

COMPATIBLE INJECTED FILL SPECIFICATIONS

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Section 04901

These specifications describe materials, equipment, personnel, procedures, and nondestructive testing quality control requirements for injection of compatible injected fill (CIF) into masonry wall sections. The formulation and injection of cementitious fill for and into masonry walls is a highly specialized application. The process requires an experienced applicator and professional engineer trained to work together before and during the work. The finished product is not visible for inspection and a thorough knowledge of available and appropriate non-destructive evaluation methods is an essential component of this specification.

1.0 MATERIALS

Ingredients for CIF shall include cement and cementitious materials, with no more than 0.5% by volume of admixtures, as required to fulfill project objectives. No polymers, acrylics or epoxies will be accepted in the final materials. All CIF materials shall be non-chloride and non-corrosive. Mix formulations shall be developed for the specific combination of materials present, the condition of the structure, the pattern of the units, and the weathering characteristics of the structure. Effort should be made to utilize existing MSI formulations used under similar conditions, customizing these to match the properties of their host. Additional customized mix designs may be required for other existing conditions within the project.

Submittals will include appropriate test data, along with information on three (3) projects at which the cementitious fill(s) were utilized. Historical information will include wall section, type of project, scale of project, quality control test results, contact names and phone numbers. The injector will certify that the submitted materials are the same materials or an upgrade as those used at similar conditions the past projects. Photos or details may be required depicting project similarities. In addition, the professional engineer of the previous project will provide certification as to the similarities and goals and success of the previous project.

Pre-blended CIF is to be stored in a covered location, protected from environmental moisture. A covered staging area of at least 200 square feet will be required. Access to the area shall be sufficient to offload pallets of material using a forklift. In addition, an interior temperature controlled area of at least 150 square feet is to be provided to protect materials and equipment from freezing, as necessary.

For CIF work in conjunction with Cathodic Protection of embedded metals CIF will be formulated to achieve materials characteristics as identified above, and alkalinity requirements as required by the Cathodic Protection supplier

1.1 CIF Performance Criteria

CIF mixed according to the proportions and mix procedures determined by the injection engineer shall have demonstrated properties suitable for masonry injection. Demonstration that the CIF formulation meets performance criteria shall be provided prior to beginning the project in the form of test reports from a qualified laboratory. Performance criteria include

- Flow time: API Recommended Practice 13b or ASTM C 939, *Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)*; materials shall be

required to flow without separation; flow time will be specified for the project by injection engineer, typically in the range of 9 to 55 seconds.

- Bleeding: ASTM C 940, *Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory*; no greater than 0.5 percent.
- Mix stability: measured with the Gelman pressure cell; water loss under 10 psi pressure shall not be more than 1 ml per 350 ml sample.
- Expansion: ASTM C 940; range shall be specified by the injection engineer, considering the in-place material and project objectives, typically in the range of 1 to 4 percent.
- Shear bond strength: ATC (Tentative Provisions for the Development of Seismic Regulations for Buildings); shall be greater than 100 psi., as tested in a mockup panel constructed to be representative of in-place construction.
- Compression strength: ASTM C 1019, *Standard Test Method for Sampling and Testing Grout*; strength shall be compatible with base material.
- Flow within a compatible material: MSI 101 *Test for injection of compatible materials*; flow shall be within historical and empirical guidelines.

2.0 EQUIPMENT

The contractor shall provide all necessary equipment for completing CIF, including mixers, pumps, and quality control equipment. Equipment shall be in working order and calibrated, where applicable. Equipment shall be verified as appropriate for use on historical projects, where applicable.

Equipment for injection shall be low pressure range self-dosing, automatic mixing with automatic pressure shutoffs, and rheostat wall controls, self leveling mixing controls, and pressure valves at the pump. Material flow will be calibrated daily by flow cone tests. No hand-mixing or small (200 pound or less packages) mixes will be allowed except for material within one-half meter of windows, doors or wall terminations, or secondary fine material injection.

