingredients in water repellents are intended to be deposited in the pores of the substrate while not closing or blocking them, so that moisture vapor can pass from within the wall, but liquid moisture is not absorbed at the surface. Water repellents should reduce the adherence of dirt to building walls because they render the wall less absorptive. They should reduce or eliminate a "wet look" in rainy weather. They should reduce humidity in cavity walls. An effective water repellent will create these effects

without altering the color of the substrate, and without creating a shine, or sheen.

In common usage, water repellents are sometimes called sealers, or waterproofers, or dampproofers. These misnomers are confusing; worse, they tend to instill a false sense of security in users. Water repellents will not render a wall waterproof, nor will they "seal" it. Waterproofers or sealers are by definition coat-formers; they change the color and texture of the substrate. Ideally, a masonry wall treated with a water repellent should not differ in appearance, during dry weather, from a similar, untreated wall.

Water repellents are not waterproof. They will not bridge gaps in mortar or sealant joints. Their use is not a fail-safe for poor mortar practice, nor a substitute for dampproofing. Water repellents have been suspected of contributing to surface scaling in some cases. It is possible that a water repellent allowing vapor transmission may reduce the *rate* of transmission compared to identical, untreated, substrates.

Water repellents should be applied only on completed walls, with mortar or sealant joints in place. They should not be applied over wet or stained stones, nor to stone backs, nor stones under grade.

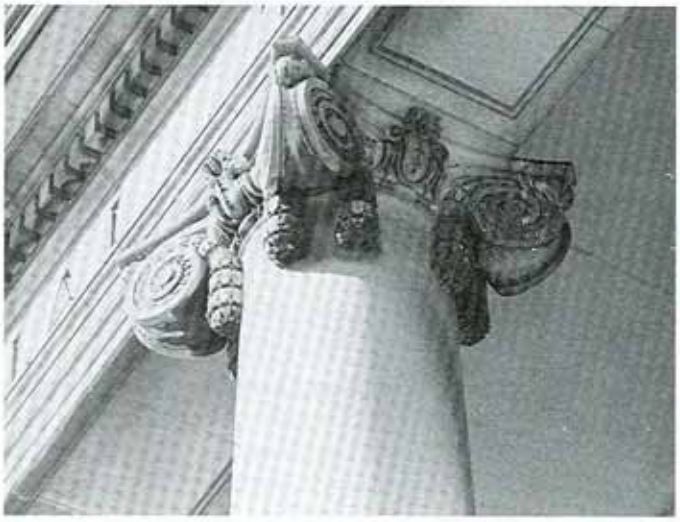
Good workmanship is essential in the application of water repellents. As a class, the materials tend to be labor-sensitive; substrate condition, weather condition, application tool, flow rate, etc., should all be in accordance with manufacturers' instructions.

ILI does not recommend specific types or brands of water repellents. Product types including silicones, stearates, acrylics, silanes, and siloxanes have all been used with apparent success on Indiana Limestone. ILI does recommend that (1) stone samples be treated on only one-half their surface for initial evaluation; (2) manufacturers provide statements on both vapor transmission and guarantee; and (3) that applier and manufacturer agree on the condition of the wall and the weather prior to application.

An understanding of probable retreatment costs, probable length of time until retreatment may be needed, and alternatives to retreatment should be part of the consideration of water repellents.

ILI will respond to requests for further information on this subject.

Drip Marks. Water alone will not cause objectionable permanent discoloration to Indiana Limestone. However, rain water moves collected dirt and grime from building surfaces and deposits them in the form of drip tracings on lower areas. On complex or ornate buildings, the deposits tend to collect in locations where the flow of water is interrupted or slowed; locations protected from the elements are not washed by rain, and the gray tinge of the drip tracings may become quite dark.

