Masonry Conservation Handbook

Cottage Grove, Oregon

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Architecture and Allied Arts
Historic Preservation Program

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Unless otherwise stated, all photos were taken by authors and are of buildings in Cottage Grove, Oregon.

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Adhered Veneers

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Statement of Purpose

The purpose of this section is to provide building owners with an appreciation of Adhered Veneers and their care and maintenance. Adhered veneers are those surfaces that are directly attached (with - or are part of - an adhesive compound or mix) to the substrate of a building, - usually vertical surfaces - whether it be wood frame, brick, stone, or concrete. Through their adhesion rather than relying solely on mechanical fixings, Adhered Veneers are different from brick veneer or terra cotta. Examples of adhered veneers in Cottage Grove, Oregon include structural glass, stucco, and paint. Adhered veneers are an integral part of many buildings and on older buildings are an important feature of building design and construction through time. As such Adhered Veneers are equally important to preserve appropriately as a part of the overall building.

Structural Glass

History & Characteristics

Historical Overview

Between the beginning of the Great Depression and World War II, the Moderne, Art Deco, and Streamline movements were responding to and encouraged by the increasing availability of new technologies and materials. Stainless steel, plastics, and pigmented structural glass are just a few examples of a large range of commercial products developed for and by the construction industry during this period. Versatile and well suited for projects ranging from new construction to stylistic updates, glass panels, including Carrara Glass and Vitrolite, enjoyed a brief popularity, falling out of favor by the mid-20th century. As a result, surviving examples of these materials mark an increasingly rare facet of the historic American built environment, and are worthy of careful attention.

Technical Overview

Structural glass panels were adhered directly to a dry, smooth, masonry substrate with the generous use daubs of asphaltic mastic. Metal brackets, anchored into the backing masonry every other course, provided an additional source of support. A 1/16” cork cushion separated horizontal joints, and vertical movement gaps of

1/32" between adjacent panels were buttered with color-matched joint cement. Many colors were available, especially during its peak popularity in the mid-1930s.

Problems & Causes

Superficial - Class I

As is true of most glass products, the surface is non-porous; cleaning must always begin with the gentlest means possible. All cleaners and stain removers should be tested on a small, inconspicuous area before use. Most surface staining can be cleaned simply with water and a mild detergent.

Minor Repairs - Class II

Over time, the original joint cement will deteriorate. While itself a seemingly small difficulty, it can lead to much bigger issues over time. Subsequent exposure to water can deteriorate the anchoring system, as well as the masonry structure beneath. This is especially problematic if any water that enters becomes trapped behind the material.

It is important to repoint cement joints in a timely manner as they become cracked or exposed. However, it is not recommended to use the original joint compound materials as these have a limited lifespan and quickly become stiff and brittle. Silicone compounds provide a recommended alternative, when tinted to match the color of the glass. This technique is also recommended for patching chips or minor cracks in the panels themselves.

Total Replacement - Class III

As with joint cement, the original mastic itself deteriorates over time, hardening and losing its adhesive power. This can lead to the total failure of the panel, which may fall and be destroyed. In addition, glass is naturally brittle and thus subject to destruction by vandalism or accident. It may currently be very difficult to find replacement panels for heavily damaged or missing pieces of glass. Currently, there is only one manufacturer of these panels in the world, located in Germany, with a limited color range. However, with careful planning and expert workmanship, it may be possible to move a panel from a less crucial or visible loca

an effective replacement. Alternatively, the backside of a pane of transparent glass can be painted to match its opposite side in some situations. However, paint applied in this manner may fade over time. Therefore, it may become necessary to use a piece of plastic that matches closely, despite the tendency of plastic to fade and warp with prolonged exposure to the outdoor climate. If panels must be removed as part of a treatment for a building, they can be carefully cleaned with mild solution of detergent and water. The wall should be cleaned in a similar manner before the tiles are re-applied, using the same mastic method (asphaltic mastic).

Recommendations

Local Resources

Fieldwork conducted in the Cottage Grove area revealed a selection of surface-mounted glazed ceramic tiles that appeared to have been applied in a similar fashion with mastic. Our team believes that the same recommendations apply. However, glazed ceramic tile is by nature somewhat porous, so cleaning must likewise begin with the gentlest means possible. All cleaners and stain removers should be tested on a small, inconspicuous area of the wall surface prior to wider application.

Stucco

History & Characteristics

Historical Overview

Stucco has been in use since ancient times in many applications. Stucco was primarily lime-based until the late 1800s; popularization of Portland cement changed the composition of stucco to a harder material. The terms “plaster” and “stucco” both continue to see rather interchangeable use, although the former tends to refer to the more historic lime-based coating, while the latter generally describes exterior applications. This is particularly true in the United States, where stucco is primarily used on residential buildings and relatively small-scale commercial structures. Some of the earliest examples herein include examples of the Federal,Greek and Gothic Revival styles of the 18th and 19th centuries, which tended to emulate influential European architectural fashions. Stucco gained popularity in the mid-nineteenth century as a result of widely circulated plan books published by authors such as Andrew Jackson Downing. It was believed to be superior in many respects to unfinished brick or stone because it was cheaper and could be tinted through the addition of pigments; additionally, it offered the added benefit of increased thermal insulation and moisture protection.

The introduction of many new revival styles of architecture around the turn of the 20th century, combined with the improvement and increased availability of Portland cement, resulted in a sharp increase in the demand for stucco in the United States. This subsequent popularity became increasingly associated with architectural styles including Prairie, Art Deco, Art Moderne, Spanish Colonial, Mission, Pueblo, Mediterranean, English Cottage and Tudor Revival.

Stucco continues to be today as an inexpensive material that can be "scored" or "lined" to simulate finely dressed stonework, or ashlar. A stucco coating over a less finished and less costly substrate such as rubblestone, fieldstone, or brick can lend the building an appearance of a more expensive and impressive structure. It is also considered a weather-repellent coating that not only protects the building from wind and rain penetration, but also offers a certain amount of fire protection when properly maintained.

Technical Overview

Stucco is a type of exterior plaster applied as a coating directly onto masonry, which exists in a wide variety of forms. Historic stucco is often incorrectly viewed as either a disguise or a sacrificial coating, and consequently removed to reveal stone or brick that, historically, was never intended to be exposed. The leading cause of stucco deterioration on historic buildings is simply sustained exposure to weather and climate, due to a lack of maintenance over time; additionally, stucco is particularly susceptible to water damage. It is important to understand that stucco repair requires the skill and experience of a professional plasterer. Realistically, each project is unique, presenting its own set of problems that requires individual solutions and qualified expertise.

Before the mid-to-late 19th century, stucco consisted primarily of hydrated (or "slaked") lime, water and sand, with straw or animal hair included as a binder. Natural cements were frequently used in stucco mixes after their discovery in the United States during the 1820s. Portland cement was first manufactured in the United States in 1871, which steadily replaced its natural predecessor. After the turn of the 20th century, most stucco was composed primarily of Portland cement, mixed with some lime. As a result of this development, stucco became even more versatile and durable.

The composition of stucco depends heavily on local customs and available materials. Common materials in stucco have covered a wide spectrum, including mud, clay, marble, brick dust, and even sawdust. A vast array of traditional additives have also be added to stuccos throughout history to increase their strength and durability, ranging from ingredients as strange as animal blood, urine, eggs, keratin or glue-size (animal hooves and horns), and varnish, to comparatively common wheat paste, sugar, salt, sodium silicate, alum, tallow, linseed oil, beeswax, wine, beer, and rye whiskey. Waxes, fats, and oils increase water-repellent properties, while sugary substances reduce the amount of water needed and slow down the setting time.

The appearance of stucco is determined by the color of the sand, or burnt clay, used in the mixture. Stucco can also be tinted with natural pigments, or painted with whitewash or house paint after stuccoing is complete. Until the early-20th century, when a variety of novelty finishes or textures were introduced, the last coat of stucco was commonly given a smooth, troweled finish and then scored or lined in imitation of ashlar. The illusion of masonry joints was sometimes enhanced by addition of a thin line of white lime putty, graphite, or some other pigment. Other novelty or textured finishes associated with the "period" or revival styles of this time period include pebble-dash, also known as dry-dash, and roughcast, also known as wet dash. Both variations involve the addition of small pebbles to alter surface texture. If the pebbles are added to the mix before being applied to the stucco before it sets it is called pebble-dash.

Problems & Causes

Historic stucco is not inherently a particularly permanent or long-lasting building material; regular maintenance is required to keep it in good aesthetic and working condition. Most stucco deterioration is either the result of water infiltration into the building structure or water splashing up from the foundation. Any necessary repairs to the building should be made before repairing the stucco. This includes removing previous incompatible repairs that may have caused additional deterioration. Before beginning any stucco repair, an assessment of the stucco should be undertaken by a qualified professional to determine the extent of the damage and how much must be replaced or repaired.

Hairline Cracks - Class I

Small hairline cracks are generally not considered to be a serious issue. They may be sealed with a thin slurry coat of the finish coat, paint or whitewash. However, commercial caulking compounds are not suitable materials for patching hairline cracks. Although gently washing the surface with water may clean some stucco, the relative success of this procedure depends on the surface texture of the stucco and the type of dirt to be removed. As with any masonry treatment, cleaning should begin with the gentlest means possible to avoid all irreparable damage to existing materials.

Recommendations

Patching - Class II

In the interest of saving and preserving as much as possible of the historic stucco, patching rather than wholesale replacement is preferable. When repairing lime-based stucco applied directly to masonry, the new stucco should be applied in the same manner (directly onto the stone or brick). It is vital that this new stucco be compatible with its historic counterpart, which should be carefully analyzed to inform the selection of a mix for repair. When patching or repairing a tinted historic stucco, it may be possible to determine through visual or microscopic analysis whether the source of the coloring is sand, cement or pigment. Many stucco building have been painted over the years and will require repainting after the stucco repairs have been made.

Total Replacement - Class III

Complete replacement of historic stucco with new stucco of either a traditional or modern mix will probably be necessary only in cases of extreme deterioration (a loss of bond on over 40-50 percent of the stucco surface. Incompatible and ill-conceived repairs may comprise another basis for total removal, in their presence may so thoroughly compromise the physical and visual integrity of the historic stucco that continued patching offers little chance for success. When stucco no longer exists on a building there exists more inherent flexibility in choosing a suitable mix for replacement, yet this should still be conducted with care by a qualified professional. The most important factors to consider for replacement are material durability, color, texture and finish.

Conclusion

Historic stucco is a character-defining feature and should be considered an important historic building material, significant in its own right. When repairing historic stucco, the new stucco should duplicate the old as closely as possible in strength, composition, color and texture to maintain vital historic integrity.

Paint

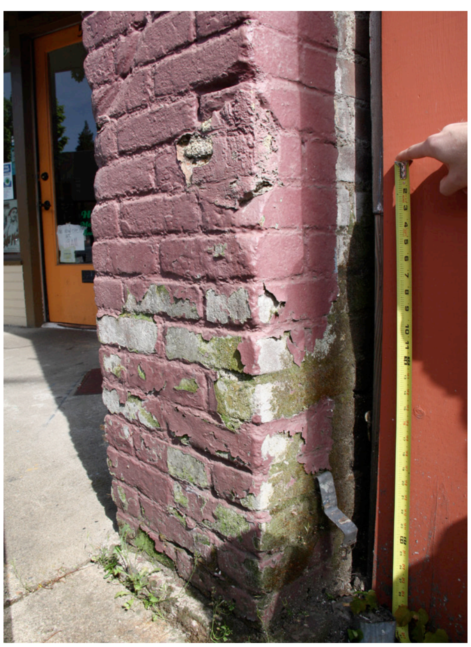
History & Characteristics

Historical Overview

Even though it has coated and colored the walls of America's past buildings, exterior paint has undergone a series of transformations. Due to their puritanical beliefs, the early colonists of Massachusetts Bay strongly opposed the generous usage of paint. This did not, however, stop others from experimenting with different paint recipes. By this time, the "Dutch method" was already a popular process that consisted of combining lime and ground oyster shells to create a white wash. As paint evolved, both in North America and around the world, the general trend of development was away from the use of natural ingredients like milk, egg whites, clay and ground stone towards the use of synthetic ingredients like alcohol, epoxy and petroleum. Through the 18th century grinding pigment had to be done by hand, which exposed painters to regular contact with white-lead powder and its little-understood health hazards. Yet its color remained a valued and popular product well into the 20th century. Also, lead paint maintained good durability and color retention, and for this reason was not prohibited in house paint sold or used in the United States until 1978. During the mid-19th century, increased access to linseed oil and mass-produced industrial pigments led the transition from costly small batches of paint to its comparatively inexpensive industrial production. After the Second World War linseed oil became relatively scarce, resulting in the increased production of chemical-, solvent-, and petroleum-based paints. Today most exterior paints are either latex (water-based) or oil- (or alkyd-) based.

Technical Overview

Paint is the product of four components: binders, solvents, pigments and additives. The binder, or vehicle, provides adhesion and forms a film over the substrate. The binder strongly influences properties such as gloss, durability, flexibility and toughness. It can include either synthetic or natural resins such as alkyds, acrylics, epoxy, oils, etc. The solvent, or dilutent, improves the working properties of the paint, but does not become part of the paint film and is an optional component. The pigment contributes properties such as color, opacity, weatherability and gloss, and is classified as either natural or synthetic. Additives modify the coating of the material, which include properties that may affect drying time, ease of application, and resistance to fading. There are two overarching categories for modern paint composition, water-based or solvent-based. The former are also known as latex paints, which employ water as their solvent. The latter coatings are also referred to as oil or alkyd paints, including solvents such as turpentine, alcohols and hydrocarbons. Paint as a whole is an extremely variable material. The type and ratio of binders, solvents, pigments and additives determines a wide range of properties for a given paint. For example, a "flat" paint contains high proportions of pigment and relatively low proportion of film-forming solvent. This results in a completely matte surface texture. Enamel paints, on the other hand, contain a low proportion of pigment and a high proportion of vehicle that results in a glossy surface. Stains are yet another variation of paint, which can be transparent, semi-transparent or solid. Transparent stains contain little or no vehicle or pigment, instead employing a high proportion of solvent and a dye additive. Such a composition is intended to alter the paint's color and is commonly applied to concrete. Semi-transparent stains contain more pigment or vehicle. Solid stains are usually water based and contain much more pigment and vehicle. They resemble a diluted paint. Clear coatings are high in vehicle and solvent, containing little or no pigment and are used to protect the substrate. Clear coatings are commonly used on both bricks and stone, as a means of providing a protective coat without obscuring the visual character of the materials beneath. Two of the most commonly used



clear coatings are lacquers and varnishes.

Problems & Causes

Minor Blemishes - Class I

These issues concerning painted masonry generally do not require pain removal.

- The accumulation of dirt, soot or pollution on a paint surface can be easily removed by gently washing the surface.
- Staining or rust discoloration can be identified by the presence of orange-brown stains on the paint surface.
- Mildew on surfaces generally occurs when the environment remains moist or shady for an extended period of time. Grey, brown, green or black splotches will be apparent on the surface.
- Chalking is an issue that may arise for a number of reasons. Its leading causes include a previous application of low-quality, improper, or over-thinned paint on an inadequately-sealed or prepared porous surface. Chalking results in the appearance of an excessive amount of fine chalky powder on the surface of the paint.

Most Class I issues can be resolved by washing the masonry surface. There are different solutions for washing masonry. However, as a general rule, always begin with the least harmful method, water, then progress to using a mild detergent and water solution. For certain issues a more specific repair solution may be necessary. For example, rusting steel should be replaced if rust discoloration is present and a trisodium phosphate cleansing solution will remove mildew. Such issues may persist if underlying problems are not first treated with careful and informed maintenance.

Surface Coat Failure - Class II

Minor repairs are often necessary as a result of a failure of the top layer of paint; typically only limited paint removal is required

- ***Crazing*** occurs when incompatible paint types have been used, the surfaces were not properly cleaned before paint application and when an

intercoat is peeling. Crazed paint is frequently recognizable by its thick and brittle surface.

- ***Wrinkling*** occurs when the topcoat dries too quickly. If this occurs while the lower coat remains wet, it will continue to move and cause a wrinkled pattern easily seen at the surface.
- ***Sagging***, or running, may occur when too much paint is applied in a single coat; when a paint is excessively thinned and then applied; when paint is applied under improper conditions, such as high humidity; when the surface is not cleaned properly prior to painting; or when the surface is too glossy. Sagging paint appears to be dripping or drooping, even when dry. If the paint is still wet when this occurs, simply redistribute the paint to achieve a more even consistency.

The typical method of repair for Class II issues with painted masonry involves an abrasive treatment. Abrading, or wearing down the surface, can be carried out manually and/or mechanically. Sanding and scraping are two common examples. After the problem area of the paint has been carefully sanded or scraped down, it is important to properly clean, prime, and repaint it. Consult a qualified before attempting to repair a class two paint issue.

Total Paint Failure - Class III

If multiple layers of the paint are failing, total removal is necessary.

- ***Alligatoring*** occurs when a second, incompatible paint coat is applied to a previously painted surface, or when a second paint coat is applied too soon. A deep relief-cracking pattern, which resembles the texture of an alligator's skin, is the common symptom of this condition.
- ***Peeling*** occurs moisture becomes trapped beneath the surface of the paint; when the surface was improperly prepared for painting; when the paint has poor adhesion to the substrate; when the quality of the paint applied was low, or when blistering paint was allowed to progress. (Blistering paint is a class two problem that is less common in masonry buildings).

Recommendations

Paint Removal

Abrasive, thermal and chemical methods are used for class three paint removal. (Abrasive paint removal is discussed above within Class II treatments). Chemical removal involves using a paint or varnish remover. Such a treatment will soften the paint, so that it can then be scraped or washed away. This is typically the fastest and easiest method of removal, but should be conducted with care and precision. Thermal paint removal involves using a heat plate or gun to heat up the paint surface, breaking down its adhesion and making it easier to scrape. It is imperative to consult a qualified professional before dealing with Class III paint issues.

Murals

History & Characteristics

Historical Overview

There are many thousands of murals in America– 2,500 in Philadelphia and 1,500 in Los Angeles alone. Few, if any, were ever created with thoughts towards maintenance and conservation. Many, painted even as recently as the 1980s. are beginning to show their age, especially those that have not been properly cared for.

Problems & Causes

Common Maintenance Challenges

Generally, the same problems that plague all masonry - exposure to surface water, cracking due to uneven settlement, rising damp, temperature fluctuation, freeze-thaw cycles - effect murals by disturbing the underlying "canvas" of the building and leading to failure of the paints that make up the mural. In addition, the paints themselves are vulnerable to additional outdoor challenges. UV radiation from the sun, ozone layer and other atmospheric pollutants, while an implicit part of many murals' environment, consistently degrade the paint. Vandal

ism, including graffiti and scratching, directly damages the paint itself. Despite good intentions, the use of anti-graffiti coatings can, in fact, actually damage a mural as it ages. The use of incompatible paints, in either composition or color, during repairs may also lead to problems (see "Common Paint Problems").

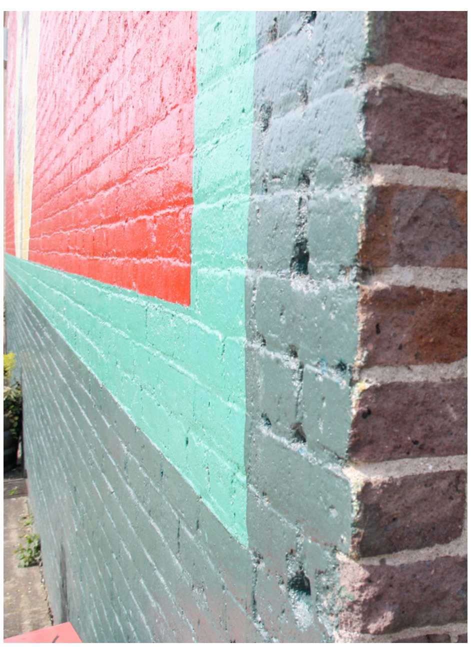
Recommendations

Preventive Maintenance

If at all possible, it is best to keep the mural dry with the use of overhangs or by repairing any failing water diversion apparatus. Regular inspection and timely maintenance, such as the removal of encroaching vegetation, repairs to wall damage, and the prompt removal of graffiti, not only helps to preserve the mural itself, but communicates to the community the importance of the mural in its surrounding context thus decreasing the risk of vandalism.

