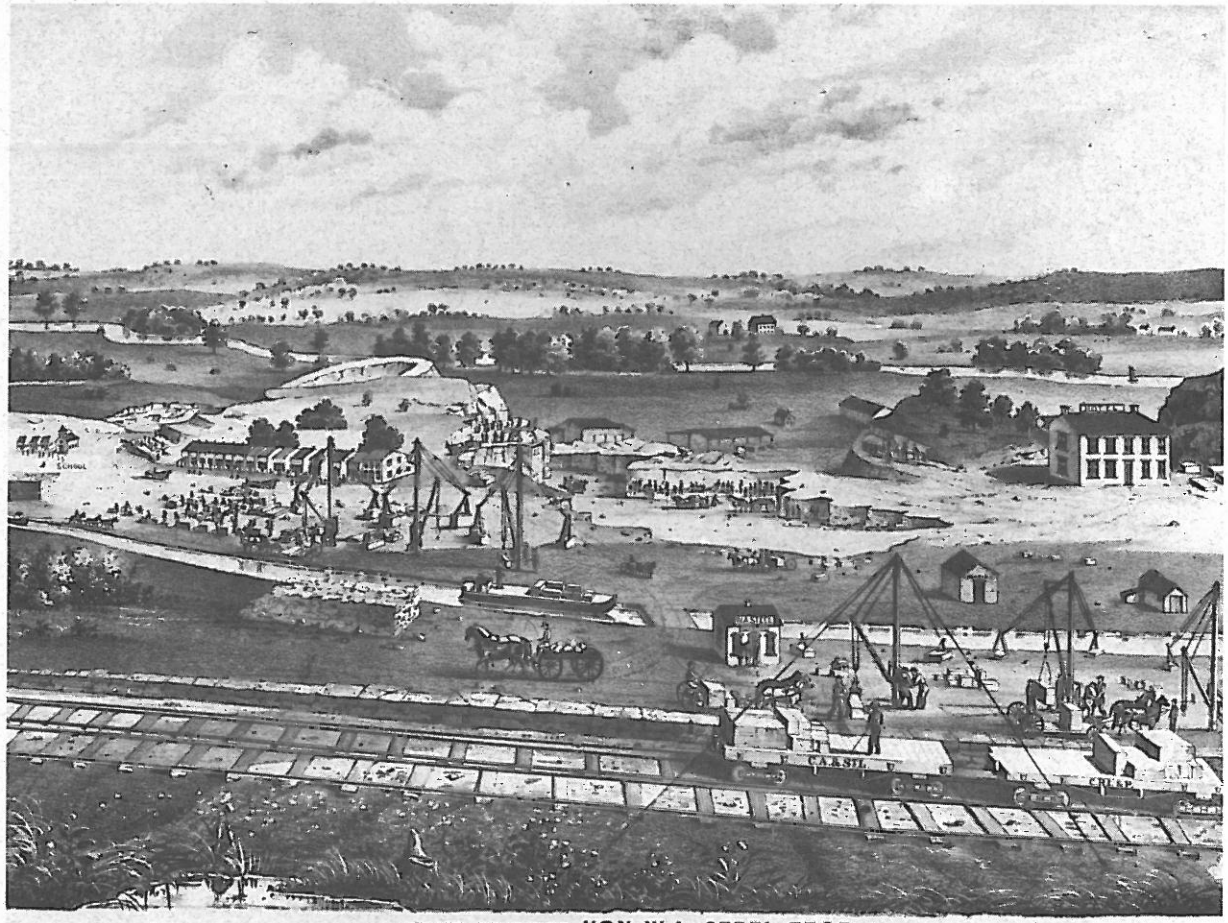
Preservation of an Historic Building Material

JOLIET–LEMONT



JOLIET QUARRIES. HON. W. A. STEEL, PROP.
Joliet, Will County, Ills

LIMESTONE

Landmarks Preservation Council of Illinois

53 West Jackson Blvd.
Chicago, Illinois 60604
(312) 922-1742

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Published By
Landmarks Preservation Council of Illinois

Editors

Vincent L. Michael
Landmarks Preservation Council of Illinois

Deborah J. Slaton
Wiss, Janney, Elstner Associates, Inc.

By Primary Authors

James C. Bradbury
Illinois State Geological Survey (Geology)

Deborah J. Slaton
Wiss, Janney, Elstner Associates, Inc. (Conservation)

Joseph La Rue

Donald G. Mikulic
Illinois State Geological Survey

Vincent L. Michael
Landmarks Preservation Council of Illinois (History)

Layout and Production donated by Christine Harmon and Janet Bloch

Illinois Historic Preservation Agency
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Introduction

The Landmarks Preservation Council of Illinois (LPCI) initiated this publication as part of a continuing series of booklets designed to further the use and preservation of historic building materials. Several years ago Amy R. Hecker, Emily J. Harris and Therese Kelly laid the groundwork for the publications.

This booklet follows our publication of *Terra Cotta: Preservation of an Historic Building Material,* and is intended as a practical guide to the conservation of Joliet-Lemont limestone. This dolomite stone is a native Illinois building material that was used widely in the nineteenth century for every type of construction from canal locks and bridges to churches, homes and businesses. LPCI hopes that the information contained in this booklet will raise public awareness of the value of this nineteenth-century building material and the means for its preservation.

This booklet is designed to assist building owners, architects and contractors in making informed decisions and to provide scholars and the public with an historical and technical understanding of this stone that was so important to the settlement and industrialization of our state. The recommendations here comply with The Secretary of the Interior's Standards for Rehabilitation. The Secretary of the Interior's Standards are used by the National Park Service, State Historic Preservation Offices and many local preservation commissions as the reference for appropriate preservation actions. Compliance with the Standards is a requirement for all federally funded undertakings.

The study is divided into two main sections; the first on the geology, history and use of Joliet-Lemont limestone and the second on the deterioration and conservation of this historic building material. It is hoped that this publication will inspire further study into the history and use of this native Illinois stone.

Landmarks Preservation Council of Illinois is a private not-for-profit membership organization dedicated to preserving the character and vitality provided to Illinois communities by historic architecture.

The editors are indebted to the following persons for valuable assistance in the research and production of this booklet:
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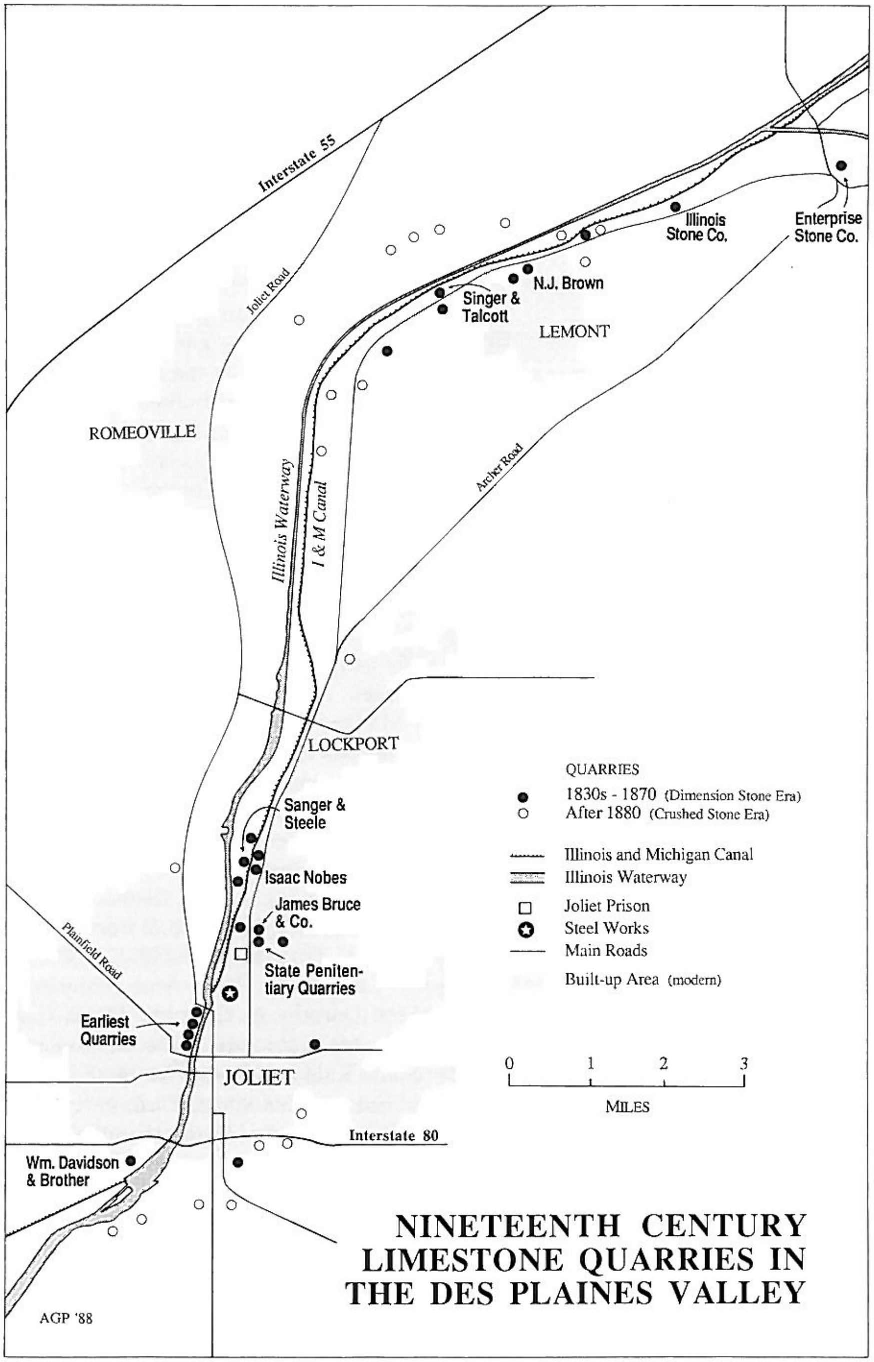


Cover graphic of the Joliet quarries of "Hon. W.A. Steel, Prop." from "The Illustrated Atlas of Will County" (1873). Note the importance of the I & M Canal and the Chicago, Alton and St. Louis railroad to the quarry industry. Courtesy Upper Illinois Valley Association.

