NYC Buildings

FAÇADE CONDITIONS

An Illustrated Glossary of Visual Symptoms

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1. Intent, Scope and Purpose

This glossary is intended to be used only as an educational tool by those interested in visual inspections of facade conditions. The glossary does not include any guide as to the impact of the various listed conditions on the public safety or buildings' structural stability. Such determination needs to be the result of the qualified inspector's professional consideration based on a specific examination of the façade where all visual symptoms are assessed based on their location, prevalence and in their relationship to the façade system. Such determination shall comply with all New York City Construction Code requirements and prescriptions.

The visual symptoms listed in the Glossary refer to types of facades common in New York City high and mid rise buildings. The glossary is by no means exhaustive, but hopefully it describes most of the typical façade problems encountered in New York City. As this manual refers to façade conditions only, the roofing conditions are not included, but one should note that their impact on the proper performance of the facade can be significant.

Following a visual inspection, the evaluation of a façade's condition should take into account all of the visual distress symptoms, together with consideration of other building components as well as with the building's structural, thermal insulation and HVAC systems and fire protection systems.

In many cases the source of a façade defect cannot be established without probing.

While the glossary associates causes to symptoms, the reader needs to be aware that many other causes, or a combination thereof, can produce the types of distress presented. It remains the responsibility of the professional performing the inspection to provide the proper diagnosis.

This glossary is the result of discussions with an ad-hoc round table of façade inspection professionals who contributed with some of the text, pictures and reviews.

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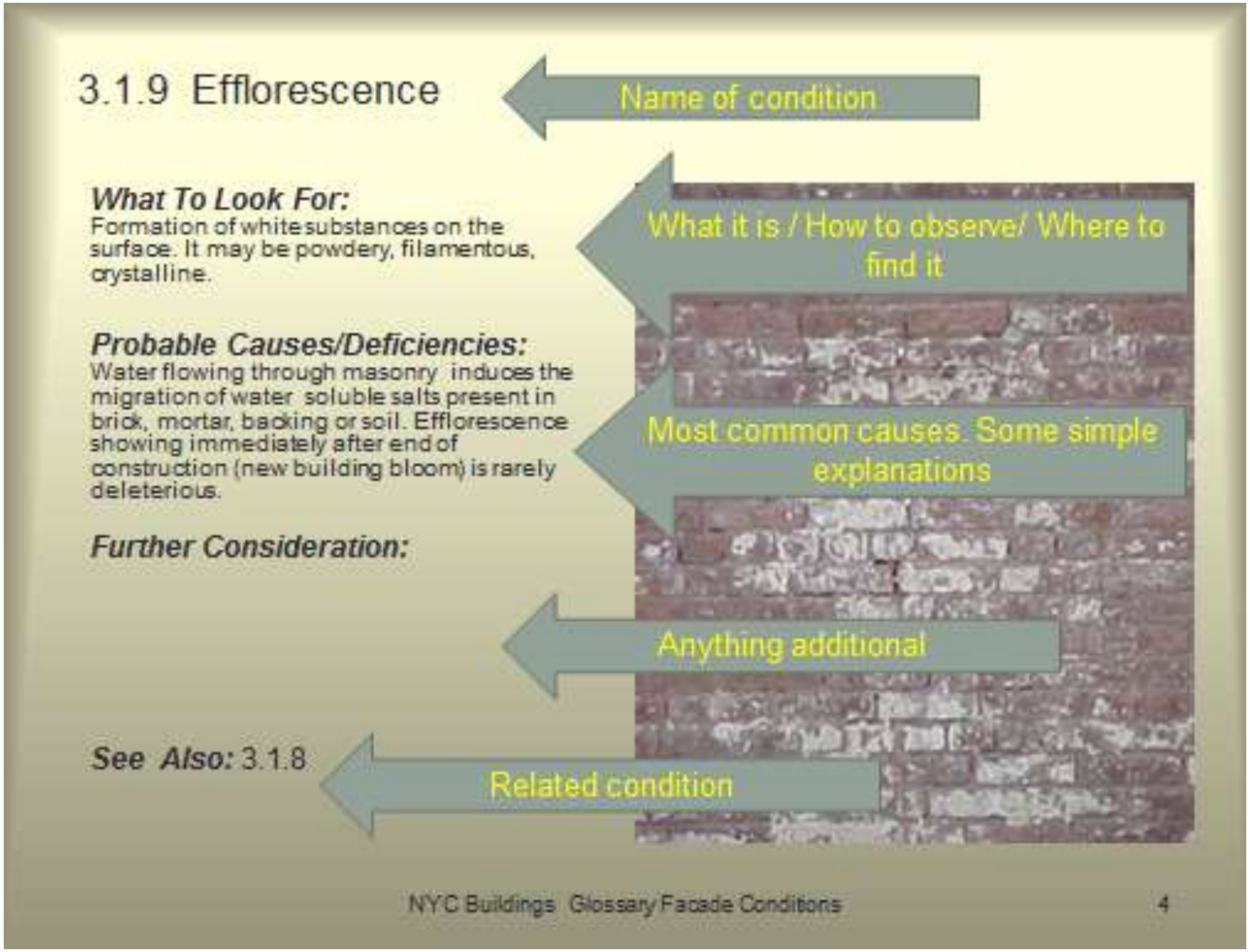
2. Organization of the Illustrations



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3.1 Masonry

Since the 1850's, to protect against spread of fire, building regulations in New York City have required the use of masonry as a building separation material. As a result brick and stone have become the basic building materials used in New York City facades. They have remained the most common materials used in facades, despite the evolution of façade systems from bearing masonry to infill masonry and to Cavity wall as well as curtain wall systems.

Masonry Units and Binder

Masonry is described by type of units, coursing, and number of wythes, bonding of wythes or attachment of exterior wythes to backup system. While the binder in joints is almost always made of mortar, units in masonry facades can be brick, stone, terra-cotta, concrete, etc. or combinations of these. The following section illustrates various conditions of clay brick and mortar components of masonry. For other type of façade materials see specific sections.

Clay Brick Units

Burnt clay brick as a masonry element has been used for centuries. For façade evaluation brick is characterized mainly by its quality and the condition of its exposed face.

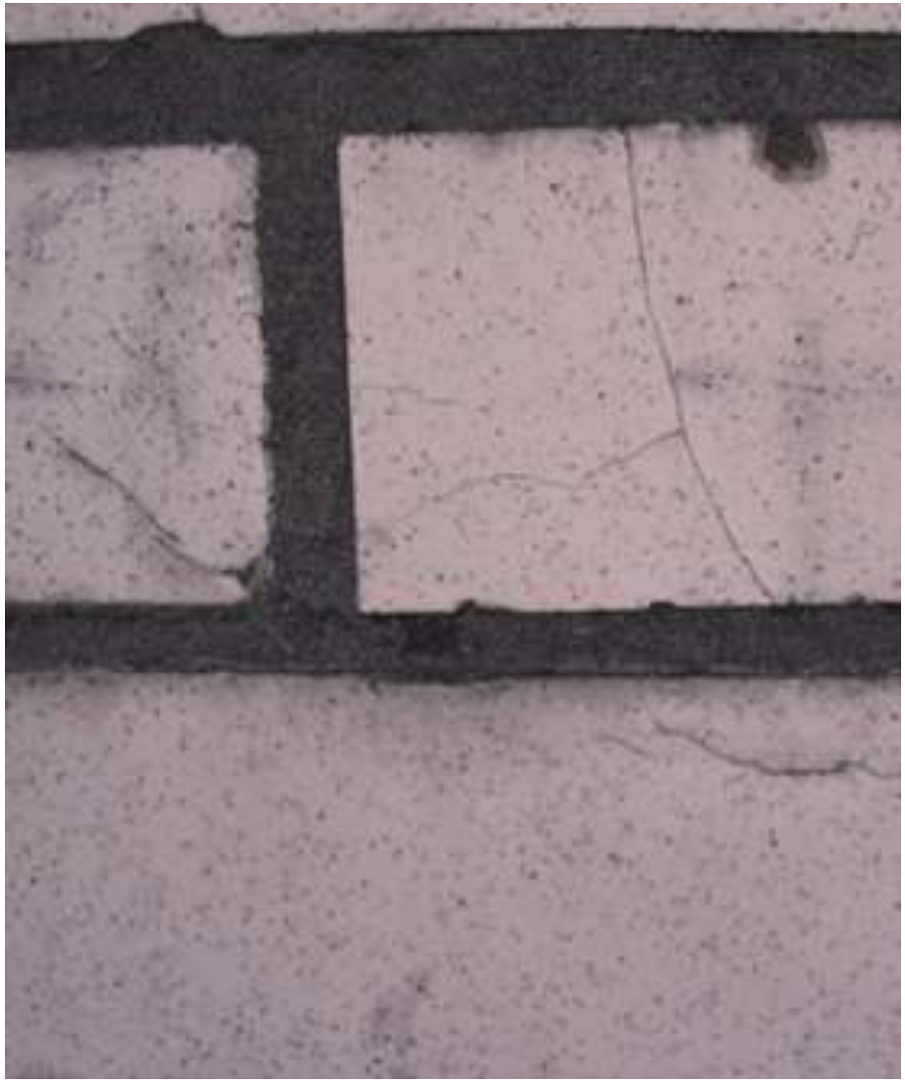
3.1.1 Brick Crazing

What To Look For:

Fine surface cracks without clear directional pattern.

Probable Causes/Deficiencies:

Improper brick manufacture and quality. Freeze/thaw. Usually in glazed brick.



3.1.2 Cracks in Brick Surface

What To Look For:

Cracks in brick surface that do not continue in mortar. Some spalling.

Probable Causes/Deficiencies:

Freeze/thaw. Ice lensing. Usually in glazed brick. Constrained ceramic expansion. Brick with high saturation rate.

3.1.3 Staining/Soiling

What To Look For:

Alteration, change in color due to deposits of materials. Film, very thin layer of deposit.

Probable Causes/Deficiencies:

Deposits not belonging to the substrate, such as rust, paints, smoke, etc. Usually not deleterious.

Further Consideration:

Staining/Soiling can describe deposits on other materials such as stone, concrete, etc.

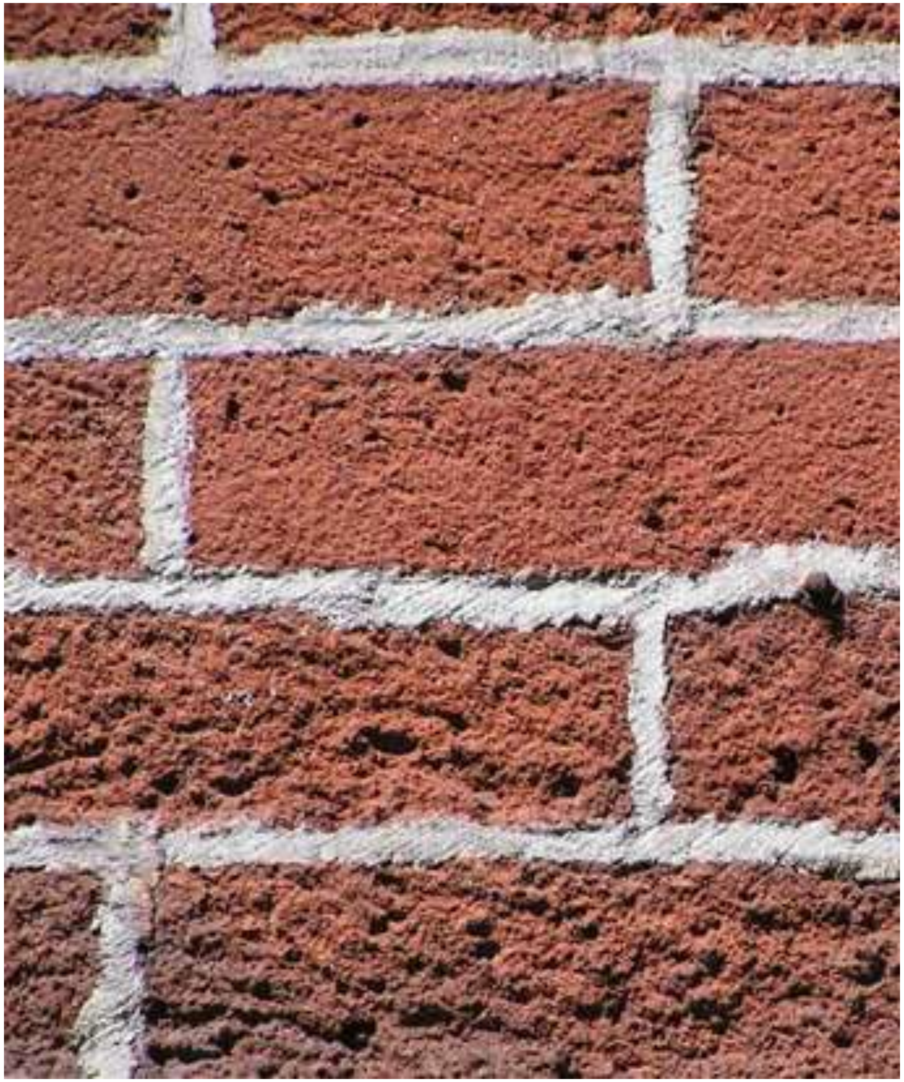
3.1.4 Erosion/Pitting/Abrasion of Brick Face

What To Look For:

Extremely small cavities in the surface. Miniscule disintegration.

Probable Causes /Deficiencies:

Poor quality of brick. Previous cleaning by sandblasting or improper cleaning.



3.1.5 Organic Growth

What To Look For:

Algae, lichens, mold, plants, vine.

Probable Causes /Deficiencies:

Moisture. Wet brick.

Further Consideration:

Organic growth can occur on many other materials such as stone, concrete, etc.

3.1.6 Efflorescence

What To Look For:

Formation of white substances on the surface. It may be powdery, filamentous, crystalline.

Probable Causes/Deficiencies:

Water flowing through masonry induces the migration of water soluble salts present in brick, mortar, backing or soil.
Efflorescence showing immediately after end of construction (new building bloom) is rarely deleterious.

3.1.7 Cryptoefflorescence Spall

What To Look For:

White substances present in the spalling brick.

Probable Causes/Deficiencies:

Migration of water thru porous brick. Soluble salts that are deposited in the mass of the brick. Cryptoefflorescence (subflorescence) increases volume from crystallization adding pressure on the brick internal structure or on the brick skin.

See Also: 3.1.6 , 3.1.9

3.1.8 Brick Spalling/Delaminating

What To Look For:
Outer surface of the masonry splitting apart. Uneven break of outer face. Burst. Popup. Outer face (skin) of bricks fallen or about to fall. The term *delaminating* is used mostly for splitting in thin layers parallel to the brick surface.

Probable Causes/Deficiencies:
More common in glazed brick and coated brick where migration of water out of the brick unit is severely blocked by lack of permeability of outer layer. Freeze/thaw of entrapped water.

See Also: 3.1.9

3.1.9 Brick Chipping/Spalling

What To Look For:

Outer surface of the masonry splitting apart into small fragments. (Use *spall* for larger fragments). Uneven break of outer face. Burst. Popup. Outer face (skin) of bricks fallen or about to fall.