Important Reminders:

- Always apply gentlest cleaning methods first.
- Never sandblast as this weakens the surface of the uderlying masonry and reduces its effective life.
- Whenever possible, repair historic f abric rather than replace it.
- Always ensure that repairs are reversible so that future, more effective methods and materials can be employed to preserve the original mural.



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Mortars

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Statement of Purpose

The section on mortars is designed to help owners of buildings recognize and diagnose mortar-specific problems. Topics covered here include introduction to common mortar issues and technical terminology, tests to identify mortar ingredients, and suggested standards for repair and replacement. With this information, an owner will be better able to correctly and appropriately repair mortar problems with the assistance of a qualified contractor. A glossary of terms follows the body of this chapter.

History & Characteristics

Historical Overview

Ancient and modern recipes for mortar typically call for binders that promote adhesion of masonry units, as well as aggregates that help the mortar remain flexible after setting. Since antiquity, recommended ratios of binders to aggregates have remained unchanged. In his work from 15 BC, Vitruvius observes that a good mortar can be obtained from a 1:2 or 1:3 mix of a lime binder with a sand aggregate (Vitruvius 1914, 45). Today, a typical bag of premixed mortar contains the same approximate ratio of cement binder to sand aggregate. Ingredients in mortar, on the other hand, are historically and locally specific. Older mortars often include close at hand things like hair, straw, rice, and egg yolk. In the United States, the most common historical binder is hand-made lime, which is very soft after setting. After 1872, it became common to mix hand-made lime with a much harder commercially available product called Portland cement. In the 1910s, a more pure manufactured lime became commercially available and was typically mixed with cement. Between the 1930s and 1950s, cement eclipsed lime as the primary binder used in American mortars. These different mortars are not interchangeable. The wrong mortar can permanently damage a building.

Mortar in Cottage Grove

Before1899, mortars in rural Oregon were predominately natural lime and are very unlikely to contain manufactured ingredients. A cement factory did briefly operate from 1884-85 in Oregon City, but by the 1910s cement was still being imported from Europe (Lesley 1924, 66; 171). Even by the late date of 1913 there were only two cement manufacturers in the state, and only one lime factory (Oregon Bureau of Labor 1914, 93). Cottage Grove's buildings tended to be made from local materials well into the 20th century. From the 1890s to mid 1900s, Charles Hamilton Wallace produced handmade bricks on the North side of Cottage Grove and was the mason for several downtown buildings (Voss 1993, 8). The natural lime binders in his mortars were likely self-made in kilns at his brickyard, and his ggregate was likely taken from the Coast Fork. As a caution, the age of a building does not necessarily tell its mortar type. Some relatively early structures like the 1911 National Bank Buildings were made using non-local materials, and other older buildings were radically changed later in life (Voss 1993, 9). Instead of using

Lime Test

Run your finger across a mortar joint. How does your finger look?

A) Clean: no lime. This exterior chimney was built in 1982 and uses a cement binder.

B) Chalky: significant lime present. This exterior chimney was built in 1928 in Eugene and likely uses a manufactured lime binder.

C) Very Chalky and Soft: natural lime. This interior chimney was built before 1900 near Cottage Grove. Its mortar easily crumbles to the touch.

age to guess a mortar type, a series of simple tests are the best way to identify mortar ingredients, beginning with the "Finger Test" for lime—pictured to the right.

Types of mortars

Five mortar types are commonly used in historic preservation. Following standard recommendations, measured by volume in part, sand should never be less than 2¼ and not more than 3 times the sum of cement and lime.

Name	Cement	Lime	Sand	Crush
S	1	½	4 – 4 ½	1,800 psi
N	1	1	5 - 6	750 psi
O	1	2	8 - 9	350 psi
K	1	3	10 - 12	75 psi
"L"	0	1	2 ¼ - 3	<75 psi

(adapted from Mack and Speweik 1998, 9, 18)

Water should be added to the mix slowly until it is A) thick enough to stick to the underside of a trowel held mid-air, yet B) still workable and capable of jiggling like Jello. If a brick or stone can be sacrificed for destructive testing, an excellent matching mortar can be selected. As indicated below, brick strength should significantly exceed recommended mortar strength. A pure cement and sand mix tests at 2,500 psi after curing. It is far too strong to use in most old and new buildings in Cottage Grove.

Brick Strength	Rec'd Mortar Strength
Very High 10,000 + psi	3600-4108 psi
High 7,000-9,000 psi	1,800-2500 psi
Medium 3,000-5,000 psi	600-1000 psi
Low 1500 psi	150-450 psi

(adapted from Sickels-Taves 1995, 451)

Water should be added to the mix slowly until it is A) thick enough to stick to the underside of a trowel held mid-air, yet B) still workable and capable of jiggling like Jello.

Masonry Type	Sheltered	Moderate	Exposed/severe
Granites, vitrified brick	O	N	S
Limestones, manufactured brick.	K	O	N
Hand-made brick	"L"	K	O

(adapted from Mack and Speweik 1998, 18)

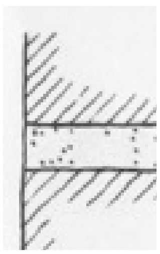
When replacing mortars, it may be prudent to replace higher strength mortars with a lower psi type.

Mortar features can be identified through observation and testing

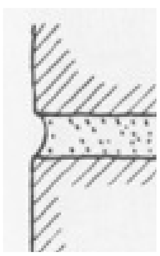
Any repair of mortar joints should begin with a careful effort to assess aesthetic and functional features of the original mortar before starting the work. Important features include color, aggregate size and appearance, type of binder, mortar strength, and brick strength. Seemingly odd ingredients, such as hair, should be identified and matched to preserve both appearance and functionality. Take note of instances of poor original workmanship and use of incompatible or inappropriate materials. These features should not be replicated.

Types of Joints:
(McKee 1973, 70)

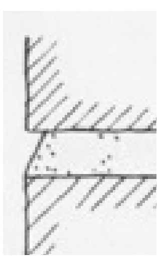
- Flush



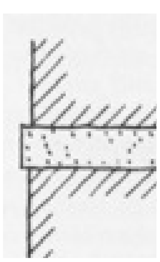
- Rodded



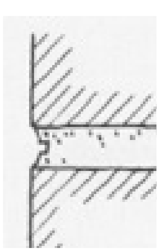
- Struck



- Raised



- Grape-vine



Types of lime binders: their availability, production, and application

Natural Lime (hand made): This item is not commercially available. It is made by burning oyster shells and other high-calcite materials like limestone. In a dangerous chemical process, the burned lime powder is mixed with water to make a putty called hydrated lime. This traditional manufacturing process leaves impurities in the putty, like shell pieces and cinders, which give strength and hydraulic qualities to the otherwise delicate material. It is easy to identify natural lime in a mortar joint because of these impurities. Instead of making natural lime, owners can purchase a manufactured lime and add impurities to match the appearance and strength of the historic mortar.

Hydrated Lime (manufactured): This item is available in local specialty stores in powder form, and online as a hydrated lime binder or render (see www.usheritage.com). Because it is more pure than natural lime, it is weaker. As mentioned above in Mortar History, manufactured limes entered general use around 1910 and are often mixed with Portland cement. To replicate a handmade lime, this product should be tempered with cement (Foulks 1997, 112).

Hydraulic "will harden under water" Lime (manufactured): This item is available as a special order through local suppliers, and online as a hydraulic lime render (see http://www.lime-mortars.co.uk). Like hydraulic Portland cement, this product contains silicates that allow it to set under water. This product is often preferable as a replacement for cement in mortars, giving greater flexibility and resilience while retaining strength and water resistance.

Testing An Existing Mortar: What Is It? Can It Be Replicated?

What Binder?

If a lime-based mortar comes into contact with muriatic acid (hydrochloric acid), it will bubble vigorously and turn the fluid a greenish color. Mortars without lime will not bubble or react to the acid in any way. A subdued reaction indicates a cement + lime binder.

What Aggregate?

The binder test dissolves lime, leaving behind aggregate. If then sent through a series of sieves, the aggregate itself can be separated by size. This allows for matching of the original aggregate's proportions, strength, texture, and color—helping the new mortar to blend in. The mortar aggregate pictured below was taken from a Cottage Grove building, and matches sand gathered in the Coastal Fork of the Willamette River.

What Aggregate?

A mortar sample can be weighed, and then subjected to the acid binder test. Since the acid dissolves lime, only the aggregate will be left behind for lime-based mortars. If the aggregate is then thoroughly dried, and its weight compared to the original sample, an estimate of the mix's proportions can be made through simple arithmetic.

What Else?

Pay attention to any items, like hair (which does not dissolve in muriatic acid), that add to the function and appearance of the original mortar.

Problems & Causes

Some Things Are Problems, Some Are Not

A good mortar is weaker than the masonry around it. Cracks that follow a mortar joint, but do not break bricks or stones, indicate that the mortar is doing a good job. The mortar is able to adjust to any movement in the building structure, and has sacrificed itself to save the masonry around it. In a good mortar joint, hairline cracks are actually known to heal themselves. This is called microcrystalline bridging. Mortar cracks as large as 1/16th of an inch are usually not problems, but should be monitored (Weaver and Matero 1993, 5). A good mortar joint also helps release water that finds its way into the wall. If mortar is denser than the surrounding masonry, it will not help discharge water. The masonry will likely develop salt crystals and possibly flake apart or "spall." If a damp joint is chemically sealed or replaced with a hard impermeable cement, moisture will be forced into the surrounding masonry and irreversibly damage it.

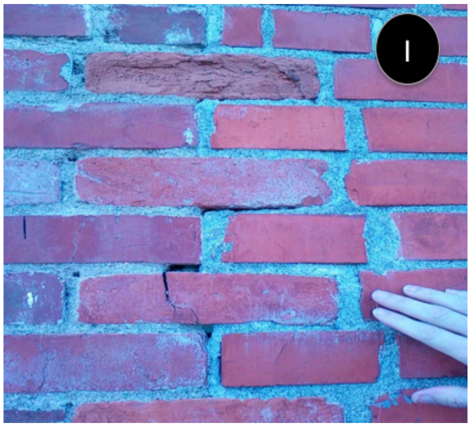


Figure 1:

Cracking and spalling caused by a replacement cement mortar that is too strong to accommodate movement and too dense to release water.

Figure 2:

A missing “butter” joint in a stone cornice, with water staining. The joint should be repointed only after investigating and repairing other potential causes of the failure.

Figure 3:

Damp mortar covered with moss. The mortar is performing well under difficult circumstances. The root problem with the wall is “rising damp” and is not a mortar-specific problem.

Figure 4:

Salt crystallization on a modern brick and cement wall. Repointing with a lime mortar might help fix the problem.

Reversibility: The Golden Rule

As a golden rule, all interventions in an historic building should be reversible. Otherwise the building's integrity may be compromised.

- Power tools should not be used on a repointing project. The tools will almost always damage the fragile edges of bricks and other masonry. It will be costly or impossible to repair the damage.
- Cement mortars should be used only after careful, informed consideration. Cement is very difficult to remove without damaging adjacent masonry. Cement is also harder and denser than most other historical materials, and is likely to cause irreversible damage to the surrounding masonry.
- Do not put a "breathable" sealant over mortar or masonry. Seals are difficult or impossible to remove, and can cause irreversible damage.
- Retain original materials whenever possible because they are irreplaceable.

Recommendations

Repointing and Repair of Historic Mortars

Repair work should start only after the source of a mortar problem has been definitively identified and after all other root problems are corrected (e.g. rising damp, missing flashing). Once the existing mortar has been carefully examined, and the history of the building reasonably researched for important clues, a plan for repair can be drawn up. Note that repointing should be part of a building's routine maintenance. Masonry is not eternal, and good mortar is actually designed to break when it needs to—as has happened in the picture to the top right

Health and safety

Mortar work and repointing are remarkably dusty and noisy activities. A scaffold and other measures should be taken to protect workers and the public below. Read warning labels and follow manufacturers' safety recommendations.

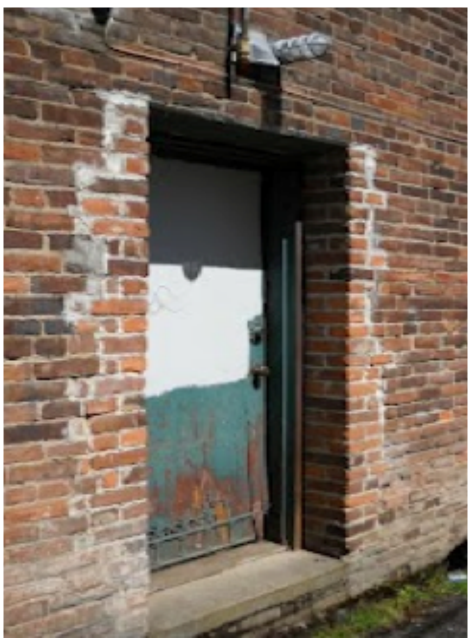
Features that should be retained

When working on an historic building, reasonable efforts should be made to retain and reuse original materials before resorting to replacement. For example, it may be possible to save old mortar and use its aggregate for the new mortar. This will help retain qualities of the original mortar like color, texture, and overall appearance. If materials cannot be reused or salvaged, the tests outlined above can be used to help find a good substitute. Aesthetic features like the tooling of the joint should be replicated by a qualified mason.

Features that should not be retained

If a mortar analysis suggests that a mixture outside the 1:2 -1:3 range was originally used, and it did not perform well on the structure, do not replicate the error. For cement mortars, particularly those that have broken the masonry around them or are causing salt crystallization it is appropriate to consider repointing with a hydraulic lime mortar instead (Mack and Speweik 1998, 7; Sickels-Taves 1989, 1). Lime binders also deserve skepti cism. One authoritative text suggests near-systematic defective workmanship was common in making lime putty since "the operation is almost invariable carried on by laborers who have little or no conception of the importance of their task" (Kidder and Parker 1949, 1966). Looking at specific buildings, the same mortar should not necessarily be used on all façades of the

building, even if it was done that way originally. Some elevations may be more exposed and call for a stronger type of mortar. Some buildings may not have the same masonry throughout—like the St. Vincent de Paul building in Cottage Grove which has a brick front and structural terra cotta back (the terra cotta calling for a special 1:3 mix of hydraulic lime binder and sand/stone dust aggregate).



The white cement repair pictured above does not match the color, texture, or workmanship of the original mortar. Unfortunately, it will be nearly impossible to remove the dense cement mortar without irreparable damage to the bricks.

Workmanship

For repointing, old mortar should be cleaned out of the joint at least ¾ of an inch deep. New material should fill all voids in the joint and be tooled to mimic the old joint profile. Do not repoint in excessively hot, cold, or rainy conditions (Foulks 1997, 119-123). Mix mortar thoroughly, do not mix in too much water, and protect the finished job as it dries.

Summary

Mortar holds masonry units together. Through observation and testing, an owner can recognize and diagnose mortar-specific problems, and proceed with necessary repairs to their buildings. This chapter suggests ways to retain functional and visual qualities of well-performing original mortars, as well as standards and measures to follow when an original mortar is found to be defective. One special note worth repeating is that a mortar should never be stronger than the masonry around it. This general rule means that Portland cement is almost always incompatible with the materials in an historic building. Moreover, use of Portland cement often violates the golden rule of historic preservation: all work should be reversible. By following the guidelines in this chapter, an owner can avoid making ill-advised repairs.

Glossary

Aggregate:

Gravel, sand, slag or other material combined with a binder to form a mortar.

Binder:

An agent, primarily lime or cement, which causes materials to stick together.

Cement:

A general term for binders of stones and bricks (see below, Portland cement).

Efflorescence:

A powdery chemical deposit of salts on the surface of bricks or mortar (also called crystallization)

Hydrated lime:

A type of lime binder that when immersed in water does not harden.

Hydraulic lime:

A high-silicate lime binder that hardens when immersed in water, and is impervious after setting.

Microcrystalline bridging:

On a microscopic level, a process through which lime mortars self-heal small cracks.

Mortar:

A paste-like mixture of aggregate, binder, and water used to fill the joints between masonry units.

Muriatic acid:

A commercial name for hydrochloric acid.

Natural lime:

A common historical and contemporary binder, made from burned limestone or oyster shells.

Pointing:

The act of filling outer joints between bricks, stone, etc. (hence "repointing" or replacing mortar joints).

Tuck pointing

Portland cement:

A modern manufactured hydraulic cement used as a binder in mortars and in concrete.

Spalling:

Breaking or splitting apart (as happens when salt crystals form inside a brick and it splinters apart).

Tuck pointing:

Pointing in which the middle of the mortar band stands slightly proud of the joint, and is a different color from the surrounding mortar. It is used to make irregular brickwork appear more uniform.

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Stone

Richard Balkins
Kristine Steckbeck
Michael Atkinson

(http://oregoncub.org/news/posts/cub-legislative-update)

Statement of Purpose

Stone maintenance and repair will save the owner/occupier more money than simple upkeep. Knowing what to look for and keeping a watchful eye is the key to proper maintenance and this section of the guide will inform the reader about key issues with stone maintenance and repair. This section is not meant to be the last resort for addressing problems but instead an information resource for owners prior to calling in a professional is required.

History & Characteristics

Historical Overview

Stone masonry is relatively rare in Oregon. However, through the late 1800s, a few buildings were built using the rugged material though most were located in the booming city of Portland. Outside of Portland, many of the stone structures were public buildings (court houses, libraries, etc.), school buildings, or private residences. Research on historic architecture and the general history of Oregon and the Willamette Valley shows a predominant use of wood (a major product of the region) and brick (likely due to the high clay content of the soils.)

Figure 1: Portland's Pioneer Courthouse (http://www.loc.gov/pictures/collection/hh/item/or0030.photos.130793p/resource/)

Public buildings, such as Portland's Pioneer Courthouse (built in 1873), and Corvallis's Education Hall (built in 1902) show the sheer size of buildings constructed from local stone. The courthouse is faced with sandstone quarried in Chuckanut, Washington. Education Hall is built with a sandstone exterior and a basalt foundation.

Stone in Cottage Grove, Oregon

The early history of Cottage Grove, Oregon, includes several stone quarries, mostly limestone. The Currin quarry, west of town, was one of the earliest. The quarried stone did not feature prominently in the construction of Cottage Grove. Most of the materials were used in the manufacture of concrete. Horn Concrete opened in 1920, and although renamed Zumwalt & Williams in the 1940s, is still in operation today. The first bricklayer in Cottage Grove was Hamilton Wallace. He founded a brickyard in 1889, although research shows he occasionally worked in stone. Across from his own farm "was a rock ledge which Wallace made use of for stone work including foundations and facing for some fireplaces. It was very soft to cut…but hardened upon exposure" (Dole 1983, 17). Tradition states Wallace fireplaces "were of stone or had stone faces," but no surviving examples remain to confirm this (Dole 1983, 17). One Wallace house, the David Mosby House, east of Cottage Grove, boasted hearths "of flat stones, a large central rectangle rimmed by smaller pieces about one foot in width…the stone was probably hauled from "up on Mosby Creek" (Dole 1983, 17). Stone in Cottage Grove did not play a key role in construction beyond foundations and details such as fireplaces or a slate roof or two.

Figure 2: Education Hall, Corvallis (http://djcoregon.com/news/tag/corvallis/)

One exception is the First National Bank Building, built in 1911. Located on the corner of Main and Sixth, this building is mostly constructed from brick, but has limestone dressings and cornices. Historic photos show that the building has minimally changed. Renovations to the building have largely been on the interior, preserving the original exterior. The exterior image, from 1913 (from the Cottage Grove Historical Society), shows the building as it stood two years after completion. The interior image is also from the Cottage Grove Historical Society and shows what patrons in 1911 would have seen as they walked through the front doors. Marble was used as decoration around the entrance and the bottom of the teller desk.