Map prepared by the University of Chicago Committee on Geographical Studies, Professor Michael Conzen, Chairman. Alexis Papadopoulos, Cartographer.

Chapter One

"Therefore when we build let us think that we build forever — let it not be for present delight nor for present use alone — let it be such work as our descendants will thank us for and let us think as we lay stone on stone that a time is come when those stones will be held sacred because our hands have touched them and that men will say as they look upon the labor and the wrought substance of them: 'See! This our fathers did for us!' "

—John Ruskin, 1849

Stone has long been one of man's most important building materials. It was probably first used for simple temporary shelters. As the nomadic hunters-and-collectors lifestyle gave way to more permanent community organization, stone increased in importance. The enormous stone structures built by the Egyptians, Ancient Hindus, Chinese, Mayans, Greeks and Romans attest to its importance to early civilizations. The temples, monuments and tombs of these peoples were at once their sacred and cultural centers, and had they been constructed of less durable materials, we would know little of these civilizations today. The permanence of stone gives to humankind's creations an immortality denied the creator.

Natural stone was also an important building material during the early settlement of the United States. Limestone was especially important, providing not only building stone, but also lime for use in mortar and later, cement. Before the advent of concrete blocks, building stone was used for foundation stone in the construction of most permanent structures. If quarried rock was unavailable locally, fieldstone (glacial cobbles and boulders) was used for foundations.

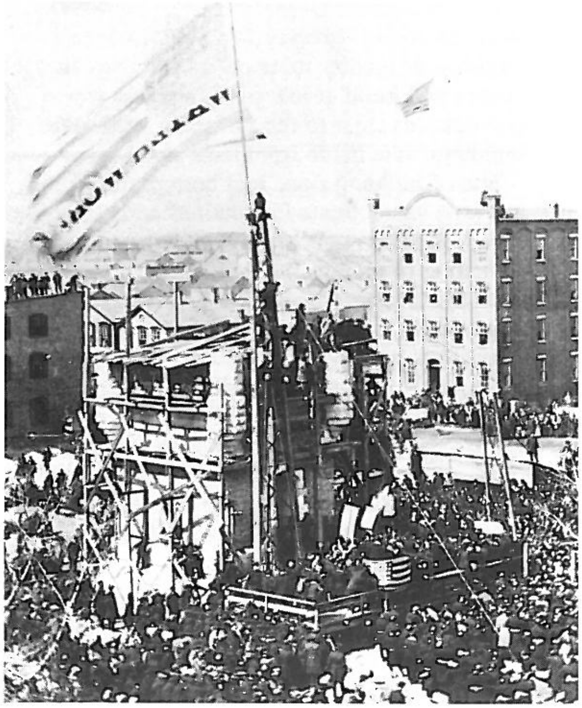
The great cost of quarrying and transporting cut stone prohibited all but the wealthiest individuals and businesses from constructing buildings made entirely from cut stone. However, if a landowner had outcrops of quality stone on his property, he could quarry and build at low cost. In places where bedrock was close to the surface, a wide variety of buildings were made from local stone.

Use of building stone had both practical and aesthetic value. Stone foundations added stability even to wooden structures. Its durability and insulating properties were practical benefits. Finally, stone buildings were an attractive alternative to the commonplace wooden or brick structure of the nineteenth century.

Some of the earliest recorded uses of building stone in Illinois were the 1753 rebuilding of Fort de Chartres in Prairie du Rocher with "stone quarried from nearby cliffs"[1] and the use of foundation stone in the Pierre Menard House in Chester in 1802.[2] Many other less notable structures utilized local stone supplies at this time.

The continuing influx of settlers into the state during the early 1800s resulted in the discovery of additional stone deposits, improvements in the transportation network and employment for specialized stone cutters. These factors together produced a rapidly expanding building stone industry.

The "Marble" Beds of the Des Plaines River Valley. 400 million years ago Illinois was submerged by an inland sea that covered most of the North American continent. In this Silurian sea, invertebrate cephalopods, crinoids and the ubiquitous trilobite held sway. Over vast periods of time the calcurous shells of microscopic plants and animals, along with fragments broken from the shells of larger organisms, accumulated on the sea floor, forming beds of limestone which were later altered to dolomite. These dolomites form the upper strata of the bedrock (the



William W. Boyington's famous Chicago Water Tower under construction in 1868. This rare photograph appears courtesy of the Chicago Historical Society with thanks to the Commission on Chicago Landmarks.

solid rock beneath the glacial drift) of the eastermost counties in northern Illinois (Lake, Cook, DuPage, Will and Kankakee) and the eastern part of the next tier of counties west (McHenry, Kane and Kendall). The part of the Silurian succession that furnished most of the building stone was the Sugar Run Dolomite.

Quarries in these Silurian rocks began operating around Chicago during the 1830s, producing excellent lime, but substandard building stone. Chicago area limestone was poorly bedded, coarse and broke into irregular pieces. Rough foundation stone could be made only after much trimming and cutting.

West of Chicago along the Des Plaines River Valley, however, were extensive exposures of building stone quality Silurian rock.[3] The shallow topsoil of the glacial floodplain barely concealed well-bedded, smooth-textured rock of the Sugar Run Dolomite. Easily quarried and split into a variety of bed thicknesses, the stone from the quarries in Juliet (now Joliet) was considered a valuable building material.[4] It was first used by M. Demmond to construct a three-story stone building in Juliet in 1835-6.[5] The I & M Canal Commission built a limestone warehouse at Lockport in 1838. The first documented use of Joliet area limestone in Chicago occurred in 1846, when cut stone was transported by wagon to the Scammon School Building.[6]

The opening of the Illinois and Michigan Canal in 1848 proved a major boost for the use of Des Plaines River Valley limestone. The I & M Canal was excavated through the Silurian bedrock of the Des Plaines River Valley between Lemont and Joliet. The 15 canal locks (themselves) were constructed out of the native stone. During canal construction several contractors realized the economic potential of these sites located at the edge of a cheap transportation system. The stone could now be easily and cheaply transported to the center of Chicago. The building of the canal also resulted in the discovery of additional quarry sites near the community of Athens (now Lemont) in 1846.[7]

Limestone, Marble, Dolomite—What is this Stone?
Of the three major classes of rocks (igneous—formed from molten magma deep in the earth; metamorphic — a rock changed by heat and pressure from its original character; and sedimentary — formed by the consolidation of bodies of sediment), only sedimentary rocks are generally exposed in the bedrock of Illinois.

The major sedimentary rocks in Illinois are sandstones, shales and limestones. Sandstones are composed of grains of quartz sand, eroded from older rocks, carried by streams and deposited in shallow seas, beaches, deltas and floodplains. Shales are created by weathering of smaller particles (quartz silt and clays) than those of sandstones. Limestones, on the other hand, are composed of materials that originated in the seas themselves, shells (and other skeletal parts of organisms) and precipitated carbonate. The shells and skeletal parts may be collected by wave action, or they may be preserved in the rocks much as the organisms lived, such as in the reefs. Reefs are common in northeastern Illinois rocks, and one of the largest and best known is Thornton Reef, site of the second largest quarry in the United States.

Like limestone, dolomite, the predominant rock type in northern Illinois, is a carbonate rock and has properties very similar to those of limestone. The chief component of the rock is the mineral, dolomite, a calcium-magnesium carbonate; while the principal mineral in limestone is calcite, a calcium carbonate. Dolomite generally forms by replacement of limestone (or limy sediments) with magnesium substituting for calcium.

Marble, a metamorphic rock composed of carbonate minerals, does not occur naturally in Illinois. However, the building stone industry has long seen fit to apply the term "marble" to any carbonate rock that will take a polish and has an attractive appearance. Buff white when freshly quarried, the dolomite stone of the Des Plaines Valley was thus marketed as "Athens Marble" and "Joliet Marble."

The terms limestone, dolomite and marble have all been used for the dolomite strata of northeastern Illinois. In modern terminology, the preferred scientific term is dolomite, whether referring to the rock itself or to the rock formation. During the period when quarrying was a thriving industry in northeastern Illinois, the source beds of the Athens or Joliet Marble were referred to as limestone, or Niagaran Limestone.[10]

Geologic Structure and History of Illinois. The bedded strata of Illinois have been deposited, one on top of another, over a period of 500 million years. At various times these strata have been subjected to gentle warping, resulting in the present structural configuration of the state; a spoon-shaped basin Pennsylvanian-age strata are in the center of the state, bordered by older strata. The northern part of the state is affected by a structural high, the Wisconsin Arch. The older Cambrian and Ordovician strata are exposed in north central Illinois along the crest of the arch, and the overlying Silurian strata (containing the dolomite limestone of the Des Plaines and Fox River Valleys) are exposed along its flanks in northeastern and northwestern Illinois.

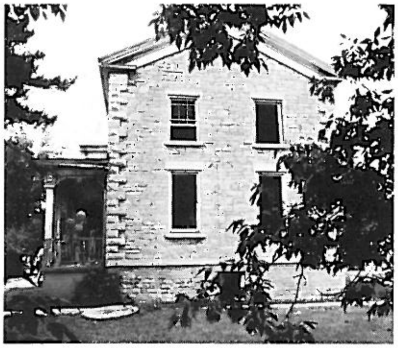
The great continental glaciers were the most recent source of sediments in Illinois. The glacial deposits (Pleistocene Series) cover more than 80 percent of the

Quarry workers at Lemont, 1880s. Photograph courtesy Lemont Area Historical Society.

state. In northeastern Illinois, the glacial drift is 100 to 200 feet thick and may reach 300 feet in places. This drift put severe limitations on the quarrying industry, which had to search for buried limestone "hills" and other areas where the drift is thin. Thus the Des Plaines River Valley — where the drift is so thin the rock literally pokes through the surface at places — became very important to the early quarrying industry.