Probable Causes/Deficiencies:

Occurs when the brick face is under uneven local compression. (e.g. strength of pointing mortar highly exceeds strength of brick, expansion/shortening of adjoining metal, etc.). Constrained expansion of brick.

See Also: 3.1.8

3.1.10 Peeling of Paint or Stucco

What To Look For:

Peeling (shedding off) of coating and outer layer of brick. Presence of non-breathable coating.

Probable Causes/Deficiencies:

Moisture accumulation due to presence of coating with limited vapor permeability leads to the separation of paint or stucco layer. Also disintegration of brick (following several freeze thaw cycles).

3.1.11 Brick Coving

What To Look For:

Cavity or hollowing of brick. Brick condition in areas with standing water, especially in areas close to grade.

Probable Causes/Deficiencies:

Loss of material due to presence of standing water.

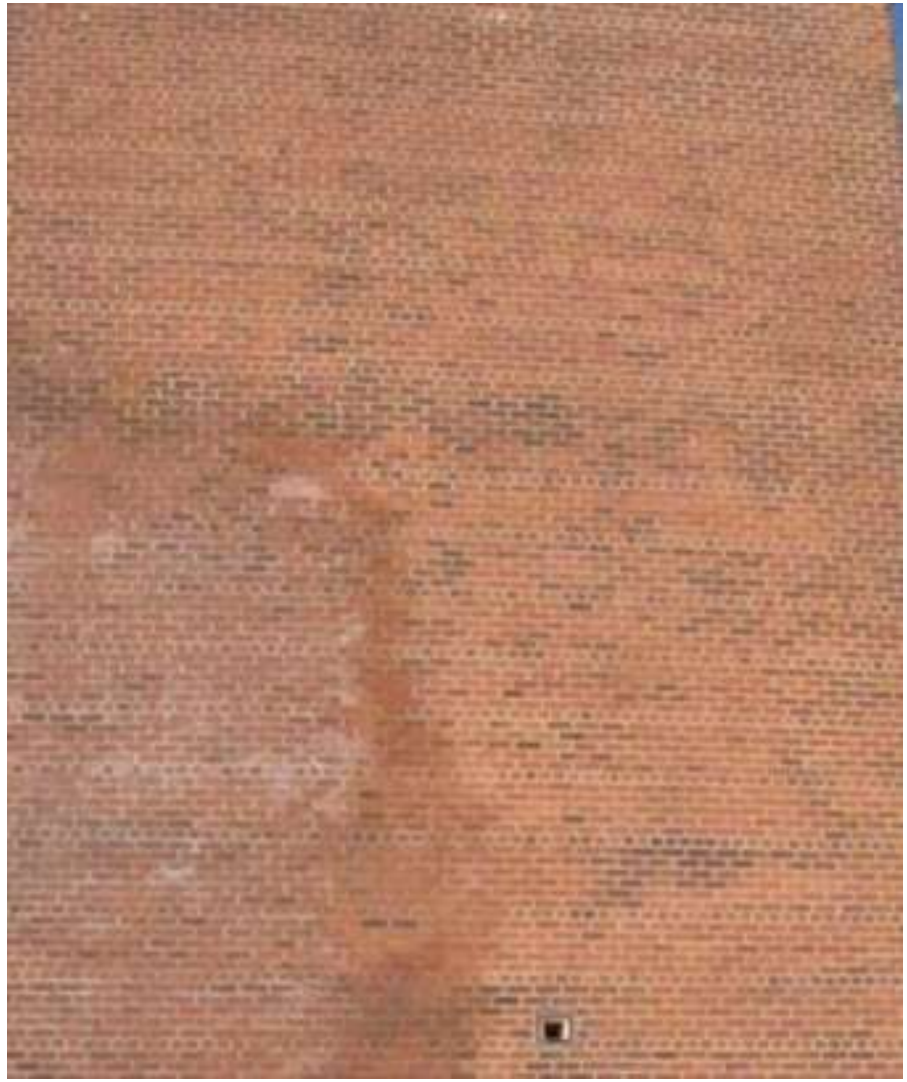
3.1.12 Wet Wall

What To Look For:

Water stains on masonry walls, organic growth, difference in coloring.

Probable Causes/Deficiencies:

Dampness rising from foundations. Problems with the mechanical or plumbing systems.



3.1.13 Mortar

Mortar binds the various masonry units. The essential mortar characteristic is its composition. This composition, especially the relative proportion of lime and cement, has evolved since the late 1800s to present times. The lime content of the mortar has diminished over time being replaced first by natural cements (usually Rosedale variety) and since the early 1900s by Portland cements. Lime mortars were weaker than bricks and allowed some movement without cracking (or with cracks auto healed.). Present day cement mortars have strengths similar to brick. Quality of mortar is also heavily determined by the conditions at the time of its placement. Visual inspections of mortar describe its degree of deterioration.

3.1.14 Slightly Eroded Mortar Joint

What To Look For:

Slight or local erosion of mortar in joint. Small erosion depth relative to exterior face of brick. Aggregate (fine sand) exposed. Compare with original tooling of mortar. Location of eroded mortar joints. Condition of brick surface and edges. Compare with original joint tooling.

Probable Causes/Deficiencies:

Erosion due to wind or frost cycles. Disaggregating of lime component of the binder.

3.1.15 Open/Eroded Mortar Joint

What To Look For:

Erosion of mortar in joint. Loss of outer layers of mortar. Depth of erosion relative to exterior face of brick. Location of eroded mortar joints. Condition of brick surface and edges. Compare with original joint tooling.

Probable Causes/Deficiencies:

Erosion due to wind or frost cycles. Disaggregating of lime component of the binder.

3.1.16 Disintegrating Joint Mortar

What To Look For:

Crumbling, deep deterioration of mortar in joints. Disintegration of binder component (usually lime) and washout of sand particles. Size of joint.

Probable Causes/Deficiencies:

Frost cycles. Dissolving of constituents (especially lime) in water, especially in areas where water is trapped. Sulfate attack.

Further Consideration:

When mortar loses its binding function masonry is held in place only by gravity forces and friction. Friction is highly dependent on the level of humidity and the weight of elements above.

3.1.17 Missing Mortar From Joint

What To Look For:

Apparent lack of mortar in joint. Depth of mortar erosion in joint might not be visually observed at tight jointed masonry.

Probable Causes/Deficiencies:
Disaggregation of mortar reaches deep into the joints. Deep disaggregating is associated with lime mortar and extremely fine sand. (High ratio of lime vs. sand).

Further Consideration:
See also 3.1.16 Joint Mortar Disintegration. In some cases (extremely rare in building façade) stone might be placed dry, that is, without a mortar bed.

3.1.18 Debonding of Masonry Units

What To Look For:

Lack of bonding/adhesion along multiple joints. Neat separation between mortar and unit. Depth of separation.

Probable Causes/Deficiencies:

Improper initial construction (e.g. lack of wetting the brick, lack of compatibility brick/mortar). Separation occurs under minimal stresses.

3.1.19 Mortar in Joint Reduced to Sand

What To Look For:

Only sand present in joint.

Probable Causes/Deficiencies:

Loss of binder (lime) component.
Disintegration of mortar as a result of multiple freeze thaw cycles.

See Also: 3.1.16

3.1.20 Loose/Detached Brick

What To Look For:

Washout of mortar that leaves a brick without any bond to the rest of masonry.

Probable Causes/Deficiencies:

Decomposition of lime binder in mortar over large periods of neglect. Cracking/debonding of mortar followed by successive cycles of icing/thawing.

See Also: 3.1.16 , 3.1.17

3.1.21 Improper Joint Repair (Pointing)

What To Look For:
Lack of continuity of pointing mortar. Cracks separation of repair mortar

Probable Causes/Deficiencies:
Lack of compatibility of existing and repair mortar, lack of sufficient depth of repointing.

3.1.22 Lime Run

What To Look For:

Crusty build-up on masonry surface (usually white) originating at mortar joints. Many times originates at small cracks or holes in masonry at balcony parapets, also around walls retaining planters.

Probable Causes/Deficiencies:

Soluble calcium carbonate deposits. Formation of lime run requires large quantities of water passing thru the crack or opening.

See Also: 3.1.6

3.1.23 Eroded/Missing Mortar in Stone Joint

What To Look For:

Mortar completely missing, eroded deep in the joint between stone panels or blocks. Surfaces with rain water buildup.

Probable Causes/Deficiencies:

Lack of compatibility mortar/stone. Mortar poorly adhered to stone separates and is carried away by rain water. In some horizontal joints the mortar might be kept in place by weight of stone above. Differential movement between veneer stone panels. Weathering.

Further Considerations:

Acceleration of deterioration due to water ingress.

3.1.24 Cracks in Masonry Façades

Cracks in masonry are described by size, location and direction as well as by number in a region. Cracks are always the result of stresses that exceed the material's capacity to resist. They may be caused by local conditions or system wide conditions. They can be the result of environmental loads, design or construction inadequacy, or failings of the structural system. See each type of material and façade envelope system for specifics as cracks can denote changes in structure. Cracks may be the result of overstress or of changes in the local or general structure and may indicate structural problems. Separately from structural effects, their presence and size can have a significant effect on the protective adequacy of the envelope. They must be analyzed and characterized with regard for such effects.

The size of a crack can be evolving and may be dependent on conditions at the time of the observation as general thermal movement of a building may change the size of the opening. Depth of crack inside the masonry is an important element in the description of the condition but cannot be determined by visual observation only.

Once a crack has started to develop, it creates an opportunity for moisture penetration and additional increase in size due to repeated freeze thaw cycles. Also when a crack is in vicinity of a steel element, the rate of corrosion will increase.

3.1.25.a Thin (Hairline) Crack in Masonry

What To Look For:

Hairline cracks are those usually with opening less than .04” (1mm). Direction and location of crack can provide additional indications. Size of crack might vary in time. Crack is present in mortar and unit.

Probable Causes/Deficiencies:

Hairline cracks might represent an incipient condition at the surface of the masonry or the front end of a larger interior crack. Long hairline cracks might be the result of an observation made at a time when temporary movement of the façade closed a larger crack.

Further Consideration:

Number of thin cracks in local area.

See Also: 3.1.26 for cracks in mortar joint only.

3.1.25.b Slight Vertical Crack in Masonry

What To Look For:

Cracks larger than .04” (1mm) and smaller than 3/16” are described as slight. Size of crack may vary in time. Crack is present in mortar and unit.

Probable Causes/Deficiencies:

Cracks are always the result of stresses in masonry that exceed resistance of brick or mortar or both. See various type of wall construction for specifics.

See Also: 3.1.26 for cracks in mortar joint only.

3.1.25.c Large Vertical Crack in Masonry

What To Look For:
Cracks larger than 3/16" are described as large. Size of crack may vary in time. Large cracks present only in mortar and unit.

Probable Causes/Deficiencies:
Cracks are always the result of stresses in masonry that exceed resistance of brick or mortar or both.

Further Considerations:

See various type of façade systems for specifics.

See Also: 3.1.26 for cracks in mortar joint only.

3.1.25.d Crack in Masonry Unit Only

What To Look For:

Crack is present in masonry unit only.

Probable Causes/Deficiencies:

Might represent an incipient condition at the surface of the masonry unit due to composition of brick. Significant difference between properties of brick and mortar.

See Also: 3.1.2

3.1.26.a Longitudinal Crack – Joint Only

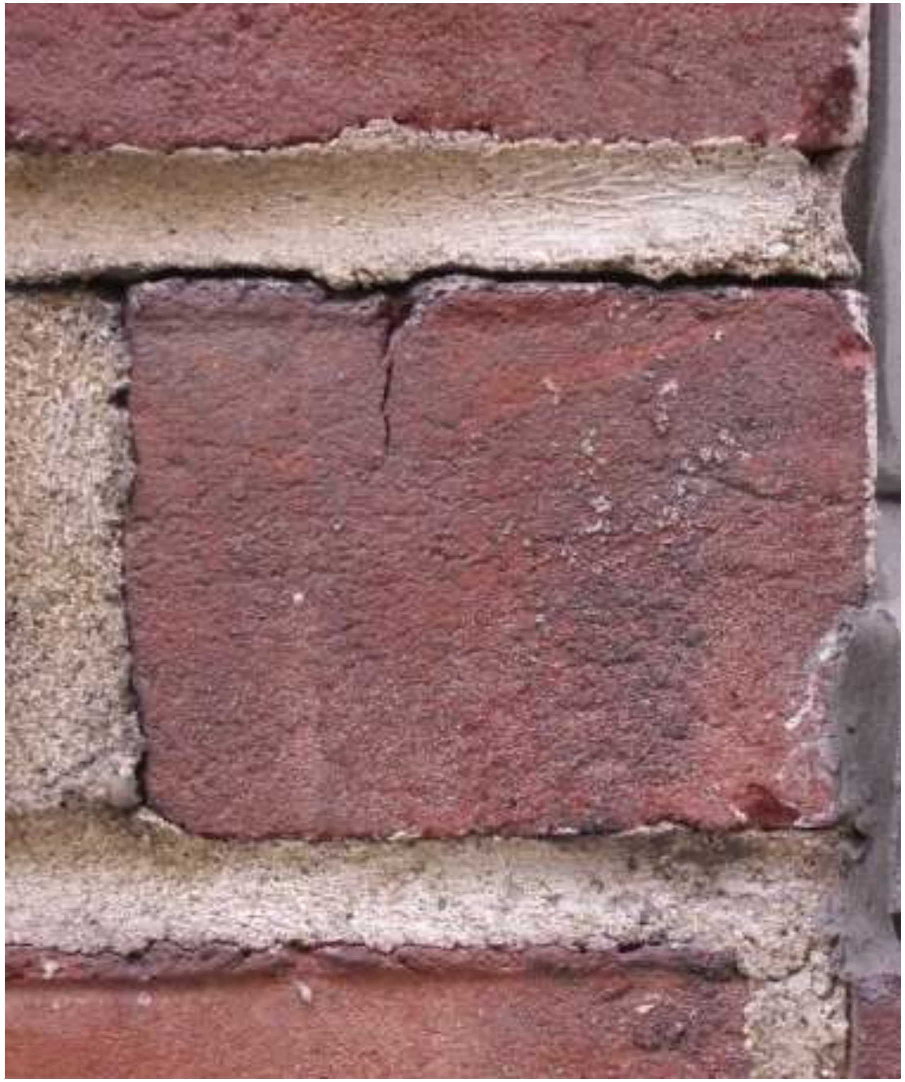
What To Look For:

Longitudinal crack in the mortar or separation along interface of mortar and unit. Length of separation, condition (sagging or slippage) of structural supporting elements. Presence of bulge.

Probable Causes/Deficiencies:

The bond between the unit and the mortar is usually the weakest component of brick masonry. Horizontal cracking or debonding is usually the result of failure under tensile stresses.

See Also: 3.1.18



3.1.26.b Vertical Crack in Brick Masonry

What To Look For:
Crack perpendicular to coursing. For characterization of crack size see 3.1.25.

Probable Causes/Deficiencies:
Several types of high loading can produce vertical cracks: out of plane pressure from inside the masonry (e.g. steel corrosion), high vertical compression load (e.g. expansion of brick blocked by concrete spandrel beams) or vertical compression associated with horizontal loads (e.g. load of masonry above combined with horizontal pressure from rusting corner column).

Further Consideration:
Number of cracks in one area.