3.0 PERSONNEL

3.1 Qualifications

Qualification data shall be submitted 14 days prior to start of CIF operations. All injection personnel shall have training in CIF as certified by the Masonry Injection Training Center, Boulder, Colorado. Qualifications shall be current as demonstrated by certification and remedial training conducted within the previous 6 months and updated on a 6-month basis.

3.2 CIF Applicator Qualifications

CIF of masonry walls is a specialized technique. The applicator for this work shall have demonstrated capabilities by way of Masonry Solutions Injection Certification and a minimum of six years successful experience with projects of similar scope and size using the techniques described herein.

3.3 CIF Engineer Qualifications

A qualified independent CIF engineer shall be approved by the project architect for inspection and nondestructive testing of the CIF work. The engineer shall have as minimum qualifications 10 years previous experience in CIF, testing, analysis, and application of injection techniques for

masonry repair, as demonstrated by previous projects and articles published in industry publications.

3.4 Injection Personnel

A three-man crew is required to conduct CIF. The crew must be familiar with masonry construction and be certified for CIF. Crewmembers are designated as the foreman, a material and equipment person, and one assistant.

The foreman must have had previous experience with CIF and must be competent in all skills of the CIF operation. The foreman will direct wall preparation, equipment setup, injection, and cleaning operations. The crew foreman will also act as the nozzleman and will operate the injection hose at the wall. The foreman will record the following in a daily log:

- personnel involved
- weather conditions including temperature, humidity, cloud cover, and wind
- time of operations
- total production and tasks completed
- equipment performance
- personnel performance
- notes regarding any special or non-typical situations encountered during the day

One person is in charge of CIF materials, including material storage, batching, mixing, and conducting flow tests. Information regarding batch volume, flow, and injection area is entered into a logbook for each batch. This person is also charged with equipment setup and maintenance, including proper cleaning of mixing and injection equipment.

Two persons will act as assistants to the foreman during wall preparation, CIF injection and masonry cleanup. During CIF injection, one assistant will be stationed at the outside wall face and will plug injection holes as CIF flows from them. The second assistant will be stationed at the building interior to watch for potential CIF leakage and will notify the foreman to halt injection if any CIF is observed at the inside wall surface. The interior observer must have adequate access and lighting to identify CIF leaks in the vicinity of the injection area. The two assistants must be within voice or radio contact. Where finishes cover interior masonry surfaces, nondestructive means shall be employed to monitor for CIF leakage.

4.0 PROCEDURES

4.1 Pre-Injection Evaluation

A visual assessment of masonry material condition should be conducted by the qualified engineer or his representative for each area to be injected. The initial survey will include mapping the extent and size of any visible surface cracks, mortar blockages, mortar joint delaminations, cracked or spalled units, or other visible surface damage which may have an effect of CIF confinement or the injection process itself. Note any situations requiring special treatment before CIF injection, such as wall penetrations, expansion joints, flashing, weepholes, and parapets.

4.2 WALL PREPARATION

4.2.1 Surface Repairs

Do not allow CIF to flow into existing expansion or control joints. Provide a means to interrupt CIF flow at each existing movement joint such that CIF is prevented from penetrating into the joint. Seal around all wall penetrations (including electrical outlets, water cocks, doors, windows,

etc.) flashing, and beam seats to prevent leakage such that all CIF will be contained within the wall.

Masonry walls containing significant interior voids such as empty or partially empty collar joints must have sufficient connection between wythes to resist injection pressure, as determined by the injection engineer. Deficient areas shall be strengthened by installation of remedial dry-fix wall ties at a spacing not to exceed one tie equivalent per 2.67 square feet of wall area.

4.2.2 Injection Holes

Injection holes are to be drilled in the mortar joints. Holes for collar joint injection must be drilled through the exterior wythe to intercept the collar joint but not into the backup wythe. Use a depth gage mounted on the drill to obtain the proper hole depth. The diameter and spacing of injection holes shall be determined during the initial site investigation, but in no case should the hole diameter exceed ½ inch nor the hole spacing exceed 16 inches vertical spacing and 48 inches horizontal spacing.