Geologic Setting of the Building Stone Beds. The building stone beds are called the Sugar Run Dolomite, and are part of the Silurian-age bedrock in northeastern Illinois. The Silurian rocks dip east from the Wisconsin Arch (see geologic map), and the surface of the ground intersects increasingly older formations from east to west. The total thickness of the Silurian section is greatest along the Lake Michigan shore and Indiana state line (nearly 500 feet). The location of building stone beds is controlled by these geologic parameters of dip and formation thickness. Thus the outcrop belt of the Silurian beds lie west of center within the Silurian area.[11] One other geologic factor that exerts a strong influence on the exposure of Sugar Run Dolomite is

Western Stone Company, Joliet, 1907. Stone is quarried on several levels in this photograph taken by E.F. Burchard. Courtesy United States Geological Survey (Burchard, E.F. 454).



Patrick Fitzpatrick House, Route 53 near Lockport. This large stone farmhouse was built in the popular Greek Revival style in the early 1860s. LPCI photo.

glacial drift, which, as noted, is greater than 100 feet thick in much of northeastern Illinois. Where the drift is thin, the bedrock is close enough to the surface to be quarried. Production of building stone took place along the Des Plaines River, chiefly between Lemont and Joliet, along the Kankakee River in Kankakee County and along the Fox River in Kane County.

The early popularity of stone from the Sugar Run Formation for architectural use was due to its occurrence in smooth beds of a favorable thickness. The stone was a pleasing color and relatively durable. No other part of the Silurian section has these characteristics nor was used to any extent in the Chicago-Joliet area for building construction.

Quarrying in the Nineteenth Century. Pinpointing the specific locations of quarries or names of producers of dimension stone in northeastern Illinois in the 1800s is difficult. We know that the major sources of building stone in Cook and Will counties from the 1860s to 1880s were the quarries along the banks of the Des Plaines River from Sag Bridge to Joliet. An attempt has been made to map the many quarries that existed in the Des Plaines River Valley during the nineteenth century.

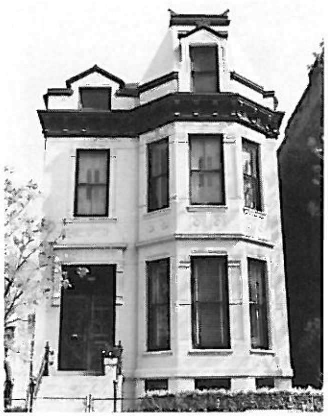
Production of dimension stone in the 1800s depended on hand labor and the quarryman's skill and experience. The layers of stone were pried up along bedding planes by the use of wedges and pry-bars. Open joints were used as major working boundaries; other joints were probably utilized as natural planes of breakage when prying up and dislodging the rock layers.

Quarrymen could control this slabbing operation by scoring the upper surface of the bed with hammer and chisel. The extracted slabs were dressed by hand methods, depending partly on the quarryman's skill in detecting natural planes of weakness in the rock but also undoubtedly aided by scoring with a chisel. The thicker beds (six inches or more) probably required the use of wedges to split them into blocks of desired shapes.

As the popularity of Joliet and Lemont stone increased, numerous quarries started up throughout the Des Plaines River Valley. Most of these quarries were small and short-lived because of poor stone quality, economic fluctuations, lack of room for expansion and many other reasons. A notable exception, however, was the quarry operated by the Singer family.

Horace Singer came to Lockport at the age of 13, accompanying his father, who had a contract to construct part of the Illinois and Michigan Canal. The Singers were joined by Horace's uncle, Isaac Singer, who developed and patented a rock drill to speed up the task of removing stone from the canal right-of-way. Later, this drill was used by Horace in the quarries which he began to develop in 1852. In 1854 Singer took on Mancel Talcott as a partner, and the Singer and Talcott firm grew through mergers and lease purchases to become a dominant force in the industry, setting prices for the Chicago area.[12]

In 1851 Anson Smith Sherman opened a quarry at Lemont, beginning the large-scale commercial exploitation of "Athens Marble" as a building material. He founded the Illinois Stone and Lime Company and was involved in free distribution of lime for sanitation purposes during the cholera epidemics of the 1850s.[13] Lime was also used in agriculture, to "sweeten the soil" where there was a high acidity.



1880s townhouse on Chicago's west side, entirely faced with "Marble" (dolomite limestone). LPCI Photograph courtesy William L. Lavicka.

The impact on the landscape of the Des Plaines River Valley was important and immediate. Joliet became known as "Stone City" for the many quarries surrounding the industrial canal community, and even today the stone is most commonly identified as "Joliet Limestone." The streetscapes of Lemont, Lockport and Joliet are still dotted with dolomite limestone buildings of every sort.[14] The number of quarries in the Des Plaines River Valley increased steadily until the 1870s, but by the end of the century mergers and purchases had created fewer, and larger, firms. The culmination of this process occurred in 1889 when the Singer and Talcott Company and five other firms were absorbed into the giant Western Stone Company.

Over fifty quarries are known to have existed in the Des Plaines River Valley between Sag Bridge and

Illinois State Penitentiary at Joliet (Joliet Prison), William W. Boyington, architect. "From The Illustrated Atlas of Will County" (1873), courtesy Upper Illinois Valley Association.
#26
Tower at Joliet Prison as it appears today. Courtesy Upper Illinois Valley Association.

Joliet. Others probably existed but have been obliterated by urban expansion, especially around Joliet, leaving no record.

Three principal products came from the Lemont-Joliet quarries: (1) dimension stone, used for rock-faced blocks or foundation stones, veneer, cornices, pillars, columns, vault covers, etc.; (2) flagstone, basically an uncut, naturally splitting building stone in fairly thin beds; (3) rip-rap and crushed stone; coarse, broken pieces for filling, concrete, macadam, and railroad ballast. The rock from this area was not as suitable for lime as the Chicago-area stone.

Although most of the high-quality building stone was quarried from the Sugar Run Dolomite, at least four other geological rock units are present in the area. Stone quality varied between quarries and between beds within quarries, even within the Sugar Run.

Because of gentle northeast tilting of the bedrock, the quality rock that occurs above the river level in the bluffs at Joliet is located at a lower elevation in the river bed around Lemont. Many of the quarries in the river bed south of Lemont to Joliet produced poor building stone. The commercial names "Joliet Limestone" (or "Marble") and "Athens Marble" were used for many years, but in reality there was no difference in the quality or appearance of the rock from these two areas as it came from the same beds. Lemont's greater proximity to Chicago may account for the preference for Lemont stone in Chicago.[15]

Use of Joliet and Lemont Limestone in Buildings. The Merchants and Mechanics Bank in Chicago was the first building to be veneered with sawn "Athens Marble" and many other businesses followed suit. In 1853, however, local quarries were unable to supply veneer for the Chicago Courthouse, which was faced with gray marble from Lockport, New York, instead.

Commercial structures in Chicago boasted many sawn limestone fronts, and until recently, many survived even in the central area. Examples can still be found in the Pilsen neighborhood, along Milwaukee Avenue in West Town, and on Clark Street north of the Chicago River. Joliet first saw commercial use of native dolomite in 1837 with the construction of "Merchant's Row" on Bluff Street, and throughout the century the stone served for every type of structure.

U.S. Steel headquarters building at Joliet Works. This Classical Revival monument employs rusticated, rough-faced Joliet stone and the true arch to convey solidity and dynamism. Courtesy Upper Illinois Valley Association.

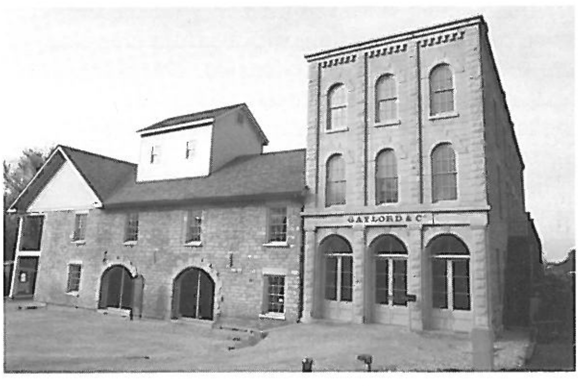
Canal contractors, quarry owners and other industrialists in Joliet, Lockport and Lemont have fine homes constructed of native stone, sawn into smooth ashlar blocks. The Milne House in Lockport is an early (1842) example. In Chicago, limestone front row houses began to spring up in the expanding neighborhood areas to the south and west in the late 70s and 80s, many of which can still be seen. Examples are found near Hull House and Arrigo Park, in Tri-Taylor, throughout the Near West Side, as well as scattered survivors in the Gold Coast, Old Town, Near South Side and Douglas neighborhoods. A few large homes fronted with Lemont or Joliet stone still survive in Chicago as well.

Angular Gothic churches were often faced with "Athens Marble." One of the earliest was the First Presbyterian Church on Wabash Avenue near Van Buren in 1857. The front facade of this edifice was highly ornamented with richly carved work in stone. Other churches built of this stone that still remain include Holy Name Cathedral (1875), First Congregational Church (1869), Holy Family Church (1860) and St. James Episcopal (1857). In the quarry towns, many churches of native stone survive, including St. James of the Sag Church near Lemont (1859); the Methodist Church (1861) in Lemont; the Congregational Church (1840), Methodist Church (1855) and St. John's Episcopal Church (1873) in Lockport; St. Mary Carmelite (1882), St. Peter's Lutheran Church (1884) and Christ Episcopal (1886) in Joliet.

Limestone was often used for large structures such as the home for the first University of Chicago erected in 1857-65 near 34th Street and Cottage Grove Avenue and the famous Water Tower and Pumping Station erected in 1869 at Chicago Avenue. These structures were designed in an embattled Gothic style by architect William W. Boyington, who used the stone — and the style — in many of his buildings. Boyington's castellated Illinois State Penitentiary at Joliet, begun in 1858, still stands across the street from a dolomite quarry.