3.1.26.c Stepped Crack in Masonry Joints

What To Look For:
Diagonal crack in the mortar joints or separation along interface of mortar and unit. Rarely in unit. Direction of crack alternates horizontally and vertically. Length of separation, condition (sagging or slippage) of structural supporting elements. Photo displays a repaired crack.

Probable Causes/Deficiencies:
Cracks are always the result of stresses in masonry that exceed resistance of brick or mortar or both. See various type of wall construction for specifics.

Repaired Stepped Crack

Unrepaired Stepped Crack

3.1.27 Separation of Brick Masonry – Outer Wythe

What To Look For:
Vertical crack/separation along the wythes noticeable at edge of openings. Bulging of masonry.

Probable Causes/Deficiencies:
Insufficient or deteriorating bonding between wythes.

3.1.28 Improperly Repaired Crack

What To Look For:
Crack opening along previously repaired crack.

Probable Causes/Deficiencies:
Improper workmanship and detailing of repair. Original cause of cracking was not eliminated. Proper repair usually requires replacement of cracked bricks.

3.1.29 Loose Masonry

What To Look For:

Unattached chunks of masonry. Masonry areas separated by cracks all around.

Probable Causes/Deficiencies:

See appropriate Façade System

See Also: 3.1.16 , 3.1.20, 3.6

3.1.30 Crack in Stucco over Masonry

What To Look For:
Size and direction of crack. Thickness of stucco layer. Presence of bulges. Condition of back-up masonry.

Probable Causes/Deficiencies:
Check masonry condition/problems. Differential thermal movement and elasticity of stucco versus underlying masonry. Stucco cracks might reflect cracks in supporting masonry.

Further Consideration:
Relationship to crack in base material. Without removing the stucco it is difficult to determine if it had developed only in the rendering or it mirrors a crack in the base masonry.

3.1.31 Crack and Debonding of Stucco from Masonry

What To Look For:

Size and direction of cracks. Thickness of stucco layer. Bulging and separation of stucco layer.

Probable Causes/Deficiencies:

Failure of adherence between stucco and back-up system. Failure of underlying masonry skin. Build-up of water and pressure at the interface of brick and stucco.

3.2 Concrete Elements

Balconies

Eyebrows

3.2.1 Cracks in Reinforced Concrete

Common causes of cracks in concrete are structural or thermal overstress. In exposed façade concrete, cracks are most usually the result of the corrosion of the reinforcing bars. Reinforcing bars not sufficiently protected by the depth of concrete cover, are likely to corrode. Corrosion might be accelerated by the chemical composition and carbonation of the concrete. Subjected to "rust jacking", concrete will crack or spall. Whatever the originating cause, once cracking starts, it will allow increased water penetration. Consequently corrosion will accelerate. Icing of the rainwater standing in the crack will also contribute to an increase of the crack's opening.

3.2.1.a Hairline Crack

What To Look For:

Hairline or thin cracks with opening less than 1/32”. Barely perceptible.

Probable Causes/Deficiencies:

Incipient reinforcing bar corrosion. When cracks develop early after the concrete pour they may be the result of shrinkage due to improper placement or concrete mix.

3.2.1.b Slight Crack

What To Look For:

Surface cracks around openings, spandrels, edges and floor lines. Slight (Small) cracks are those with opening between 1/32" and 3/16". Rust stains.

Probable Causes/Deficiencies:

When the crack follows direction of reinforcing bar it is the result of "rust jacking". It is usually a worsening of a thin crack .

Note. Cracks are always the result of an overstress. This may be caused by a surface/local condition or by inadequacy to applied structural loads..

See Also: 3.6

3.2.1.c Large Crack

What To Look For:

Cracks larger than 3/16” in concrete surface, around openings, spandrels, edges and floor lines.

Probable Causes/Deficiencies:

Excessive corrosion of embedded steel structural shape or reinforcement.

Note: Overstress may be due to structural deficiencies or movements.

3.2.2 Crack and Spall of Concrete Around Steel Member

What To Look For:

Cracks of various sizes along concrete cover of exterior steel columns, steel spandrel beams or lintels.

Probable Causes/Deficiencies:

Rust jacking following corrosion of steel element. Usually steel member has structural function.

See Also: 3.6

3.2.3 Delaminating Concrete Over Reinforcement

What To Look For:

Splitting/separation of concrete surface exposing reinforcing steel. Cracking of concrete surfaces in an isolated area with defined borders.

Probable Causes/Deficiencies:

"Rust jacking". Excessive local corrosion of reinforcing or embedded steel. Lack of sufficient protection against corrosion. Poor quality concrete and/or concrete or rebar placement (insufficient cover).

See Also: 3.6

3.2.4 Pattern Cracking/Crazing of Concrete

What To Look For:

Very fine crack with no clear direction.

Probable Causes/Deficiencies: Differential change in volume between surface of concrete and interior. Poor quality concrete and/or placement. When crazing forms during first year after pour - poor vibrations or curing Alkali- silica reaction.

3.2.5 Honeycomb

What To Look For:

Small voids in surface of concrete.

Probable Causes/Deficiencies:

Lack of adequate vibration. Inappropriate concrete placement.

3.2.6 Scaling of Concrete (Topping)

What To Look For:

Separation of a thin layer (fish scale like) parallel to the concrete surface. Horizontal splitting of concrete or concrete topping from base.

Probable Causes/Deficiencies:

Poor quality concrete and/or placement, poor vibrations of concrete leading to the formation of a plane of weakness. Over finishing and/or poor curing practices. Freeze thaw action. Poor quality of prior repairs. Differential thermal expansion topping vs. concrete.

3.2.7 Exfoliation of Concrete

What To Look For:
Separation/Disintegration of fine surface layer.

Probable Causes/Deficiencies:
Improper forming/finishing of concrete.

3.2.8 Spalling of Cast Stone

What To Look For:
Separation of an isolated fragment with defined borders.

Probable Causes/Deficiencies:
Local concentration of compression stresses. Uneven mortar in joint. Freeze/Thaw action.

3.2.9 Crazed Cracking Cast Stone

What To Look For:
Integrity of surface. Thin surface flakes or cracked mortar.

Probable Causes/Deficiencies:
Freeze/Thaw action. Alkali-silica reaction from deep into the unit and spreading to the surface

3.2.10 Peeling of Cast Stone Surface

What To Look For:
Integrity of surface. Thin surface flakes. Crazing. Shrinkage cracks.

Probable Causes/Deficiencies:
Freeze/Thaw action. Difference in thermal movement between surface layer and interior of cast stone.

3.3 Terra-cotta

Terra-cotta was extremely popular as a façade material between 1880 and 1930. The "brownstone" variety of terra-cotta was used as a decorative element in conjunction with brick masonry facades.

Glazed terra-cotta was very popular after 1900 because of its similarity to stone. While it was sometimes used in bearing brick masonry facades, the most extensive usage was as a cladding system for tall buildings. Most commonly used as a hollow unit. The terra-cotta cladding system for transitional facades involved extensive use of steel for support and anchorage. Most of terra-cotta deficiencies can be traced to the original manufacturing and detailing. The most common areas of terra-cotta deficiencies are: surface condition, anchorage/support system and joints.

3.3.1 Loss of Glaze – Terra-cotta

What To Look For:
Localized loss of glaze.

Probable Causes/Deficiencies:
Abrasion due to wind. Improper manufacture. Surface glazing is broken by increase in volume of terra-cotta mass due to water absorption.

3.3.2 Surface Crazing of Terra-cotta

What To Look For:
Traces of surface cracks in glaze with no discernible pattern.

Probable Causes/Deficiencies: Increase in volume of terra-cotta mass (that shrank during manufacture) due to long term atmospheric moisture absorption. (Ceramic expansion).

Further Consideration:
Cracks extending past the glaze in the body of the terra-cotta.

3.3.3 Directional Fine Cracking of Terra-cotta Surface

What To Look For:
Surface cracking favoring a certain direction.

Probable Causes/Deficiencies:
Manufacture process. The pattern of the surface cracks may be caused by stresses produced by a specific loading of the terra-cotta unit.

3.3.4 Glaze/Surface Chip - Terra-cotta

What To Look For:
Small loss of mainly glazed surface.

Probable Causes/Deficiencies:
Trapped water inside the masonry tends to migrate outward. Water penetration through joints or surface cracks. Impact damage (construction equipment).

Further Consideration:
Increased water absorption due to loss of protective glaze.

3.3.5 Spall - Terra-cotta

What To Look For:
Uneven breakage and loss of chunks of material at the surface of the unit.

Probable Causes/Deficiencies:
Stress concentrations from abutting masonry. Pressure from trapped water. Pressure from freeze/thaw of water penetrating through joints or cracks.

3.3.6 Crack in Load Bearing Terra-cotta Unit

What To Look For:
Cracks in units used as bearing masonry systems (unanchored by steel rods).

Probable Causes/Deficiencies:
Local stress concentration. Freeze/thaw. Change in volume of water trapped in terra cotta cavity. Clogged or missing weepholes. Thermal movement of façade.

3.3.7 Missing Terra-cotta Unit

What To Look For:
Entire units missing.

Probable Causes/Deficiencies:
Preventive removal of deteriorating units. Collapsed units due to poor or deteriorated anchorage. Fracture of unit due to rust jacking. Steel lacking corrosion protection. Water penetration at horizontal ornate surfaces.

Further Consideration:
Void allows accelerated water penetration in the masonry.

3.3.8 Cracked and Fragmented Terra-cotta Units

What To Look For:
Deep cracks that led to separation or fragmentation of units. Cracks and surface spalls. Out of plane displacement of units. Condition in photo typical at vertical ornate fins.

Probable Causes/Deficiencies:
Stress concentration due to changes in load transfer or movement of the building or of the façade. Linear, vertical ceramic expansion.

3.3.9 Broken Terra-cotta Unit

What To Look For:
Fragment of terra-cotta units missing.
Visible hollow structure.

Probable Causes/Deficiencies:
Water penetration through cracks and open joints. Rust jacking. Freeze-thaw damage.

Further Consideration:
Allows accelerated water penetration and accumulation in remaining elements.

3.4 Stone Facades

Dimensional stone facades have been used since the 1800's in New York City. More recent facades use thin stone veneer and slab type veneer. Stone facing was used in all façade systems - bearing masonry, transitional, cavity walls, etc. In older façade systems, the most common backing was masonry. In more recent usages the backing can be steel or steel studs. In most cases the stones elements are anchored into the backing for lateral support (that in some cases is also designed as support for the weight of the stone). Some facades include stone only as decorative elements (bases, bands, etc…). The principal elements of a stone façade is type and quality of the natural stone used, alignment of units, tightness of joints, types and condition of anchorage and of support.

3.4.1 Crack in Stone

What To Look For:
Location, size and direction of crack. Condition of mortar in joints. Support system for stone. Rust stains.

Probable Causes/Deficiencies:
Natural imperfections of stone are exploited by water and freezing cycles. Concentration of vertical stresses due to non-uniform transmission of loads from above.
Excessive movement of supporting elements.
Corrosion of supporting steel frame.
Thermal movement of envelope.

Further Considerations:
Individual anchorage of each separated stone piece.

3.4.1.a Crack in Various Types of Stone

Limestone

Marble

3.4.1.a Crack in Various Types of Stone

Granite

Travertine

3.4.1.b Crack By Directionality

Vertical Crack

Horizontal Crack

3.4.2 Crack in Corner Stone

What To Look For:
Crack at base of stone façade. Extent of crack in vertical direction. Direction of crack. Condition of mortar in joints. Rust stains.

Probable Causes/Deficiencies:
Concentration of vertical stresses at corner.
Thermal movement of façade above.
Freezing of water present in incipient cracks.
Movement of supported elements.
Accidental impact from street vehicular traffic.

3.4.3 Cracked and Fragmented Stone Unit

What To Look For:
Lack of vertical or horizontal alignment. Presence of cracks. Displacement. Movement occurring along joints or along separating cracks. Lack of mortar in adjoining joints. Condition of supporting frame, weeps, condition of surrounding façade.

Probable Causes/Deficiencies:
Water penetration and ice buildup in the back of the stone, loosening of anchorage or vertical support, pressure from corrosion byproducts, movement of the building structure.

3.4.4 Displacement/Bulging of Stone Panels

What To Look For:
Out-of-vertical plane movement of panel system, away from backing system. Separation along joints. Displacement/ position of face stone in relationship of façade or of underlying structure. Alignment of panels. Presence and condition of weepholes.

Probable Causes / Deficiencies:
Failure or loosening of anchorage, sliding of stone off horizontal supports. Movement of underlying system (e.g. frame shortening). Ice buildup between backup masonry and face panels.

Further Considerations:
When stone element carries vertical load from above the condition can lead to a buckling failure.

3.4.5 Peeling/Delamination of Stone

What To Look For:

Separation of thin surface layer. Peeling. (fragments of various sizes),

Probable Causes/Deficiencies:

Long term effect of rain water, icing. Separation occurs along natural bedding plane of stone. When occurring in vicinity of sidewalk–splashing with deicing chemicals.

3.4.6 Gypsum Crust

What To Look For:
Black deposits on stone surface (usually marble and limestone). Usually in areas not exposed to washout by heavy rains.

Probable Causes/Deficiencies:
Atmospheric acidity. Atmospheric particles incrusted in gypsum components. Chemical disintegration of gypsum components in stone.

3.4.7 Erosion of Stone

What To Look For:
Slow wearing away of stone surface and edges. Especially noticeable around decorative sculptures or carvings.

Probable Causes/Deficiencies:
Long term action of wind and rain.

3.4.8 Spalling of Stone

What To Look For:

Surface breakage of stone (fragments of various sizes), depth of spall. Irregular surface cracks (star shaped) that might precede spalls.

Probable Causes/Deficiencies:

Increase in localized internal pressure or localized pressure form adjoining elements. Natural imperfections of stone exploited by water and ice lensing. Decomposition or increase in volume of some inclusions.

3.4.9 Corrosion of Steel Anchorage/Insert

What To Look For:
Craters and surface breakage of stone, rust coloring, rusted steel elements, shifting of stone.