Figure 3: First National Bank Building – Cottage Grove, Oregon 1911

Figure 5: First National Bank Building – Cottage Grove, Oregon 2012

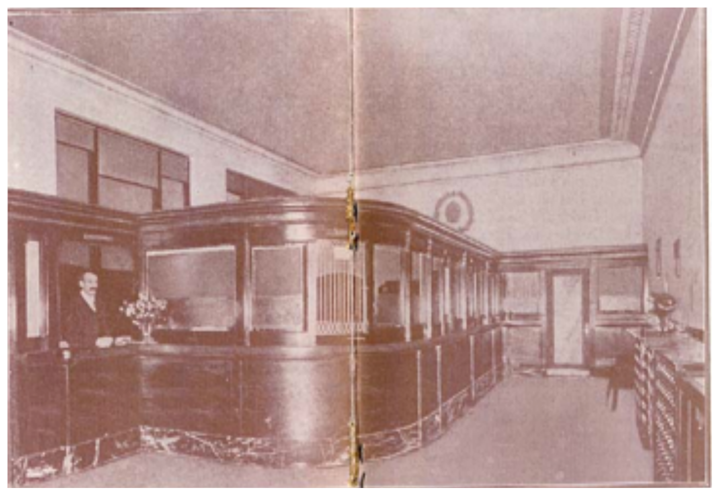

Figure 4: First National Bank Building – Entrance with teller desk – 1913

Figure 6: First National Bank Building – Close up of the cornice trim where it displays “Erected 1911”

Figure 7: First National Bank Building – Stone

Stone Masonry – What is it?

The craft of stonemasonry (or stonecraft) has existed since the dawn of civilization - creating buildings, structures, and sculpture using stone from the earth. These materials have been used to construct many of the long-lasting, ancient monuments, artifacts, cathedrals, and cities in a wide variety of cultures. Famous works of stonemasonry include the Taj Mahal, Cusco's Incan Wall, Easter Island's statues, the Egyptian Pyramids, Angkor Wat, Borobudur, Tiahuanaco, Tenochtitlan, Persepolis, the Parthenon, Stonehenge, and Chartres Cathedral ("Stonemasonry").

Types of uses of Stone Masonry:

- Load bearing walls of buildings.
- Sculptural objects and features on a site.
- Partial bearing decorative uses such as cornices, trims and various elements of the buildings.
- Retaining walls.

Common uses in Cottage Grove and surrounding communities:

- Wall foundations.
- Footing pads in some older buildings before the readability of concrete.
- Windowsills on larger public or commercial buildings.

Other uses seen in Oregon that may be seen in Cottage Grove:

- Retaining Walls
- Components of load bearing walls and other structural components of buildings.
- Freestanding walls as an alternative option to fences
- Sculptural works
- Planters

Stone Types

To understand how stone is best used in Cottage Grove, Eugene, Springfield and other places in Oregon, it is helpful to understand some basic geology and common Oregon rock types. There are three rock categories used in geology with common types of stones used in stone masonry in Oregon. Most of the rocks used in stone masonry come from local or regional quarries. The Three Rock Types are:

Figure 8: Basalt (www.pacificstonescape.com/shop/images/SceneryBslt4.JPG)

Figure 9: Sandstone

Figure 10: : Metamorphic rock used for decorative lower panel on Cottage Grove building

Igneous:

"Igneous rocks (from the Greek word for fire) form when hot, molten rock (magma) crystallizes and solidifies. The melt originates deep within the Earth near active plate boundaries or hot spots, then rises toward the surface. Igneous rocks are divided into two groups, intrusive or extrusive, depending upon where the molten rock solidifies" ("Igneous Rocks").

- Common igneous rocks used in stone masonry in Oregon: Basalt, Gabbro, Granite, Andesite, Diabase.

Sedimentary:

"Sedimentary rocks are formed from pre-existing rocks or pieces of once-living organisms. They form from deposits that accumulate on the Earth's surface. Sedimentary rocks often have distinctive layering or bedding. Many of the picturesque views of the desert southwest show mesas and arches made of layered sedimentary rock" ("Sedimentary Rocks").

- Common sedimentary rocks used in stone masonry in Oregon: Sandstone, Limestone, Shale

Ways in which stones are commonly used in Oregon

Metamorphic:

"Metamorphic rocks started out as some other type of rock, but have been substantially changed from their original igneous, sedimentary, or earlier metamorphic form. Metamorphic rocks form when rocks are subjected to high heat, high pressure, hot, mineral-rich fluids or, more commonly, some combination of these factors. Conditions like these are found deep within the Earth or where tectonic plates meet" ("Metamorphic Rocks").

- Common metamorphic rocks used in stone masonry in Oregon: Marble, Schist, Gneiss

Ways in which stones are commonly used in Oregon

Structural:

- Wall Foundations and footings: Igneous rocks such as basalt, gabbro, and granite are the most commonly used. Occasionally, sandstone, limestone and other similar sedimentary stones have also been used.
- Load-bearing walls: All types are of stone are used. Stones used for full load bearing walls are typically strong, durable igneous rocks such as basalt, gabbro, and granite. Sedimentary rocks such as sandstone and limestone are also used, though less often. In cases where the stones are only partial load bearing or where the load is limited, sedimentary and metamorphic stones such as marble are commonly used.
- Non-bearing walls: Locally, stones are rarely used except for as a veneer in interior walls. If used, they maybe of any rock type. Freestanding walls tend to be of common local stones of sedimentary or igneous types.

Sculptural & Artistic Stone Work:

- Any type of stone can be used for this. Many examples of public sculptural works used throughout Oregon are made from granite, basalt, sandstone or marble.

Problems & Causes

Historic stone masonry in Oregon appears in limited quantities. However, it can be found as architectural details such as lintels, sills, entablatures and foundations. Additionally, statues and cemetery headstones are familiar items in Oregon's historic built environment. Although stone is a resilient building material, it is vulnerable to chemical, physical and mechanical decay over time. This section will explain and illustrate some of the most common problems of stone masonry and the causes behind them.

The most common cause of distress in historic masonry relates to the presence of excess water. Moisture is the responsible culprit for many primary and secondary manifestations of deterioration in stone. Another problematic area for stone masonry is physical damage, often complicated by human intervention. Masonry in Cottage Grove displays a variety of the most common problems found in historic stone masonry. It is vital to understand these problems and their causes. With this information in mind, building owners can make informed choices regarding the maintenance and preservation of their unique historic building and its stone details.

In Cottage Grove, Oregon

The most prominent use of stone in Cottage Grove can be found on the First National Bank. The foundation, lintels and cornice are composed of sandstone. Stone by itself is a water resistant natural material, but sometimes surrounding building components can add strain. This is especially true with poorly sloped concrete sidewalks adjacent to foundations, which tend to promote water pooling and encourage plant growth (Figure 11). Also as rainwater drips off of a building onto the sidewalk, it can eventually cause damage to the foundation as it coves or splashes back toward the building.

Coving is the process in which splash back from rainwater hits the foundation several inches above the ground. Repeated action usually creates a horizontal inden-

Figure 11: Coving from rainwater, resulting in delamination of the sandstone foundation. Plant growth also indicates moisture.

tation where the water hits and erodes the stone; spalling or delamination usually follows the erosion. The additional water at this line can also affects the entire area, especially if there are pre-existing gaps in the mortar, or the stone has been otherwise compromised. This becomes problematic during freeze-thaw cycles as it places extra pressure on the microscopic pores of the stone. If left untreated, the deteriorating foundation can cause additional stress on the surrounding load-bearing masonry, sometimes leading to structural failure. Improper water shedding is a common cause of masonry distress; fortunately, it can usually be repaired. In the case of many buildings, a quick visual inspection can easily identify problem areas that require maintenance

When problems with stone masonry are left untreated, they can precipitate more extensive damage, ultimately affecting larger sections of a building and its usability. This is often the case with broken mortar joints (Figure 12), which readily admit water into the wall cavity, quickly causing other issues as serious as settlement and corroded wall ties. Soft stone, such as sandstone, is susceptible to these issues, as shown in Figure 12 where original tooling details have been lost due to the uncontrolled moisture penetration and subsequent failure of the dressed stone, and Figure 13 where a lintel has cracked due to settlement. Once the face of the stone has been compromised, it becomes even more vulnerable to environmental, mechanical and physical stressors.

Figure 12: A compromised mortar joint has left the stone exposed to weather, resulting in spalling of the masonry.

The patina on historic building materials has both a protective and aesthetic function. While a minimal amount of age-related grime can offer microscopic protection, too much can lead to distress in the underlying masonry. Air pollutants often coagulate on stone elements, making the building look tired. Carved stone details are most at risk for this type of soiling. Figure 14 displays evidence of such pollution. Besides being aesthetically displeasing, soot and various other pollutants can attach to masonry and introduce foreign chemicals to the surface. This can microscopically and mechanically interfere with the natural processes of the stone. Fortunately, this type of problem can generally be remedied with simple cleaning techniques.

Figure 14 also displays some classic problems found in stone. Damage in the form of chipping has occurred from passing vehicles, which has left several scars. These are both an aesthetic and mechanical concern for the building, as they create new opportunities for infiltration by foreign substances. In this case, an iron bumper has been attached to the foundation, presumably to protect the remaining stone beneath. Although this is a proactive solution, this area should be monitored closely to ensure that the connections between metal—especially metal that shows signs of rust—and stone do not interfere with one another. Metal expands as it corrodes, and thus, can crack the stone where the rusting anchors are attached.

Figure 13: A vertically cracked lintel indicates horizontal settling of the building..

Figure 14: This stone plinth clearly shows soot accumulation as well as damage caused by passing vehicles.

University of Oregon Campus

To expand the range of problems for owners buildings in Cottage Grove where stone is used, we have included some examples from the University of Oregon campus in Eugene.

Use of historic stone on the University of Oregon's campus includes mostly decorative elements. The stone details exhibit a variety of problematic symptoms, most of which can be readily repaired after locating and repairing the source of the problem. It appears that most of the stone on the University of Oregon's campus is not yet structurally compromised, but there are some tell-tale appearance problems that should be addressed to mitigate costly structural issues in the future.

The Pioneer Mother Statue rests on a massive granite plinth. Although the granite is in relatively good condition, copper staining from the metallic mural attached to the plinth has begun to discolor the granite (Figure 15). This is mainly an aesthetic concern, but it is best for the staining to be removed. Elements that leach out of metal tend to compromise the stone's integrity because they alter the pH of the surface. The granite base of the Pioneer Mother Statue also displays evidence of biological growth in the form of algae and moss. This is also an aesthetic concern, but the greater meaning behind biological growth is that moisture is often present in the material.

Another common problem with masonry results from the presence of excess water. In the case of the Volcanology building, efflorescence, which is the appearance of migratory salts carried by water, has manifested itself on the surface of the stone. Generally, this problem appears as a white or light grey powder (Figure 16). It usually indicates that water has infiltrated the subsurface of the material and has migrated outwards. In many cases, efflorescence can be cleaned using simple techniques and then monitored to see if the problem reappears. It must be remembered that efflorescence is only a symptom, so the true problem must be investigated and remedied. Without this precaution, efflorescence is likely to return and eventually lead to further decay.

Safety Issues

The biggest safety issue with stone in historic buildings is falling masonry. Human safety around historic buildings is of utmost importance, both for inhabitants, workers or passersby. If a building is properly monitored and maintained, there are few reasons why failed stone ornamentations should accidentally separate from the facade.

The most dangerous objects on a building are those located high up. Cornices are prime areas for decay, which could potentially cause failure of masonry. If necessary, temporary netting can be placed around potentially dangerous areas. This is the most extreme safety issue around historic stone.

Taking precautions during cleaning procedures of historic stone are also important. Sidewalks and public right-of-ways must be protected for pedestrians. This can be accomplished in various ways, depending on the job. Proper environmental care should also be observed so that run-off from the cleaning is properly disposed. It is important to remember that safety issues need not arise if buildings are kept in good operating condition. When there are potentially dangerous hazards around historic stone features, pro-active decisions must be enacted before someone is hurt.

Recommendations

Problems that affect the integrity of the stone surface are considered to be mechanical, since they influence how the material reacts to the environment. These issues are largely a result of water infiltration and physical damage caused by human hands.

Perhaps the most dangerous problem in stone is loss of structural integrity. The beginnings of this process can occur when spalling takes place. Coving, resulting from unchecked water dripping from the above cornice, can cause a stone foundation to rapidly spall or delaminate. Spalling may also follow when the slope of the sidewalk encourages water to run towards the foundation, instead of directing water into the gutter. Recommendations for this repairing spalled stone include a layered approach. Finding the true causes of water infiltration must be the first order of business. Because the damage is noted in one area of the building, it is likely a localized problem. For a spalling foundation, a plastic repair could be used to make the surface flush again. However, this repair should not happen before the source of the trouble is determined and corrected. Once the source of excess moisture is corrected, plant growth between the sidewalk and foundation must also be removed.

Another recommendation for the stone in Cottage Grove is to protect and repair chipped surfaces. On a mechanical level, these chips open up the vulnerable interiors of the stone, inviting foreign particles. The best repair for this is conservation, which means doing no further harm and mitigating future damage. Sometimes protection is the best option as seen in Figure 14. Although the iron bumper wrapping around the corner provides additional security for the stone, it also increases risk to the building materials. Currently this remedy appears in good condition, but it should be monitored to ensure all fasteners are relatively water tight to prevent iron oxide, or rust, from forming in the stone. A future improvement to this feature might be a bumper formed of another material, one less likely to respond dramatically to moisture exposure.

The final recommendation for stone in Cottage Grove concerns settlement patterns in the building. Vertical cracks of around 1/8" were noted on some stone lintels. Usually, vertical cracks indicate horizontal settling in a building. It appears that many of the lintels examined are cracked, illustrating settlement. However, it is unclear whether they are a result of seismic activity or settling in general. For the time being, the cracks do not appear problematic, but they should be monitored. If the cracks widen, it would be wise to contact a structural engineer to evaluate the situation.

There are a variety of mechanical failures associated with historic masonry. For stone, vulnerability appears with excess moisture, which can result in spalling, delamination and biological growth. Deterioration such as chipping, coving and cracks can seriously alter the integrity and aesthetics of a wall, eventually leading to partial or even total failure. Most serious damage to historic stone can be curtailed or prevented altogether with a regular maintenance schedule.

Aesthetic Concerns

Figure 15: Copper staining, biological growth and missing mortar on the Pioneer Mother Statue require some attention before they become truly problematic for the stone

Figure 16: Efflorescence under the stone details of the door surround on the Volcanology building indicates moisture and salt movement through the materials.

Aesthetic concerns in buildings are often the precursors to more serious problems. Accumulation of pollutants, dirt and biological growth damage the stone surface by interfering with the microscopic pores of the stone. If caught early, aesthetic concerns generally require basic cleaning in order to be resolved. The reasons for cleaning a historic building are to improve the appearance, slow deterioration and provide a clean surface. These are crucial to the over-all health of the building.

In Oregon, the most common problem areas arise with excessive biological growth in the form of lichens, algae and moss. While these attractive plants may appear harmless, they represent danger to all historic masonry, particularly in the form of water infiltration. These plants require moisture to thrive and indicate high water content in whatever surface they adhere to. On historic masonry, this is problematic because the stone is unable to breathe or dry out. This constant exposure to moisture can lead to serious mechanical problems, as discussed in the above section. To remedy this, the masonry should be cleaned using a mild, non-ionic detergent and natural or synthetic bristle brush. This is the gentlest method and should be tested in an inconspicuous location before widespread use. Removal of soot uses the same procedure and materials, although oily soiling might require more removal effort. Even if a stain is difficult, abrasive methods should never be used, as they can permanently damage the building.

Another aesthetic concern for historic stone is copper staining. The remedy for this problem is again, a layered approach. The reason behind the copper staining is the run-off of copper salts corrosion products from neglected bronze or copper surfaces (Ashurst 1988). The sculpture should be cleaned and protected before the stone is cleaned or the problem will reoccur. The next part of the procedure involves simple cleaning of the stained stone. A poultice, prepared by an experienced professional, needs to be applied to the wetted stone surface. Several treatments may be necessary, and once complete, the stone should be washed thoroughly with water to remove any residue. An application of a water repellent to the stone is not recommended and does not solve the bronze problem.

The third major aesthetic concern is efflorescence. When this condition appears, it may or may not be indicative of a greater problem. For the purpose of this chapter, efflorescence will be labeled as an aesthetic concern, but every building and piece of stone ornamentation will be unique. The problem behind efflorescence is migrating moisture, so this is the first issue to be corrected. The point of water infiltration, whether it is failed flashing or another cause, must be determined and remedied. Only then can the efflorescence be gently washed by hand to remove the powdery white coating. As with all historic materials, the most gentle but effective means such as a soft bristled brush and elbow grease should be used to clean historic materials.

Historic stone in Cottage Grove appears in a limited quantity, making it a precious resource. Much of the existing masonry has problems, ranging from minor to more severe. Many of the problems are related to water damage, or indirectly so by secondary problems. Although simple cleaning techniques have been discussed, every situation will require a slightly different solution. It is advisable to consult the Preservation Briefs published by the National Park Service for more detailed information about specific historic materials and their needs.

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Terra Cotta

Jacquelin Flores
Jobie Hill

Statement of Purpose

The purpose of this chapter is to help the owners of buildings with terra cotta. By providing the history of the product, its characteristics, its potential for problems and advise on its care and repair, a full understanding of terra cotta can be obtained for its longevity.

History & Characteristics

Historical Overview

The word terra cotta is derived from the Latin word meaning; "cooked earth." Terra cotta clays vary widely in color according to geography and types, ranging from red and brown to white. It is one of the oldest and most popular building materials known to man. Chicago's Great fire of 1871 was one of the main reasons for the large-scale use of terra cotta in the United States. Terra cotta proved to be a fire resistant material that could be erected quickly and cheaply. It was used for enclosing structural iron or steel framing. It was also molded or extruded and used as decorative features.

Figure 1. Forming Terra Cotta Unit (www.history.org/almanack/life/trades/tradebri.cfm

Terra cotta refers to a high grade of weathered or aged clay which, when mixed with sand or with pulverized fired clay, can be molded and fired at high temperatures to a hardness and compactness not obtainable with brick. Terra cotta is an enriched molded clay brick or block and therefore is a stronger structural unit than brick. It was usually cast as hollow blocks. The blocks would be open on the back and have internal compartment-like stiffeners called webbing. Webbing substantially strengthened the load-bearing capacity of the hollow block without greatly increasing its weight.

Terra cotta blocks were often finished with a glaze. A slip glaze (clay wash) or an aqueous solution of metal salts was brushed or sprayed on an air-dried block before firing. Glazing changed the color, could imitate different finishes, and produced a relatively impervious surface on the weather face of the terra-cotta unit. The glaze on terra cotta units possess excellent weathering properties when properly maintained. They have rich color and provide a hard surface that is not easily chipped off. Glazing offers the designer an unlimited palate of fade-resistant colors.

Terra Cotta in Cottage Grove

The ability to mold intricate and elaborate designs made terra cotta a highly suitable material for a building's details. Terra cotta was popular in Oregon, especially Portland, but was not manufactured in the state. The Gladding, McBean & Co. in Lincoln, California produced most of the architectural terra cotta as early as the 1880s. The City of Cottage Grove chose glazed terra cotta to help their original city hall make a presence. It used terra cotta for the framing of the building's entrance, choosing a detailed pediment and side details such as a rope molding. The City also employed structural terra cotta on the non-façade walls of several buildings.

Characteristics of Terra Cotta:

- Fired clay
- Typically hollow
- Formed by molds, or by extruding
- Usually low-fired
- Durable
- Fireproof
- Strong
- Can be molded into virtually any shape
- Available in a variety of designs, colors and finishes

Figure 2. Brown Stone Terra Cotta (www.traditionalproductgalleries.com)

Typical Uses of Terra Cotta

- Sculpture
- Unglazed units used for structural purposes
- Glazed units for building exteriors
- Cladding
- Used in both commercial and residential applications

Brownstone Terra Cotta

This is the earliest type used in American buildings (mid- to late-19th century). The brownstone type is a dark red or brown block that can be either glazed (usually a slip glaze) or unglazed. It is hollow cast and is generally used in conjunction with other masonry in the imitation of sandstone, brick or real brownstone. Brownstone terra cotta is associated with the Gothic and Romanesque Revival movements and used as ornamental detailing such as moldings, finials and capitals.