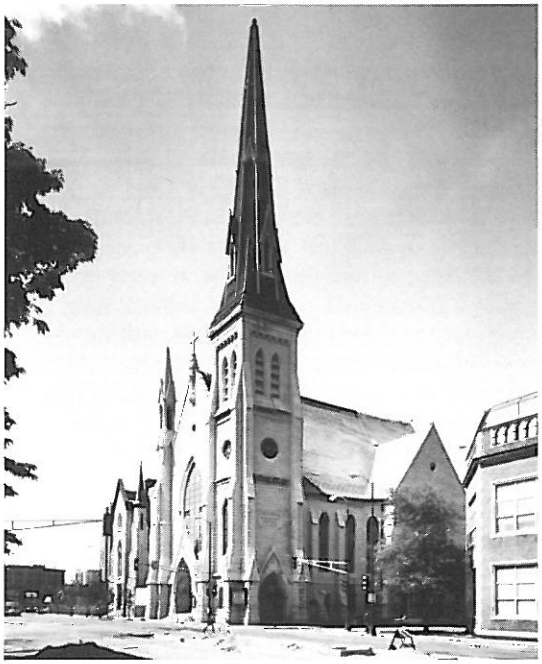
In the Des Plaines River Valley, limestone was important for industrial buildings such as the Gaylord Building (1838, 1859) and Norton Building (1855) in Lockport. In Joliet, the steel and wire works that opened north of downtown in the Civil War boasted buildings with stone from Joliet quarries, and the railroads which followed that canal through the valley made use of the stone for a variety of structures. Limestone train stations have been restored recently in Lemont and Lockport, and train sheds survive in Joliet.

By 1870, Illinois limestone quarries were able to



Gaylord Building, Lockport. The 2-story section was built with local stone in 1838. The 3-story Italianate addition, also dolomite, was built in 1859. Courtesy Upper Illinois Valley Association.

First Congregational Baptist Church, Chicago. This limestone church in the Gothic Style has graced Union Park since 1869. Photo courtesy Commission on Chicago Landmarks.



supply the facing for two added wings and a third story to John M. Van Osdel's 1853 Chicago Court House. When the Court House was destroyed in the 1871 fire, Lemont stone was used only for the County section of the new building, with Bedford limestone from Indiana used in the city section. This combined use of Athens marble and Indiana limestone foreshadowed what was in store for the Illinois limestone industry.

The stone gained a wide reputation. Joliet stone was used for the State Capitol in Lansing, Michigan, a county building in St. Louis and post offices in Des Moines, Iowa and Madison, Wisconsin. The Federal Government tested Joliet stone in 1867 and found it resisted a crushing force of 15,000 pounds per square inch.[16] This lead to several large government contracts, including the Rock Island Arsenal.

By this time, quarrying firms were following general patterns of American business expansion. For example, Singer and Talcott had grown from its modest beginnings in 1852 to one of the largest in the region with some 800 acres of quarries and excellent transportation facilities on the new Chicago and Alton Railroad as well as the I & M Canal. Using rapidly advancing technology and management skills, the firm was an industry leader in the West in the 1870s. It had yards and offices in two locations in Chicago and regularly carried a large stock of smooth, sawn and dressed limestone, as well as curbing, coping and paving blocks. During these years, Chicago investors had taken an interest in buying stone lands since the limestone had value both as a building material and for the manufacturing of lime, an important nineteenth-century product.

By the late 1880s, Athens Marble that had been in use in Chicago and other Illinois towns for approximately 40 years was begining to show signs of age. Critics began to publicize shortcomings of the stone. An 1891 publication stated:

> "Limestone for front has properly gone out of use. The old smooth ashlar fronts to be see on Washington Boulevard and Michigan Avenue are now considered out of date. In sawed ashlar the grain is exposed to weather, and, in consequence, soon shows the effect of such treatment. In the rock faced and trimming work that is now so generally used, the stone rests as it does in the quarry, which enables it to better resist exposure. Scarcely a block in our great city is free from noticeable defect in stone. Formerly, the number of quarries shipping to Chicago was

very few, and the choice was necessarily limited. This is the reason for the use of decaying stone, which is noticed in some of our buildings. At present time, about 60 limestone and sandstone and many granite and quartzite quarries are shipping here."[17]

The writer claimed that due to its poor weathering qualities the stone was being superceded for building purposes by Indiana limestone. There was also the suggestion that the Indiana limestone was superior for flagging and should replace the Athens Marble for that purpose.[18]

In the canal towns along the Des Plaines River Valley, the local stone continued to be used for major buildings through the 1890s. Lemont School, built in 1869 of smooth-faced limestone, was expanded by a massive Richardsonian addition in 1896 by Joliet architect John Barnes. After the Great Fire of 1895, Lockport built a new Central School in the same style and used the same architect. Barnes' brother Julian designed the limestone Auditorium Building in Joliet in 1891, an excellent example of mixed commercial/institutional use.

Joliet's East Side Historic District contains two churches, two homes and a school built of local limestone in the 1890s. Architect Frank S. Allen built the Joliet Township High School (1900-01) with Joliet stone highlighted by the use of Indiana limestone for lintels, sills and quoins. Adam Groth Stone Company provided the stone for the school and for the landmark Public Library, which was designed by Daniel Burnham in 1903 and used granite trim to highlight the Joliet stone.[19] By this date, however, Indiana limestone was becoming the preferred building material even in the quarry towns.

The Eclipse of Joliet-Lemont Limestone. A number of factors worked to make Bedford limestone eclipse

Joliet-Lemont stone rowhouses on West Bowler Street, Tri-Taylor Historic District, Chicago. LPCI photo by Mary Jane Keitel.

the use of Athens marble in Chicago. First, where Joliet-Lemont limestone was one of the few stones available in Illinois up until about 1871, by the 1890s 60 different kinds of stone were available to Chicago builders, allowing architects to be more selective. Second, new types of less expensive building materials came into use, such as Portland cement, terra cotta, and artificial stone. These products were substitutes for cut stone in much construction work. Third, architectural styles called for new materials and new colors. The polychrome of the High Victorian era had called for different colors of stone, but the trend in the 1890s was toward a more restrained use of exterior color.

A fourth factor in the displacement of the role of local building stone was the direct result of aggressive market expansion of a superior product. For instance, the Chicago and Bedford Stone Company in Lawrence County, Indiana, in 1878 published a price list stating:

Lockport Central Square, formerly Lockport Central School, John Barnes, architect, 1896. Barnes used the Richardsonian Romanesque Style. Courtesy Upper Illinois Valley Association.

Joliet High School, designed in 1901 by Frederick S. Allen in a Gothic style using both local and Indiana limestone. Photograph courtesy Joliet Area Historical Society, by Nick L. Contos, all rights reserved.

"We justly claim that we are prepared to furnish larger quantities of strictly first-class stone than any other quarry in the country. Our facilities for quarrying and shipping stone are unequaled, being provided with all the latest and most improved machinery for quarrying as well as steam derricks, capable of handling and loading the largest possible required at the shortest notice."

Yet Indiana stone did not eclipse native Illinois stone until the 1890s, when poor economic conditions forced many quarries to close. More importantly, violent labor strife witnessed at the Lemont quarries in the 1880s and 1890s led to unionization and higher labor costs which made it hard for Illinois quarries to compete with their non-union Indiana counterparts. The labor factor also made it hard for Joliet-Lemont limestone to compete with the new, inexpensive building materials.

The geological features of the Silurian rocks, however, made the biggest impact on the decline of the building stone industry in the Chicago area. The Indiana stone occurs in relatively thick uniform deposits easily cut into large or small blocks. In contrast, the Illinois stone occurs in layers seldom more than a foot thick and may be interbedded with poor quality layers. Therefore, it requires more careful selection, specialized handling and removal of waste rock. This, in turn, increases labor costs and limits the available size range of blocks. For these reasons, Indiana stone eventually dominated the market; however, in recent decades it has also been replaced largely by a cheaper, more convenient product — concrete.

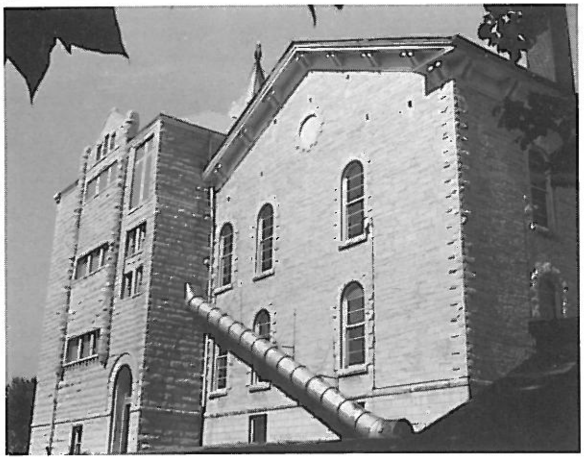
The decrease in demand for Illinois building stone in Chicago greatly affected the Des Plaines River Valley quarries. Production went largely from building stone to crushed stone. Where half of the Illinois limestone production was in building stone in 1890, only 25 percent was so involved by 1917. Half of all limestone by then was used for the manufacturing of concrete, with the remaining 25 percent used for road making and railroad ballast. The shift in production can be shown by the fact that in 1917, 75 percent of Illinois stone production was in crushed stone, and Illinois produced more crushed stone than any other state in the United States. However, Illinois' rank in the production of building stone had fallen from first in 1896 to 14th in 1917.[20] The precipitous decline was due to two factors: first, the subsitution of concrete and other materials in building construction and second, competition from the superior Bedford (Indiana) Limestone.

Quarrying continued along the Des Plaines River Valley for the production of crushed stone, but dimension stone was procured only when there was a specific demand for it. By 1925, only two quarries supplied building stone, and only upon demand. Sag Quarry near Lemont was worked by the Works Progress Administration and Civilian Conservation Corps in the early 1930s to produce stone for picnic shelters, bridges and culverts. The last building constructed of Joliet stone was the All Saints Greek Orthodox Church in Joliet, completed during World War II.[21] The use of Illinois Silurian rock as a building stone in Chicago had completely disappeared by that time.

There was some rejuvenation of the building stone industry in the late 1930s when Lemont stone was cut for interior use.[22] Polished stone panels from the Joliet quarries of the Adam Groth Stone Company were furnished for the interiors of the State Archives building in Springfield in 1938 and for the Natural Resources Building in Urbana in 1940. However, this interior use of the stone did not seem to take hold in Chicago.

Large quarries still operate along the Des Plaines River, but most produce only crushed stone, and only a few small one-man operations still quarry flagstone. Building stone can be obtained from the Brown-Barrick quarry at Lockport, but must be cut elsewhere. Several area quarries are pleased to sell stone for select projects such as historic restoration.