Probable Causes/Deficiencies:
"Rust jacking" when stone installation used anchors of materials susceptible to corrosion. Decomposition of some inclusions. Corrosion of some metal components (e.g. shutter anchors). Concentration of stresses around anchors. Stone movement blocked by anchor. Insufficient cover of anchor

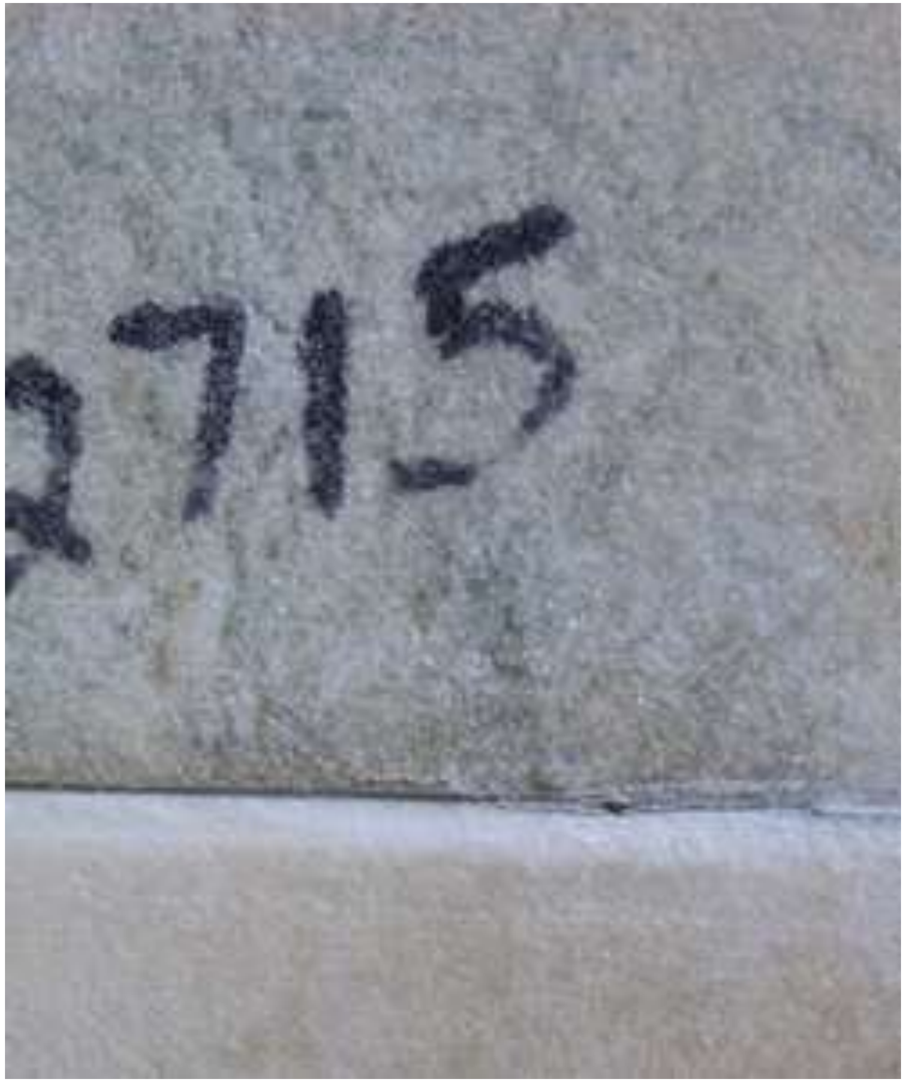
Further Considerations:
Capacity of anchors to support stone. Capacity, condition of remaining anchors to support the stone. Hidden deterioration of anchors.

See Also: 3.6

3.4.10 Sugaring

What to Look for:
Powdery surface disintegration.

Probable Causes/Deficiencies:
Chemical disintegration of calcite (a granular components of marble). Air pollution.



3.4.11 Bowing of Marble Panels

What To Look For:

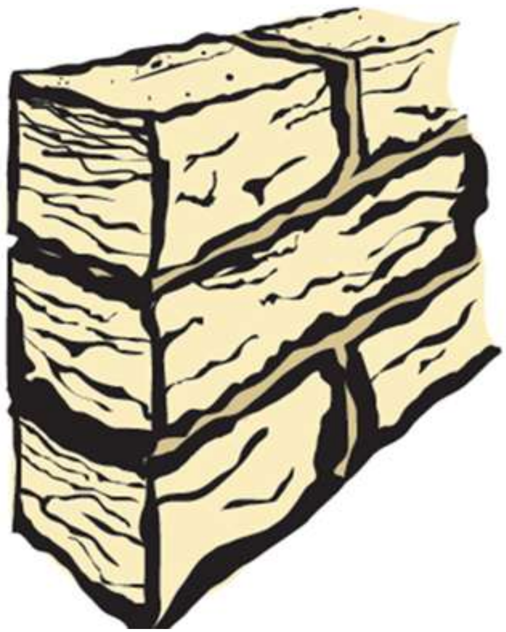
Bowing of individual marble panels.
Separation along joints.

Probable Causes/Deficiencies:

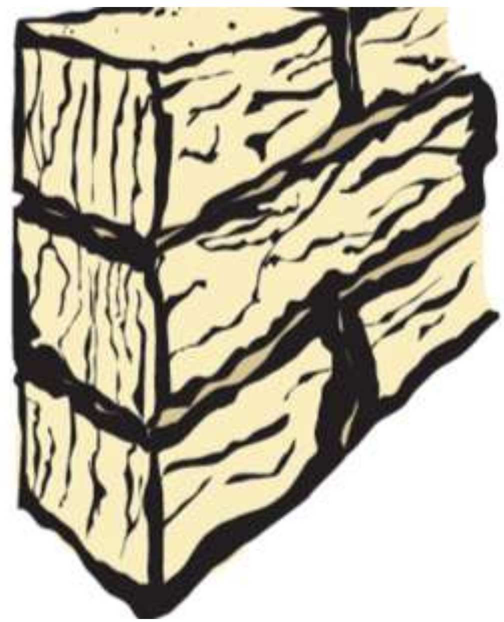
Usually on thin marble panels. (Can occur in limestone). Permanent expansion of stone panel (due to hysteresis - accumulation over time of irreversible thermal expansion) is restrained by adjoining panels or anchors.

3.5 Brownstone

Bedding Planes Set Horizontally



Bedding Planes Set Vertically



Brownstone façades were extremely popular around 1880-1910. Most of the defects illustrated in the following slides are the direct result of the brownstone's poor original quality or of its installation without regard to the direction of its bedding planes.

3.5.1 Disaggregating Brownstone

What To Look For:
Crumbling or degradation of stone material.

Probable Causes/Deficiencies:
Poor quality of original stone. Separation of sand from binder component of stone. Erosion of binder.

3.5.2 Exfoliating/Delaminating Brownstone

What To Look For:
Separation of stone surface thin layers along the natural bedding plane.

Probable Causes/Deficiencies:
Improper original setting of brownstone and poor quality of brownstone allow weathering and delamination.

3.5.3 Scaling of Brownstone

What To Look For:
Thin stone crust deterioration similar to fish scales. Separation does not follow stone structure.

Probable Causes/Deficiencies:
Poor quality of brownstone allows weathering.

3.5.4 Sagging Brownstone Lintel

What To Look For:
Separation of stones, deterioration or opening of joints between stone pieces. Deterioration of entire stone assemblage.

Probable Causes/Deficiencies:
Improper original setting of brownstone. Deterioration of brownstone attachment to support. Deteriorating stones and joints allow water access and subsequent corrosion of the supporting steel.

See Also: 3.5.1 , 3.5.3 , 3.6

3.5.5 Failure of Brownstone Repair Coating

What To Look For:
Separation / peeling of coating (stucco) from base brownstone.

Probable Causes/Deficiencies:
Trapped moisture turning to vapor (and exerting pressure on surface layer). Improper repair mix, insufficient removal of deteriorated brownstone. Improper surface preparation.

3.6 Corrosion of Metals

Metals can be found in buildings as basic components of the structure. They are also found in devices and systems used to support and/or anchor façade elements. Corrosion is the most common form of deterioration of metals in buildings. It is an electrochemical oxidation process that results in the deterioration (separation and loss of mass) of the metal.

Most commonly corrosion (rust) occurs on steel that is exposed to air and humidity. Other forms of corrosion are galvanic and pitting of metals. As steel is rarely present at the very surface of a façade, only in some cases can visual inspections directly determine presence of corrosion. But if rust is rarely visible, the damage resulting from "rust jacking", cracks or movement of façade materials, can be easily observed. Corrosion of metals in buildings may affect not only the performance of the envelope but also the reliability of the structural frame.

3.6.1 Corroding Window Frame

Steel Jamb corrosion, not visible without probing.

3.6.2 Corroding Veneer Anchor

Not visible without probing.
Anchors should be galvanized or have other sufficient type of protection against rust.
Stainless steel is preferred.

See Also: 5.3 , 5.3.7

3.6.3 Galvanic Corrosion

Corrosion resulting from contact of two dissimilar metals. (e.g. aluminum post and steel reinforcing). Dissimilar metals should be isolated from each other.

3.6.4 Pitting / Crevice Corrosion

Corrosion occurring due to stagnant chloride solution in holes. Can affect aluminum and stainless steel as well.

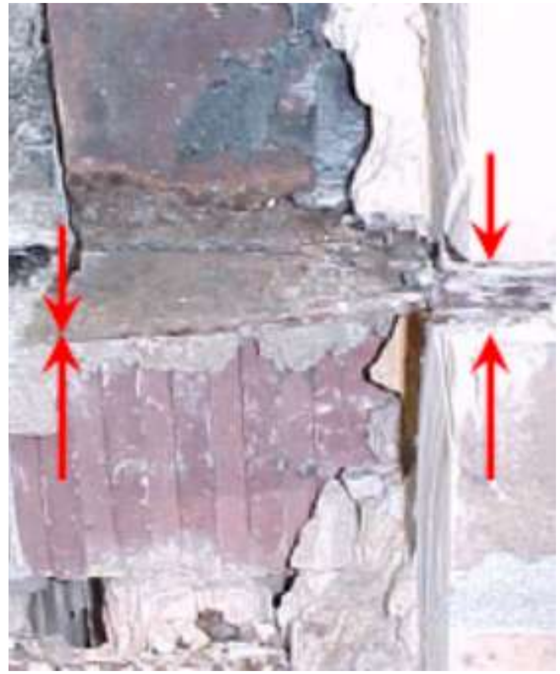
3.6.5 Loose, Flaking Paint

Paint is a steel protective treatment. Loss of paint due to weathering leads to the surface corrosion.

3.6.6 Corrosion Effects – "Rust Jacking"

Rust jacking is a term used in the vernacular to describe the pressure resulting from steel corrosion. The corrosion byproducts have a volume several times larger (4 to 6 times) than that of the steel. As corrosion continues over time the byproducts start to exert pressure ('jack") on the adjoining materials. These materials might crack or deteriorate as they are subjected to forces they have not been designed for. (see incipient crack in bottom picture.)

The arrows in the top picture contrast a section of steel after corrosion products were cleaned off to a section where the rust "jacks" the brick vertically. The thickness of the cleaned steel is smaller than that of the original metal, while the thickness including the exfoliated rust is significantly larger than the original metal.



4. Façade Elements

- 4.1 Fenestration Framing
- 4.2 Lintels / Sills
- 4.3 Parapets / Cornices
- 4.4 Balconies
- 4.5 Other

4.1 Fenestration Framing

Section 4.1 covers condition of framing and sealants around the glass panels or around other exterior openings in facades (e.g. HVAC).

4.1.1 Missing / Curling Sealant Around Window Frame

What To Look For:
Presence and condition of sealant. Signs of water infiltration.

Probable Causes/Deficiencies:
Improper installation/application of sealant.
Improper curing of urethane based sealant.
Aging of sealant.

4.1.2 Gap in Sealant (Window Frame and Masonry)

What To Look For:
Continuity of sealant. Condition of sealant. Signs of water infiltration.

Probable Causes/Deficiencies:
Improper installation/application of sealant. Improper curing of sealant. Loss of elasticity of sealant due to aging. Adhesive failure. Loss of cohesion of sealant. Local rust of frame material. Organic growth.

4.1.3 Missing Sealant at Sleeve

What To Look For:
Presence and condition of sealant. Signs of water infiltration. Organic growth.

Probable Causes/Deficiencies
Improper original anchorage of louver or application of sealant. Aging or weathering of sealant. Improper size (undersized) of louver in rough masonry opening.

4.1.4 Dried/Cracked Caulking Around Glass

What To Look For:
Missing or chipped sealant (caulking/putty) around window panel. Dried or cracked sealant.

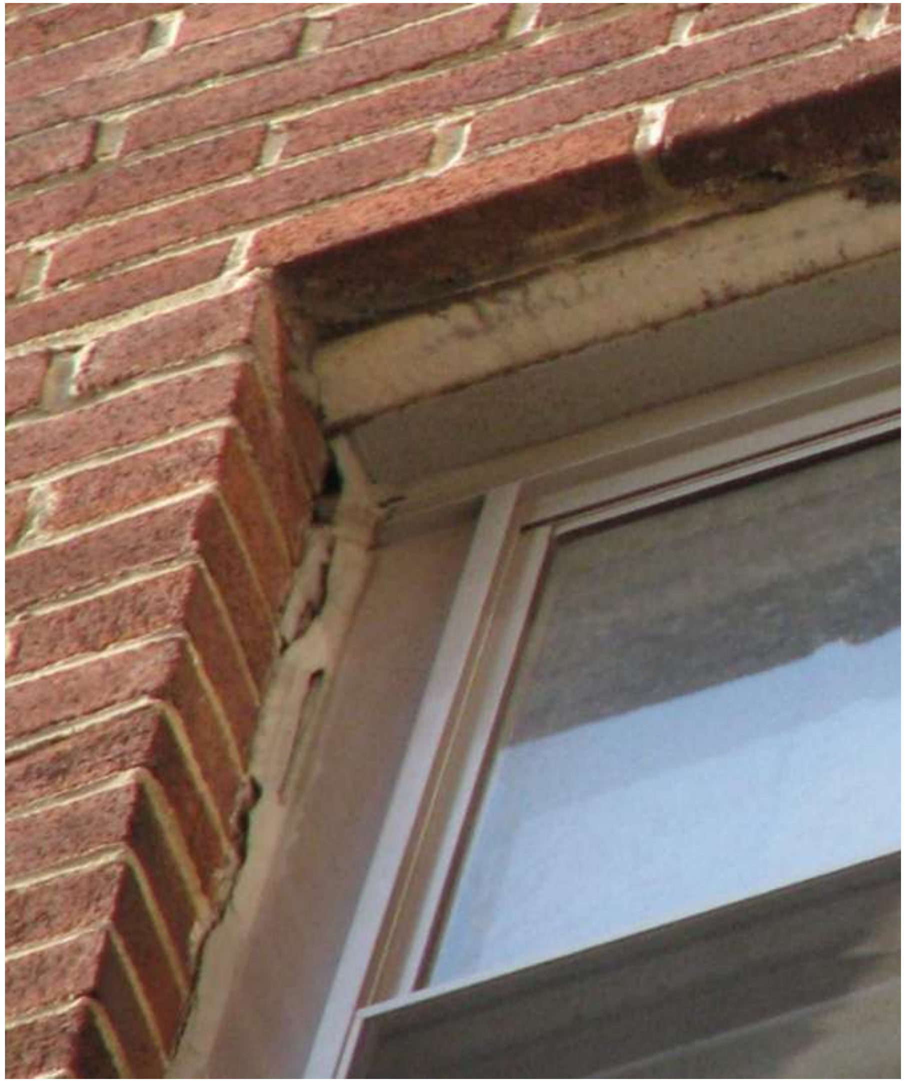
Probable Causes/Deficiencies:
Aging, weathering of sealant. Corrosion of base metal.

Further Considerations:
Water infiltration, increased rate of corrosion, loss of thickness.

4.1.5 Open Caulk Joints

What To Look For:
Adherence of sealant to base frame.
Condition of sealant.
Signs of water infiltration.

Probable Causes/Deficiencies:
Loss of elasticity of sealant due to aging.
Adhesive failure. Loss of cohesion of sealant.
Local disintegration of frame material.



4.1.6 Hanging or Loose Gasket At Window Frame

What To Look For:
Protrusion in frame that should be flush or smooth.