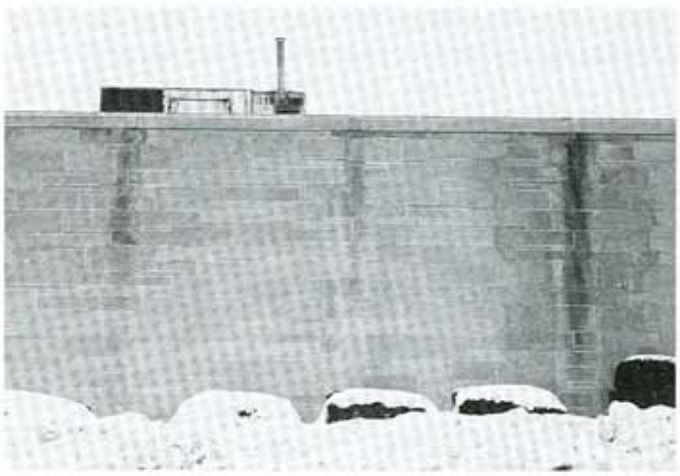


The lower areas of the volutes on this Ionic cap are protected from weathering. The resultant encrustation from years of soot could be greatly lightened if not entirely removed by scrubbing.

These accumulations will not harm the stone. In atmospheres polluted with high concentrations of sulphur dioxide (SO_2), minor surface fretting resulting from sulphuric acid may occur, but ordinary dirt, grime and soot are benign and removable.

Design precautions such as drip molds, projecting sills and back-sloped copings will eliminate most drip tracings and accumulations; however, eccentric wind currents carrying atmospheric dirt may produce patterns, even in areas protected by these aids.

One prevalent condition producing drip tracings occurs where joints in aluminum or other metal coping and gravel-stop are poorly made, or where their surfaces are unsloped. Water pooling in such areas collects dirt, and



Leaking connections in this metal coping collect water and dirt which flood over the stone below in a concentrated flow.

subsequent rains flood the pools, sending the dirty water over the face of stone below.

This same condition is seen where joints in stone coping are deteriorated, especially on vertical faces. Deteriorated joints can act as flumes, channeling water in a concentrated flow. Joints in copings, properly tooled to the same plane as the matching stone face, will help eliminate this condition. Drip molds and wash surfaces will reduce this problem.

Dirt accumulations and drip tracings are not stains. Beyond the architectural means of avoiding this problem, removal can be considered either a maintenance item or a major cleaning effort. Water repellent materials are sometimes applied for additional protection.

STAINS FROM METALS. ***Iron and Steel.*** Ferrous metals produce the most obvious and objectionable of the metallic stains, although cupreous metals (brass, bronze, copper) also develop objectionable stains.

Rusting steel and iron in any form will produce a typical

Lack of maintenance on this air conditioner has produced a badly stained sill and other stones in the splitface wall below.

rusty drip tracing. Unlike other types of stains, the source is immediately obvious. Alkali stain is sometimes mistaken for rust stain because of the color similarity.

Continuing maintenance on sources of rust should be a rule. Stains are easily removable in early stages; older stains can be lightened and often removed completely by using the same methods.

To remove rust stains, scrub with a hot concentrated solution of oxalic acid; after scrubbing, drench thoroughly with clear water.

Occasionally, a buildup of the deposit from rusting metal will require chipping or abrasion to reach the stone surface. After removal, apply the oxalic acid solution. Complete removal of indurated rust stains may not be possible. Oxalic acid is poisonous and should be handled carefully to avoid excessive exposure of skin, eyes and lungs. It can be purchased in most drug stores.

Cupreous Metals. Cupreous metal stains are produced in the same way as rust stains, and will develop in identical drip patterns. Copper, bronze and brass are used for their appearance as well as their resistance to deterioration. Therefore, ordinary painting may not be an acceptable maintenance procedure. Clear coatings, such as weatherproof lacquer or clear liquid vinyl, may be applied to retard oxidization and its characteristic green stain. These coatings may be applied over the oxidized metal if a green color is desired.

Removal of the cupreous stains may be accomplished by scrubbing the stone with a solution of water and potassium cyanide—one to two ounces of cyanide per quart of water. A sodium cyanide solution of the same strength will work equally well. After scrubbing, drench the surface thoroughly with clear water. This procedure usually will remove such stain and leave no apparent damage to the surface of the stone. **These compounds are poison and must be carefully handled. Do not allow them to come in contact with any form of acid.** Household bleach will decompose remaining cyanide.