The Joliet-Lemont limestone that was used for many fine structures in Chicago during the mid-to-late 1800s simply went out of use around the turn of the century as a building stone. It became obsolete due to changing styles, to the availability of a better and cheaper stone, and to the development of new building materials. Fortunately, a number of gracious survivors from the era of Joliet-Lemont limestone remain as landmarks of the early history of northwestern Illinois, when pioneers pulled the stone from the prairie, called it marble, and built their schools, churches and homes.



Lemont Central School. The first section was constructed of local stone in 1869 in the Italianate Style. In 1896 John Barnes designed the addition (left) in a Richardsonian Romanesque Style, using the same stone. The tube attached to the building is a fire escape. Photo courtesy Lemont Area Historical Society.

Footnotes for Chapter One

1. **Koeper, Frederick.** *Illinois Architecture,* Chicago and London: University of Chicago Press, 1968, p. 222.
2. **Drury, John.** *Historic Midwest Houses,* Chicago and London: University of Chicago Press, 1949, pp. 57-59.
3. **Mikulic, D.G., M Sargent, R. Norby, and D. Kolata.** "Silurian geology of the Des Plaines River Valley, Northeastern Illinois." *Illinois State Geological Survey Guidebook 17,* 1985, p. 56.
4. **Shepard, C.V.** *Geology of Upper Illinois,* American Journal of Science, Series 1, Vol. 34, No. 1, 1838, pp. 134-161.
5. **Woodruff, George.** *The History of Will County, Illinois,* Chicago; Wm. LeBaron Jr. & Co., 1878, p. 436.
6. The school was located on West Madison near Halsted. "History of Chicago Architecture," recollections of John M. Van Osdel, *Inland Architect,* Vol. 1, No. 5, June 1883, p. 64.
7. The first quarrying operations in Lemont were begun by Nathaniel Brown, a canal contractor, in the early 1840s. Letter from Sonia Kallick to Wilbert Hasbrouck, April 11, 1981.
8. **Andreas, A.T.** *History of Chicago,* Chicago; Vol. 1, 1884.
9. *Illinois State Gazeteer and Business Directory,* 1893, p. 1111 ff.
10. The term *Niagaran* comes from the fact that the bedrock is part of a formation that reaches to Niagara Falls.
11. Major sources for this information are: **F.H. Bradley,** "Geology of Will County," *Geological Survey of Illinois,* Vol. IV, 1870, pp. 207-225, and **H.B. Willman,** "Rock Stratigraphy of the Silurian System in Northeastern and Northwestern Illinois," *Illinois State Geological Survey,* Circular 479, 1973, p. 55.
12. Isaac Singer later went on to fame in the sewing machine business, and Horace Singer was buried in Lockport rather than Lemont because his family feared reprisals after violent labor strikes at the Lemont quarries. *Lockport Illinois: A Collective Heritage,* Bank of Lockport, 1980, pp. 17-18.

13. **Karamanski, Theodore.** Mid-America Research Center, Loyola University, *Brown Property Historical Evaluation,* May, 1986. Also, Sonia Kallick, letter to Landmarks Preservation Council of Illinois, November 3, 1987.

14. **Conzen, Michael P. and Hanson, David B.** "The Des Plaines Valley; Historical Landscape of Business," *Bulletin of the Illinois Geographical Society,* Vol. XXIII No. 2, Fall 1981, pp. 3-17.

15. **Pierce, Bessie Louise.** A History of Chicago, 1848-1871, Chicago and London, University of Chicago Press, 1940, Vol. 11, pp. 105-06. Also **Frank A. Randall,** *History of the Development of Building Construction in Chicago,* Urbana, Illinois: University of Illinois Press, 1949.

16. *Joliet Evening Herald News,* Centennial Edition, June 3, 1936, p. 2. Also *Joliet Illustrated,* 1897, p. 10. Information provided by Jackie Garcia of the Joliet Area Historical Society.

17. *Price List of the Chicago and Bedford Stone Co.,* 1878.

18. "Our Lemont and Joliet dolomites were much used for both building and flagging. Because of their generally poor weathering qualities, the oolitic limestones (from Indiana) are fast superceding them for building fronts, and the oolitic stone ought to come in good demand for flagging, as it is superior for that purpose." *Industrial Chicago, The Building Interests.* Chicago: The Goodspeed Publishing Company, 1891, p. 454.

19. Mr. and Mrs. Mel Schroeder of the Joliet Area Historical Society provided information about the Adam Groth Stone Company which is documented at the Joliet Public Library.

20. **U.S. Geological Survey.** *Mineral Resources of the United States,* 1882-1923: U.S. Geological Survey, Department of the Interior, Washington, D.C.

21. Dorothy Crombie of the Joliet Area Historical Society reported the last use of Joliet limestone in the All Saints Church, letter to Landmarks Preservation Council of Illinois, November 28, 1987.

22. **Lamar, J.E.** "Illinois Building Stones," *Illinois Society of Architects Monthly Bulletin,* Vol. 26, Nos. 8-9, 1942, p. 6.

Chapter Two

Characteristics. Joliet limestone, which occurs in deposits in northeastern Illinois, has been quarried near Joliet, Lemont, Kankakee, Elgin and Aurora. The stone is a member of the Niagaran formation of Silurian age.

Limestone can be either highly calcitic or dolomitic in composition. Indiana limestone is calcitic, while Joliet limestone is dolomitic. The two general types of limestone can be readily distinguished by chemical and petrographic analysis; however, there is no other way to easily verify that a sample is Joliet limestone. If the stone is acquired in an area where Joliet limestone is commonly found, is dolomitic and contains a small amount of iron, then it is probably Joliet limestone.

Row houses on West Bowler Street in Chicago's Tri-Taylor Historic District were constructed in the 1870s with Joliet-Lemont limestone panels attached to a brick wall. The cornice is ornamental sheet metal. The present condition of the limestone varies from house to house and sometimes from block to block. Wiss, Janney, Elstner Associates, Inc. photograph.

Mineralogically, Joliet limestone is primarily composed of calcium carbonate ($CaCO_3$) and contains dolomite ($CaMg(C^{o}_{3})_{2}$). Joliet limestone is grey to white in color when freshly quarried or cut. On exposure to weather, much of the stone changes to a yellowish buff color as a result of the oxidation of iron in the stone. The yellow color of Joliet limestone after aging is its primary distinguishing visual feature. However, limestones from some deposits in Kansas, Wisconsin and Minnesota have similar colors.

The texture and structure of limestone can vary widely, from soft, poorly consolidated stone to hard, densely compacted stone. In the past, certain limestones were selected for use primarily because they had good strength characteristics. However, sections of stone within the same quarry or even within the same block may have different properties and weathering characteristics. Initial selection of sound stone is an important factor in assuring the longevity of this building material.

Deterioration. Limestone has proven to be very durable if not exposed to deleterious environmental conditions. Deterioration of limestone on buildings may be caused by one or more factors including water penetration combined with freeze-thaw cycling, cyclic wetting and drying, atmospheric pollutants, soluble salts, organic growth, wind erosion, and thermal expansion and contraction without relieving joints. Determination of the causes of deterioration of limestone building facades and the development of repair, conservation and maintenance procedures normally require the services of specialists.

Water penetration

As is the case with most historic building materials, water is a primary source of deterioration. In a limestone building, water penetration may occur at joints or other openings to the interior of the wall. Water penetration may also occur through rising damp if the stone is in contact with the ground. Once within the wall, water penetration may result in rusting of metal anchors and freeze-thaw deterioration, which may cause cracking, spalling, efflorescence due to migration of salts, alkali staining and damage to interior finishes.

Freeze-thaw cycling

The pore structure at the stone determines its susceptibility to frost damage. When water penetrates the wall in cold weather and freezes, pores and cracks in the stone are filled or coated with ice. Pressures from the expansion of the water as it freezes can cause fracturing of some stone. Cyclic freezing of water near the surface typically causes small incipient scale and microcracks along the surface of the stone. If ice forms in larger cracks beneath the surface of the stone, loosening and eventual spalling of large pieces of stone may occur. Freeze-thaw cycling typically has a more pronounced effect on stone located farther from the interior wall of the building because it is farther from the heated space of the building.

Deterioration is evident in the stone panels below a window sill course on this rowhouse. The window sill itself has been replaced, and the adjacent sill course shows spalling. Water collecting and passing through open joints in the sill to the stone panels below is likely the principal cause of deterioration. Wiss, Janney, Elstner Associates, Inc. photograph.

The limestone buttresses at Christ Church in Winnetka have been damaged by the effects of freeze-thaw cycling. Pressure from the expansion of freezing water within the wall has caused the mortar joints to open up and step cracking to occur throughout the stonework. Photo by Harry Hunderman, AIA.

Cyclic wetting and drying

In areas where climactic conditions are not severe enough to cause cyclic freezing and thawing, cyclic wetting and drying can cause deterioration of the stone due to capillary action or due to crystallization

Efflorescence is visible on adjacent areas of these West Bowler Street rowhouses, which exhibit a remarkable range of conditions. At left, a limestone facade has an intact sill, while spalling and efflorescence have occurred below the sill where water has penetrated the wall. At right, a masonry facade with ornamental limestone sills and quoins reveals severe spalling and cracking on the stone sill and efflorescence on the brick wall below. Wiss, Janney, Elstner Associates, Inc. photograph.

of soluble salts carried into the stone. Capillary action acts as the application and removal of forces within the stone. These forces can exceed the tensile strength of the stone, causing cracking and scaling.

Atmospheric pollutants

Although "acid rain" is perhaps the best-known carrier of atmospheric pollutants, pollutants may be carried in the air. Acid snow and acid fog also exist. When these precipitants fall on alkaline soil, they are neutralized. Acid-insoluble materials such as granite and most sandstone, brick and terra cotta are not affected by acid rain. Carbonates such as limestone, marble, travertine, lime mortar, some sandstone and cement products are acid-soluble and are therefore vulnerable to acid rain. Pure rain water is neutral and has a pH of approximately 5.0. If the pH is lower than 5.0, the water is acid. The typical pH of rain in Chicago today is between 4.0 and 4.5, and in parts of New York State and Canada is between 3.5 and 4.0. The acidity of rainfall is an important problem in the conservation of limestone.