Probable Causes/Deficiencies:
Aging and weathering of gasket material, lack of adhesion.

4.1.7 Loose Trim at Window Frame

What To Look For:
Alignment of trim. Signs of water infiltration.

Probable Causes/Deficiencies:
Deficient installation, age, water infiltration.
Corrosion at lintel.

4.1.8 Loose Louver Blade

Possible Cause/Deficiency:
Installation defect. Deterioration of connection.

4.1.9 Deteriorating Window Frame (Wood)

What To Look For:
Condition of frame. Condition of paint.
Water stains. Decay of wood.
Splitting of wood.

Probable Causes/Deficiencies:
Aging and weathering of protective paint.
Inadequacy of paint.

4.1.10 Wood Frame Separated From Brick and Displaced

What To Look For:
Condition of frame. Frame alignment. Cracks, voids around frame.

Probable Causes/Deficiencies:
Decay of wood. Shrinkage of wood. Inadequacy of frame attachment to masonry.

4.1.11 Cracked Parging at Window Jamb

What To Look For:
Condition of parging around opening

Probable Causes/Deficiencies:
Differential movement. Insufficient thickness of parging, lack of mesh in parging. Corrosion at concealed anchors.

4.1.12 Cracked/Broken Glass

What To Look For:
Integrity of glazing. Integrity of interior and exterior glass pane.

Probable Causes/Deficiencies:
Glass impacted by falling objects, windborne debris. Vibrations. Overstress due to unequal thermal movement of frame and glass. Integrity.

See Also: 6.1.1

4.2 Lintels / Sills

4.2.1 Exfoliating of Slate Window Sill

What To Look For:
Loose shards, horizontal separation along stone layers.

Probable Causes/Deficiencies:
Poor stone quality. Water infiltration and freeze/thaw cycles separate the bedding planes of the stone.

Further Considerations:
Additional water penetration and icing.

4.2.2 Cracked Cast Stone Window Sill

What To Look For:
Condition / integrity of sill. Extent of crack penetration / separation. Extent of sill displacement. Condition of joint under the sill. Presence of crack at underside of sill. Observe from above.

Probable Causes/Deficiencies:
Corrosion of concealed anchor. Differential movement. Flaw in the stone. Load transfer from center window mullion.

Further Considerations:
Water penetration and icing.

See Also: 3.2.8

4.2.3 Masonry Cracks Around Sill

***What To Look For*:**
Location and size of crack. Deformation at window frame, condition of sealant, protrusions in adjacent façade areas that should be flush or smooth.

***Probable Causes/Deficiencies*:**
Overstress due to movement/load transfer from above or behind. Corrosion of concealed anchor.

4.2.4 Corroding Lintel In Masonry (Isolated Lintel)

What To Look For:
Presence of rust or rust stains, changes in apparent thickness of flange of steel lintel, especially at the support end embedded in masonry, cracks in masonry. Photo displays insufficiently repaired lintel corrosion.

Probable Causes/Deficiencies:
Lack of corrosion protection (flashing or paint). Lintel installed too close to exterior face of brick.

Further Considerations:
Protective painting maintenance requires removal of adjoining bricks.

See Also: 3.6

4.2.5 Masonry Crack Due to Lintel Corrosion

What To Look For:
Cracks in masonry originating at the end of the steel lintel. Direction and size of cracks. Cracks usually start at end of steel lintel but do not extend to adjoining openings.

Probable Causes/Deficiencies:
Rust jacking at embedded end of lintel.

See Also: 3.6.6

4.2.6 Bowed Steel Lintel

What To Look For:
Horizontality of lintel**.** Presence of rust or rust stains. Gap between lintel and masonry units above. Deformation of window frame.

Probable Causes/Deficiencies:
Corrosion around lintel mid-span. Absence or deterioration of corrosion protection. Improperly sized steel.

See Also: 3.6.6

4.2.7 Crack at Underside of Stone Lintel

What To Look For:
Condition of decorative stone/concrete covering steel lintel. Observe from below.

Probable Causes/Deficiencies:
Rust jacking allowed by insufficient or missing corrosion protection. Differential deformation lintel and stone covering.

See Also: 3.6

4.2.8 Loose, Flaking Paint at Steel Lintel/Frame

What To Look For:
Adherence and condition of paint, signs of corrosion, loss of steel thickness.

Probable Causes/Deficiencies:
Aging, weathering, paint type non-compatible with substrate, poorly installed flashing.

See Also: 3.6.5

4.2.9 Loss of Cast Stone Unit

What To Look For:
Missing or deteriorated cast stone unit.

Probable Causes/Deficiencies:
Rust jacking. Differential deformation lintel and stone covering. Lack of anchorage. Removed as a precautionary measure.

4.2.10 Crack of Masonry Jamb at Inserts

What To Look For:
Condition of jamb, presence of cracks originating at embedded bars and/or anchorages. Condition of window frame.

Probable Causes/Deficiencies:
Rust jacking.

See Also: 3.6

4.3 Parapets / Cornices

Parapets are the building element most exposed to the action of rain, wind or thermal variation. Sometimes the parapet condition might be worsened by the detailing and construction of the joining to the roofing system.

4.3.1 Crazing of Terra-cotta Camelback

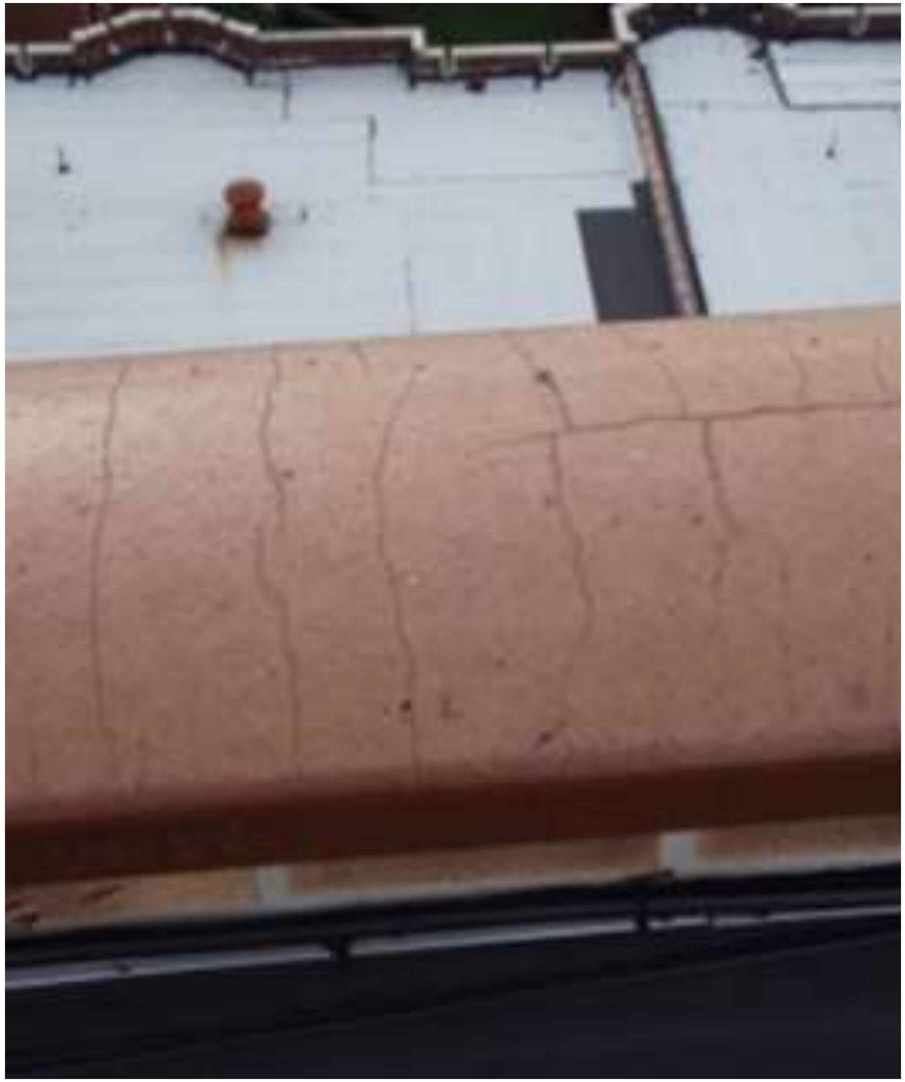
What To Look For:
Hairline cracks in terra-cotta crust.

Probable Causes/Deficiencies:
Expansion of entrapped moisture; poor original construction /manufacture.

Further Considerations;:

Potential fragmentation of top of coping material.

See Also: 3.3.2



4.3.2 Open Cross Joints - Coping

What To Look For:
Mortar condition. Loose, cracked mortar.

Probable Causes/Deficiencies:
Water penetration and freeze/thaw cycles

4.3.3 Failure of Sealant – Coping Stone Cross Joint

What To Look For:
Lack of continuity in jointing material.
Inadequate joint dimension.

Probable Causes/Deficiencies:
Poor original construction /material. Excessive water penetration in adjoining masonry. Aging and deterioration of cohesiveness and elasticity of jointing material. Excessive movement of coping stone.

Further Considerations:
Deterioration of coping dowels or fasteners.

4.3.4 Deformation of Metal Coping

What To Look For:
Condition of metal coping, alignment of metal coping.

Probable Causes/Deficiencies:
Deterioration of cleats, fasteners. Poor original quality.

Further Considerations:
Excessive water penetration into masonry. Possible loosening and/or "fly-off" of coping.

4.3.5 Misalignment of Coping Stone

What To Look For:
Movement of coping stone from originally intended position. Verticality/alignment of parapet.

Probable Causes/Deficiencies:
Out of plane movement of parapet and masonry below, thermal movement of parapet.

4.3.6 Loss of Mortar at Parapet (Roof Side)

What To Look For:
Condition of mortar on the inside face of parapet, vertical and horizontal alignment of parapet.

Probable Causes/Deficiencies:
High lime presence in the mortar composition, water accumulation due to presence of waterproofing membranes on the roof side of the parapet.

Further Considerations:
Unanchored, unreinforced parapet, sliding of parapet over thru-flashing, size of joint.

See Also: 3.1.16

4.3.7 Diagonal Crack at Corner of Parapet

What To Look For:
Cracks at the end /corners of parapets.
Presence of crack on both intersecting faces.

Probable Causes/Deficiencies:
Stresses due to thermal movement.
Changes/movement in the structure below.
Rust jacking. Deterioration of mortar strength over time.

See Also: 3.1.26.c

4.3.8 Crack in Corner Masonry at High Parapet

What To Look For:
Cracks at the return/corner of masonry (that provides stability) to high parapets. Verticality of parapet.

Probable Causes/Deficiencies:
High level of wind demand on the parapet. Original design insufficient to support loads. Deterioration of mortar components and strength over time. Stresses due to thermal movement. Changes/movement in the structure below. Rust jacking.

See Also: 3.1.26c , 3.6

4.3.9 Leaning Parapet

What To Look For:
Out of plumb position of parapet, bulging or cracks at base of parapet.

Probable Causes/Deficiencies:
Insufficient thickness of parapet, deflection of parapet under wind (including wind on cornice), failure of support structure.

4.3.10 Stone Cornice Crack

What To Look For:
Condition of stone.

Probable Causes/Deficiencies:
Stresses due to blocked thermal expansion.
Thaw/frost cycles along original stone bedding defects.

See Also: 3.4.1

4.3.11 Loss of Cornice Metal Cover

What To Look For:
Missing sections of metal cover.

Probable Causes/Deficiencies:
Loss of anchorage due to deterioration of the underlying structure (e.g. rot of wood).
Weakening and failure of the nailing in wet wood, or general fastener failure.
Insufficient clips. Special wind effects.

4.3.12 Corrosion of Sheet Metal Cornice

What To Look For:
Deterioration of sheet metal. Rust or white coloration. Holes. Missing sections.

Probable Causes/Deficiencies:

Insufficient thickness of original tin sheet or tin covering layer. Improper fabrication.

Improper anchorage

4.3.13 Rot of Wood at Cornice

What To Look For:
Condition of wood material. Loss of paint protection.

Probable Causes/Deficiencies:
Excessive humidity, lack of maintenance.

4.3.14 Deterioration of Underside Cornice

What To Look For:

Cracks/deterioration of decorative elements (stone, concrete, cast stone).

Probable Causes/Deficiencies:

Excessive water accumulation followed by icing/ thaw cycles. Stresses due to blocked thermal expansion

4.4 Balconies and Railings

4.4.1 Underside Balcony Spall / Crack

What To Look For:
Condition of underside material (terra-cotta pictured). Spalls. Cracks. Rust stains. Standing water.

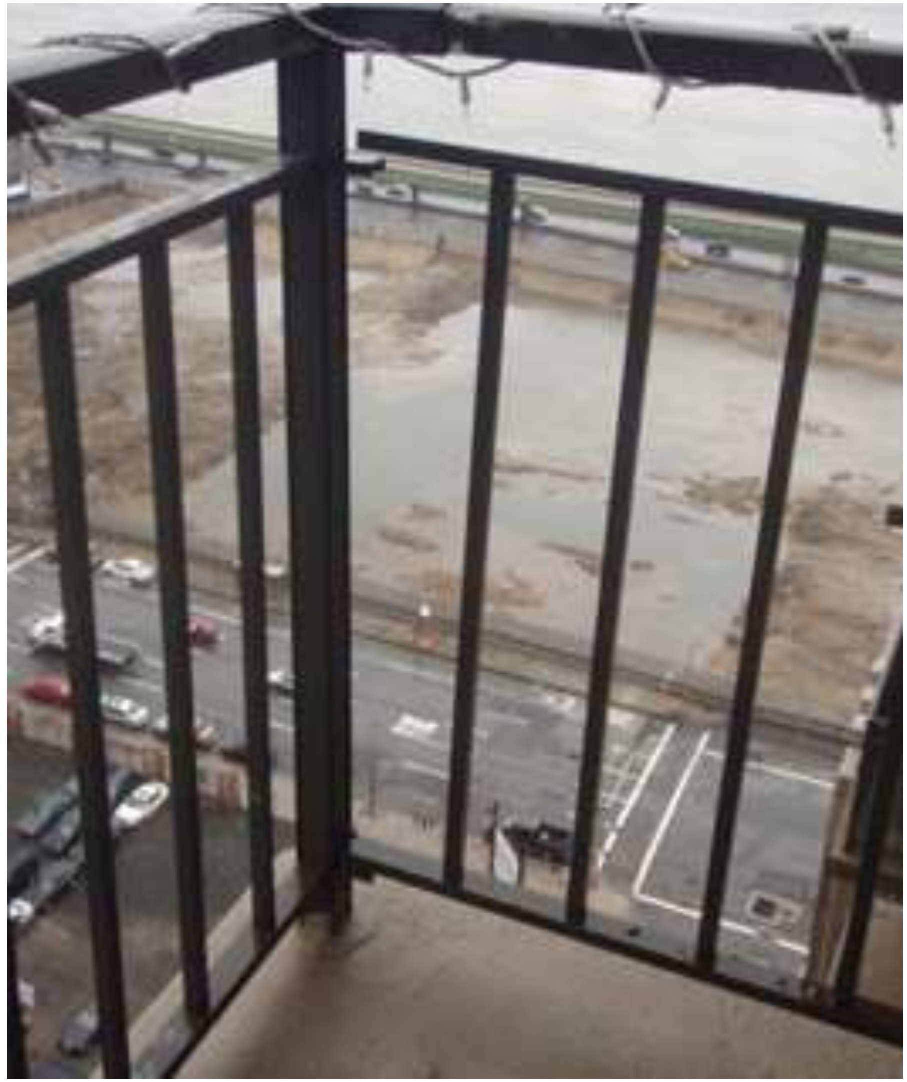
Probable Causes/Deficiencies:
Corrosion of reinforcing or supporting steel. *Rust jacking due to inserts.*
Lack of drainage. As exposed horizontal surfaces , balcony components can easily deteriorate under repeated water accumulation.