Figure 3. Structural Terra Cotta
(www.sandkuhl.com)

Structural Terra Cotta

This is also known as fireproof construction terra cotta. It was developed in conjunction with the growth of the High Rise building in America. The light-weight, fireproof, and roughly-finished hollow blocks were ideally suited to span I-beam members in floor, wall and ceiling construction. Structural terra cotta was meant to be covered with a final finished material. Exposed hollow cells were meant to be filled to ensure that water was kept out. Certain varieties are still in production today, but structural terra cotta is no longer a popular building material.

Ceramic Veneer Terra Cotta

This was developed during the 1930s and is still used extensively in building construction today. Unlike traditional architectural terra cotta, ceramic veneer terra cotta is not hollow cast, as its name implies. It is a veneer of glazed ceramic tile with a ribbed back. Ceramic veneer terra cotta is typically attached to a grid of metal ties that are anchored to the building. Ceramic veneer can never be structural.

Glazed Architectural Terra Cotta

This is the most complex masonry building material in America. It was developed and refined throughout the first third of the 20th century. The hollow units were hand cast in molds or carved in clay. They were covered in a heavy glaze (often in imitation of stone) and then fired. Glazed architectural terra cotta is also referred to as "architectural ceramics."

Figure 4. Ceramic Veneer and Glazed Architectural Terra Cotta.
(http://concretecropcircles.blogspot.com)

Problems & Causes

Problems and Deterioration

Problems Associated With Terra Cotta Fall Into Two Categories:

- Natural and inherent problems
- Vandalism and human-induced problems.

Natural And Inherent Problems

Natural and inherent problems are based on the characteristics of the material and the degree of exposure to the elements. The most common cause of deterioration is the failure of the material itself. Occlusions in the clay, improper clay selection, inadequate mixing, and under firing can all lead to a product's deterioration. Inherent material deterioration problems generally occur gradually over long periods of time, at predictable rates and require appropriate routine or preventive maintenance to control.

When glazing was common in the early 1900s, material failures of terra cotta were common. The applied exterior coating had different thermal properties than those of the terra cotta body, therefore creating different stresses between the two. The most stable terra-cotta has a glaze that is always under mild compression. This is achieved by having the coefficient of thermal expansion of the glazing being less than that of the clay.

Glazing is not a breathable material and therefore acts as a vapor barrier that causes moisture to build up in the terra cotta's body. The water trapped in the terra cotta creates salts and minerals that exert pressure on the bond between glaze and terra cotta resulting in spalling. Once this happens, the terra cotta's body is exposed to the environment allowing moisture to be absorbed and creating a cycle of deterioration. This absorbed moisture can lead to corrosion and accelerate the process of deterioration of the anchoring systems. Other conditions that can contribute to the deterioration of terra cotta are the freezing and thawing cycle of moisture, acid atmospheric conditions and acid rain.

Vandalism & Human-Induced Problems

Human-induced problems are of two types: improper design specifications or workmanship, and improper maintenance. Human induced problems, especially vandalism, tend to be random in occurrence, can produce catastrophic results, are difficult to prevent, and require immediate action to mitigate the spread of surface and structural problems.

Two of the most critical requirements in the design of terra cotta construction are to allow for movement of the terra cotta elements and to provide ways for water to escape. Terra cotta blocks that are rigidly connected to the masonry backing or metal supporting structure can produce substantial vertical cracks as a way to relive the stresses caused by thermal movement. Once the terra cotta itself has cracked or the joints between the pieces have failed, water can get behind the surface and corrode metal anchors.

Failure to properly repair deteriorated flashing, mortar joints, and sealant joints are the most commonly neglected maintenance tasks. Without proper maintenance, water can penetrate behind the surface of the terra cotta. Abrasive cleaning can also cause damage to the terra cotta by removing the hard outer surface. Terra cotta should never be sandblasted. Cleaners containing hydrofluoric acid etch the glaze and can damage surface sheen. Alkaline cleaners are not harmful to the glaze but they may be a source of salts, and if absorbed, can create efflorescence or subflorescence.

Inspection and Analysis

Prior to any intervention it is essential to conduct a survey to locate as many defects as possible. Because most problems with terra cotta are from excess water exposure, it is crucial to identify the source(s) of water.
Before a terra cotta building is analyzed for deterioration, the area should be cleaned especially if the area has been exposed to heavy urban pollution. Dirt on glazed architectural terra cotta can hide many types of problems.

Methods of Inspection

Prima facie analysis is the unit by unit, external inspection of the building surface. Areas of visible surface deterioration (staining, crazing, spalling, cracking, etc.) should be photographed and recorded on elevation drawings.

Tapping is a method used to identify internal deterioration. Tapping involves the striking of each unit with a wooden mallet. When struck, an undamaged glazed architectural terra-cotta unit gives a pronounced ring, indicating its sound internal condition. When deteriorated units are struck, they produce a flat, hollow sound. Metal hammers are never to be used.

Metal Detection is a non-destructive way of locating the position of internal metal anchoring. Metal detectors indicate the presence of metals by electromagnetic impulses. The information produced by metal detection is, at best, only rough. However, it is the most viable way of locating the internal metal anchoring without physically removing, thus irreparably damaging the glazed architectural terra cotta units themselves.

Laboratory Analysis is carried out on samples of removed original material to find glaze absorption, permeability or glaze adhesion, or to evaluate material for porosity. These tests are useful in determining the present material characteristics of the historic glazed architectural terra cotta and how they may be expected to perform in the future.

Deterioration


Figure 5. Biological Growth.

Biological Growth:

Any type of biological development such as plant, bacteria lichens, algae, mosses and fungi.

Cracking:

A break without complete separation of parts. A slight opening.

Crazing:

The formation of small random cracks in the glaze is commonly referred to as hairline cracks. It is a common form of water-related deterioration in

Figure 6. Severe Biological Growth and Deterioration of Terra Cotta.

Figure 7. Cracked Terra Cotta.

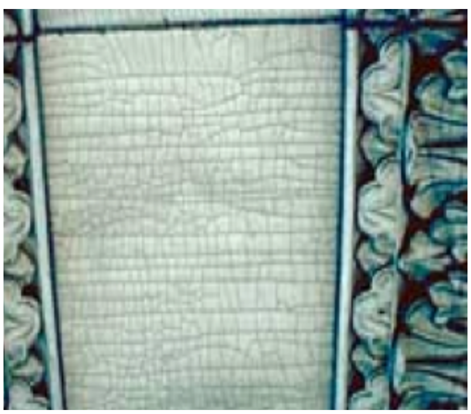

Figure 8. Crazing on Glazed Terra Cotta. (Tiller 1979)

glazed architectural terra cotta. Crazing is normal and is typically not a problem unless the crazing goes through the glaze and into the clay body. It does, however, tend to increase the water absorption capability of the glazed architectural terra cotta unit.

Efflorescence:

The crystallization of salts on the surface of a terra cotta unit. See also Subflorescence.

Fracturing:

Often caused by the corrosion of the iron anchoring system. Upon exposure to moisture, the anchors expand and cause the terra cotta to fracture.

Graffiti:

Markings, such as initials, slogans, drawings, that are spray-painted or sketched on a sidewalk, wall of a building or public restroom, or the like.

Incompatible Materials:

Any material other than the original that is different in color, texture, strength, and physical and chemical characteristics.

Metal Anchoring Deterioration:

Deteriorated anchoring systems tend to be the most difficult form of deterioration to locate or diagnose. Often, the damage is severe and irreparable before it is noticed. When water gets into the glazed architectural terra cotta system, it can rust the anchoring system and substantially weaken or completely disintegrate those elements. Partial deterioration results in staining and material spalling. Total deterioration results in the lack of any anchoring system and creates loose units within the wall system, which threatens the architectural and structural integrity of the building.

Moisture:

The presence of water.


Figure 9. Efflorescence on Terra Cotta


Figure 10. Graffiti on Terra Cotta Wall


Figure 11. Improper terra cotta repair with incompatible material

Mortar and Adjacent Materials Deterioration:

Deteriorated mortar has always been a key to the survival or failure of any masonry system. This is particularly true with glazed architectural terra cotta because it is an extremely fragile system. Sound mortar is the first and most important preventative step in ensuring the survival of any terra cotta system. It is also a must in any maintenance routine. Deteriorated mortar joints are a source of water ingress and, therefore, of deterioration. Lack of ongoing maintenance is the main cause of mortar deterioration, although it may also be the result of improper craftsmanship or air and waterborne pollution. Deteriorated mortar should not be overlooked as a major source of terra cotta failure.

The deterioration of materials adjoining the terra cotta (flashing, capping, roofing, caulking around windows and doors) can play a significant role in its deterioration. When adjoining materials fail, water-related deterioration results.

- Look for terra cotta spalling next to windows and doorways where the caulking has deteriorated.

Spalling:

The breaking off or peeling away of the outer surface or layers of the clay unit. It is typically caused by the build-up of pressure from moisture trapped under the surface. Trapped water is often caused by poor water detailing in the original design, insufficient maintenance, rising damp or a leaking roof and subjected to cycles of freezing and thawing. This pressure can cause small pieces of the terra cotta glaze or body to “pop-off”.

Glaze Spalling:

Glaze spalling is commonly referred to as blistering. It appears as small coin-size blisters. It occurs where the glaze has ruptured and exposed the porous tile beneath. When it is in its advanced stages of deterioration all of the glaze will have disappeared. Spalling of the glaze may also indi

Figure 12. Open Joint with Deteriorated Mortar

Figure 13. Spalling on Structural Terra Cotta

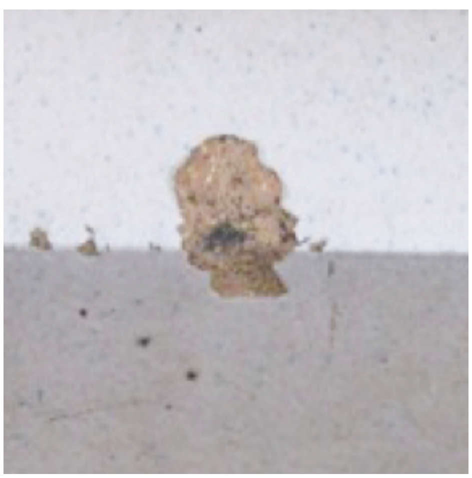

Figure 14. Glaze Spalling on Glazed Terra Cotta (Tiller 1979)

cate deterioration (rusting) of the internal metal anchoring system. The increase in volume of the metal created by rusting creates increased internal pressures in the terra cotta unit, which, in turn, may spall the glaze, or in more ex treme cases, cause material spalling.

Material Spalling:

Indicates severe deterioration. Material spalling exposes the porous underbody, webbing and metal anchoring to the destructive effects of water. Both glaze and material spalling must be dealt with as soon as possible. Unlike brick or stone, damaged glazed architectural terra cotta is exceedingly difficult to replace. New production is extremely limited. Missing units create gaps, which increase the structural load on the remaining pieces. Missing units also permit water to enter the system. Exposed and/or freestanding glazed architectural terra cotta detailing (balusters, urns, parapet walls, etc.) are particularly susceptible to extensive loss of material.

Subflorescence:

The crystallization of salts on the inside of a terra cotta unit. See also Efflorescence.

Recommendations

Repairs and Maintenance

Most problems with terra cotta are from excess water exposure. Therefore before any repair or restoration measure is taken, the source(s) of water penetration should be addressed and rectified.

- (M) Major Repair
- (m) Minor Repair

The surface of the terra cotta should always be properly prepared before repairing. This includes: removing broken, blistering and failing glaze or slip and cleaning the surface of oil, grease and any other substance that might interfere with the coatings adherence. Manufacturer directions for method of application and environmental conditions required during application should always be followed.

Figure 15. Material Spalling
(Tiller 1979)

Cleaning

The goal of cleaning is to remove excessive soil from the surface without damaging the masonry unit itself. Of the many cleaning materials available, the most widely recommended are water, detergent, and a natural or nylon bristle brush. Stubborn pollution or fire-related dirt or bird droppings can be cleaned with steam or weak solutions of muriatic or oxalic acid. (M)

Unglazed terra-cotta cleaning products usually include acid cleaners with diluted minerals and organic acids or hydrofluoric acid based masonry-cleaning compound.

Cleaning techniques not recommended for terra-cotta:

- All abrasive cleaning measures (especially sandblasting),
- Strong acids, (particularly fluoride-based acids),
- High-pressure water cleaning
- Metal bristle brushes
- Any acids, when used in strong enough solutions may deteriorate mortar and release salts within the masonry and produce efflorescence.
- Glazed architectural terra cotta was designed to be cleaned cheaply and easily.
- Before using any chemical cleaner for a major cleaning project it should be tested in small areas. Inappropriate use of a chemical cleaner can result in irreversible damage to terra cotta.

Figure 16. Cleaning Architectural Terra Cotta
(www.preservationarts.net)

Coatings Repairs

A new coating is necessary if the slip layer or glaze in the terra cotta has deteriorated. Coating should have high water vapor permeability. The coating should also be stable in ultraviolet light and selected to match the appearance of the terra cotta in color, gloss, and light reflectance. Both silicate-based coatings and methyl methacrylates have been successfully applied to terra cotta. (m)

Figure 17. Coating Repair on a Glazed Terra Cotta Unit (www.preservationarts.net)

Figure 18. Cracked Terra Cotta Repair (www.preservationarts.net)

Cracked Terra Cotta Repairs

Cracked pieces of terra cotta may be secured with reinforced resin. If the anchors in the terra cotta will not be affected, the cracks can be filled with injected resin that possesses characteristics that are close to the original. If the anchoring system is believed damaged, holes can be drilled into the terra cotta units and anchored into place with metal tubes or bolts grouted in epoxy. This should only be undertaken by a qualified, experienced professional. (M)

Missing Terra Cotta Replacement

It is always best to replace with in-kind materials wherever possible. Common substitution materials are: cast stone, glass fiber reinforced cement, glass fiber reinforced plastic, cement and stone. (M)

Replacement of severely spalled, damaged, or missing glazed architectural terra cotta elements is always difficult. In-kind replacement is preferred, but can have a number of drawbacks. Using unlike materials such as stone, fiberglass, and precast concrete are practical choices, but also have their inherent problems. (M)

Replacement units should be anchored in a manner similar to the original. Both structural and visual compatibility are major considerations when choosing replacement materials. (M)

Stone is a suitable replacement material for damaged terra cotta. Its durability makes it highly appropriate, but the increase in weight over the original hollow units may be of some concern. Cost can be the major drawback in stone replacement, particularly when used to replace architectural terra cotta that has rich detailing.

Fiberglass is a viable alternative for architectural terra-cotta, especially when elaborate ornamentation has to be duplicated. Casting from original intact pieces can produce precise replicas and anchoring can be easily included in the casting. Drawbacks in using fiberglass are color compatibility, fire code violations, and poor weathering and aging processes.

Precast concrete units can replicate nuances of detail through casting. Units can also be cast hollow and be made to accommodate metal anchoring. Concrete can be colored or tinted to match the original material with excellent results. It is cost effective and can be produced quickly and easily.

- When replacing glazed architectural terra cotta, all original deteriorated material should be completely removed.

Figure 19. Anchoring of a replacement Terra Cotta Unit (www.preservationarts.net)

New Terra Cotta Units

New units must be carefully made to match the original in size and profile, as well as surface color and texture. Other options for replacements can be made with cast stone, glass fiber reinforced cement, and glass fiber reinforced plastic. (M)

Patching Repairs

Broken terra cotta units can be successfully patched with mixes based on synthetic, epoxy or acrylic resins. Care should be taken to understand the deterioration of the resins, which discolor badly upon exposure to sunlight. Cementitious patching mixes can be formulated in special colors for use in filling small areas of damaged terra cotta. (m)

Plastic Repairs

Plastic repairs use composites of mortar materials, special aggregates, nonfading pigments, and small quantities of synthetic resins to make workable patching compounds. These compounds are used to correct spalled terra cotta. (m)

Figure 20. Plastic Repair (www.preservationarts.net)

Previous Repairs

Incompatible materials from a previous improper repair should be removed when the work has either deteriorated or has become visually incompatible. Evaluation of the repair should always be done before removing a previous repair. Damage to the original terra cotta from removal of an incompatible material should be weighed against the damage caused by the existing improper repair. (m)

Relieving Stress

Removal of the terra cotta unit is required when metal anchors corrode and crack the terra cotta. Stress cracks usually extend over a greater surface area and can be repaired with expansion joints created by caulking with an elastic sealant. The trapping of unwanted moisture behind the vapor impermeable sealant should be taken into account and weep holes should be provided on the bottom of the joints to allow water to escape. This should be undertaken by a qualified, experienced professional. (m)

Figure 21. Improper Repair of Structural Terra Cotta

Repointing

Repointing is one of the most useful preservation activities that can be performed on terra cotta buildings. Ongoing and cyclical repointing guarantees the long life of this material. Repointing should always be done with a mortar that has a compressive strength lower than the adjacent masonry unit. Hard (Portland cement) or coarsely screened mortars may cause point loading and/or prevent the outward migration of the water through the mortar joints, both of which ultimately damage the terra-cotta unit. Repointing with waterproof caulking compounds or similar waterproof materials should never be undertaken. Like waterproof coatings, they impede the normal outward migration of moisture through the masonry joints. (m)

Repointing joints should meet three criteria:

- The repointing should reestablish the surface continuity of the wall, leaving no opening through which water can enter.
- The mortar should be softer, and have a lower compressive strength than the terra cotta.
- The mortar should be appropriate in appearance, matching the original in color and texture.

Figure 22. Repointing procedure (www.preservationarts.net)

Repair of Glaze Spalling

Glaze spalling is the result of water-related deterioration. Spalled areas should be corrected to prevent further entry of water into the terra-cotta system. The exposed material should be cleaned of all loose or friable material and then painted. Acrylic-based proprietary products and masonry paints can be used effectively, but should be applied by a qualified, experienced professional. These materials typically need to be reapplied every 5 to 7 years. They also can be tinted to approximate closely the original glaze color. (m)

Stabilization

Stabilization measures are necessary when deterioration is so severe that pieces of glazed architectural terra-cotta may fall from the building, especially with details such as: cornices, balconies, balustrades, urns, columns, buttresses, etc.

Restoration work is expensive and often must be carried on over a long period of time. (M)

Repair of Material Spalling

Patching is not appropriate. Terra cotta units with severe spalling should be replaced. (M)

Repair of Structural Damage

Holes, sign anchors, slots for channel steel, or structural cracking in the surface of glazed architectural terra cotta should be permanently sealed with a material that will expand with the normal dynamics of the surrounding material. (M)

- Waterproof caulking compounds are not acceptable repointing materials!