Important contributors to rain acidity are carbon dioxide, sulfur dioxide and nitrous oxides. Sulfur dioxide is created when sulfur is oxidized by burning coal, oil and gasoline. This tends to oxidize to sulfurous and sulfuric acid, which may oxidize and form sulfuric acid, which is highly corrosive. Much of the sulfur contained in fossil fuels may be removed; carbon dioxide, however, cannot. Nitrogen oxides are formed during automotive combustion, and they react with air to form nitric acid. Nitrogen can contribute to the formation of ammonia. Ozone in the atmosphere may act as the catalyst for oxidation of ammonia to nitric acid, and of sulfur dioxide to sulfuric acid.

The reaction of atmospheric sulfuric and sulfurous acid with limestone results in the formation of gypsum on the surface of a limestone wall. Gypsum is moderately water soluble and will dissolve in rain water. The weathering effect of rainfall will therefore cause the gypsum layer on the deteriorated stone surface to partially wash off the wall. Where rain does not reach the wall, the gypsum coating may not form or, if formed, will not be flushed off the wall. Sulfur dioxide in the air can react with moisture in the stone to cause the same physical deterioration as acid carried by rain. Loss of detail and severe deterioration of the surface can eventually occur. Where the gypsum is not washed off the wall, minor and sporadic fine cracks will occur in the stone.

Soluble salts

Efflorescence is the deposition of salts on the surface of masonry caused by water passing through the masonry and evaporating. Salts may originate in water or in masonry. Soils contain soluble salts which move by capillary action into porous stone. Subflorescence, the accumulation of salts below the surface of the masonry, is a more severe problem which frequently leads to spalling of the surface. This problem can be exacerbated by application of a nonpermeable coating to the wall.

Gypsum deposits can be formed within limestone by dissolution and recrystallization in the presence of sulfates. Dissolution may occur in combination with the expansion-contraction cycles associated with moisture.

Salt action can cause severe deterioration of limestone. Some salts in porous stone can attract moisture hygroscopically, therefore retaining moisture within the stone and contributing to increased deterioration. The hydrates of some salts occupy a much larger volume than the original salt. For example, if sodium sulfate reacts with water and then crystallizes as sodium sulfate decahydrate, the decahydrate crystal occupies ten times the volume of the original crystal. This process can cause exfoliation.

Organic growth

Biological factors contributing to the deterioration of limestone include algae, fungi, lichens and mosses. Other organic factors such as bacteria and bird patination also contribute to deterioration. The deterioration processes caused by these plants or animals are primarily chemical in nature. Algae, fungi and lichens survive where there is continual moisture. Algae may be green, red or brown in color, and powder or filament in texture. It may be slimy if considerable moisture is present. Algae will not usually destroy stone, but will retain water and may make paving slippery and hazardous. Fungi are molds or mildew which form spots, patches, or a grey-green, brown, or black layer over the surface. They depend on organic material for food, so they generally occur where other types of growth are present.

Lichens, which may appear in many colors, grow very slowly and can survive over long periods without moisture. Lichens can also withstand extremes of temperature. In addition to their problematic appearance, lichens change the surface texture of stone. This type of growth is very difficult to eliminate without using substances that might damage the stone. The growth of mosses on stone or in mortar joints indicates abnormal amounts of moisture, and suggests that serious decay may be occurring. Mosses may hold moisture and keep the wall continually wet, and should not be permitted to grow on building stone.

Certain types of ivy project needle-like probes into mortar joints and masonry. Growth of such ivy accelerates deterioration of the stone wall. Photo by Harry Hunderman, AIA.

Growth such as algae, mosses and ivy may also lower the temperature of the wall by shielding it from sunlight, and may slow evaporation of moisture by wind. Moisture-related deterioration will therefore be accelerated. Certain types of ivy can also open joints in the wall.

Wind erosion

Wind erosion of limestone generally occurs through attrition by wind-borne solids. In coastal and desert areas, wind-driven sand may abrade wall

Discoloration of the lower stone walls of this Belden Street building in Chicago has been caused by rising damp and water entering through the sill joints. Conservation measures should address both elimination of the sources of water penetration and repair of the wall. Wiss, Janney, Elstner Associates, Inc. photograph.

surfaces. In other areas, gritty dust carried by wind may have an effect on the wall which is similar to sandblasting.

Thermal expansion and contraction

Thermal expansion of stone, caused by temperature changes on a daily basis and more gradually on a seasonal basis, may accelerate weathering. Thermal expansion and contraction occur on a large scale as structural movement of the entire wall or building mass. This type of movement also occurs on a smaller scale as the sun warms the stone surface more than inside mass of stone during the day, and the surface is cooled more than the interior at night. Differential thermal stresses also occur on a microscopic scale, as minerals within a unit move differentially. Because the physical structure of the stone may vary throughout a block, and may also alter with time, resistance to thermal stresses may vary over time. Large-scale movement is typically addressed in the design of a building by use of control joints.

The thermal coefficient of the stone and its bonding material should match. In older buildings, joints between stones were generally pointed with mortar that was less hard than the stone. Therefore, if significant movement occurred, the mortar rather than the stone would crack. Use of an inappropriate pointing mortar and differential thermal expansion and contraction may result in spalling of the stone.

Other causes of deterioration

The selection of durable stone is an important factor in the longevity of a building facade. A weak or poorly consolidated stone is more susceptible to deterioration. The manner in which the stone is set is also important. Limestone, for example, may contain bedding planes. In construction, units should be set parallel to the bedding planes. If the stone is set with the grain running vertically, vertical cracks may develop, and water penetration and cyclic freezing may cause layers of the surface to spall off.

Conservation. The services of specialists are required to determine the factors leading to deterioration of building facades, to develop maintenance procedures, and to implement corrective or restoration procedures. Testing to verify the causes of deterioration and proper repairs may include taking core samples, X-ray diffraction analysis, chemical analysis, microscopic analysis, and other petrographic methods.

The watertightness of stone walls improves their longevity. Smooth surfaces that shed water well are easier to maintain than rusticated or ornamental surfaces. However, Joliet limestone on older buildings frequently exhibits rusticated surfaces which are more difficult to maintain.

The importance of preventive maintenance in keeping water out of a wall cannot be overemphasized. All water leaks into the wall from the roof, mortar joints, windows and doors should be identified and sealed. Gutter and flashing systems, a common source of water penetration into cornices

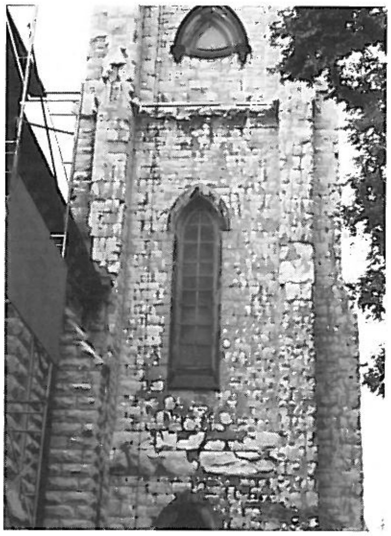
St. James Cathedral was the subject of extensive exterior restoration and interior rehabilitation under the direction of Walker Johnson, AIA, of the architectural firm of Holabird & Root. Contractors for the work were Gerhardt Meine and Company and George Court Company. This photo was taken prior to restoration.

A detail of the tower at St. James Cathedral shows variation in color and texture of rusticated limestone blocks and the smoother sill course. Note localized cracking and old patches on this part of the wall. Much of the limestone was found to be in good condition, but open head joints and open joints along the top of the stone belt courses had led to water penetration and spalling of adjacent stone.

and friezes, should be surveyed, including soldered and welded joints. All drainage water should be diverted to downspouts or drains so that it does not run down the face of the walls. Snow, ice and rain water should not be permitted to accumulate on a building.

It is also important to maintain a normal level of heat in interior spaces adjacent to limestone facades, even if the building is vacant. Proper heating of interior spaces will help to prevent moisture from accumulating in the wall, therefore preventing deterioration from freeze-thaw cycling. If the interior space is not heated, moisture may be retained by the limestone and may lead to freeze-thaw deterioration.

Water penetration into stone may also come from the ground, as water can wick up into the stone above grade by capillary action. This can be avoided by setting the stone above grade, or the base of a wall can be isolated by coating the top of the foundation with a water-impenetrable material such as coal tar



Before restoration work began at St. James Cathedral, the east face of the tower showed the effects of the Chicago Fire of 1871. Several levels of intervention were required to restore this wall, which had previously been repointed and parged with portland cement mortar. The mortar was removed and the joints were repointed with lime mortar. All photos courtesy Wiss, Janney, Elstner Associates, Inc.

pitch. The foundation may be backfilled, but the stone should remain above grade.

In the conservation of limestone, as in other historic masonry, four levels of intervention exist. The least intervention is effected by cleaning, followed by physical waterproofing, chemical waterproofing, and finally patching, repairing and replacing the stone.

Cleaning Cleaning an historic building can enhance the appearance of the building and, in some cases, improve its condition and maintenance. Heavy surface deposits of dirt contribute to the progressive decay of masonry substrates. Severely soiled or stained surfaces are more vulnerable to damage from atmospheric pollutants. Accumulation of dirt on the surface of masonry may slow or prevent the evaporation of moisture or draw in moisture and result in freeze-thaw damage. Cleaning may also be used to remove inappropriate coatings that trap water within the wall. If completed in conjunction with a visual inspection of deteriorated facades, cleaning also helps to reveal cracks, spalls and improper repairs.

An acceptable level of cleanliness must be established before the cleaning method is selected. It is generally preferable to remove most rather than all of the dirt in order to avoid very harsh or severe cleaning methods, which are likely to damage the stone. Improper cleaning can affect appearance and later weathering of the stone; therefore, the selection of a cleaning system and level of desired cleanliness are extremely important.

Because most cleaning methods involve a great deal of water, the wall should be watertight when cleaning is undertaken. It is important that mortar joints in the wall areas being cleaned are in good condition and do not allow excessive amounts of water into the walls. Therefore, it may be necessary to point a limestone wall before cleaning. According to the Brick Institute of America, it is safe to clean newly applied mortar after the mortar joints have completely set. A waiting period of 28 days after pointing is considered conservative, and cleaning can then be safely undertaken. Wall cleaning must also be confined to the warm summer months so that the walls can dry before the freezing weather of winter.