See Also: 3.3.5

4.4.2 Loose / Defective Intermediate Panel

What To Look For:
Guard, railing components (panels, rails, posts) unattached or out of plane.

Probable Causes/Deficiencies:
Inadequate design or construction.
Deterioration of connections.
Displacement of post. Impact.



4.4.3 Balcony Sagging

What To Look For:
Horizontality of balcony slab. Verticality of handrail post. Deterioration of panels.

Probable Causes/Deficiencies:
Improper design or construction.
Creep of concrete.

4.4.4 Failed Guard Panel

What To Look For:
Guard, railing components (panels, rails, posts) fractured, missing or loose. Cracked/broken glass panel.

Probable Causes/Deficiencies:
Improper design or construction. Deterioration of connections. Displacement of post. Impact. Glass breakage at point attachments.

4.4.5 Spall in Concrete Slab at Underside of Post

What To Look For:
Spalling/deterioration of concrete underneath rail post.

Probable Causes/Deficiencies:
Improperly waterproofed insert (post base) above. Crevice corrosion of aluminum base post.

See Also: 3.6.4

4.4.6 Concrete Spalling Around Inserts

What To Look For:
Uneven breakage of concrete surfaces around posts. Cracks around posts. Post movement.

Probable Causes/Deficiencies:
Improper concrete placement and finishing. Freeze/thaw. Insufficient post embedment creates excessive local pressure.

See Also: 3.2.2

4.4.7 Concrete Spall at Anchor Bolts

What To Look For:
Condition of base concrete around or close to post anchorage. Missing anchor bolts. Condition of underside of anchorage.

Probable Causes/Deficiencies:
Anchor originally installed too close to edge of concrete.

See Also: 4.4.9

4.4.8 Delaminating Concrete or Topping

What To Look For:
Horizontal splitting of concrete or concrete topping from base, especially around drains. Separation of concrete topping.

Probable Causes/Deficiencies:
Poor quality concrete and/or placement, poor vibrations of concrete leading to the formation of a plane of weakness. Over finishing and/or poor curing practices, freeze thaw action, poor quality of prior repairs. Differential thermal expansion property topping vs. concrete. As exposed horizontal surfaces , balcony components can easily deteriorate under repeated water accumulation.

See Also: 3.2.6

4.4.9 Handrail Connection Failures

Deterioration and failure of connections.

4.5.1 OTHER – Fire Escapes

Attachment to wall and condition of fire escape.

See Also: 3.6

4.5.2 OTHER- Chimney Leaning

What To Look For:

Verticality of chimney. Condition of mortar joints. Presence of cracks.

Probable Causes/Deficiencies:

Unequal deterioration of chimney mortar joints. Repeated wind acting on chimney.

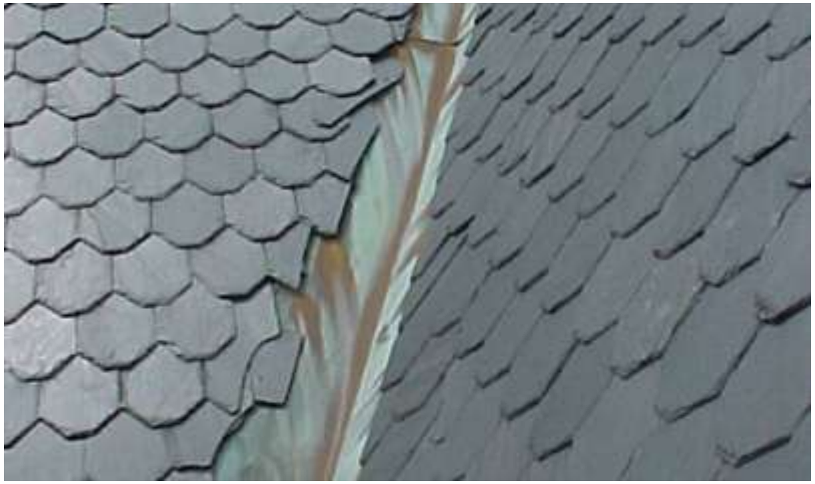
4.5.3 OTHER - Slate Roof

What To Look For:

Detached or loose slate tiles. Deterioration or lack of nails.

Probable Causes/Deficiencies:

Delamination of slates. Rust of nails. Deterioration of supporting wood base.



5. Traditional Façade Systems

- 5.1 Bearing Masonry
- 5.2 Transitional Masonry
- 5.3 Brick Veneer Cavity Walls
- 5.4 Concrete Facades
  - Cast In Place
  - Precast Concrete

5.1 Bearing Masonry

Main Characteristics Bearing Masonry Facades

- Wall thickness and coursing of brick.
- Type of original mortar.
- Brick type and quality
- Structural defects vs. weathering of façade materials.

5.1.1 Façade Bowing Inwards (or Outwards)

What To Look For:
Inward or outward displacement (arching) of middle sections of wall, over large spans.

Probable Causes/Deficiencies:
Movement of the building structure due to structural weakness.

Further Considerations:
Requires structural engineering analysis.

5.1.2 Out of Plumb - Bearing Masonry Wall

What To Look For:
Lack of verticality of wall. Compare with adjoining buildings. Lean of building.

Probable Causes/Deficiencies:
Movement of the building structure due to structural weakness.

***Further Considerations*:**
Requires structural engineering analysis.

5.1.3 Diagonal Cracks at Base of Bearing Masonry Wall

What To Look For:
Diagonal cracks, usually stepped, at base of building. Photo displays a repaired crack.

Probable Causes/Deficiencies:
Usually the result of settlement or movement at the foundation level.

Further Considerations:
Requires structural engineering analysis.

Note: Photo displays repaired cracks.

See Also: 3.1.25 , 3.1.26.c

5.1.4 Diagonal Cracks at Spandrel

What To Look For:
Diagonal, stepped cracks originating on one side of opening only, more common near building corners. Crack traversing spandrel.

Probable Causes/Deficiencies:
Lateral displacement. Heavier loaded area of masonry tends to move outwards (due to larger stresses on mortar or foundation). Condition might have appeared soon after erection. Deflection of lintel. Lean of building.

Further Considerations:
Condition can occur due to differential settlement of foundation.

Note: Photo displays repaired cracks

See Also: 3.1.26.c

5.1.5 Intersecting Diagonal Cracks – Connecting Opening

What To Look For:
Intersecting diagonal cracks in spandrels.
More common near corners.

Probable Causes/Deficiencies:
Structural weakness as a shear wall under the action of reversible loads (e.g. wind, thermal displacement) or successive loads acting in opposite direction.

Further Considerations:
May require engineering analysis.

See Also: 5.1.4

5.1.6 Inverted "V" Crack at Lintels

What To Look For:
Inverted V shaped stepped cracks. More commonly originating at lintel.

Probable Causes/Deficiencies:
Deflection of lintel. Crack forms along the lines of the *relieving masonry arch*
Condition might have appeared soon after erection. Differential settlement under load (spandrel/pilaster)

Further Considerations:
Presence, condition of steel lintel needs to be investigated.

See Also: 3.1.26.c

5.1.7 Crack at Bearing Masonry Arch Crown

What To Look For:
Cracks above arched openings. Displacement of crown stone.

Probable Causes/Deficiencies:
Lateral displacement of bearing base of crown. Heavier loaded area of masonry tends to move downwards (due to larger stresses on mortar or foundation) and outwards (due to arch effect). Condition might have appeared soon after erection.

Further Considerations:
Condition can occur due to differential settlement of foundation.

See Also: 3.1.26

5.1.8 Vertical Crack in Bearing Masonry

What To Look For:
Crack of both brick and mortar – extending vertically***.***

Probable Causes/Deficiencies:
Vertical crack in bearing brick masonry is typical for failure in compression. Significant vertical overload (e.g. at end of supported beam , roof equipment) . Crack might correspond to a change (plan) in masonry thickness. Rust of metal inclusions.

Further Considerations:
When caused by compression loads, masonry requires engineering analysis.

See Also: 3.1.26.b

5.1.9 Vertical Crack at Building Corner

What To Look For:
Vertical cracks in the immediate vicinity of corner. Condition of joint of face and ordinary brick. Condition of masonry tooth. Differentiate crack in masonry vs. construction joint formed between ordinary brick and face brick. Cracks in parging/stucco might only reflect the presence of stresses at joint or actual cracks in masonry.

Probable Causes/Deficiencies:
Cracks might be caused by differential movement due to perpendicular orientation of walls and quality of brick. (face brick vs. ordinary brick set at right angle.) Corner cracks in bearing masonry buildings might represent a weakening or serious damage of the load paths. Insufficient corner toothing or anchoring.

Further Considerations:
May require structural engineering consideration.

See Also: 3.1.26.b

5.1.10 Bulging of Bearing Masonry

What To Look For:
Lack of verticality of wall. Inspect interior as bulging can occur in the outside wythe only or it might involve the entire masonry section.

Probable Causes/Deficiencies:
Bulging in outside wythe might indicate improper/insufficient bonding between wythes. Bulging of the entire masonry might be caused by the expansion of the floor structure.

Further Considerations:
Requires structural engineering analysis.

Interior cracks on wall perpendicular to bulge

5.1.11 Bulge/Displacement of Bearing Masonry at Floor Level

What To Look For:

Bulge, swelling, , outward displacement of masonry at the level of the roof or floor line.

Probable Causes/Deficiencies:

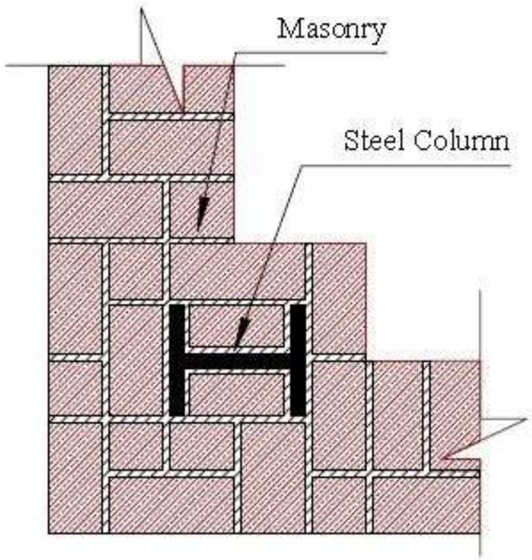
Outward displacement or bulge at base of parapet can be caused by pressure from roof/floor structure, especially trussed roofs. Rust of roof or floor structural frame.

5.2 Transitional Masonry

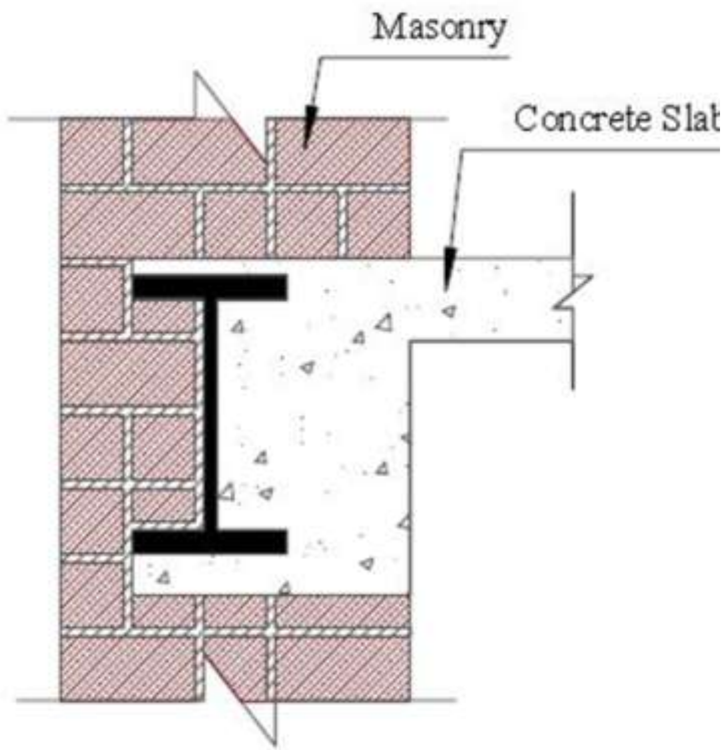
Transitional Masonry Facades

In transitional facades systems, the masonry infills the space between the skeleton elements. Masonry might also have a shear wall.

As it is surrounded by masonry, the structural framing system blocks the vertical or horizontal expansion of façade material. Water is not flushed out of façade



Horizontal Section



Vertical Section

Main Characteristics Transitional Facades

- Composition of the exterior wythe and back-up system.
- Corrosion protection of the structural steel.
- Details of attachment and support of the façade to the structure (e.g. position of steel frame in relation to the exterior wythe, connectivity exterior wythe to the back up).

Collapse of Brick at Improper Corner Repair

Repair included cutting vertical joints on both sides of the corner. Masonry in transitional facades was not anchored to columns. Losing attachment as a result of the repair, some bricks fell.

See Also: 5.2.5

5.2.1 Thin (Hairline) Crack in Transitional Façade

What To Look For:
Direction and location of crack, especially position of crack relative to steel frame elements.

Probable Causes/Deficiencies:
Movement of clay brick restrained by the structural (steel) frame. Long term and irreversible moisture expansion of fired clay brick. Thermal expansion due to daily or seasonal temperature variations. Corrosion of enclosed steel. Creep of concrete structural frame.

See Also: 3.6 , 3.1.25.a

5.2.2 Bulge At Parapet of Transitional Facade

What To Look For:
Swelling away from building vertical line occurring at base of parapet. Differences in size and alignment of joints. Lean outwards or inwards of parapet.

Probable Causes/Deficiencies:
Corrosion of structural steel. Slippage of parapet over flashing. Rain water penetration and accumulation at base of parapet.

See Also: 3.6

5.2.3 Crack At Parapet Along Spandrel Beam

What To Look For:

Position of crack relative to the structural supporting elements, verticality of parapet. Alignment of parapet. Separation of parapet from masonry below. Condition of back-up masonry.

Probable Causes/Deficiencies: Corrosion of supporting steel, thermal movement of parapet, creep and deflection of parapet under wind loads, possible water penetration due to failed roof flashings.

See Also: 3.6

5.2.4 Crack Around Opening In Transitional Facade

What To Look For:

Cracks of various sizes and directions stemming from openings in masonry.

Probable Causes/Deficiencies:

Corrosion of supporting steel. Displacement or excessive deflection of supporting steel (that might have been affected by corrosion).