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Concrete

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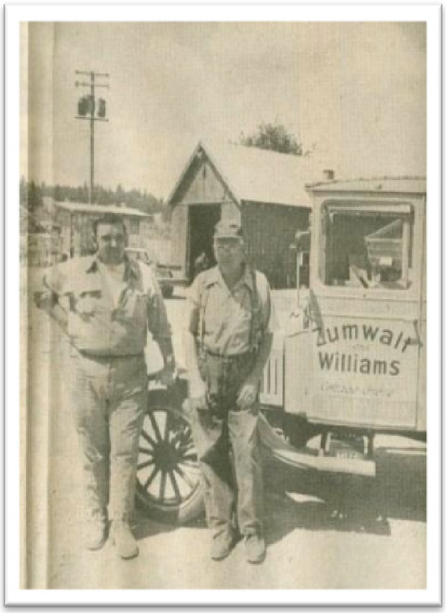
Lys Opp-Beckman

(Cottage Grove Historical Society)

Statement of Purpose

The goal of this document is to serve as a guide for the citizens of Cottage Grove, Oregon, for maintaining and preserving concrete buildings throughout the community. Specifically, this section focuses on techniques for the visual inspection of concrete in order to determine the necessary methods for repair. Structural repair methods and recommendations are beyond the scope of this document. For a complete structural analysis, the services of a structural engineer are required

History & Characteristics



Ken Zumwalt and Harley Williams from Zumwalt & Williams with their Model T mixer. (Cottage Grove Historical Society)

Historical Overview

With the fall of the Roman Empire, the technology for making concrete was lost. John Smeaton is attributed with rediscovering concrete, when in 1756 he mixed hydraulic lime with pebbles and powered brick. It was called pebble mortar. It was initially used predominantly for foundations. In 1824, Portland cement was invented in England by Joseph Aspdin (Mary Bell, Internet). This new cement was a stronger material that used calcified lime and clay. In 1849, the concept of re-enforcing concrete with metal rods came into practice, which allowed for taller structures to be built. One of the first large scale applications of this technology in America was the W.E. Wards House built in 1873. By 1908, concrete had move past purely industrial applications and into the residential realm. It captured the imagination of great designers like Thomas Edison and Orson Squire Fowler (Gaudette and Slaton (NPS), 3). Since the 1890s, concrete and cement have grown to become one of the most popular building materials in the United States. Today, concrete is made by mixing together a fine aggregate (sand), a coarse aggregate (gravel), water and either natural cement or Portland cement. This mixture is then poured into a mold. Historically, molding was constructed on-site. Today, many concrete components are completed off-site and then assembled at the construction site.

Ken Zumwalt and Harley Williams from Zumwalt & Williams with their Model T mixer. (Cottage Grove Historical Society)

Concrete in Cottage Grove

In the early 1900s, concrete was introduced in Oregon. In 1920, Horn Concrete opened in Cottage Grove. The company changed owners in the 1940s, and was re-named Zumwalt & Williams, which is still in operation today. Horn Concrete constructed several exemplary local examples of concrete construction, including the Cottage Grove Armory (Berger, 12). The company used a bucket mixer on the back of a Model T. Another major concrete company was Hubble Concrete. Founded in 1926 by "Benny" Hubble, this business is responsible for Cottage Grove Landmarks such as the Wards Department Store and the I.O.O.F. building (Kislingbury, Internet). Concrete forming changed in 1945 with the invention of plywood during World War II. Plywood was more cost effective and warped less because of its cross-grain composite structure. Concrete continues to be a readily used building material in American architecture.

Incompatible color match

Construction, Repair & Changes

In compliance with the Secretary of Interior's Standards, repair is always recommended above replacement (National Park Service, Introduction to Standards and Guidelines). One of the most common issues that concrete faces is the loss of material and cracking. This issue can often be repaired by patching with compatible concrete. Two of the most important issues to recognize are color compatibility and security of the patch. The color of concrete can be adjusted with pigments like charcoal or using aggregates comparable to those in the original mix. Historic concrete was often comprised of local materials. The use of gravel from Saginaw and sand from the coastal fork of the Willamette River have been confirmed in Cottage Grove.

When planning changes to one's building, the first aspect to consider is whether or not the alteration will affect the building's character-defining features. After it is determined that those features are being maintained, the next step is to ensure the alteration is compatible. This can be achieved through use of like materials and sensitivity to existing design and color.

Maintenance Documents

Local:

The City of Cottage Grove has Downtown Historic Guidelines that touch upon general maintenance guidelines for historic structures, including drainage control, cleaning, painting and stuccoing. These guidelines can be found on the Cottage Grove City Planning website: http://cottagegrove.org/commdev/faq.html#Historic .

State & Federal:

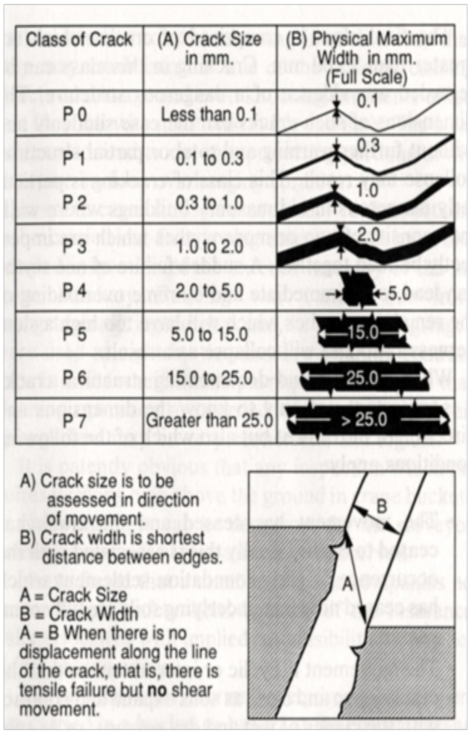
The National Park Service's Preservation Brief 15 is a useful guide for the preservation of historic concrete structures. The brief includes a short history of concrete, causes for deterioration, how to visually inspect your concrete structure for damage, and a detailed section on maintenance and repair methods, and preservation techniques for historic concrete buildings. Preservation Brief 15 can be found on the National Park Service website at: http://www.nps.gov/history/hps/tps/briefs/brief15.htm.

The United States Department of the Interior's Technical Service Center has put a Guide to Concrete Repair together that provides an in-depth description of causes of concrete damage and standard methods of repair. The Guide to Concrete Repair can be found at: http://www.usbr.gov/pmts/materials_lab/repairs/guide.pdf.

The Secretary of the Interior's Standards for the Treatment of Historic Properties provides general guidelines for the preservation, rehabilitation, restoration and reconstruction of historic properties. The Standards can be found at: http://www.nps.gov/hps/tps/standguide/.

Character-Defining Features

A character-defining feature, as defined by the National Park Service's (NPS) Preservation Brief 17, is a prominent or distinctive aspect, quality, or characteristic of a historic property that contributes significantly to its physical character. Structures, objects, vegetation, spatial relationships, views, furnishings, decorative details, and materials may be such features (Nelson (NPS), 1).



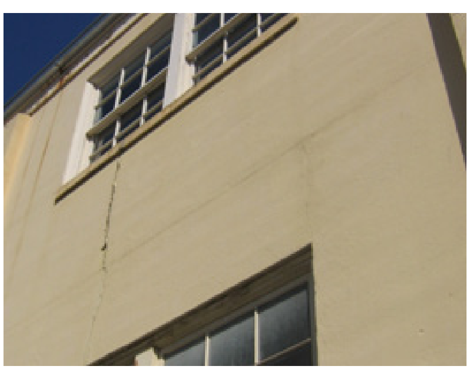
Class of Crack	(A) Crack Size in mm.	(B) Physical Maximum Width in mm. (Full Scale)
P 0	Less than 0.1	0.1
P 1	0.1 to 0.3	0.3
P 2	0.3 to 1.0	1.0
P 3	1.0 to 2.0	2.0
P 4	2.0 to 5.0	5.0
P 5	5.0 to 15.0	15.0
P 6	15.0 to 25.0	25.0
P 7	Greater than 25.0	> 25.0

A) Crack size is to be assessed in direction of movement.
B) Crack width is shortest distance between edges.

A = Crack Size
B = Crack Width
A = B When there is no displacement along the line of the crack, that is, there is tensile failure but **no** shear movement.

Cracking: Improper Drainage
(Weaver 1993, 5)

Cracking: Improper Drainage



Cracking: Foundation Settlement

The Armory is an structure with character-defining concrete features in Cottage Grove. These features must be taken into consideration when maintaining/preserving, cleaning and repairing the structures.

Problems and Causes

Frequent problems found with concrete buildings in Cottage Grove are cracking, discoloration, poor consolidation, biological growth, coving and spalling. Each of these problems has one or more causes that can be alleviated through proper repair and maintenance methods. Before you can select the proper repair and preservation methods, it is important to understand the causes of deterioration (Gaudette and Slaton (NPS), 7).

Cracks:

Cracks occur in a variety of sizes for a variety of reasons. Cracks that are 2.0 mm or less in size generally have no effect on the structure other than to be unsightly. Sizes between 2.0 and 5.0 mm should be repaired as they will permit water to enter and will, thus, create larger problems. Any crack larger than 5.0 mm is associated with serious structural damage, and requires immediate attention (Weaver, 5).

Cracking

The following include the major causes of concrete cracking in Cottage Grove. For more information regarding types of cracking, refer to the Illustrated Glossary later.

Poor Water Path Provisions:

Lack of proper drainage, flashing or vapor barrier systems can cause water retention. Water absorbed by the masonry expands and contracts with climactic changes, causing cracking (Foulks, 127).

Settlement:

The tensile strength of concrete is typically about 200 to 300psi (US Bureau of Reclamation, 37). If the tensile strength of the concrete is exceeded, foundation settlement can lead to cracking.

Discoloration/Stains: Improper Drainage


Poor Consolidation: Aggregate Ratios


Plant Growth: Improper Drainage with Efflorescence on the right

Incompatible Materials:

Cracking can be caused when two or more materials are joined in the same building and possess different expansion rates. Commonly encountered materials cause damage to concrete such as epoxies and oxidized iron.

Discoloration/Stains

Drainage:

Much of the discoloration that was discovered in Cottage Grove resulted from water staining due to lack of proper drainage. Leaking gutters and pipes, and improper flashing were the most prominent causes of water stains.

Efflorescence:

On several concrete structures in Cottage Grove, white stains have appeared due to efflorescence, the deposition of soluble salts on the surface due to water migration (Gaudette and Slaton (NPS), 7). Although it can be scrubbed off while in this stage, if left untreated, salts can lead to permanent staining.

Patching:

A few of the concrete structures in the community are patched with incompatible materials that do not match the color or texture of the original concrete. This reduces the aesthetic integrity of the building.

Poor Consolidation

Aggregate Ratios:

In several foundations of historic buildings in Cottage Grove, the local aggregate used consisted of large stones and was not properly integrated into the mix. This has resulted in frequent spalling.

Biological Growth

Drainage:

Inadequate drainage has been caused by lack of proper gutters and pipes at the roof level, and drains at the ground level. Leaking pipes along the walls of buildings and few drains or shallow grading at the building edges are of particular concern. Water retention along the walls and edges of the concrete buildings has caused frequent biological growth.

Coving: Repeated water Backsplash with resulting Spalling below

Coving

Backsplash:

This phenomenon is caused along the foundation of buildings when large amounts of water are present. The water repetitively strikes the same point on the ground and splashes back on the building, creating a horizontal concave recess in the concrete's surface.

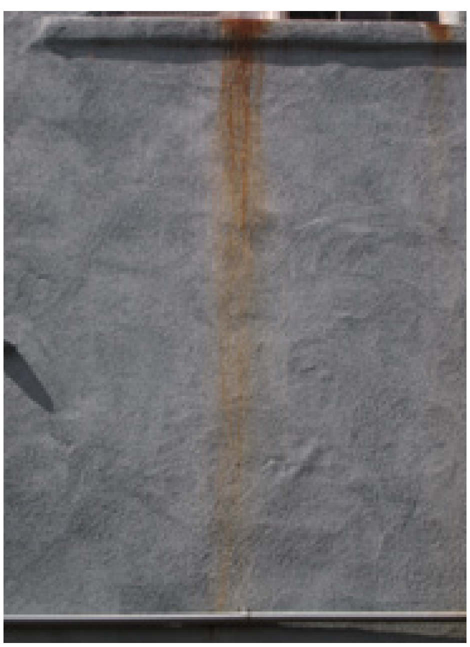
Spalling & Delamination

Corrosion:

In several instances in Cottage Grove, spalling, or the loss of surface material, has occurred due to the corrosion of metal members embedded in the concrete. When water reaches metal structural parts, the parts begin to rust, expand and contract, causing chunks of concrete to crack and fall off (Gaudette and Slaton (NPS), 7).

Water Penetration:

Freeze and thaw of water that has been absorbed by concrete can also cause spalling.



Spalling: Corrosion

Recommendations

Methodology

When choosing cleaning methods for the maintenance and preservation of concrete building elements, you should choose the gentlest means possible in order to prevent harming the building, your health or the environment. Restoration methods for your concrete building should be as unobtrusive as possible, and repairs should be reversible. Consulting multiple professionals as well as your City Planning Department prior to beginning substantial cleaning or restoration projects is always advised.

Cleaning

As with most buildings, concrete structures are cleaned for three predominate reasons: as a part of regular maintenance, in preparation for repair or to enhance the appearance of the building. When one decides to clean a concrete building, the gentlest means possible should always be used first (Gaudette and Slaton (NPS), 9). For more detailed information on how to clean specific stains, refer to the Illustrated Glossary.

Water Methods:

Often with minor staining, water and a plastic scrub brush is sufficient. Low-pressure water (less than 200 psi) or steam cleaning is also effective in removing surface stains on concrete. However, use caution when using these methods on deteriorated concrete because it is more sensitive to abrasion and moisture. High-pressure cleaning is sometimes used to remove deeper soiling, however power washing is typically damaging to historic concrete, and is not often recommended (Gaudette and Slaton (NPS), 9).

Abrasive Methods:

Abrasive cleaning methods are rarely recommended due to the damage it can cause to historic structures. However, because concrete is a harder material, low-pressure, micro-abrasive methods using fine particulates are sometimes appropriate. It is important not to damage the texture of the concrete (Gaudette and Slaton (NPS), 9).

Chemical:

Detergent cleaners or mild acid cleaners may be acceptable for severe soiling or staining. However, stronger acids are not recommended, as they can harm the concrete as well as the environment (Gaudette and Slaton (NPS), 9). Graffiti, rust, and other stains can often be removed by a paste of water and cleaning agent/solvent—called a poultice--applied to a concrete surface and left for several days.

Repairs

Repair measures should visually match the existing fabric as closely as possible in color, compressive strength, permeability and additional characteristics important to the mix design of the concrete (Gaudette and Slaton (NPS), 12).

Composite Patching/Plastic Repair:

When patching eroded areas of a concrete structure, care must be taken to use compatible materials. The patching material should match the color and texture of the original concrete as closely as possible. Test patches should be used in smaller areas in order to match the original material. The concrete to be repaired should always be cleaned in order to ensure the patch adheres to the existing fabric. The area to be patched must be keyed in order to allow for the new material to properly adhere to the surface. For larger or load-bearing patch jobs, pins should be used to provide support for the new material. Pins should be adequately protected to prevent water from penetrating and causing them to corrode, or use stainless steel pins that will not corrode.

Mortars:

Cracks can often be repaired by mixing a slurry of concrete mortar. Epoxies should only be used by a professional and should “never be used in visible areas of concrete” (Gaudette and Slaton (NPS), 13). The causes of cracking should be addressed prior to determining the appropriate method of repair. Hairline cracks that are inactive may often be left unrepaired (Gaudette and Slaton (NPS), 12). However, active cracks, such as those caused by foundation settlement, call for additional action, and the appropriate professionals should be consulted.

Replacement

If concrete elements are beyond repair (missing material exceeds three inches deep), replacement may be necessary (Grimmer (NPS), 52). Replacement of ornamental, historically significant, concrete features should be considered the last resort. Secondary and structural elements, such as concrete windowsills facing alleys and concrete steps on the side of a building, are more acceptable to replace.

When replacing historically significant concrete features, replacement material should be carefully mixed, placed and finished in order to match the original fabric. Test repairs should be carried out in an unobtrusive area such as a rear wall to ensure that replacement work is consistent with the historic concrete. Both repairs and replacements should match the historic material when it is clean, not its soiled condition (Gaudette and Slaton (NPS), 13).

Maintenance

Although protection systems such as coatings or sealants are often used on non-historic, concrete structures to reduce the amount of maintenance required, sealants and coatings are not recommended for historic concrete structures because they can change the color and appearance of the building. Sealants can also trap moisture into the masonry, causing further deterioration. For more information regarding sealants, refer to the Illustrated Glossary below.

The implementation of a maintenance plan is the most effective way to preserve your concrete building. For instance, lack of proper roof maintenance, flashing and drainage systems can lead to water related damage. Regular inspection of your concrete structure to establish baseline conditions and needed repairs is crucial.

Glossary

Abrasion

Abrasion:

Abrasion refers to the breakdown of the surface material as the concrete comes in contact with another material (US Army Corps of Engineers, 1). Sandblasting and hydro silica cleaning--previously common abrasive cleaning methods for masonry--can reduce the integrity of the surface and lead to other serious problems. Abrasion damage occurs most commonly in heavily trafficked areas. Impact damage can result in severe material loss.

Capillary Action:

Capillary action is the result of the surface tension effect that pulls water though any opening that can be bridged by a water drop. It is the primary force that transports water through the pores of a masonry wall (Allen and Iano, 720). Water will usually rise to about four feet from the ground.

Chemical Deterioration:

Possible Chemical Reaction Cracking, but laboratory tests are needed for verification

Chemical deterioration is defined by the chemical inaction that allows for the separation of the material components of concrete. Reactions can occur between the aggregates and binder; most common is an alkali- silica reaction (ASR), which creates a gel that expands with contact from water (Winter). Only laboratory testing can confirm if the problem is truly ASR. Additionally, assault from exterior chemicals such as acid rain can damage surface concrete, which leads to water penetration. See also: Chemical Reaction Cracking.

Active Cracking:

Also known as moving cracks, active cracking will worsen over time until the source of the distress is resolved. To fix active cracks, the service of a professional should be sought to identify the cause and best solution to the problem. Active cracks can be caused by variations in atmospheric temperature, absorption of moisture, corrosion of the reinforcement materials, chemical reactions, settlement, or various loading conditions (US Army

Corps of Engineers, 12).


Cracking: Corrosion

Chemical Reaction Cracking:

Chemical reactions within the concrete mix can cause cracking. Expansive reactions between the alkalinity of the curing concrete, especially if alkaline water is used, and the silica content in some aggregates can produce tensile stresses beyond the tensile strength of the concrete (US Army Corps of Engineers , 16).


Cracking: Foundation Movement

Corrosion Cracking:

If water penetrates far enough into concrete to come in contact with the metal reinforcement, it will cause the metal to rust and expand up to nearly twelve times its original size. The consequential oxidation of the reinforcement metal results in a loss in tensile strength within the concrete structure, and if not resolved, it can lead to structural failure (US Army Corps of Engineers, 25).


Map Cracking

Cracking Due to Construction Practices:

"Inadequate form supports, improper concrete construction practice, and improper placement of construction joints contribute to cracks in concrete. Settlement of forms causes cracks because the concrete has not hardened enough to support its own weight. Construction joints placed at points of high stress can cause cracks" (US Army Corps of Engineers, 17). A structural engineer should be contacted for a full investigation.

Foundation Movement Cracks (upheaval & settlement):

Due to inadequate bearing area on subgrades or an inadequate placement of expansion joints, material will transfer crack-causing forces to the superstructure (US Army Corps of Engineers, 12).

Map (or Pattern or Crazing) Cracking:

Map cracking, sometimes known as pattern cracking or crazing, is characterized by fine cracks on the surface of the concrete. Typically, this is

Crack: Continuous

Discoloration from the Oxidation of Metal

Erosion.

just a cosmetic issue rather than a structural one. Map cracks generally result from a decrease in the volume of the material near the surface or an increase in subsurface material volume. The cracking is usually shallow (less than 1/8-inch deep), but the square area can vary greatly. Map cracking is structurally significant if the pattern follows the pattern of the underlying reinforcing steel or if it demonstrates symptoms of Alkali-Silica Reaction (ASR) (Gromicko and Shepard).

Passive Cracks:

Passive cracks, also referred to as dormant, are static and do not worsen over time. Hairline cracks are negligible, as they rarely interfere with the structural integrity of the wall. Most passive cracks can be easily fixed (Foulks, 134).

Single Continuous Cracks:

Single, continuous cracks with a definite direction and magnitude can indicate a structural deficiency. Singular cracks displaying a definite direction and magnitude longitudinal, transverse, diagonal, vertical, or spiraling can be an indicator of a structural deficiency. Often, if the cause, typically a structural deficiency, is not identified, the crack will often continue to grow in depth and length (US Army Corps of Engineers, 12).

Discoloration

Discoloration of concrete can result from improper concrete mix specifications. Coloring agents or aggregates of differing alkalinity in the mix can cause changes in the concrete material. Concrete naturally darkens as it ages, and a change in the color of the concrete from the one intended is generally not critical to the structural capacity. Discoloration from biological growth is common as well. A white gel that hardens on the surface of concrete is characteristic of an Alkali-Silica Reaction and is potentially detrimental to the structural integrity. Oxidation or rust stains can indicate corroding reinforcement, and can create a structural deficiency, which can worsen over time (US Army Corps of Engineers, 17). See also: Stain Removal.