Methods of cleaning

Three major types of cleaning methods are available: water, chemical and mechanical (abrasive). The proper selection of a cleaning method, preliminary testing and the supervision of a skilled professional in the field are all essential to a successful masonry cleaning project. If improperly handled, any cleaning method can result in substantial and irreversible damage to masonry surfaces.

Water methods

Properly applied water methods are the gentlest approach to cleaning masonry. Water is used to soak the masonry over time to soften dirt deposits, which can then be rinsed from the surface. These methods may include a low-pressure wash over an extended period, moderate-to high-pressure washes, and steam. The lowest pressure water cleaning method is water soaking, in which soaker hoses or sprayer devices direct water or water vapor at the building for a long period of time. The continuous soaking causes dirt deposits to swell and loosen, and the dirt can eventually be rinsed away. Water soaking is sometimes used in conjunction with the application of mild chemical cleaners for short periods of time.

Moderate-to high-pressure water washing can be very damaging to masonry if used improperly. Therefore, it is important to consider the pressure, water flow rate, and type and size of nozzle or spray tip of the equipment to be used. Manufacturers typically recommend rinsing stone with 400 to 600 psi water pressure, at a flow rate of 3.5 gallons per minute over an arc greater than 15 degrees. High-pressure methods, such as a 1500 psi water rinse over a 40-degree arc, are often used in an effort to save labor and enhance results. However, hand scrubbing cannot be totally eliminated from the cleaning process, and should be used for gentle scrubbing of deteriorated masonry and for thorough cleaning of severely stained surfaces. Some application of hand labor provides better overall results at a lower rinsing pressure. Even with the mild water cleaning, surface material will be lost from the areas that are severely deteriorated. Hand scrubbing should be limited in these areas.

Steam cleaning has been used for many years. Steam is applied to the masonry at pressures of 10 to 80 psi, and the combination of heat and moisture swells and loosens dirt deposits that can then be rinsed away. This system has generally been replaced by water and chemical cleaning methods. However, steam cleaning is useful because it limits the amount of water needed for cleaning.

Despite certain special requirements and precautions, water cleaning methods are generally the simplest and safest for both the building and the environment. However, these methods are not as effective in cleaning masonry as chemical cleaning methods.

Chemical methods

Chemical cleaning methods, which are popular today, are harsher than water cleaning methods, but if properly conducted may still provide acceptable results without injuring the building fabric. Chemical cleaners work by reacting with the dirt and/or masonry to permit removal of the dirt and to dissolve stains. Deposits and chemicals are then rinsed away with water.

Test applications should be conducted with varying concentrations of commercially available cleaning compounds to determine a final cleaning specification. Test application allows the strength of mixtures to be properly selected and controlled, and permits some flexibility in the degrees of cleanliness achieved without damaging the masonry.

If not carefully selected and applied, chemicals can cause changes in the color or appearances of masonry beyond that effected by the removal of dirt, or physically damage masonry surfaces. Adjacent surfaces of glass, anodized aluminum finishes, etc., must be protected during chemical cleaning because these materials are vulnerable to attack by the chemicals.

The majority of chemical cleaning compounds are either acidic cleaners, alkaline cleaners or organic solvents. Acidic cleaners are *not* appropriate for use on limestone, because limestone is subject to dissolution by acids. Alkaline cleaning chemicals include sodium hydroxide, potassium hydroxide, and ammonium hydroxide. Organic solvents include aromatic hydrocarbons and chlorinated hydrocarbons. These solvents are especially useful for removal of paint, caulking compounds, oils, and other nonwater soluble stains.

Poultices may be used for removal of localized stains. A poultice consists of a combination of cleaning ingredients mixed into an absorptive paste that is applied over the stain and allowed to dry. As it dries, the stain is drawn into the absorptive component of the poultice. The poultice with the absorbed staining material is then brushed or vacuumed off the surface of the stone.

Stains on limestone may be caused by alkali, copper and bronze, oil, tar and rust. Alkali stains, which appear brown, are caused by alkalis in cement. These stains are not effectively removed by treatment but will eventually disappear with natural weathering of the stone. Green copper and bronze stains may be removed with a chemical poultice. Oil stains may be removed with a lime poultice if fresh; otherwise, a chemical poultice may be effective. Tar should be carefully removed with a razor blade. Stains are sometimes more easily removed if the surface is chilled with ice. Tar oils which have penetrated the surface may then be removed with a poultice. Rust stains may also be removed with a chemical poultice. A detailed description of poultices for removing these stains is included in the booklet, "Design and Procedure Aids," published by the Indiana Limestone Institute.

Proprietary cleaning agents are available for many chemical cleaning systems. Use of proprietary cleaning agents is generally recommended. Because the agents have been premeasured and pretested, better quality control of cleaning mixtures is therefore provided. However, the supplier of the proprietary product should provide a generic description of the chemicals in the cleaning agent.

Mechanical methods

Mechanical methods are harsher than water or chemical cleaning systems, and are *not* recommended for limestone. Mechanical methods include high pressure water blasting, sand blasting, combination wet sand methods, and cleaning with grinders or sand discs. These systems "clean" by abrasion of the surface, and actually remove the surface of the masonry. Cleaning limestone by this method is seldom if ever justified.

Testing

Testing of proposed cleaning systems is critical to the success of a masonry cleaning project. A building may be severely and irreparably damaged by improper cleaning agents or applications. Use of test panels is an essential part of the cleaning process, and the importance of this pretesting cannot be overemphasized. While a proposed system may have worked on another building, field test samples are still essential to each new project.

Field tests should be conducted on sample areas of the facades before cleaning is undertaken. Proper testing procedures should address the types of cleaning agents required, chemical concentrations, rinsing pressures and the process to be used. Pretesting should also address the systems to be used for protecting building elements, the environment, workers, and passers-by. The proposed protection system for glass, metals, etc. should be installed and tested with the proposed cleaning specification. After cleaning of the test area is completed and the area has dried, the protection materials should be removed and all adjacent materials should be carefully inspected.

Pretesting of cleaning systems should be completed by a skilled contractor, under the direction of a professional experienced in masonry cleaning. The proposed system should be tested on all representative materials and stains, utilizing the same materials and techniques as proposed for the general cleaning process.

Cleaning tests should be applied to an area of sufficient size to accurately assess the effectiveness of the system. Each test area should be at least several square yards in size. The test area should at least be allowed to dry completely before it is evaluated. A period of at least one week should be permitted to pass before the panels are examined. Simple pH tests for degree of acidity may be applied to determine the presence of any soluble alkaline or acidic cleaned residues on the cleaned sample. Before any final decisions are made, the cleaned test areas should be examined by an experienced petrographer to evaluate whether or not damage has been caused by the cleaning. Such damage may not be immediately visible to the naked eye but could significantly affect the long-term performance of the materials.

Protection considerations

Organic and manmade elements of the environment, cleaning workers and passers-by need to be protected from the materials and effects of the selected cleaning system. Both acidic and alkaline chemical cleaners in liquid or vapor form can pose a health hazard unless adequate precautions are taken. Workers must wear proper protective clothing and eye protection. Where chemical cleaners are used, adjacent building materials as well as trees, shrubs, grass and plants in the area should also be protected. Chemicals from cleaners can be carried by wind onto nearby automobiles and may damage the glass and paint finish, therefore parking restrictions may be necessary. Steam used in cleaning can also present a safety hazard to workers and passers-by.

Water-repellent coatings

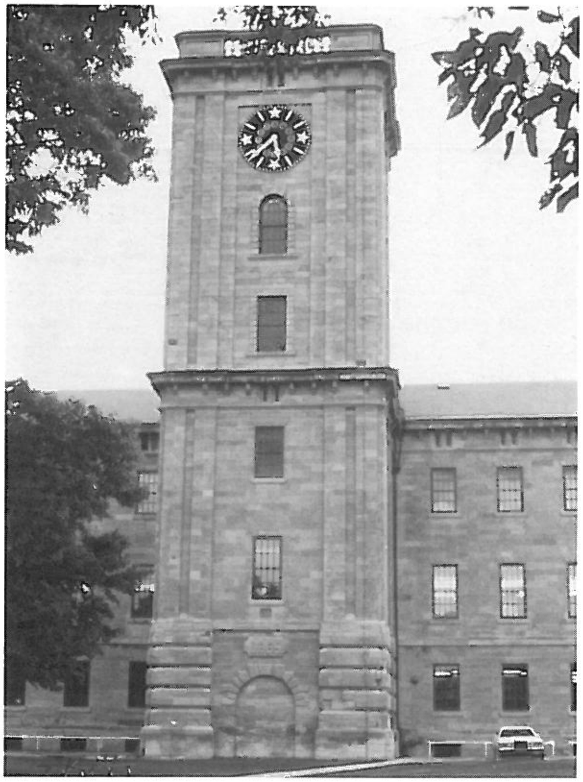
Today, water-repellent coatings that are vapor permeable are available for use on stone. Breathable coatings prevent penetration of water into stone, but permit water vapor to pass through the surface. Application and testing are necessary before use of water-repellent sealers. Proper chemical bond must be achieved, and certain materials may effect the color of some types of stone. A test area of at least nine square feet should be selected, treated, and allowed to stand for at least several months to establish whether or not staining or discoloration will result from treatment. In addition, accelerated weathering tests should be performed in the laboratory to assess potential long-term effects of such a sealer. Although coatings have been used successfully on stone, they should not be applied unless conditions warrant their use, i.e., if more irreparable damage will occur without the sealer than with it. In fact, improper use of water-repellent coatings can cause damage or accelerated deterioration of the stone. The advice of a professional should be sought in selection and application of these coatings.

This rowhouse facade exhibits deterioration in an area of stone which has been painted. Improper use of coatings may contribute to the deterioration of limestone, since many paints are not vapor-permeable. Moisture is trapped within the stone substrate, contributing to damage from cyclic freezing and thawing. Common symptoms of this problem include peeling of the paint coating and spalling of the limestone. Wiss, Janney, Elstner Associates, Inc. photo.

