3.0 FOUNDATIONS ARTICLES

NOTES

CONCRETE FOUNDATIONS 3.1

3.1.0 INTRODUCTION

Analysis of the structural integrity and adequacy of concrete foundations will be required on a case by case basis as deterioration is noticed or building rehabilitation occurs. The composition of concrete mixes, reinforcing, and footing design adequacy has not been evaluated by this study.

Concrete foundations should be inspected on an annual basis to identify new problem areas and deterioration.

Structural concrete work predating 1940 should be tested in-situ and under laboratory conditions for composition, density, porosity, and compressive strength before any repair is undertaken.

New or patching mixes should have the same ultimate compressive strength as the existing material and conform to ASTM or comparable specifications.

3.1.1 TYPICAL REPAIRS

3.1.1.1 Minor cracking evident on surfaces.

CAUSE

Cracks may be due to natural shrinkage of materials or minor foundation settlement.

They are not serious as long as they do not admit water to the building, corrode reinforcing materials, or cause spalling.

REPAIR

Minor cracks including seasonal or hairline cracks may be painted, filled with epoxy, or drypacked depending on the severity of the crack.

Cracks treated in this manner must be stable.

Epoxy treatment is appropriate only when cracks are large enough to let the epoxy flow into them.

Cracks must be clean and dry.

Cut a trough at the top edges to permit effective flow.

Inject epoxy to the full depth of the crack to ensure bonding.

Drypack methods require chipping all unsound material to a depth of one inch.

Widen cracks by cutting and scraping and provide undercut interior edges to create a mechanical lock for the patch.

Clean area with water or compressed air, allow full drying, and prime with an acrylic latex bonding agent.

Pack the area with cement mortar that has similar characteristics (compressive strength and thermal expansion properties) as the original materials.

3.1.1.2 Major cracks indicating building movement or structural failure. Cracks that run in the direction of reinforcing bars, show evidence of rust stains, or that are located at openings and accompanied by buckling are serious.

CAUSE

Major cracks are caused by inadequate footing design, sections spanning unsuitable soils or voids created by organic fill, and structural failure of reinforcing.

REPAIR

Identify specific cause.

This requires consultation with and design by an architect and a structural engineer familiar with historic structures.

Causes must be corrected before any final patching occurs.

This may include designing new footings or grade beams, replacing major sections of the foundation, or removing and replacing deteriorated or inadequate reinforcing.

Remove concrete from around exposed or rusting reinforcing bars using hand held hammers and chisels.

If more than 1/2 the circumference of any bar is exposed, remove material from around entire circumference.

Clean steel and adjacent concrete by sandblasting or pressure wash to eliminate dirt, grease, and scale.

Dry thoroughly with hand-held blowers and paint steel immediately with a corrosion inhibiting primer.

Inspect condition of steel.

Severely rusted bars must be cut out and replaced.

New steel must overlap original reinforcing bar as specified by an engineer.

Repair remaining voids by priming surfaces with an acrylic latex bonding agent and either drypacking area with a concrete or mortar mix that has similar characteristics to the adjacent concrete or, in the case of larger holes, by using formwork.

Formwork should be carefully installed adjacent to visible surfaces to maintain, as best as possible, a flush finish surface.

3.1.1.3 Chips and spalls on concrete surfaces.

CAUSE

Spalls may be caused by incidental mechanical damage (e.g. trucks backing into corners), freeze/thaw moisture damage, severe efflorescence, or deteriorating reinforcing steel.

REPAIR

Minor spalls and mechanical damage less than 2 inches deep with no exposed reinforcing bars may be treated by either painting or light patching.

Remove all loose material with light hammers.

If the adjacent foundation is not painted, cut or chip edges perpendicular to surface of concrete to a minimum depth of 1 inch (providing slightly undercut edges for anchoring), clean surface with water or air, and allow to dry.

Prime area with acrylic latex bonding agent and dry pack area with cement mortar or concrete mix to match original finish and composition.

Major spalls include those with exposed reinforcing bar or a depth greater than 2 inches.

Repairs to major spalls should be supervised by an experienced architect and structural engineer.

Remove all loose materials with a small hammer.