Flaking

Erosion

Erosion is the gradual destruction of concrete from contact with liquids or solids. Continued exposure coupled with abrasion causes a loss of material, which can expose reinforcing material or reduce the mass enough to critically affect the function of the structure (US Army Corps of Engineers, 36).

Expansion

Expansion refers to the difference in volume concrete will experience under different conditions. These conditions may include water saturation, temperature differences, and chemical reactions.

Flow Line

Flaking (Scaling)

Flaking refers to the separation of surface concrete from the subsurface mass. It occurs because of improper construction, most commonly if finishing techniques are executed while excess bleed water is still present on the surface (US Army Corps of Engineers, 21). Water penetration coupled with common freezing and thawing cycles of permeable concrete also produce flaking (Gromicko and Shepard, Internet).

Flow (lift) Lines

The presence of flow lines is an indicator of a cold joint which occurs when the first layer of concrete has hardened too much before the new layer of concrete is poured (Gromicko and Shepard, Internet). This condition results in a weak bond between the layers and offers an opportunity for water penetration allowing for damage to occur especially with freezing and thawing cycles. Flow lines can also be the result if the concrete was poured into formwork from an excessive height, which allows for material separation. Flow lines are primarily a construction related deficiency (US Army Corps of Engineers, 20).

Graffiti

Graffiti

Graffiti refers to the unauthorized drawing, scribbling, and writing upon public surfaces, the most common being walls (Merriam-Webster's Collegiate Dictionary). Some common forms include latex paint, chalk, spray paint, and engraving. The line between art and graffiti can become blurred.


Pitting

Pitting

Small cavities in the surface of the concrete can result from corrosion or localized disintegration (US Army Corps of Engineers, 25).

Stain Removal

For stain removal, the gentlest method should be attempted first to avoid damage to the concrete. Each type of stain produces its own challenges and consequentially its own solution. Always read the manufacturer's instructions and test on an inconspicuous spot. Abrasive cleaning methods such as acidic cleaners and sandblasting are not typically recommended (Foulks, 64).

Cleaning with water is one of the most simple and safest methods to use. A variety of methods exist including: spraying, misting, pressure washing, and steam cleaning. Prolonged contact with water can potentially do structural damage if the water reaches the reinforcement. A non-ionic detergent can be used in conjunction with water. Non-ionic detergents cannot leave salt deposits, which secure the safety of the material, but it should always be rinsed thoroughly with water. If water does not work, a chemical cleaner is often utilized (Foulks, 63-65).

Oil

Small stains can potentially be cleaned by a non-ionic detergent, which does not allow for salt deposits to form. Rinsing with water should immediately follow.

Poultices combine a dry, absorbent powder with a liquid to form a wet paste. Once applied, it should be covered with plastic wrap to prevent premature drying. Poultices work by lifting out the oil through the process of osmosis. Once the paste is dry, it stops working and if it is a deep stain, may require multiple coats. If the poultice is ineffective after successive tries, the application of an alkaline chemical cleaner may be employed (The

Concrete Network, Internet).


Stratification

Paint

Paint is a very difficult stain to remove due to all the different types available. Always start with the least abrasive method possible. After washing with water, washing with soap, and poultices have been tried, a commercial cleaner could be considered. Always read the instructions before beginning cleaning.

Rust

Rust stains are particularly difficult to remove completely. If the source is not identified and resolved, it could potentially lead to structural failure. After a poultice is attempted, a stronger cleaning agent may be deployed (The Concrete Network, Internet).

Stratification

The separation of concrete materials into their component parts during the pouring of concrete is referred to as stratification. Early concrete was mixed by hand and were often sourced locally. Naturally, the heavier objects settle near the bottom of the pour, leaving lighter objects near the top.

Stratification is also evident when successive batches differ in appearance. This prevents a homogenous mixture from forming. When poured, the formwork of older concrete was usually not vibrated. Poorly bonded layers or uneven distribution of aggregate and binder within the concrete can alter the structural capacity and performance of the structure (US Army Corps of Engineers, 40).


Water Drainage System

Water Drainage

Water should drain away from the building's foundation. Water-saturated soil in contact with the foundation wall increases horizontal pressure. Moisture penetration can cause corrosion of the reinforcing and will contribute to freeze/thaw deterioration. Algae and fungi can begin to grow on the surface of the concrete. Evidence of ponding or erosion can indicate drainage problems. If an active body of water, such as a stream, underground spring, or run-off from a downspout passes near the building, erosion could result. Soil erosion can lead to structural collapse. Moving water erodes soils and sub-soils from around the base of the structure and can abrade the concrete surface material (US Army Corps of Engineers, 47).

Waterproof Coatings

Also commonly known as sealers. With the exception of silane-based products, the use of waterproofing and sealing products is generally not recommended. Sealers trap water inside the concrete (Foulks, 134). There are two main types: film-forming and penetrating. If a sealer must be applied, the surface has to be dry, clean, completely cured, and tested for reactivity with the sealer (Gromicko and Shepard, Internet).

For more information regarding deterioration problems and preservation treatments for historic masonry, please refer to the National Park Services' A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments: http://www.nps.gov/tps/how-to-preserve/preservedocs/Historic-Masonry-Deterioration.pdf.

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Cast Block and Brick

Paula Barnett
Hayley Van Hiel
Stacey Urlacher

Statement of Purpose

This report is intended to educate building owners on the history of rock faced cast brick and block, and how to take care of it. Common names include ornamental, rock faced, mold formed, and rusticated concrete blocks, but this report will refer to them as rock faced. Simply, cast bricks and blocks are made from typical concrete. The rock face pattern was introduced in the first quarter of the twentieth century as a decorative, affordable, and easy to install building material. When preserving, restoring, or repairing rock faced concrete block or brick it is important to consider material compatibility, and to always start with the least invasive solutions for the building. It is also important to locate and fix the cause of the problems before fixing the damage: such as repairing leaky gutters, before replacing bricks. Rock-faced cast bricks are a rarity as most were manufactured block sized, so it is important to understand this material and preserve it for future generations.

History & Characteristics

Figure 1: Colonial Café building

Historical Overview

Between 1905 and 1930, rock-faced concrete block reached the height of its popularity as a building material in the United States. Various patents were issued in the early part of the century to individuals who had developed methods of producing concrete block. However, it was not until Harmon S. Palmer's invention of a cast-iron machine with removable core and adjustable sides in 1900, that concrete block truly "took-off," as a building material. The machine came as a result of years of trial and error, resulting in his successful production of six houses with blocks he had produced. Yet, true success of these blocks came with the simultaneous standardization and improved production of Portland cement in around 1900. Portland cement was the most durable form of concrete, and when used to make concrete block, was considered a strong and reliable building material.

Within the first decade of the twentieth century, the production of concrete block grew exponentially. By 1902, Palmer had sold over four hundred machines, and by 1907, there were over one hundred companies producing machines similar to his original model. The rapid rise in popularity for concrete block was due to the facility and economy of its production. It was fast, easy and most importantly, inexpensive to make; it was a viable building material alternative at a time when brick and wood prices were skyrocketing. The popularity of concrete block and the machines continued to grow well into the 1920s and 1930s with the help of advertisements in Sear's catalogs and builder's manuals (Simpson 1989, 108-118).

Figure 2: Hotel on Main Street

Machines were commonly purchased and used on site since it was cheap, and the bricks were heavy. Rock-faced concrete block was used to construct every type of structure from bungalows to banks. Several interchangeable plates were available and used to create blocks with different rock-like finishes, mimicking actual stone. There were also plates to cast scrolls, wreaths and other decorative features in addition to the common rock-faced finish. After 1930, rock-faced concrete block seemingly ceased to be used. This sudden decline is attributed to a shift away from hand-tamped machines to an automated process and a general favor for flat-surface cinder block. Therefore, virtually no rock-faced concrete block buildings were made after 1930.

In the city of Cottage Grove, there are two buildings constructed with rock-faced concrete block: The Cottage Grove Hotel and the Colonial Cafe. The Cottage Grove hotel, located at 811 Main St., is the only building in the state of Oregon built of structural, rock-faced concrete block. Built in 1911 by contractor William B. Cooper, it is likely that either block machine was purchased to produce the concrete blocks on site, or that one of the two brick makers in Cottage Grove at the time, Gleason Brick Co. supplied the bricks. Gleason Brick Co. was the only brick manufacture in the area that is known to have produced bricks by machine. Thus, it is reasonable to assume he may have purchased a concrete block machine, considering its wide spread availability and popularity at the time. If this is so, Gleason likely also supplied the smaller, rock-faced concrete bricks used on the Colonial Café, a.k.a. Bader Building, now the Grove Tavern and Cafe building, located at 521 Main St. The Colonial Cafe was constructed in 1912, a year after the Cottage Grove Hotel. Rock-faced concrete block, shaped as brick is used on the second story facade, while the primary building is made of brick. This is likely because rock-faced concrete block was fashionable at the time of its construction and was thus intended to be displayed to the public as a symbol of its trendy style. The builder of the Colonial cafe is unknown, however, since it was built only one year after the Cottage Grove Hotel, it was perhaps built by the same contractor, William B. Cooper. If this were known for certain, perhaps it was Cooper who owned a concrete block machine (Simpson 1989, 110-115; Kibbel).

Figure 3: Cast iron block machine (OldHouseWeb)

Cast Block and Brick in Cottage Grove

There are two buildings in Cottage Grove with rock faced cast brick and the first step in knowing how to care for the brick. Thorough notes and photographs were taken as a methodical material analysis was conducted from the ground up. Various stains, markings, and vegetative growth on the brick can indicate things like improper water drainage, and looking at the building at a large scale will indicate these issues that should be addressed (Historic Resource Survey, 1992-1994).

Character Defining Features

Figure 4: Features the decorative keystones over the windows, and string courses

The unique texture and character of the rock-faced brick on the facades needs to be protected and maintained in order to keep the overall appearance of a two rock-faced buildings in Cottage Grove. There are also character-defining keystones above windows, and decorative string courses and lintels that add detail and depth to the facades. Although these are not rock-faced features they are important masonry elements that need to be protected.

The cast brick "mousetoothing" near the roof line is a detail that adds character and definition and should be protected. The simple string course, as well as the dental band dividing the first and second floor, give the front façade dimension and are important masonry features.

Figure 5: "Mousetoothing" near the top of the façade

Problems & Causes

Water Damage

Water can harm masonry that is not maintained. If not properly directed away from the building, the cast brick will soak it up, and if asked to absorb more than it can handle, it will eventually cause structural problems to the bricks and blocks. In the case of the Cottage Grove Hotel, the watermarks seen coming from the roof line are probably due to water from cracks in the roof seeping in behind the brick, but without getting on the roof it is hard to tell.

Improper Water Drainage

Figure 6: Water Damage

The gutter systems should be replaced with a continuous gutter that has proper flashing and downspouts to direct the water away from the building. The corners have eroded due to water run off, where the gutter ends about a foot before the pavement. Leakage due to cracks in the gutter on the facade has causes efflorescence or water stains. The water has also eroded away many of the lintels and segmental arches above the windows, as well as the string courses which also see a little bit of biological growth. This could be resolved with flashing. The best course of action would be to remove the source of damage, which in this case is water not being directed away from the building.

Temperature Changes

Freeze/thaw cycles will also cause cracks in unmaintained concrete block masonry. When water is trapped in the mortar and surrounding bricks or concrete blocks, it will expand when the water freezes and retract when the water thaws. Ultimately, this can damage the bricks or blocks, as the freezing of water in the cracks and concrete can cause severe spalling and cracking (Foulks 1997, 127).

Repair of cracks should always be performed using a compatible material, such as a lime-based mortar. The mortar must be weaker than the material to which it adheres in order to accommodate movement and water absorption. A qualified professional should determine if the cracks are affecting the building's structural integrity.

Vegetation

Biological growth is defined as plants or moss growing on the surface near mortar joints or at the foundation of buildings, if water is not running off properly. If the growth is happening at the foundation, the ground around it should be dug up and filled with aggregate, or the sidewalk should be graded so that the water will run down and away from the building. All plants should be removed if they are close to the walls to allow the building to properly breathe and dry after rain.


Figure 7: Vegetation

Cracking (Settlement)

When repairing cracks in masonry buildings, one must always use a mortar weaker than the material to which it adheres. People often mistakenly think that Portland cement, the strongest of all cements, will work wonderfully if used on their buildings for repair. This is a misconception; since all bricks, regular or cement, move with thermal and seismic changes; the mortar must be flexible enough to accommodate those changes. If a building owner or contractor decides to use a material that does not breathe and is inflexible such as Portland cement for mortar repair, the bricks or blocks will not move with the changes and the cracks will eventually become worse. Since bricks and cement absorb moisture, the mortar should as well. When mortar is so dense it will not absorb moisture, the bricks and the cement blocks will be asked to take in more water than their share, and weakening of the material will ensue.


Figure 8: Step Cracking and other vertical cracks indicate horizontal movement

Spalling and Brick Replacement

Spalling is present on many of the bricks and blocks. A few things can cause this. One is the way in which the cement was mixed during the manufacturing of the bricks and blocks. Two, there was not enough curing time. Cast blocks should be cured for approximately two weeks after formation. Spalling comes in the form of popping and surface shearing of bricks and blocks. Many of the cast bricks in Cottage Grove are experiencing spalling, and this can be repaired a few different ways. The first way would be to determine if the bricks are cast on all four sides, as in the back of the brick that is not showing has the same rock face pattern. A mason would remove the damaged brick, turn it around, and replace it. Unfortunately and in most cases, the rock face brick molds were three-sided leaving the bricks or blocks with a blank surface at the back, meaning it can not be turned around. In the case of three sided bricks, a qualified mason could per-


Figure 9: Spalling of rock-faced brick

form a plastic repair. A plastic repair is when a compatible material is spread over the damaged brick, and shaped by the mason to match the rest of the bricks in both form and color. A third course of action would be to outright replace the bricks with new bricks that match the old. A manufacturer of rock-faced bricks and blocks would need to be identified, or a rock-face brick and block machine would need to be acquired.

Figure 10: Inappropriate brick repair

Dirt, Grime, and Biological Growth

Dirt and grime, while unsightly, is not harmful to masonry. Specific cleaning techniques, and chemicals, however, can permanently damage the structure if not carried out properly and by experienced hands. A water wash is generally the gentlest means possible when considering the cleaning of your historic masonry. A second rinse may be necessary to wash away loosened dirt, grime, and biological growth.

Figure 11: Biological growth can be seen on a large percentage of the front façade. A majority is underneath the windows indicating possible water drainage problems from the windowsills

It is best to avoid "waterproofing" a masonry building. There are many cement and brick coatings on the market that claim to be "breathable" as well as "waterproof", which is a contradiction in and of itself. The products have not been on the market long enough to withstand the test of time and their potential effects on masonry. The most effective "waterproofing" of a building is to make sure water drains properly away from the building, there is no groundwater problem, and there are no plants and trees that may be trapping moisture up against the walls.

In the case of Cottage Grove rock-face concrete brick, the best means of cleaning would be water to preserve the unique patterns and texture of the bricks. If the bricks need to be scrubbed, one should always use a natural or synthetic bristle brush and avoid wire or stainless steel, as they are much too abrasive (Mack and Grimmer 2012).

Recommendations

Cleaning

The best treatment for dirt and grime is a low-pressure water wash, starting at 100 psi and going up to 300-400 psi. One may also use a garden hose instead of a pressure washer. When washing with water and a detergent, the building should be cleaned from the bottom to top, while keeping the area below wet at all times (Mack and Grimmer 2012). If using mild cleaning product, it is important to start with the least invasive methods possible and work your way up to stronger chemicals as needed.

Fix Gutters

Water damage can be avoided by making sure drainage at the windowsills and gutter are sufficiently moving water away from the building. In Cottage Grove, there are gutters that do not go all the way to the pavement, causing water to drain directly on to the corner of buildings. Or, gutters on the top of a building lead water right on to the front elevation and not away from the building. It would be advisable to add on to these gutters so they sufficiently drain the water.

Plastic Repair or Block Replacement

When spalling occurs, it may be necessary to execute a plastic repair or replace a block if the damage has become irreparable. Plastic repair is more commonly used because it is always important to remember to approach preservation with the least invasive solution possible. With rock-faced blocks, it may be difficult to find the original or a similar block mold, nor can the block/brick be turned around. There are no visible rock-faced bricks or blocks in Cottage Grove that needed immediate attention for replacement, but it will be important to keep an eye on the bricks so plastic repairs can be applied in a timely manner.

Glossary

Biological Growth

Cracking

Efflorescence

Spalling

References

Similar maintenance issues and solutions can be found in material referencing regular concrete or even brick masonry. These resources include: Preservation Brief 1- Assessing Cleaning and Water Repellent Treatments for Historic Masonry Buildings, and various chapters and notes in books on concrete, and cast stone which is sculptured concrete pieces. Some Historic Preservation briefs on Brick Masonry walls and mortar are Preservation Brief 42: Maintenance, Repair, and Replacement of Cast Stone, or Preservation Brief 15: Preservation of Historic Concrete.

Appendix A

Since it is very difficult to replace rock-faced cast blocks and bricks, researching the bricks on the Hotel and Colonial Café more in depth could be of benefit as that would allow exact matches to be made in the future. As of now, it is unsure where those machines are, and therefore, if new blocks could be created. These two buildings do not seem to need replacement of blocks yet, and careful maintenance could prolong this need further. These rock-faced cast brick buildings are rare, beautiful, and a gem to the downtown Cottage Grove Historic District, and finding the original machines and information would enrich the history of the buildings and downtown.

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Brick

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Statement of Purpose

The purpose of this document is to inform the owners of historic brick buildings in Cottage Grove, Oregon, on the history of brick masonry, issues and problems related to brick changes and deterioration, and steps towards maintenance and safe cleaning. This document is meant to be used as an introduction. Further consultation with an historic preservation or masonry professional is advised before work begins on an historic structure. This guide can be used as a tool to understanding the types of questions you have about the state of your specific building before work is to be done. In addition, many of the sources utilized in this document are cited and available later in the Bibliography section and should be referenced for further information.

History & Characteristics

Fig 1. Great Wall of China
(http://www.full-stop.net)

Historical Overview

Archeologists believe molded brick has been used in buildings for over 5000 years in areas with scarce stone and wood but large clay deposits, such as the Nile Valley and the Tigris-Euphrates Valleys in the Middle East (Redstone, 1984, 1). In about 3500 BC, people started firing the brick, which made it more resilient to the elements. Romans used brick in many of their structures such as the Pantheon and bathhouses. On the other side of the world, China was developing brick construction to eventually create the Great Wall and many of their beautiful pagodas (Campbell & Pryce, 2003, 13). Brick is always made with clay, but other ingredients are added to create a better building material, such as sand, water, and straw.

Up until the 18th century and the Industrial Revolution, bricks were made by hand, but machines and kilns were built to produce an incredible amount of product in a relatively short amount of time (Campbell & Pryce 2003, 13). By the 19th century, brick was widely available as a building material, and the standard size for brick in the United States was 8 x 4 x 2¼".