5.2.5 Vertical Corner Crack In Transitional Façade

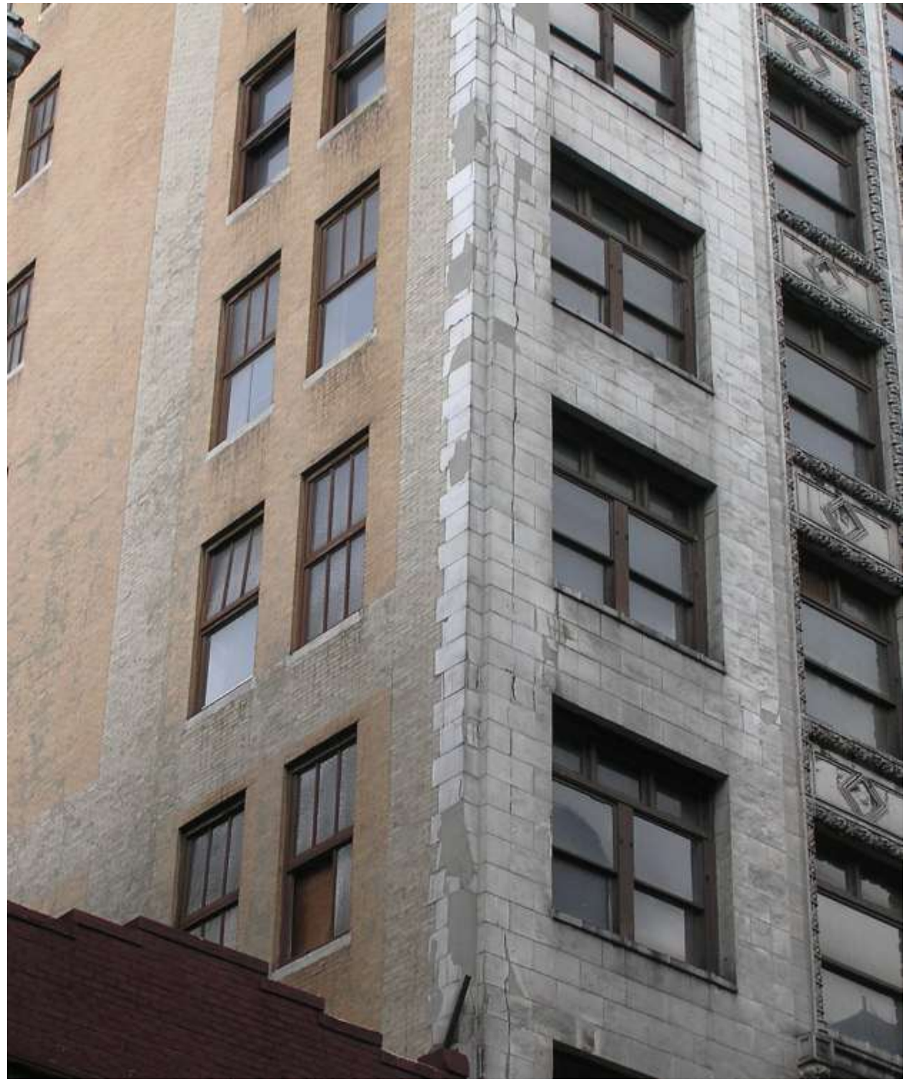
What To Look For:

Vertical crack in vicinity of corner.

Probable Causes/Deficiencies:

Corrosion of steel column "jacks" adjoining material, especially when covered by only one wythe of brick. Horizontal thermal movement of brick/terra-cotta restrained by the steel structure. Corner elements lacking structural support for entire height of corner.

See Also: 3.6



5.2.6 Multiple Vertical Cracks Along Corner of Transitional Façade

What To Look For:

Several vertical cracks in the vicinity of corner (same or both sides of the corner). Separation of masonry along cracks.

Probable Causes/Deficiencies:

Significant rate of corrosion coupled with thin brick cover of steel. The typical problems of transitional facades are aggravated at bricks around columns when the brick runs uninterrupted from bottom to top of building.

See Also: 3.6

5.2.7 Bulge and Crack at Face Masonry

What To Look For:

Out of plane displacement of face brick. Swelling of masonry. Location of bulge in relation to structural steel.

Presence of cracks.

Probable Causes/Deficiencies:

Corrosion of steel spandrels. Shearing of brick headers at steel support. Freezing of water trapped (ice buildup) in the crack space.

See Also: 3.6 , 3.1.26

5.2.8 Improper Repair of Corner Crack Transitional Facade

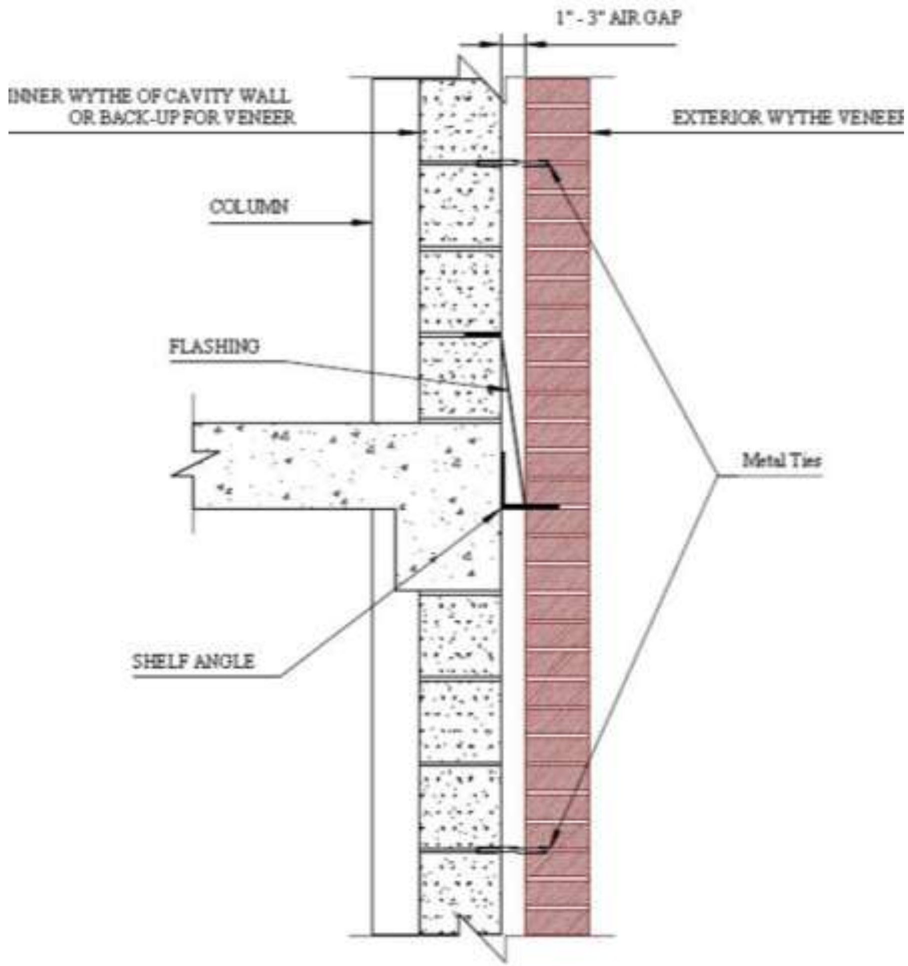
Repair of cracks by injecting or applying compounds may only temporarily reduce the rate of corrosion. The thermal movement of masonry will open cracks further up (at same or different locations) and allow direct penetration of water. Rust jacking will continue. Also this repair does not address the probable separation of masonry from adjoining support.

See Also: 3.1.26

5.3 Brick Veneer Cavity Wall

Characteristics Veneer Cavity Walls

- Exterior Brick Veneer
- Back up system usually concrete masonry units.
- Metal ties from the back-up wall to the brick veneer.
- Lintels or shelf angles that provide vertical support.
- Flashings, weeps,
- Soft Joint - The joint immediately below a gravity support.
- Expansion Joint - a joint in the veneer designed to accommodate movement in the veneer.
- G-locks - metal components typically cast into reinforced concrete frame to provide gravity (G) hold for shelf angle anchor.
- Functioning drainage system



CAVITY WALL SYSTEM

Collapsed Cavity Wall Veneer

Lack of proper and sufficient ties allowed collapse of face brick.

5.3.1 Clogged Weephole

What To Look For:
Weep hole not functioning, clogged. Clog in weephole is not always visible.

Probable Causes/Deficiencies:
Accumulation of dirt. Mortar droppings blocking the cavity or the hole. Might allow water buildup.

5.3.2 Rolling Block in Brick Veneer

What To Look For:
Verticality of face brick. Face of brick veneer undulations along a vertical plane. Examine shelf angle to veneer relationship.

Probable Causes/Deficiencies:
Insufficient bearing of brick on shelf angle; shelf angle rotation (due to excessive shims) transfers load to lower facade veneer (contrary to design intent) ; construction tolerance issues; insufficient or rusted wall ties. Loss of wall ties anchorage.

5.3.3 Bulged, Buckled Veneer at Joint

What To Look For:

Outward displacement of face brick. Bulging. Horizontal cracking and location of cracks relative to the shelf angle. Lack of soft material in joint. Veneer displaced off shelf angle.

Probable Causes/Deficiencies:

Improper installation of joint. Un-accommodated thermal movement; poor workmanship (material); poor workmanship (construction tolerances); loose G-locks; Lack of installation of soft joints; concrete frame shortening resulting in loose G-locks (shelf-angle raised up).

Further Considerations:

View soft-joint position for insufficient dimension; view wall ties.

5.3.4 Displacement and Crack of Veneer

What To Look For:
Cracks along shelf angles; out of plane displacement of bricks; loose bricks at shelf angles and parapets.

Probable Causes/Deficiencies:
Thermal loading/movement is not accommodated due to insufficient or improperly placed expansion joints. At clogged veneers pressure from water accumulation and subsequent freezing. Rotation of shelf angle.

Further Considerations:
Placement of vertical and horizontal control joints and expansion joints.

5.3.5 Mortar Joint Crack at Shelf Support of Brick Veneer

***What* To Look For:**
Cracks in mortar joints along shelf angles, spalling of brick around these joints; bowing of veneer.

Probable Causes/Deficiencies:
Rust jacking due to unprotected steel shelf. Lack of soft joint (Vertical load is transferred to the lower façade veneer instead of being transferred to the shelf angle). Incorrect installation of brick veneer or flashing at shelf angles. Hardened material in lieu of soft joint.

5.3.6 Incipient Brick Spalling at Shelf Support of Veneer

What To Look For:

Spall of brick located at shelf angle joint. Cracked mortar at joint above spall, incipient bowing.

Probable Causes/Deficiencies:

Weight of the veneer above and deflection of shelf angle is not accommodated by the soft joint. Hardened material in lieu of soft joint.

Further Considerations:

Additional spalling of brick course below shelf should be anticipated; load transfer to veneer below may result in bowing, buckling o f veneer; confirm placement/extent of soft joint in veneer.

5.3.7 Undulating Brick Veneer – Horizontal Bowing

What To Look For:
Bowing mid distance between expressed framing elements.

Probable Causes/Deficiencies:
Thermal and ceramic expansion in the horizontal direction is restrained; (e.g. restrained at building corners from an expressed reinforced concrete frame).

5.3.8 Vertical Cracks in Veneer at Corner

What To Look For:

Size and direction of cracks.

Probable Causes/Deficiencies:

Horizontal expansion in the plane of the veneer is not accommodated at the vertical control/expansion joints. Joint dimension is insufficient. Lack or improper placement of joints.

The thermal expansion develops forces that crack the brick veneer.

5.3.9 Bowing Brick Veneer

What To Look For:
Bowing/bulging of brick veneer. Location of bow in relationship to shelf angle.

Probable Causes/Deficiencies:
Insufficient drainage of water (clogged weep holes) or rust jacking pushing veneer off the shelf angle. Insufficient or rusted wall ties.

5.3.10 Rusting Lintel/Shelf Angle at Brick Veneer

What To Look For:

Rust coloration on the adjoining area, Change in shelf angle thickness. Presence of flashing

Probable Causes/Deficiencies:

Deterioration or lack of corrosion protection of steel shelf angle. Improper flashing. Larger volume of corrosion residues exerts pressure on veneer in vertical and horizontal direction.

5.3.11 Deterioration of Filler Material At Joint in Veneer

What To Look For:
Missing or squelched joint filler.

Probable Causes/Deficiencies:
Improper filler material. Insufficient joint width. Aging of filler material.

Further Considerations:
Lack of filler allows increased rain water penetration, vertical joint may become ineffective.

5.3.12 Stepped Crack in Brick Veneer

What To Look For:
Stepped crack into mortar joints or into brick and mortar joints, downward bowing of shelf support. Verticality of wall elements.

Probable Causes/Deficiencies:
Weakening of shelf support due to corrosion or due to movement of G-locks. Movement of veneer over shelf. Lack of joints. Movement of supporting frame.

5.3.13 Brick Veneer Displaced off Supporting Shelf

What To Look For:
Step in the vertical plane, rust coloration of brick, clogged weep holes, spalling of brick below shelf.

Probable Causes/Deficiencies:
Insufficient drainage of water (clogged weep holes) allows water or ice buildup behind veneer and result in the veneer being pushed out. Also rust jacking can push veneer off the shelf angle. Insufficient or rusted wall ties.

5.3.14 Vertical Cracks (distributed) in Brick Veneer

What To Look For:
Vertical cracks, size and number of cracks, presence and condition of soft joints.

Probable Causes/Deficiencies:
Brick undergoing ceramic or thermal expansion becomes compressed between shelf angles top and bottom, large distance between horizontal joints.

See Also: 3.1.26

5.3.15 Large Vertical Crack in Brick Veneer

What To Look For:
Vertical cracks, size, number and continuity of crack, out of plane movement associated with crack.

Probable Causes/Deficiencies:
Failed or blocked cavity behind crack. Settlement of supporting system. Thermal and ceramic expansion, large distance between joints.

See Also: 3.1.26

5.3.16 Improper Repair of Veneer at Corner

Vertical cracks formed following the replacement of the bricks at corner. The repair did not allow for the ceramic expansion of the newly installed brick.

5.4. Concrete Facades

Poured-in-place

Precast panels

5.4.1 Delaminating of Concrete Facade

What To Look For:
Delamination or spall of concrete at exterior of building.

Probable Causes/Deficiencies:
Corrosion of reinforcing due or insufficient cover or significant air pollution.

See Also: 3.6, 3.2.2, 3.2.3

5.4.2 Slippage Precast Concrete Panel

What To Look For:
Individual stone displacement; Heavy shadow under panel.

Probable Causes/Deficiencies:
Failure of the stone anchoring system; Rust build-up on the shelf angle; Use of non-galvanized anchoring system.

5.4.3 Crack in Concrete Panel

What To Look For:
Crack in individual precast panels. *Crack opening and separation of panel.*

Probable Causes/Deficiencies:
Mishandling during installation. Failure of attachment.

See also: 3.2.1

5.4.4 Surface Spalling of Precast Concrete Panel

What To Look For:
Surface spalling; Stone displacement;
Evidence of an applied coating.

Probable Causes/Deficiencies:
Use of non-breathable coating.

5.4.5 Crack at Joints of Precast Panels

What To Look For:
Bulging of stone not related to shelf angle location; Cracking associated with bulging.