A paste of powdered aluminum and aluminum chloride or ordinary kitchen ammonia is a less hazardous and somewhat less effective cleaning material. The paste can be applied as a poultice, or a thinner mixture can be scrubbed into the stone. After scrubbing or removing the poultice, scrub surface thoroughly with clear water.

Most metal stains in modern buildings result from materials added after construction, such as signs, marquee hangers and flagpoles. Using stainless steel or aluminum appliances for these additions will reduce stain potential.

Metal signage and other decorative or informative additions should be fixed to the stone so that they stand away from the face at least 1"—more if possible. This placement will minimize the tracings of dirt and grime moved from their surfaces by rain.

Aluminum. The oxide of unanodized aluminum causes a silvery gray deposit to form where it washes over limestone. Untreated aluminum caps and gravel stops, spacer rings on sign supports, railings, etc., may create this condition. The deposit can be removed easily by scrubbing with detergent or cleanser. Sources should be treated with liquid vinyl or waterproof lacquer similar to treatment for cupreous metals.

JOINT TREATMENTS. ***Sealants.*** Joint sealants do not generally cause stains. Some formulation types may bleed their oils through masonry substrates. In Indiana Limestone, this phenomenon takes the form of a lighter-colored blush in the area of treated joints. Specifiers should be certain of compatibility of the preferred sealant with Indiana Limestone.

Most sealants will leave "tracks" if smeared or gunned

on the face of the stone. Manufacturers' solvents will usually remove them. Installers may improve their procedure by masking stone faces adjacent to the joints.

Mortars. Mortar and tuckpointing materials contain at least a minimum percentage of soluble alkali which can cause temporary stain. However, these stains are likely to be light-colored and of short duration. Where cement with low alkali content can be used, mortar stain of organic nature will be minimal. Mortar smears are likely to be more troublesome and long lasting. Good application practice will minimize smears, and any fresh mortar on stone faces can be easily removed with wet rags or brushes. Use care that no new smears result from this procedure, through the transference of mortar fines to the stone face from the mortar joint. See p. 17 for removal of older smears.

Stains and Blemishes Caused by Environmental Factors

SOOT AND SMOKE. Soot is the black or gray material moved by water or air currents to form the drip tracings mentioned earlier. Local concentrations of soot may be removed easily by scrubbing with soap or detergent and fiber brushes. Larger areas or entire buildings may be cleaned in the same way, although other methods are usually chosen for speedier results. Steam-cleaning or a combination of steam and hot water with soapy additives are often effective in soot removal. High-pressure water also usually produces good results.

Deposits from smoke ordinarily may be cleaned with these methods. Particularly heavy concentrations, as from diesel engines, smoky fireplaces or destructive building fires may require repeated washings; in some cases abrasive treatment may be indicated.

Oily smoke deposits can be especially troublesome. A lime poultice may be used if the areas involved are small, but residue should be removed first by vacuuming. Residue on larger areas may be removed by air pressure. Professional attention to these types of stains may be required, unless affected areas are small.

BIRD DROPPINGS. Pigeons and other birds contribute to limestone stain mainly on and under horizontal surfaces in upper building areas such as window sills, copings, railings and ornamental work. Droppings are relatively harmless to the stone, although they produce a mild phosphoric acid and can roughen the stone's surface. Droppings may be hosed away with low-pressure water, and most resultant stain may be removed by scrubbing with fiber brushes and kitchen cleanser.

Bird protection materials often cause more damage to the stone than birds. Electric systems require the placement of insulators; many systems are set on corrosive metal posts. Oxide stain will occur unless stainless steel is used. Fences of wire or stamped metal often are of corrosive materials. Paste substances may be oil-based, and stone surfaces absorb the oils.

FREEZE DAMAGE. Damage to Indiana Limestone as a result of freezing is rare. Although moisture in the stone will freeze when sufficiently cooled, resultant damage almost always occurs prior to shipment. Frozen stone cannot be handled in mills and quarries because it tends to fracture and spall away as a result of minute cracks. Freeze-damaged Indiana Limestone is quite friable. Its grains tend to separate and can be rubbed off. It may split easily into sheet-like fragments. Thus, stone damaged by freezing is seldom shipped.