In Oregon, brick was used primarily in foundations and chimneys for residential structures, and exterior cladding in commercial buildings. During the 1930s,

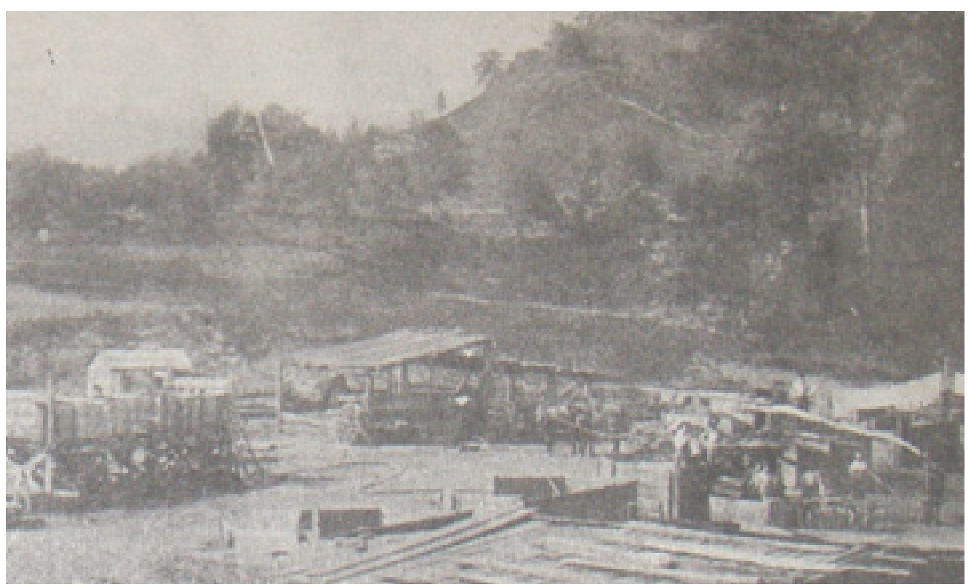

Fig. 2 Hamilton Wallace Brickyard
(Sentinel 1974, 7)

Fig. 3 Chimney by Wallace, Cottage Grove, 1890
(Dole 1983, 21)

Wallace specialized in handsome chimneys, cutting the bricks to unusual shapes such as diamonds and hearts.

Fig. 4 Chimney by Wallace, Springfield, 1873.
(Dole 1983, 20)

builders leaned toward concrete and steel, using brick only as a face treatment but its popularity was waning. Brick had a revival in the 1950s and has been used as a superficial façade treatment ever since (Redstone 1984, 12).

Brick in Cottage Grove

The first bricklayer to come to Cottage Grove was Hamilton Wallace, a Presbyterian minister from Iowa, who made his way to the area as early as 1873. By 1885, Wallace was involved in many masonry buildings in Cottage Grove, including many on Main Street.

By 1889, he founded a brickyard at the foot of Mt. David where Crest Fork and Bennett Creek join (Guzowski, 1992). Wallace took river clay, water and sand, mixed the components together with a horse-powered churning device, and hand poured the mixture into molds, which were laid out to dry. Once a year, the bricks were fired in a makeshift kiln with stacked brick in the center covered with mud, and then encased in wood, which they lit aflame (Sentinel, 1974, 7). The bricks from the Hamilton Wallace Brickyard were 8 ¼ x 2 ¼ x 3 7/8", and roughly 100,000-200,000 bricks were produced a year (Guzowski, 1992). He was particularly talented at designing and building pilastered, Gothic Revival, stacked chimneys (Dole 1983, 21).

R. A Gleason came to Cottage Grove in 1907 with a Wellington Brick machine and began to produce 20,000 bricks a day, and this allowed for brick buildings to be constructed in greater numbers on Main Street. In 1908, Hamilton Wallace retired, and Gleason and Alkinson most likely built the brick projects in town afterward (Dole 1983, 27).

Archeologists believe molded brick has been used in buildings for over 5000 years in areas with scarce stone and wood but large clay deposits, such as the Nile Valley and the Tigris-Euphrates Valleys in the Middle East (Redstone, 1984, 1). In about 3500 BC, people started firing the brick, which made it more resilient to the elements. Romans used brick in many of their structures such as the Pantheon and bathhouses. At the same time, China was developing brick construction to eventually create the Great Wall and many of their beautiful pagodas (Campbell & Pryce 2003, 13). Brick is always made with clay, but other ingredients are added to create a better building material, such as sand, water, and straw.

Features Which Should be Retained and Respected

When preserving an historic structure, it is important to recognize building characteristics that should be retained and respected. The two major goals when preserving an historic structure, according to the Secretary of the Interior's Standards for the Treatment of Historic Properties, include preserving historic materials and preserving the visual character of the building (NPS, 1988 A). It is also highly suggested that one repairs before replaces any component of an historic building. Each historic building is vastly different but by focusing on these two preservation goals along with the philosophy of repairing before replacing, each preservation project has the greatest opportunity for success. For additional information, refer to the National Park Service's Preservation Brief 17.

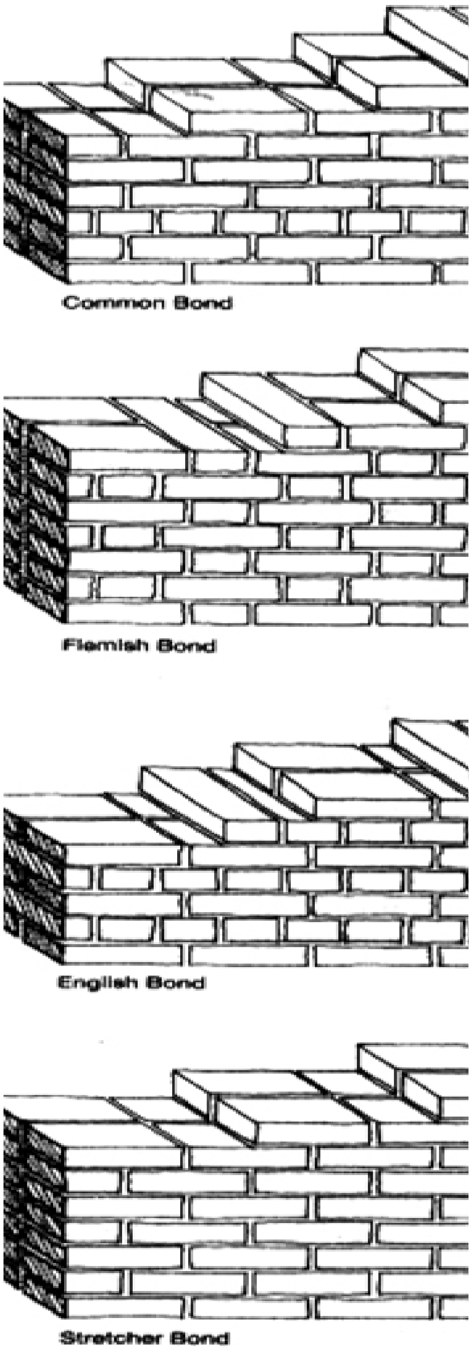

Fig. 6 Four most common bond types (Foulks 1997, 74)

Material Characteristics and Craftsmanship

The building material--in this chapter, brick--determines the aesthetic appearance of the exterior of the building. Since the historic building facade is one of the most visual of a preservation project, it is crucial to not only retain but to also respect the craftsmanship and the material in which it was constructed. The characteristics that should be retained include: bond type; brick size, color and texture; mortar recipe, color and joint type; and historic paint.

Bond Type

The way in which the individual brick fits into the overall pattern or bond type should be observed, respected and retained when preserving an historic structure. There are many different types of bonds and it is essential to recognize and maintain the existing bond when repairing a brick wall or facade. For example, replacing a section of a stretcher bond wall is different than replacing a section of a common bond wall. Figure 6 shows four of the most common bond, but it may be necessary to do additional research if the specific bond of the project is not one of these.

Brick Size, Color and Texture

Standing approximately an arm's length away from the building allows one to properly see the color, size and texture of each individual brick (NPS,

Bricklaying hasn't changed much since the Roman days. They would lay the brick with mortar between the courses and after the wall was complete, finish with a second layer of mortar. This was called "pointing."
(Campbell & Pryce 2003, 19)

The color of the brick is determined by the minerals in the clay or earth that was used.
(Campbell & Pryce 2003, 16)

Fig. 7 Example of Different Colored Brick used in Building

1988 A). When preserving, restoring or repairing an historic building, it is essential to match as closely as possible all three of these characteristics.

While brick size may not seem crucial to the preservation of a building, the sizing of the brick is the basis for the face of the building. The size of the brick is an easy match to make when undertaking repairs, yet is often overlooked for what is immediately available.

The colors of historic brick in Cottage Grove range from a light blonde colored brick to a very dark red brick. With so many color varieties, it is important when restoring or repairing the building to be aware of the specific color of the brick in order to match it.

In addition to the size and color of the brick, the texture of the brick is an important characteristic to be retained and respected. Texture of brick can be a result of age, wear, cleaning, or craftsmanship. Texture based on craftsmanship is paramount. When the texture of brick is created by age, wear or cleaning, it is difficult or even impossible to replicate. Always match the original.

Mortar color and joint type

The individual bricks are held together with mortar that is created from specific proportions of an aggregate and binder. Historic mortar in Cottage Grove typically used local river sand as the aggregate with lime as the binder. In order to properly repair an historic brick building, the mortar recipe, color and joint type must be matched. The most important element of the mortar is the recipe matching. Mortar samples may need to be taken in order to determine the most appropriate mortar recipe for the project. A preservation professional should be able to analyze the mortar to determine the original recipe. While matching the mortar recipe, one must also make sure the new mortar is never harder than the brick to which it adheres. Portland cement is a modern and convenient material often used to repoint or repair historic mortar joints, but it is more often than not an inappropriate material choice. Portland cement, while once considered the "wonder drug" in terms of masonry repair, does not work well with historic struc-

The Byzantines put brick dust into their mortar to turn it red, while 19th century Victorian builders in England put soot in their mortar to turn it black.

(Campbell & Pryce 2003, 19)

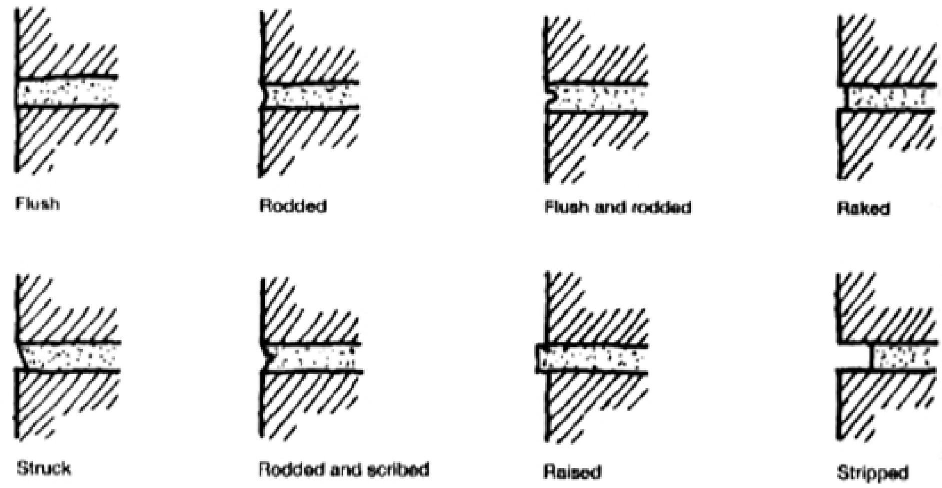

Fig. 8 Common mortar joints
(Foulks 1997, 114)

tures as the original mortar allowed the building to "breathe"; Portland cement prohibits it. Buildings that are not allowed to "breathe" face a myriad of problems. The largest is water retention. The water is not allowed to exit the building through the mortar as it did historically.

The color of the mortar was usually determined by the natural color of the aggregate used but additional pigment was sometimes added to achieve a desired color. Matching the mortar color is just as important as matching the brick color in a preservation project as the relationship between the two greatly affects the aesthetic qualities of the building. For example, a red brick with a light grey mortar has a very different aesthetic quality than a red brick with a reddish mortar pigmented with the brick's dust. Using the Munsell Color System (a universal color matching system), one can match the color of a historic mortar and specify that color in the newly created mortar.

Fig. 9 Improper brick and mortar repair

Mortar acts as a bed for the bricks to rest upon and also as a type of breathable glue that holds the bricks together. The mortar joints created between bricks bring both a functional and aesthetic quality to the building. One must observe and uphold the historic mortar joints by replicating them when repairing. Figure 8 shows the most common types of mortar joints. Failing to replicate the historic mortar joints, one faces aesthetic inconsistency, at the very least.

During the Renaissance, the upper stories of grand buildings would sometimes be made of lime washed brick to look like white stone.

(Campbell & Pryce 2003,130)

Figure 9 demonstrates an historic brick wall (left), which was repaired incorrectly (right). The historic bond was not continued and while the brick size is relatively similar, color matching has been completely overlooked. The historic mortar has not been replicated. The repair mortar is clearly Portland cement, based on its gray color and lack of white dust when rubbed. The color of the repair mortar does not match the historic mortar, but the biggest problem here is the incorrect use of impervious Portland cement.

Fig. 10 Historic masonry that has been continually painted and maintained

Fig. 11 Historic masonry painted with modern latex paint that will not stick due to water problems

Historically Painted Brick

Just as Portland cement used in mortar prevents a building from breathing, so do most modern paints. Historically, brick walls were painted to cover up poor brick quality and/or poor workmanship. It is necessary to know if the building was painted originally, since that determines whether the building should remain painted. If the paint is removed, the soft bricks beneath the paint may not be suited for weather exposure and could deteriorate at an accelerated rate. Equally, paint migrates into the pores of

Fig. 12 Improper historic window infill

Fig. 13 Character defining cornice

Fig. 14 Decorative historic cornice

bricks, making paint's removal a risky venture as doing so can harm the brick's patina and structure, permitting greater erosion. Applying modern paint to an unpainted building may seal the building, trapping water and creating moisture problems both on the interior and exterior of the building. Figures 10 and 11 are examples of historic masonry that was either originally painted or has been painted for an extended amount of time. In these cases, it is crucial to keep the masonry painted as trying to remove it could damage the brick.

Visual Character of the Building

Similar to the need to maintain the original brick and mortar characteristics is the need to match the overall visual character of the building. Visual characteristics such as roof shape, building openings, projections and trim work together to create a building as a whole. It is important to honor all of these parts of the whole for without them the overall visual character of the building changes drastically.

Roof

The shape of the roof along with its angle of slope can greatly contribute to the visual character of the building (NPS, 1988 A). Most of the historic brick buildings in Cottage Grove employ a fairly simple parapet roof shape. It is important to keep the parapet roof consistent with its history. For example, it would not be appropriate to replace the original flat roof with a gabled roof. Many of the parapet roofs in Cottage Grove appear to have water problems in which the water collects on the flat roof and has no where to go but through the brick masonry of the parapet wall, causing efflorescence and brick staining. Maintaining the roofs will prevent further damage.

Openings

Proportions of openings such as windows and doors are essential components when composing a facade of a building. In a restoration, it is important to retain the original pattern and proportions of openings in the exterior walls. Filling in historic openings should be avoided at all costs, along with creating new openings as this greatly affects the visual character of the building. If it is determined necessary to fill an historic opening, be sure

- Deterioration can occur in bricks for many reasons. These could be related to the original manufacturing and firing of the brick, maintenance or repairs that occurred during the life of the brick, poor cleaning practices, structural deficiencies, and others.

- Outlined in this section are the leading problems and causes of brick deterioration. Failure from design flaws and issues with the original mixture are very hard to detect without knowing the composition of your specific brick. What is known is that many of the buildings in Cottage Grove from before 1907 were built with handmade, softer bricks. Thus, the first two failure reasons listed may or may not be important for your building, and may aid in understanding handmade bricks issues.

Fig. 15 Hand molded bricks Fig. 15 Hand molded bricks (http://monarchstone.net/ourproducts/landscape-stone/antique-brick/)

to match the historic material and mortar type. In addition, it is important to retain the historic window material and pane pattern. If windows need to be replaced, match the new window as closely as possible to the historic window to maintain the integrity of the opening. Figure 12 is an example of an improper infill.

Projections

Any element of the building that protrudes from the exterior wall is considered a projection and is a character-defining feature (NPS 1988 A). Cornices, porches, balconies and bay windows are just a few building components considered projections. Cornices are the most common type of projection found in Cottage Grove. It is important to maintain the material, pattern and detailing of the historic cornice as it greatly contributes to the overall visual character of a building. Often the cornice may need to be reinforced due to seismic codes, but it is essential to carry out the reinforcement in the least invasive way possible while keeping the character of the historic cornice intact. The cornice of the building in Figure 14 has been enhanced with architectural detailing--mousetoothing. In addition to reinforcement, the cornice may need to be updated in order to properly move water away from the building. Flashing is typically attached to the top of the cornice to mediate this problem, however, it is necessary to be thoughtful in the placement of the flashing in order to not detract from the visual character of the building.

Trim and other Decorative Elements

While the trim surrounding windows, doors and projections may not seem significant, it plays a large role in determining the visual character of the building. These subtle details can be both structural and decorative. The lintel above a window, for example, prevents the window opening from collapsing and decorative elements may be incorporated into this structural component by way of color, texture or pattern.

Fig. 16 Hand molded bricks

Fig. 17 Wall without flashing

Fig. 18 Wall with flashing. Water being diverted away from parapet after years of damage from water infiltration.

Problems & Causes

Failure of brick from inherent brick design flaws

Brick Mixture:

The mix used for the manufacture of original brick may not have been created with high quality control. This means that the ingredients may not have been properly measured, or the firing temperature of the bricks may not have been properly controlled, all of which may have caused the bricks to form cracks during the firing process (Foulks 1997, 81).

Brick Molding:

Issues may also arise if the brick was improperly molded into shape. For example, hand molded bricks (which may be identified by their rough texture and uneven surface) tend to have more air pockets (and thus more areas where water may infiltrate into the brick) than pressed or extruded bricks (which are mechanically pressed and have fewer and smaller air pockets) (Foulks 1997, 76).

In addition, early hand-pressed bricks are more porous than extruded or machine-pressed bricks, and can absorb 20-25% of their weight in water (New York, 1997, p. 76). These bricks are more susceptible to freezing and thawing issues if water becomes trapped inside the brick and expands. By the end of the 19th century, the standard maximum absorption rate for bricks was 10%, and in general, bricks produced from the 20th century onward rarely have the same issues (Foulks 1997, 76).

Figure 16 depicts handmade bricks from Cottage Grove and shows how the softer, handmade bricks can be more susceptible to damage. This does not mean that these bricks are unusable, or should be replaced if in good condition. These bricks just need to be treated with very mild cleaning methods, and if historically painted, these bricks need to continue to be painted today.

Failure of brick from improper detailing, specifications, and workmanship

Fig. 19 Water is not being diverted away from the foundation of this building, causing rising damp

Lack of original brick and mortar bond:

If bricks and mortar did not bond well originally during the construction of the wall, this could be due to inadequate curing time associated with extreme temperatures during the laying of the bricks, than cracks may have may have occurred in the mortar which could expand and cause the mortar to be susceptible to freezing and thawing issues (Foulks 1997, 76). The bond pattern may have been flawed; for example, a running bond may have been used that did not utilize any headers to lock the wythes together, and thus cracks may have occurred during settlement from lack of wall ties (Foulks 1997, 76).

Additional issues may have occurred if bricks were either frozen or completely saturated at the time that they were laid. This is because the brick may not be able to absorb any water, and thus did not take the mortar into its pores and properly bond (Foulks 1997, 76). Joints between bricks may also have been improperly prepared. For example, mortar may not have been placed on each side of the brick fully, or it may not have been evenly and smoothly applied.

Fig. 20 Corroded metal imbedded in brick masonry

Lack of flashing or failure of flashing:

Many historic buildings were not designed to have flashing at the parapet of the roof, and have since been retrofitted to protect from water infiltration. Adding flashing to an historic building that is already having issues, as was done in Figure 18, will aid in controlling water issues, but the brick may still need to be repaired. Flashing is a very good first step if repair cannot occur right away. Flashing will not fix every problem, but should be part of an integrated approach.

Lack of proper drainage or failure of drainage:

If water is not adequately being drawn away from the building with a proper and maintained drainage system and sloped pavement, it may pool on or around the building, and cause damage. This is particularly important at the roof level, where lack of proper drainage may cause water to accumulate at the parapet level, and at the ground, where continual water near the foundation may ultimately impact it.

In Figure 19, water is being taken from the roof via a downspout, but is then splashing back on the foundation of the building and causing issues of rising damp (water being wicked up a masonry wall, that is not allowed adequate time to dry on a regular basis).