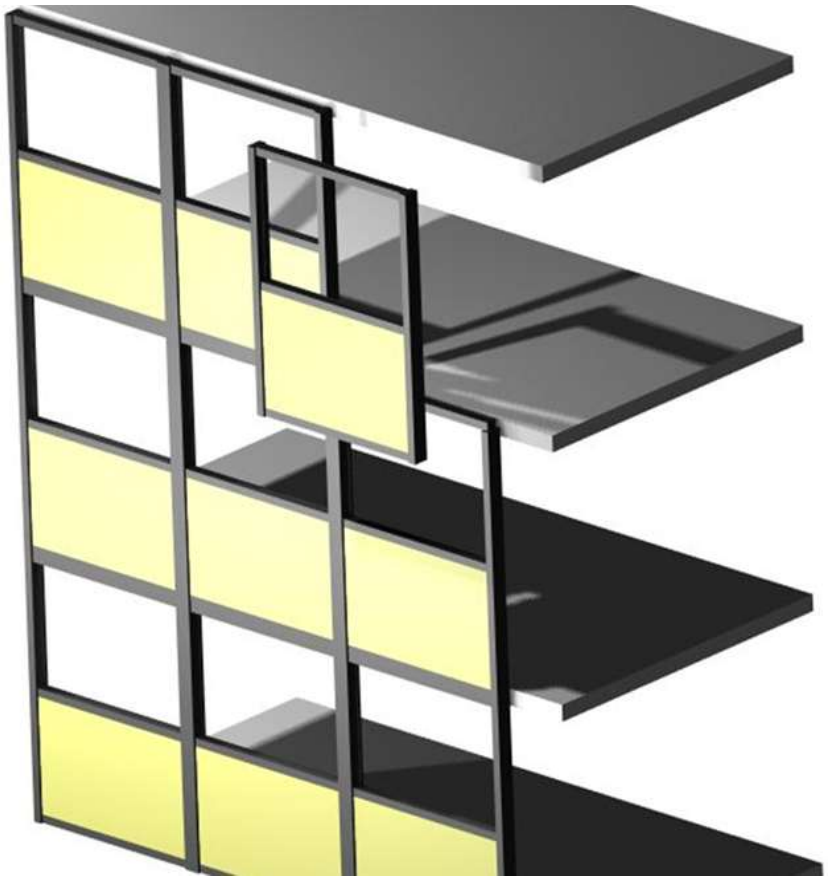
Probable Causes/Deficiencies:
Insufficient number of stone anchors provided. Defective Precast Concrete Panel Attachment.

6. Modern Curtain Walls

- 6.1 Glass and metal systems
- 6.2 EIFS-Exterior Insulation Finishing System
- 6.3 Thin Brick Panels.

Basic Curtain Wall Systems

Unit System



Stick System

6.1 Glass/Metal Curtain Wall Elements

Essential Elements

- Cladding – glass (both vision and spandrel glass), stone, metal.
- Framing system (mullions and rails)
- Gaskets and Sealants
- Setting blocks and corner blocks
- Anchors
- Pressure plates and snap caps and/or snap-on trim

6.1.1 Broken/Cracked Glass Of Curtain Wall

What To Look For:
Cracks, chips, discoloration. Interior or exterior pane defect.

Possible Causes/Deficiency:
Material failure. Impact. Thermal stress.

See Also: 4.1.11

6.1.2 Glass Defects

What To Look For:
Stains, deposits scratches and other imperfections on the surface of the glass panels and their coating. Discoloration.

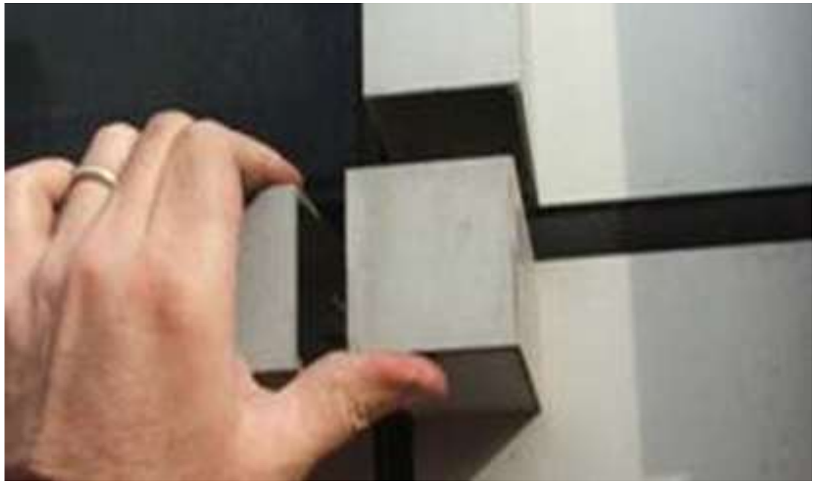
Possible Causes/Deficiency:
Mishandling during erection. Manufacturing defects that were not detected at the plant.

See Also: 4.1

6.1.3 Snap-on Trim Back Out

What To Look For:
Obvious signs of movement. Condition of hardware elements. Loose snap-on caps of metal curtain Wall Elements

Possible Causes/Deficiency:
Building element separation, original design failure, metal fatigue.



6.1.4 Missing Decorative Trim of Curtain Wall

***What To Look For*:**
Exposed underlying construction, condition of architectural hardware.

***Possible Causes/Deficiency*:**

Design failure – excessive deflection, movement of metal element, and metal fatigue due to repeat wind load. Excessive story drift. Fastener fatigue failure.

6.1.5 Loose Snap-on Trim

What To Look For:

Obvious signs of movement.-Misalignment of trim element.

Possible Causes/Deficiency:
Original design failure, metal fatigue, fastener fatigue/failure.

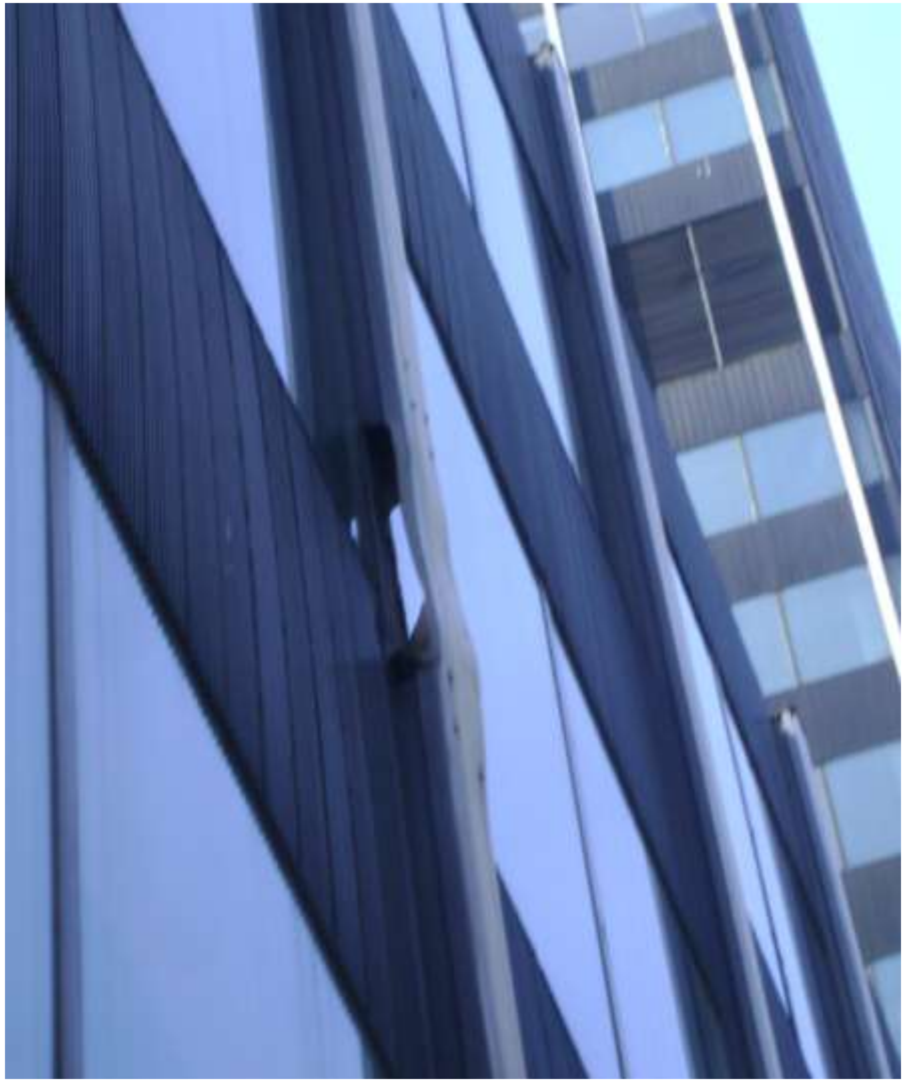
6.1.6 Mullion Deformed

What To Look For:

Misaligned or deformed mullion. Gaps around mullion.

Possible Causes/Deficiency:

Thermal expansion blocked. Mechanical impact.



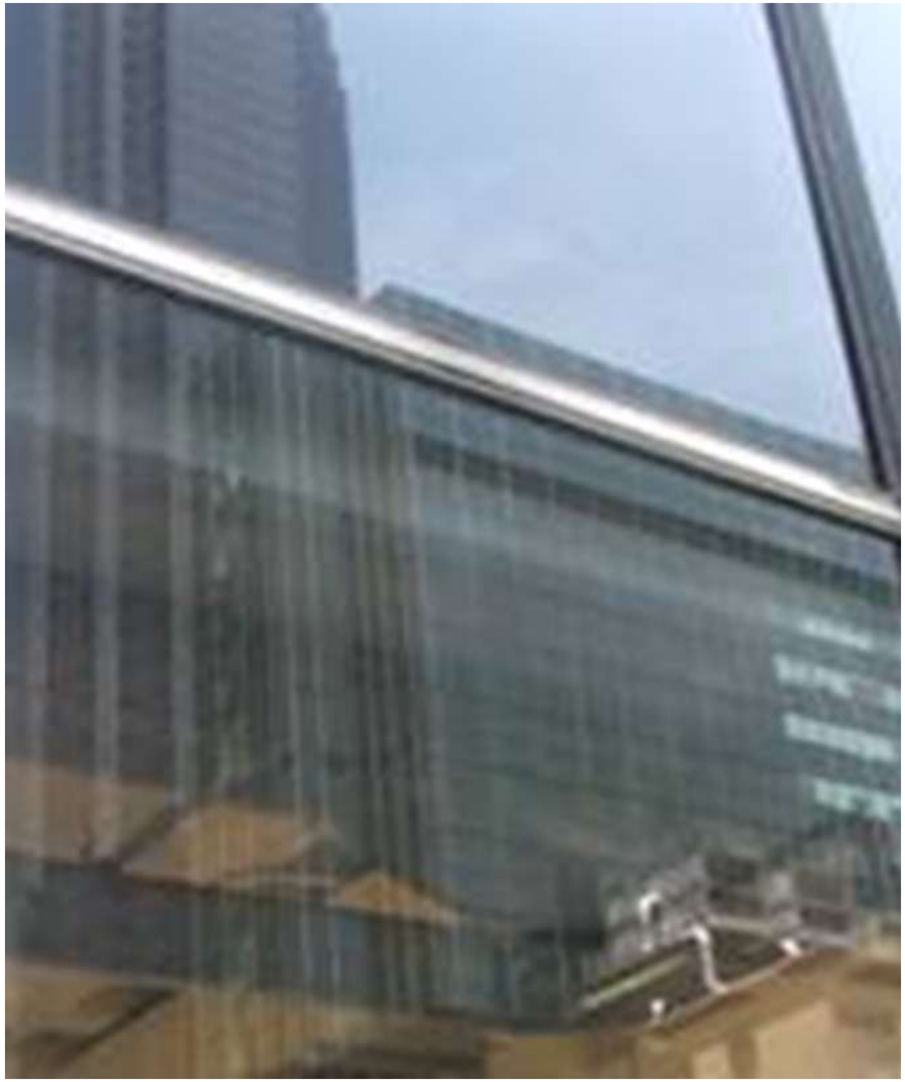
6.1.7 Condensation

What To Look For:

Unusual vapor condensation on the interior of the panel. Or between glass panels.

Possible Causes/Deficiency:

Improper original design. Air leakage. Excessive humidity.



6.2 EIFS – Exterior Insulation Finishing System

6.2.1 Sealant Joint Failure - EIFS

What To Look For:
Active water leaks; Discoloration;
Sealant recessed in joint. Wet,
gummy or bulging sealant.

Probable Causes/Deficiencies:
Water accumulating along interface of sealant and EPS substrate. Improper use of foam backer rod. Finish coat within joint.

6.2.2 Mitered Outside Corners of EPS Board - EIFS

What To Look For:
Active water leaks: Exposed reinforcing mesh at corner; Bulging at corner.

Probable Causes/Deficiencies:
EPS (aged) boards are not interlocked at corners.

6.2.3 Cracking at Penetration Corners at EIFS

What To Look For:

Active water leaks; Cracks in finish coat at or near corners of penetration.

Probable Causes/Deficiencies:

Improper back-wrapping of reinforcing mesh; lack of diagonal reinforcing at corners; EPS board is not “L”-shaped at corners.

Further Considerations:

Test exterior sheathing behind EPS board using long pins of moisture meter to confirm water penetration.

6.2.4 Cracking Adjacent to EIFS Penetration

What To Look For:

Active water leaks; cracks in finish coat at or near corners of penetration.

Probable Causes/Deficiencies:

Improper back-wrapping of reinforcing mesh; no flashing installed behind EPS board.

6.3 Thin Brick Panel

Relatively new systems, the panels are delivered at the site as a sandwich containing an exterior thin brick veneer, a rainwater water screen and management system and insulation.

6.3.1 Sealant Joint Failure

What To Look For:
Active water leaks. Sealant recessed in joint.

Probable Causes/Deficiencies:
Water accumulating along interface of sealant and substrate. Improper use of foam backer rod.

6.3.2 Efflorescence -Thin Brick Panel

What To Look For:
White substance leaching from joints between brick units.

Probable Causes/Deficiencies:
Water penetration in the brick panel; adhesive/mortar holding brick onto panel could be dissolving, eventually causing the brick to de-bond.

6.3.3 De-bonding of Individual Thin Brick

What To Look For:
Displacement of brick.

Probable Causes/Deficiencies:
Bond between thin brick and its back-up has been compromised by water or thermal movement.

6.3.4 Bulging Brick - Thin Brick Panel

What To Look For:
Bowing/bulging of thin brick veneer. Location of bowing.

Probable Causes/Deficiencies:
Thin brick is not adhered to back-up. Sealant joint spacing is insufficient.

6.3.5 Stained Brick within Thin Panel

What To Look For:
Active water leaks; rust staining on surface of brick not related to a shelf angle location

Probable Causes/Deficiencies:
Non-galvanized accessories used to attach brick to back-up; water is getting into the wall behind the brick; lack of waterproofing and/or flashing system.

References

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5. National Park Service, Preservation Briefs, www.nps.gov/tps/how-to-preserve/tech notes.htm

6. New York Landmarks Conservancy The Brownstone Guide: Maintenance & Repair Facts for Historic Property Owners