Indiana Limestone does not absorb enough moisture in normal use to overcome its natural elasticity when frozen; it rarely fails as a result of moisture absorbed in place. Exceptions occur at parapets and copings when leaking joints allow more moisture to accumulate than the stone can exude or breathe away. Such examples usually occur on north elevations, or areas protected from the sun by trees or nearby buildings.

Lower areas in the building, even those constantly soaked by grade moisture, suffer little damage because of heat absorbed from the building and the earth.

Indiana Limestone damaged by freezing cannot be repaired and must be replaced.

FUNGI, ALGAE, IVY AND OTHER VEGETABLE GROWTHS. Drip tracings and fungi often are confused. Especially in warm, humid climates, high-lime substrates may attract a black fungus which grows in protected areas on the building. In appearance and location, the fungus is quite similar to ordinary dirt encrustations, and in many cases they exist side by side.

There is little practical difference between the two conditions, in that the removal procedures for dirt also will remove the fungus. However, fungi may be expected to reappear within a short time.

To remove fungi, scrub with a 50-50 solution of household bleach, or hydrogen peroxide, and clear water. Rinse thoroughly with clear water after scrubbing. Water repellent materials also may be used as retardant treatment. Do not apply water repellent materials over dirt or fungi.

Other fungi, algae, lichens, moss and similar growths will appear on limestone when moisture, dim light,

nutrients and relatively warm temperatures are prevalent. These conditions ordinarily exist at or near grade, in shaded or north elevations, or on flush parapets with no coping overhang. Bird droppings in other areas may contribute the nutrients to produce growth if other requirements are present. Growths often cling with tendril-like feet or roots, which penetrate the stone to remarkable depths in older growth concentrations.

This corner area provides the necessary conditions for a growth of moss. Other vegetable growth may develop with the added nutrients of droppings.

To remove growths, scrape material and then scrub with soapy water or detergent. Prompt removal will aid in avoiding potentially damaging results to the stone.

Ordinary fungicides may be effective, but most of them contain deleterious materials or coloring matter. The removal program suggested earlier may be augmented by localized application of water repellent materials, which reduce moisture concentrations in growth areas.

The tradition of ivy-colored halls argues for the maintenance and care of ivy growth although specific cases of damage, particularly to mortar joints, can be cited. Ivy tendrils excrete a glue-like support substance which is extremely difficult to remove, and the tendrils themselves penetrate tiny cracks and pores in stone and mortar. This can be shown to cause minor spalling on stone faces and deterioration in joint materials. Such damage is usually of minor importance, probably because the ivy leaves help turn rain water.

Ivy roots are not known to cause damage to foundations. However, stems and roots may act as downspouts, funneling surface water down to foundation areas, where concentrated flows erode subsoil to produce dampness and potential substructure deterioration.

To remove ivy tendril glue and feet after the plants have been removed, use a high-pressure water jet. Glue residue may be reduced by scrubbing. Complete removal of residue, if required, can be accomplished by abrasion—sandblasting or grinding. Observe the precautions for all these cleaning methods listed in the "General Comments on Major Cleaning Procedures" found on pp. 7 and 8.

GRAFFITI. Graffiti materials include pencil, lipstick, felt-tip pen, spray paints, enamels, and lacquers. Each requires its own type of removal process and materials. The only general rule is that prompt cleanup will be the most successful. Specific recommendations for removal are given in this section.

Graffiti-proof coatings should not be confused with water repellent materials mentioned earlier (p. 12). Successful coatings tend to be slick or shiny. They offer no "tooth" to which graffiti materials may cling. The coatings also tend to retard the wall's ability to breathe. Therefore, their use should be limited to those areas subject to graffiti—generally within about eight feet of grade. These coatings may change the color of the stone by altering the refractive qualities of its surface; thus, they may become a design consideration. Application should be terminated at joints or other natural stops. Some coatings are fragile and easily scratched when damp. See Bibliography for an NBS study on these coatings.