Cut out deteriorated concrete so edges are sharp and perpendicular to the surface (providing undercut edges to anchor new patching material).

Expose and clean deteriorating reinforcing bars; expose the entire bar if more than 1/2 of the circumference is visible.

Treat reinforcing bars with corrosion inhibiting primer, prime concrete surfaces with acrylic latex bonding agent, and fill with a compatible concrete mix.

3.1.2 MAINTENANCE RECOMMENDATIONS

A. Inspect foundations annually for deteriorating conditions including cracks, moisture penetration, spalling, and vegetation damage.

B. Document existing cracks by measuring widths at specified points on an annual basis to identify movement. Cracks moving more than 1/8 inch in an annual cycle should be investigated to establish the cause.

NOTES

BRICK FOUNDATIONS AND PIERS 3.2

3.2.0 INTRODUCTION

Brick is composed of clays that are formed (molded) in a plastic state and fired in kilns to create a hardened building unit. Historic brick as found at Fort Lewis is softer and more porous than those manufactured today with less overall quality control and consistency between units.

Historic brick is likely to have differences in hardening between the surface and the interior (body) of the brick. The hardness of the exterior surface provides the moisture-resistant properties.

Historic mortar traditionally was a lime-based mortar mixture of lime, sand, and water. These mortars develop very low compressive strengths, take a long time to harden, and have poor durability to the freeze-thaw cycle.

Low compressive strength mortar is most suitable to the softer more porous nature of historic brick. Serious damage may occur to historic brick by using high-strength portland cement based mortars. Mortar used in repointing historic masonry must always be softer than the surrounding brick to prevent breaking-up the existing materials

3.2.1 TYPICAL REPAIRS

3.2.1.1 REPOINTING

Repointing is necessary when the mortar holding the brickwork together is eroded by weathering or decomposed to the point that it is easily scored or removed by a screwdriver.

Mortar used in repointing should always be softer than the adjacent brick. Mortars with high Portland cement content should not be used.

Evaluation of existing mortar conditions and brick strength at Fort Lewis should be part of a future program.

Historic mortar composition should be analyzed.

3.2.1.2 Mortar eroded or weathered from original joint levels. Mortar soft and easily loosened by prodding with a screwdriver.

CAUSE

Exposure to wind and driven rain; washing caused by deteriorated or improperly directed downspouts.

REPAIR

Remove weathered mortar to a minimum depth of 3/4 inches from surface or to sound mortar.

Hand chiseling is the preferred method; power tools cannot be effectively controlled on foundation piers.

Use a high lime mortar mix. ASTM Type K mortar with no more than 1 part Portland cement to 4 parts lime may be used to increase strength and workability if brick-strength analysis indicates that the resulting mix is softer than the brick.

Use sand conforming to ASTM C-144 that matches grain size from original mortar.
Use clean, potable, neutral pH water

Match color of historic mortar as closely as possible using natural materials.
Always test color by either wetting original or allowing a test sample to dry before repointing.

3.2.1.3 BRICK REPLACEMENT

Bricks require replacement if they are seriously deteriorated, are cracked from building movement, vehicular damage, or previous attempts at repair or repointing.

Replacement brick should match existing brick as closely as possible. This brick may be salvaged from demolished structures, relocated from an area where removal has a minimal effect on the historic character of the building, or obtained from manufacturers that carry reproduction specialty brick.

Relocated brick should be analyzed to ensure durability. Poorer brick was sometimes used for interior walls and may not withstand exterior use.

3.2.1.4 Spalled, cracked, or otherwise damaged brick.

CAUSE
Moisture penetrating core of brick due to use of Portland cement mortar; building/foundation settlement; freeze/thaw in poor mortar joints.

REPAIR
Work must be done by a skilled mason.
Remove brick by hand chiseling.
Ensure that adjacent sound brick is not damaged.
Use replacement bricks that are a close match to original brick in color, texture, size, and hardness.
Soak new brick in neutral pH water before laying.

Match new mortar joints to original.

New bricks should be staggered coursed into existing sound bricks.

3.2.1.5 Porous outer surface of brick; crumbling of surface.

CAUSE
Deterioration resulting from poor quality low-fired brick, improper cleaning such as sandblasting, or a deteriorating heavy coat of paint.