Stone consolidants

The primary function of stone consolidants is to hold together damaged or deteriorated stone. This is accomplished by a deposit of a fortifying material in the pore structure of the stone. Stone consolidants also act to inhibit water penetration. Historically, such materials as linseed oil were used as stone consolidants. Today, a number of new products are available; however, because stone consolidants are a relatively new product, their long-term efficacy has not been firmly established. Also, improper use of consolidants may be detrimental to the condition of the stone. The selection and application of stone consolidants should be directed by a professional, and field and laboratory testing should be conducted before application.

The Joliet-Lemont limestone buildings at the Rock Island Arsenal at Rock Island, Illinois were the subject of extensive laboratory testing by ProSoCo, Inc. Testing was conducted for the Illinois Historic Preservation Agency and the U.S. Army Corps of Engineers in preparation for conservation work on the landmark buildings. The condition of the limestone facades at the Arsenal suggested the use of stone consolidants. Conservaire H and H40 Stone Strengtheners, solvent-based materials which serve as consolidants and water repellents, were applied to samples. Both untreated and treated stone samples were evaluated in terms of composition, water and acid solubility, water absorption and water vapor transmission.

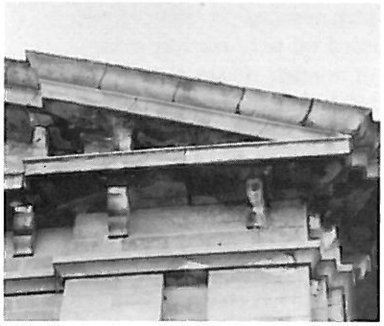


Patching and repair

Mortar joints should be pointed and maintained in good condition to make the wall watertight. Joints should be chipped or ground out to a depth of three-quarter inch to one inch, and all deteriorated mortar within the joint should be removed. Removal of mortar with hand tools is preferred, since damage to adjacent stone is more likely to occur with mechanical saws or similar tools.

The joints should then be pointed with a compatible high-lime mortar. The mortar should have a lower strength than neighboring stone; Type N mortar, following ASTM C-270, is frequently recommended. Type N mortar typically has a 28-day compressive strength of 750 psi. The limestone used in construction of the Rock Island Arsenal was found to have an average compressive strength of 6,400 to 7,500 psi.

Sealing of joints with caulking materials is appropriate if a high degree of expansion and contraction is anticipated in the wall. A proper backer rod should be installed behind the sealant, and care should be taken in selection and application of the sealant. Because a caulked joint cannot breathe and a mortar joint is permeable to water vapor, the location of the joint in the wall should be examined to determine whether sealing is appropriate.



Gable and cornice at Rock Island Arsenal. Laboratory tests on untreated samples from the Arsenal indicated that water solubility of the stone was very low, about 3.5%, and that acid solubility was high, about 91%.

Cornice and upper wall at Rock Island Arsenal. Results of testing on treated samples indicated that conservation treatments significantly improve water absorption and compressive strength of the dolomite limestone. All photos courtesy ProSoCo, Inc.

Cracks in limestone may be repaired by several methods. Minor cracks that are not moving can be routed to an approximate width of one-half inch and filled with a polymer-modified mortar. Major cracks that are not moving may sometimes be repaired by pressure-injection of epoxy. The area at the edge of the crack should be cut out, and the crack then filled with a mechanically anchored epoxy patch or other suitable material. Noncorroding anchors should be used in the stone. Moving cracks may be repaired by the application of flexible sealants.

Spalls may be repaired by removal of stone and replacement in position with polymer-modified cementitious bonding agents, some epoxies and mechanical fasteners, or by replacement with new stone.

Replacement If a block of stone cannot be repaired or conserved, then it may be necessary to have the stone removed and replaced. This work should be done by a skilled mason, under the direction of an architect or engineer. Replacement stone should be as similar as possible to adjacent stone in character, composition, and appearance. The new stone should be set with its natural bedding planes running horizontally.

Availability of Joliet limestone is limited at this time. Many deposits of limestone in Illinois are now located in areas of developed real estate, and little opportunity exists for opening of new quarries. Outcrops of stone deposits are relatively common south and west of Joliet and in the general areas of Aurora and Kankakee. Many deposits may yield stone of suitable soundness for weather exposure. However, some deposits are impure and are not acceptable for use on building exteriors. Salvaged pieces of stone from demolished buildings or other sites may be available for replacement pieces. Also, a

Inappropriate repairs can be unsightly as well as ineffective. At St. James Cathedral, a cementitious patching material had been applied. The patching material, high in portland cement content, did not match the color, texture or character of the limestone. Wiss, Janney, Elstner Associates, Inc. photograph.

A detail of the tower wall at St. James Cathedral before restoration clearly shows the inappropriate repointing which had taken place in the past. The original joints were generally less than 1/8 inch wide, but repointing with a very dark mortar overran the joints by a large margin. Wiss, Janney, Elstner Associates, Inc. photograph.

The blocks shown in this pier of St. James Cathedral were generally in good condition. Where blocks were found to be too severely deteriorated to restore, they were removed and replaced with a Niagara limestone that closely approximates the original Joliet-Lemont limestone.

Minnesota limestone or Silverdale Stone, quarried in Kansas, are similar in appearance to Joliet limestone and may be suitable for replacement blocks.

Stone Substitutes

The use of other materials for stone substitutes is not recommended. If Joliet limestone is not available, use of a similar limestone is recommended.

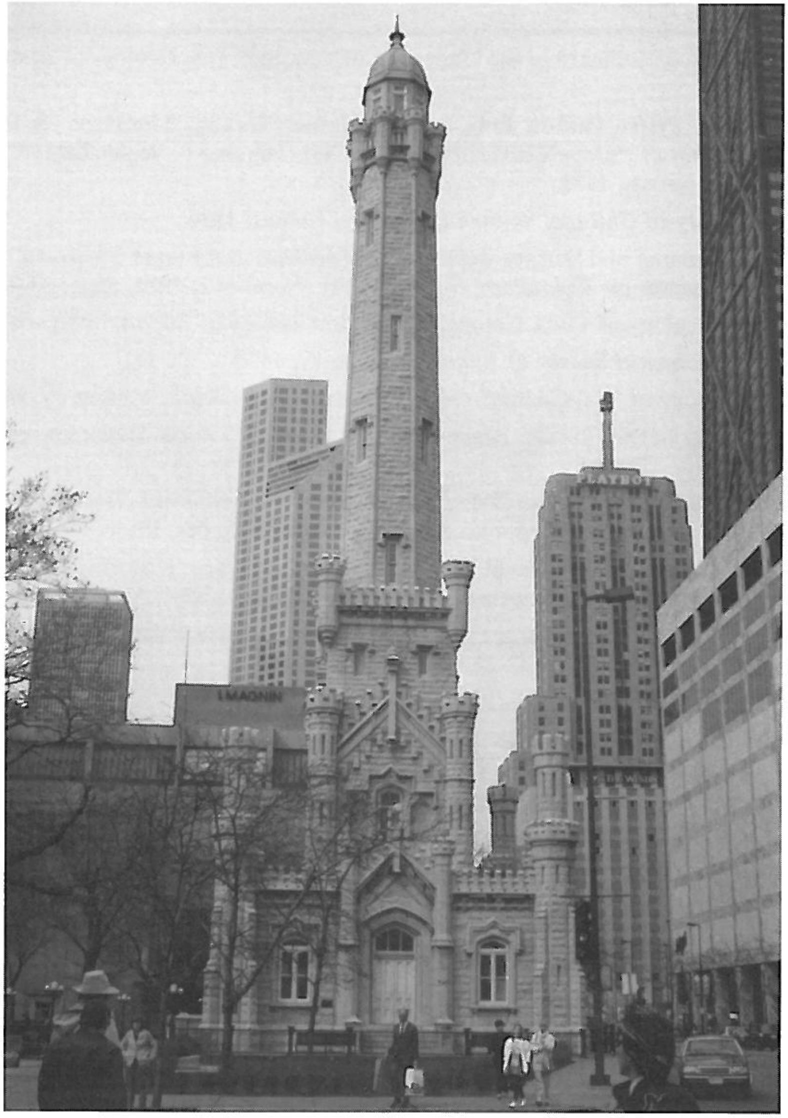
Rehabilitation. Useful guidelines are available for the restoration, conservation and rehabilitation of historic materials and structures. Primary sources include the Secretary of the Interior's *Standards for the Preservation of Historic Structures* and *Standards of the Rehabilitation of Historic Structures,* both published by the U.S. Department of the Interior in Washington, D.C.

Preservation organizations such as the Landmarks Preservation Council of Illinois, the Illinois Historic Preservation Agency, the National Trust for Historic Preservation, and the Association for Preservation Technology provide guidance to building owners interested in restoring and rehabilitating their property. Trade organizations such as the Indiana Limestone Institute also publish informational material.

Because determining the causes of deterioration and proper repair or conservation methods is quite complicated, it is advisable to seek the assistance of a professional for work on limestone. An architect or engineer experienced in materials conservation and restoration will best be able to address these issues. The preservation organizations noted above, as well as the State Historic Preservation Agency, provide recommendations for architectural firms experienced in this type of work,

The professional will need to perform a close inspection of the limestone in order to understand the material and identify the types and causes of deterioration. Recommended procedure includes the following tasks: inspect and record existing physical conditions; evaluate the location and extent of deterioration; select appropriate treatments and solutions; and test and analyze proposed treatments and solutions. The professional should develop a scope of work for the restoration and repair required, and that appropriate technical specifications be prepared. The architect or engineer should assist the owner in evaluating contractor proposals and in selecting a qualified contractor.

Proper specifications and careful selection of repair and cleaning methods are critical to the continued conservation of the limestone. Errors such as overcleaning and improper selection of water-repellent coatings can damage the material and/or create severe maintenance problems later. The selection of properly trained, skilled, and experienced workmen and foremen is also critical to the conservation of limestone.



Although restoration work has not yet begun, the Chicago Water Tower, survivor of the Great Fire of 1871, has been the subject of conservation testing by ProSoCo, Inc. Samples of dolomitic limestone were removed from the building and material characteristics including composition, porosity, water absorption, and moisture permeability were analyzed. Several conservation systems including Conservaire Stone Strengtheners were evaluated using these samples. Laboratory results indicated that the strength of the stone and its impermeance to water were improved by the treatments. Photograph courtesy J.N. Lucas & Associates.

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