Improperly designed, or insufficient number of supports and anchors:

Metal is often used in historic masonry buildings to tie features into the wall, and connect building pieces together. These metal pieces, if not made of stainless steel, have the ability to corrode, expand and deteriorate the interior of masonry walls. In addition, the building may not have been built to the original design specifications and thus there may not have been as many anchors and ties installed as there should have been.

Corroded metal will expand, and if that expansion puts too much pressure on the brick surrounding it, it may cause the bricks to crack (Foulks 1997, 77). Expansion from thermal changes may also occur even if the metal has not yet corroded, because metals have different thermal coefficients than brick (rates at which dimensional changes occur in relation to changes in temperature). It is important to regularly monitor points in the wall where water could enter, to ensure that metal anchors and ties are not encouraged to rust. Another sign that this may have occurred will be the presence of rust stains on the brick surface. The stains are clues as to which metal supports are rusting.

Failure of brick related to weather, exposure, and building use

Water infiltration:

Water infiltration is the most common cause of a brick wall deteriorating. Once water enters a brick wall, it must be able to adequately evaporate or drain back out or excessive water trapped inside the masonry can begin to erode the wall. Infiltration can occur at the ground level where it is wicked up the wall, at the roof level where there is not adequate flashing to keep rainwater from entering the wall, and along the face of the wall if joints have not been properly maintained or there are holes in the bricks. This can also cause salts to be carried into the wall that can accelerate deterioration and cause efflorescence (described below) (Foulks 1997, 80). In addition, acid may be carried into the wall through rain infiltration, which may deteriorate metal members within the walls (Foulks 1997, 80).

Fig. 21 Chipped paint is allowing water to enter into the joints of this brick wall

If the wall has been covered with modern paint and chips begin to occur on the wall, water can get trapped behind the paint and cause layers of the brick to spall or delaminate. Figure 21 is an example of this. Walls that were originally painted need to remain as such, because removing the paint may cause the fired glaze on the surface of the brick face to be taken off as well, leaving the entire brick susceptible to water infiltration. Also, biological growth keeps moisture on the building and does not allow it to fully dry out, which can equally create problems.

Expansion:

Expansion occurs for a few reasons. First, masonry units and the mortar that bonds them expand with fluctuations in freezing and thawing. This is natural, and by itself causes minimal damage. Mortar is meant to be softer than the masonry unit to which it adheres, and it is expected that the mortar will do most of the expansion and contraction. Expansion also occurs if water is brought into the wall and expands when frozen, which is why it is particularly important to keep water from entering into masonry walls, and if it is does, it needs to be able to evaporate across all surfaces. Underfired or soft bricks are more susceptible to issues with water absorption, especially bricks with absorption rates of 12% or more (Foulks 1997, 79). Lastly, expansion can occur when salts are trapped in the wall and expand (Foulks 1997, 80).

Efflorescence:

Efflorescence occurs when salts are carried by water into masonry units. When this happens, a white powder may occur on the brick surface, resulting from the leaching of salts through the bricks pores. This staining is for the most part superficial and can easily be cleaned with water and a soft brush. If the staining is not easily removed then there is subflorescence. Subflorescence is more problematic, and means that the salts are trapped inside the pores of the masonry. When this occurs, salts can expand and cause the brick to crack and delaminate (Foulks 1997, 79).

Fig. 22 Efflorescence on the surface of a brick wall

Figure 22 shows a defined area of efflorescence staining on a brick building. This staining appears to have occurred for two reasons. First, there is not adequate flashing on the window sill, which is permitting water to enter into the mortar joints of the sill and allowing it to travel into and down the masonry wall. If the salts staining the surface have imbedded into the brick face, they will eventually cause the brick to delaminate, chip, and spall.

Figure 23 is an example of the deteriorating effects of efflorescence. The expansive pressure of the dissolved salts has caused the bricks to delaminate and spall. Layers and chunks of brick, along with mortar, have cracked and fallen off of the building, leaving the softer interior portion of the brick open and vulnerable to water infiltration and expansion.

Fig. 23 Spalling and loss of mortar due to efflorescence

Settlement:

Settlement may also cause cracking within the wall, which may allow water to enter into the masonry (Foulks, 80). Settlement is natural and is countered in part in wall construction by the fact that the mortar is softer than the brick masonry units. This means that when settlement does occur, the mortar should act as a sacrificial material, taking the majority of the force and cracks. When settlement occurs and cracks form within the bricks, more serious issues can occur as water may enter directly into the core of the brick.

Chemical Attack:

Chemical attack may occur if bricks were underfired, or if spalling has caused the unglazed portion of the brick to be exposed to chemical attack (Foulks 1997, 79). The most common chemical to attack masonry is sulfuric acid deposited from rain. Often called acid rain, sulfuric acid may cause the deterioration or brick and mortar, and may disfigure finished surfaces.


Fig. 24 Incompatible brick infill

Failure of brick related to improper repair, cleaning, and maintenance

Incompatible Materials:

Portland cement mortar is not recommended for use in historic masonry buildings. Portland cement is the most common incompatible material used in brick masonry repointing today, and can have many deteriorating effects.

Portland cement leaches salts into the brick wall, but it can also cause severe damage as it expands. Portland cement is impervious and denser than traditional bricks and mortars, and thus, should not be used with softer masonry units (Foulks 1997, 119). Due to its density, it takes it less water than the surrounding masonry, forcing the latter to absorb more than it should. This excessive moisture can cause cracking and spalling.


Fig. 25 Incompatible Materials

In Figures 24 and 25, the incompatible infill composed of modern bricks and Portland cement mortar is putting pressure on the surrounding wall. This has caused the wall to bow and the mortar to crack. Proper restoration in these examples would have been a compatible infill consisting of bricks with a similar hardness and mortar of a similar lime and sand content as was used in the original wall.

Whenever replacement of bricks or mortar is necessary, an analysis of the composition of both should be done to ensure that the replacements will have similar properties, and thus expand and contrast at similar rates.

Improper cleaning:

Fig. 26 Effects of abrasive cleaning on brick and mortar

It is always advised that the gentlest means possible be employed when cleaning historic brick masonry. This means starting with water pressure no stronger than that of a normal hose (approximately 10 psi), and using gentle detergents. Abrasive cleaning has historically been responsible for causing great harm to brick masonry (NPS, 1979). Abrasive cleaning removes the glazed, fired surface of the brick, leaving it susceptible to damage and water infiltration. In addition, abrasive cleaning may cause deterioration of lime/sand mortar mixes and force salts to imbed into the mortar and masonry.

Abrasive cleaning methods include sandblasting, pressure washing, and using other small particles (e.g. glass beads and nut shells) projected in a high-pressure stream on the brick surface (NPS, 1979). These are never advised to use on historic brick masonry, and unfortunately, is often seen as a way to remove paint, causing lasting issues, brick deterioration, and delamination.

Fig. 27 Left untreated, the mortar gaps in this picture eventually cause structural damage to the building

Figure 26 shows the effects abrasive cleaning can have on a masonry building. The glazed surface of the brick has been removed, leaving grooves, gaps, and holes in the brick and exposing it to moisture. In addition, the mortar has been severely eroded, adding to the potential deterioration. Repointing is necessary to restore the wall to its original state as well as protect the wall from further damage. Any heavily deteriorated bricks may be able to be turned around and the inside face used for the exterior. If this is not an option, some bricks may need to be replaced if they are beyond small patching and repair.

Abrasive cleaning was witnessed on multiple occasions on brick buildings in Cottage Grove and it is important to highlight the deteriorating effects this can have on brick masonry. In most situations, brick can be cleaned with a low-pressure house and gentle (non-acidic) cleaners. While this might have been the intent in Cottage Grove, unfortunately, this was not employed; abrasive methods have had the greatest detrimental effects.

Fig. 28 Viable historic brick that needs repointing
(www.indestructables.com)

Fig. 29 Deteriorated historic brick unable to be reversed

Improper maintenance:

Routine maintenance is necessary with any building, and helps extend the life of the structure. This includes light cleaning when necessary, repointing mortar joints that have deteriorated with a mortar of similar characteristics (hardness, components, color, and texture) and making sure water is being drawn away from the building through a system of properly maintained flashing and gutters.

Improper maintenance includes using water-vapor-impermeable coatings (including silicone- based and cement-based coatings) to attempt to 'seal' the wall from water damage (Foulks 1979, 80). These sealants will trap moisture inside the wall, which may accelerate deterioration. Water that does get passed the coating (perhaps through a small crack in the coating) may bring salts into the wall, causing further issues related to freeze/thaw expansion (Foulks 1979, 80).

Lastly, simply leaving a building too long without any sort of maintenance is never advised. It may seem an easier fix to leave will the building alone, but when deterioration levels reach a point where the structural integrity of the wall is in danger, the building will risk needing costly structural repairs.

Web References:

Cleaning of Historic Masonry Buildings:
http://www.nps.gov/history/hps/tps/briefs/brief01.htm
Repointing Mortar Joints in Historic Masonry Buildings:
http://www.nps.gov/history/hps/tps/briefs/brief02.htm
Dangers of Abrasive Cleaning to Historic Buildings:
http://www.nps.gov/history/hps/tps/briefs/brief06.htm
Removing Graffiti from Historic Masonry:
http://www.nps.gov/history/hps/tps/briefs/brief38.htm
The Use of Substitute Materials on Historic Building Exteriors:

Recommendations

http://www.nps.gov/history/hps/tps/briefs/brief16.htm

Architectural Character:

http://www.nps.gov/history/hps/tps/briefs/brief17.htm

Repointing

Repointing is the most common repair made to historic brick structures (Foulks 1997, 81). Repointing is simply reapplying mortar to specific joints where the previous mortar has either deteriorated or failed. It is essential to match the new mortar recipe to the original mortar recipe; mortar samples and analysis may be necessary in order to determine the exact original recipe. Failure to keep the new mortar consistent with the original mortar can result in numerous additional problems so it is worth the time and effort to match the mortars as closely as possible. Most of the historic mortars in Cottage Grove were composed using sand as the aggregate and lime as the binder; however, mortar analysis is required to determine the exact ingredients and ratios. Repointing is considered a minor repair and can be the extent of repair necessary for historic brick structures. As a general rule of thumb: if more than 25% of a brick wall needs to be repointed, it may be just as cost and time effective to repoint the entire wall. The masonry wall in Figure 28 contains historic brick that is still viable. Therefore, repointing is the simple repair required to maintain this wall, assuming there are no other problems.

Fig. 30 Improperly replaced brick affects both the structural integrity and aesthetic qualities of an historic building

Brick Reversal

If, in addition to the mortar deteriorating, the historic bricks have deteriorated or cracked, major repair may be necessary. It is essential to start with the most reversible solution when repairing the individual brick. If the exterior surface of a brick is deteriorated, it may be possible to turn the brick around and rebed and repoint it into the wall. This is only possible if the interior side of the brick is capable of being exposed to the weather. Hardness, absorption and saturation levels should be determined before reversing any bricks to ensure performance. Figure 29 shows an historic brick that has deteriorated past the point of reversal and performance and therefore would need to be removed and replaced either with reclaimed or new brick.

Brick Replacement

If brick reversal is not a possibility, brick replacement is the best solution. It is inappropriate and problematic both structurally and aesthetically to replace a brick with a large patch of Portland cement or similar material as illustrated in Figure 30. Historic bricks should be replaced either with reclaimed historic bricks or with new bricks. Whether replacing with reclaimed or new brick, it is necessary to match the material characteristics such as color, size, texture, hardness and porosity in order to preserve the visual character and structural integrity of the building. If a deteriorated area is highly visible and matching brick cannot be found, brick from an inconspicuous area on the structure could be removed and used. The less visible area can then be repaired with as close a match as possible.

Fig. 31 Biological Growth

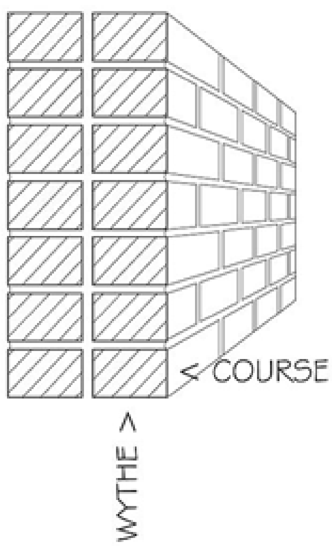

Fig. 32 Brick Course and Wythe
(http://en.wikipedia.org/wiki/Wythe)

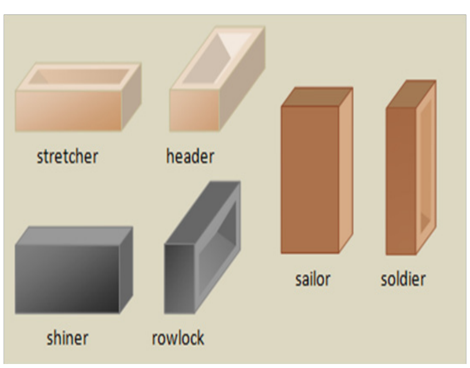

Fig. 33 Brick masonry faces
(http://en.wikipedia.org/wiki/Brickwork)

Glossary

Acid Rain

Rain that contains acid (from burning fossil fuels). Rainwater is dispersed on the masonry surface, and over time, this may deteriorate brick and mortar.

Biological Growth

Growth on the masonry surface or within masonry joints of biological origin. This includes, but is not limited to algae, moss, small plants and grasses, lichen (a dark colored fungus), ivy, fungi, mold, and other bacteria. These can trap moisture in the wall and cause deterioration of mortar.

Brick Course and Wythe

The course is a row of bricks and the wythe is the term used for the width of one brick. The example in Figure 32 is two-wythes thick and is laid in a running bond course.

Brick Faces

Figure 33 shows the names for the different faces of a brick

Capillary Action

This action usually begins at the ground level and refers to water being wicked up the wall from either standing water or water in the ground around the foundation. This condition is called rising damp, and dark staining often marks the area, up to where the water has risen.

Chemical Cleaning

Though it is always advised to use the least invasive cleaning methods possible first when cleaning historic brick masonry, chemical cleaning may at times be appropriate. Heavily soiled brick masonry may be cleaned using cleaners containing reduced acids and alkali contents. When conducting any cleaning method containing chemicals or high water pressure, an experienced professional should always be consulted.

Chipping

This may occur if bricks are damaged from cleaning, hit with abrasive materials including harsh winds, or if bricks have begun to delaminate and spall. Chips expose the unglazed interior of the brick to water infiltration and may accelerate deterioration.

Copper Staining

This may occur if copper (flashing, drainage, roofing, etc.) begins to age and turn from brown to black, and then to green. As this happens, dark green staining may occur on the brick, which can be removed.

Coving

This phenomenon is caused along the foundation of buildings when large amounts of water are present. The water repetitively strikes the same point(s) on the ground and splashes back on the building, creating a horizontal concave recess in the masonry's surface.

Cracking

Cracking may occur during settlement, after seismic activity, or if incompatible materials are used within the brick wall that put excessive pressure on the surrounding brick. In proper brick construction, the mortar serves as a shock absorber, and should be weaker than the masonry units to which it adheres. Then normal movement—and minor cracks—will form within the mortar and save the brick. If the mortar is stronger than the brick (which occurs when incompatible materials such as Portland cement is used), then cracks may begin to form in the bricks, which can lead to structural damage.

Design Flaws

This is referring to the inherent design flaws that may exist in historic bricks. This includes: bricks that were not mixed properly, bricks that were not tightly molded, and bricks that were under or over-fired.

Graffiti

Graffiti visually mars any brick building. It can stain brick by seeping into the brick's interstices and if not removed, can encourage repeat offenses. More information on graffiti removal (including finding the safest technique for your situation), please see the National Park Service Technical Preservation Brief #38: "Removing Graffiti from Historic Masonry" found at: http://www.nps.gov/tps/how-to-preserve/briefs.htm.

Hand Pressed Bricks

Hand pressed (or molded) bricks may be identified by their rough texture, uneven surfaces, and the tendency to have more air pockets than machine extruded brick. This means they are more porous, and thus, have more areas where water may infiltrate into the brick. They can absorb 20-25% of their weight in water, making them more susceptible to freezing and thawing issues. Hand pressed bricks were found in Cottage Grove and were common until 1907, when machine pressed bricks were introduced to the City.

Machine Pressed/Extruded Bricks

These bricks are harder and more uniformly shaped than hand pressed bricks. They are formed either by a machine pressing them into molds, or by extruding them through a machine and cutting them by wire. Machine pressed Bricks became available in 1875 and were common in Cottage Grove after 1907.

Pitting

Pitting is an imperfection that occurs on the surface of a brick due to the expansion of large lime particles just below the surface. Lime, used in the manufacturing of bricks, may not have been thoroughly mixed in when the

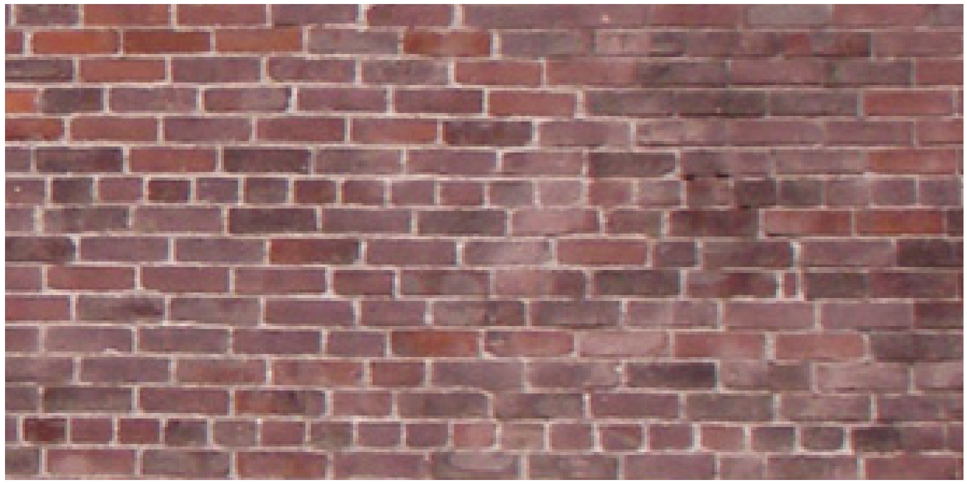

Fig. 34 Portland Cement used for Repointing

bricks were formed. This may have left small deposits of lime near the surface of the brick, which will expand with the presence or water. This is particularly evident in Cottage Grove where buildings were abrasively cleaned, exposing lime deposits below the glazed surface to water infiltration.

Portland Cement

Invented in 1824 in the United Kingdom, Portland cement became popular in America in the late 19th century. Its use, particularly in repairing brick masonry, became popular in the twentieth century, and many historic buildings were harmed by its incompatibility. Portland cement is much harder than the lime mortar used in historic brick masonry, has greater expansive qualities, and traps moisture inside the brick wall, causing spalling of the bricks. It is now largely regarded as a poor choice for repointing historic brick masonry.

Poulticing

This cleaning method is utilized to draw out deeply penetrated stains and graffiti on brick masonry. Poulticing involves mixing water with an absorptive material (most often clay) to create a paste and then, applying it to the brick masonry. The poultice is covered to ensure a slow drying process that will pull the stain out of the brick, with the poultice acting as a sponge.

This process may be done multiple times to reach the desired effect and fully lift the stain.

Salt Fretting

A severe form of spalling that is specifically linked to salt infiltration, especially from de-icing salts.

Spalling

This occurs when exterior portions of the brick deteriorate and flake off. Deterioration is most often caused by pressure being applied by internal moisture and salt deposits. Water and salt inside the brick expand and contract with thermal changes, causing the glazed face of the brick to crack and fall off.

Water-Vapor-Impermeable Coatings/Sealers

Water-Vapor-Impermeable Coatings (including silicone based and cement based coatings) are used as an attempt to 'seal' the wall from water damage and are not recommended on historic brick masonry buildings. These sealants, chosen as an attempt to protect the wall, will also trap moisture inside the wall and may accelerate deterioration. Water that does get passed the coating (perhaps through a small crack in the coating) may bring salts into the wall, causing additional problems. It is never advised to use water-vapor-impermeable sealants on historic masonry of any kind. A coating, that has not been tested and had enough time pass to see the long term effects of its use, may cause extreme harm to the building and accelerate deterioration.

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