REPAIR
Replace brick as above if only a small area is affected.

Use of sealants is not recommended except in cases of severe deterioration.

Paint may be used on foundations and piers where there is little visual effect on the structure.
Use a breathable paint such as latex; avoid oil-based or epoxy paints that will trap moisture and cause spalling.

3.2.2 MAINTENANCE RECOMMENDATIONS

3.2.2.1 GENERAL PREVENTATIVE MEASURES

A. Establish an inspection program to identify cracking, spalling, or deteriorating brick, and decomposing or weathering mortar. Inspections should occur on a 5 to 10 year schedule.

3.2.2.2 CLEANING

A. Brick surfaces should be cleaned using the gentlest possible method to accomplish the job.

B. Hand scrubbing is the preferable method for brick foundation piers although low to medium pressure water cleaning is acceptable. Do not use high-pressure washes (600-1800 psi) even though the timesavings appears more cost-effective. They will result in serious deterioration and moisture problems.

C. Chemical cleaning is acceptable under controlled conditions. Do not use caustic soda solutions; do not use ordinary modern detergents.

D. **Never sandblast historic brick.** This removes the hardened outer layer and speeds-up deterioration.

E. Steam cleaning is not an appropriate or cost-effective method.

F. Always test cleaning methods on a small, low-visibility area before starting major work. It may be useful to test several methods (water vs. chemical) to establish the most effective procedure.

G. Follow manufacturers' directions explicitly for all approved cleaning solutions (chemicals or detergents).

H. After initial cleaning, routine maintenance cleaning should occur on a 5-10 year schedule.

3.2.2.3 WATER SPRAYS OR SCRUBBING

A. Make sure that all surfaces to be cleaned are in good condition including both bricks and mortar. If not, repair before cleaning and allow adequate time for compounds or mortar to harden.

B. Remove all plant-growth (lichens, mosses, ivy, etc.) before major cleaning. Plant-growth should be removed using wood scrapers or non-ferrous brushes. Lichens can be killed with a solution of zinc or magnesium silica fluoride (one part to 40 parts water).

C. Cover all openings where water might penetrate into the interior.

D. If quantity of water used in cleaning operation is high, use tarpaulins or other coverings at the foundation level to deflect water away from the footings.

E. Water soak surfaces to soften heavy dirt.

F. Use soft-bristle brush and mild detergent for all hand cleaning.

G. Start water cleaning procedures at the top of the area that is to be cleaned. Perform a final rinse of fresh water if detergents have been used.

H. Do not use water cleaning methods during periods of cold, damp weather. Doing so will increase the chance for water penetration into materials and possibly cause long-term damage.

I. Sometimes, especially after repointing or repair, a white or green chalky coating will appear on a brick surface. This efflorescence is caused by salts leaching out of bricks or mortar. Dry-brush using stiff natural or nylon bristle brushes. If necessary, continue brushing using a neutral pH water. If efflorescence is green, brush on a solution of sodium hydroxide (12 ounces per quart of water) and allow to dry as a white salt deposit. Wash with clean water 3 to 4 days later. Do not subject to hydrochloric (muriatic) acid cleaning.

3.2.2.4 PAINT REMOVAL

A. Paint removal is difficult at best and original paint may be protecting weak or porous brick.

B. In most cases where foundations have been painted it is better to maintain the paint. Blistering sections should be scraped to remove loosened paint, any efflorescence should be brushed using non-ferrous brushes, and the area repainted with a breathable latex paint.

C. If paint removal is necessary, use an alkaline organic stripper. Allow time for adequate reaction and wash with a high pressure (1500 psi) wash. Warm water (less than 160°) may hasten removal time. It may be necessary to clean again using conventional cleaning methods if the surface will not be repainted.

3.2.3 COMMENTS

Repointing and brick repair should be done by an experienced mason through a contracting operation.

Specifications for contracted work shall require compliance with "Preservation Briefs" documents, produced by the Technical Preservation Services Division, available from U. S. Government Printing office.

Pure water cleaning may be done by self-help or general contract under the direct supervision of an experienced professional.

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