General Comments on Stain Removal

Externally caused miscellaneous stains and graffiti are of three general types classified according to the appropriate removal process: soluble in water or water with detergent, soluble in volatile or refined oil solvent, and those which must be removed by bleaching. Water, usually with a little detergent, is likely to be the best solvent for fresh stains of unknown origin, and usually will not retard the action of later removal attempts.

Where staining material is still wet when removal begins, use absorbent material to remove excessive moisture. Paper towels, blotters, sawdust, talcum powder or fuller's earth will serve.

When applying stain removal materials mask off lower areas to prevent loosened stains from redepositing below. Plastic tape and polyethylene film will usually work, except on the roughest textures.

Cleaning materials may be applied to the stain with a brush or a soft cloth. Work from the perimeter of the

stain inward to avoid spreading it. Several applications may be necessary to achieve satisfactory removal. Depending on the age and type of material, stains may not be completely removable; cleaning efforts on older stone may result in the removal of atmospheric dirt as well as stain. Often, hosing a wide area to natural sight stops such as stone joints or building returns will reduce the visual impact of the newly cleaned area.

Poultices are easy to make and use. They can be helpful in removing many of the stains mentioned in this section. Fuller's earth mixed to a paste with benzene or white gasoline will remove many fresh oily stains; older, indurated oily stains may be removed with a poultice of slaked (mason's) lime and clear water. Wet newsprint will aid in rewetting non-oily matter from which water has evaporated.

Usually, poultices should remain in place for at least twenty-four hours. The bulk of a dried poultice should be removed with a wood paddle or wedge; remaining portions may be brushed away.

Most of the solvent and bleach materials mentioned in this section may be purchased at well-stocked pharmacies. Some must be obtained at manufacturing chemists. Chemistry departments in colleges or high schools are good sources for small quantities of the more exotic chemicals.

Materials mentioned in this section include acetone, slaked or mason's lime, amyl acetate, benzene or white gasoline, carbon tetrachloride, ice, sodium peroxide, hydrogen peroxide, oxalic acid, acetic acid or white vinegar, fuller's earth and paint removers. While these materials are effective as described, water with kitchen cleansers and ordinary detergents, promptly used, will usually remove most common staining materials. (Tri-sodium phosphate may be substituted for ordinary detergents for treating problem areas.) Exceptions are tar, paint, varnish, and lacquer products and the "indelible" felt-tip markers. Prompt removal efforts will be the most successful. As staining materials dry, the vehicle is drawn more deeply in the stone and may resist all removal efforts. In general, it is advisable to dampen areas below the stain prior to applying the chemical removers. This will help avoid reabsorption in areas not masked off as suggested above. Special precautions for operator protection should be observed when using lime, sodium peroxide, oxalic acid and the materials with low flashpoints or harmful fumes.

Carbon tetrachloride is not easily available but a substitute degreasing material such as 1,1,1 trichloroethane will perform equally well. Trichloroethylene may be substituted for either, but has a toxicity factor similar to carbon tetrachloride and should be used with equal caution. Avoid prolonged breathing of vapor from these or related products, and observe manufacturers' cautions in use.

Sodium peroxide is violently reactive in water and must be used with extreme caution. Where its application is called for, mix it 50-50 with inert powder such as fuller's earth to reduce its quantity and help control the reaction. Even in this reduced concentration, sodium peroxide should be allowed to remain on the stone only a few seconds before being hosed off. Yellowish halos caused by sodium peroxide will weather away, usually in a few months.

Where it is possible to identify the material causing the stain, proceed with the method suggested. Trial and error, using variations of the suggested procedures, may prove effective depending on the formulations of the stain-producing materials. Trial patches will help determine the best procedures where large stain areas are to be treated.

Large areas of casual miscellaneous stains and graffiti may require professional attention.

Miscellaneous Stains

Egg

To remove egg, wash while still damp with fiber brushes and soap or detergent. To remove dried stains, rewet by soaking or applying a poultice of wet newspapers. Scrape away softened material, and scrub with soap or detergent. Indurated stains may be difficult to remove; rewet the stain and scrub first with vinegar; next, use soap or detergent and kitchen cleanser. Acetone or carbon tetrachloride usually will remove remaining stain.

Heel Marks

To remove the most objectionable portions of black rubber heel marks, scrub with kitchen cleanser. Repeat scrubbing to remove ground-in material. Acetone also may be effective. High-pressure water usually will remove stubborn particles.

Mortar smears

Poor mortar application practice will result in smears on the stone faces next to joints. To avoid unsightly, hard-to-remove stains, remove fresh smears promptly with clear water sponging. Remove newly set-up mortar by scrubbing with abrasive cleanser. Loose abrasives, such as fine white sand or stone dust usually are effective when scrubbed on older mortar or tuckpointing smears with wet fiber brushes. Ordinary sanding generally is not effective because it removes the stone surface, leaving mortar in pores. Commercial mortar removers may be used cautiously in trial areas; these materials usually contain acids.

Oil and Grease
Fresh stain can sometimes be drawn out with a lime poultice. For older, deep stains, saturate a blotter with either amyl acetate or benzene and place over the stain; make sure the blotter extends well over the boundaries of the stain. Move a heated iron over the blotter to hasten both evaporation of the solvent and removal of the stain. In severe cases, the treatment may need to be repeated. (Take precautions that the temperature of the iron does not exceed the flash-point of the solvent.) Carbon tetrachloride and fuller's earth in poultice form may also be used. These treatments should be followed by scrubbing with detergent and water.

Tar
Chill tar with ice and slice away bulk with a razor blade, being careful not to smear the adjoining surface of the stone.

Asphaltic or bituminous emulsions are water-based and should *NOT* be treated with degreasers or solvents. After removing the bulk of the materials, scrub stains with kitchen cleansers and fiber brushes.

Oil or solvent-based bitumens are best treated with benzene or carbon tetrachloride poultices, followed with a cleanser scrubbing. Repeated applications are usually necessary, and complete eradication may not be possible.

Blood
Wet with water and dust with a thin layer of sodium peroxide. Sprinkle with water and allow the peroxide to remain a few seconds, then scrub vigorously with copious amounts of clear water. After the sodium peroxide has been washed off, the area should be scrubbed with a 5% solution of acetic acid or white vinegar. (Note precautions on p. 17.)

Beer
Scrub with soap and water. Remove older stain by scrubbing with hot concentrated solution of oxalic acid; after scrubbing, rinse thoroughly with water.

Chocolate and chocolate milk
To remove fresh stain, scrub with soap and water. Remove older stain with acetone or carbon tetrachloride.

Soft drinks, coffee
Scrub with soap and water. If dark coloring matter remains after scrubbing, apply a poultice of carbon tetrachloride. After removing the poultice, scrub with ordinary laundry liquid bleach, and flush with clear water.

Chewing gum
Chill gum with ice and slice away bulk with a razor blade. Use carbon tetrachloride to soften remaining material and remove with a cloth. These stains are usually difficult to eradicate.

Crayon
To dissolve and soften marks, brush on a solvent such as acetone and remove with a cloth. Remaining "ghost" image should be scrubbed with kitchen cleanser and fiber brushes.

Milk/cream/ice cream
Scrub with soap and water. Any remaining stain usually can be lifted with carbon tetrachloride. Liquid laundry bleach will usually remove any halo or ghost image.

Fruit/vegetable matter
Scrub with soap and water or kitchen cleanser. Remove remaining stain "halo" with liquid laundry bleach, or with sodium peroxide as described for blood stains.

Lipstick
Soak stain and surrounding area with water. Scrub stain with soap and water or cleanser. After the area is dry, remove remaining stain with a poultice of carbon tetrachloride or acetone.

Paint/varnish
Soak stain and surrounding area with water and then apply paste-type paint remover. Rinse and reapply as required.

Felt-tip pen stains
To remove water-soluble inks, scrub with soap and water. Treat solvent or oil-type inks with either paint removers or poultices as described for lipstick. Certain quick drying, permanent marker inks are extremely difficult to remove, and may require broad-area sanding.

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