4.2.3 Lugeon Testing

Lugeon tests shall be conducted to determine CIF fluidity and aggregate requirements. The method is to be calibrated on site by determining the water flow rate that indicates void spaces greater than 1/8" wide, for coarse CIF injection, versus the flow rate for void spaces less than 1/8" wide, for fine CIF injection. Identify CIF required for each wall area based upon results of Lugeon testing. The number and spacing of injection holes tested in this manner shall be dictated by the injection engineer but shall be a least 25 percent of total number of injection holes.

4.3 CIF Mixing

Mix all CIF materials according to supplier's recommendations. Monitor flow times of CIF using appropriate quality control procedures to verify proper formulation and mixing. Flow properties must meet project specifications. If the measured CIF flow varies by more than 10% from project requirements, discard the entire CIF batch. CIF shall not be used more than 1 hour after adding water to dry ingredients.

4.4 CIF Injection

CIF injection will proceed within specific repair areas, delineated horizontally by control joints, corners, or returns, and vertically by story levels or flashing locations. The following procedure applies to each specific "repair area" to be injected with CIF.

4.4.1 Water Flushing

Flush all injection holes within the designated repair area with water before CIF injection. Starting at the top of the repair area, inject a small amount of water (from ½ to 2 pints) into each injection hole to flush away dust and drill cuttings. When operating outside in hot weather conditions, with temperatures greater than 90 F, spray additional water into each injection hole to cool and partially saturate the masonry.

Proceed across the repair area, then downward, flushing each injection hole in turn. When the second row from the bottom is reached, continue flushing until water flowing from the bottom-most holes runs clear and free from debris. It is not necessary to flush the bottom row of injection holes.

During the flushing procedure water must flow freely into each injection hole. If a hole is partially or totally blocked, drill a new injection hole approximately 4 inches (along the same row) to each side of the blocked hole. Do not allow pressure buildup in excess of 10 psi during flushing.

Immediately prior to CIF injection (within 10 minutes) spray the masonry surface lightly with water, if necessary, to prevent CIF adhesion. Keep a water hose and brush on hand during injection for cleaning any CIF spills from the masonry surface.

4.4.2 CIF Injection

Injection shall proceed from the base of the repair area to the top, moving first across the wall horizontally and then upward, in lifts of 4 feet or less. Other lift heights may be required, as determined by the injection engineer. A lift is defined as the height of CIF in a single continuous operation. An injection pressure of 8 to 12 psi is to be maintained during injection.

Injection begins at the lower-most injection hole at one edge of the injection area. Holes located above and to the side of the injection hole must be plugged when CIF flows from them. A small quantity of standing water may be present at the base course from the flushing procedure; do not plug holes along the base course until un-diluted CIF flows from each hole.

Injected CIF will stiffen rapidly after placement: injection of each lift should proceed in continuous fashion, with no time lapses of more than three minutes during injection of any single lift.

Allow in-place CIF to stiffen before proceeding to the next lift. Proceed with injection of the next lift as described above until all holes in the designated repair area have either been injected or plugged. A maximum height of 12 feet may be injected in any 24-hour period.

4.5 Wall Cleanup

Surface cleaning shall be conducted during injection by immediately flushing any CIF from the masonry surface with water. Immediately following completion of the injection process, remove any remaining surface stains using water and a stiff, non-metallic bristle brush.

Allow CIF to stiffen but not set before removing dowels from injection holes; an elapsed time of 30 to 60 minutes is sufficient. All injection holes left in mortar joints must be re-pointed. The injection hole should be flushed with water and should be damp, but not saturated, prior to re-pointing. Point a mortar similar in color and composition to the original mortar firmly into injection holes and tool to match the surrounding mortar.

5.0 QUALITY VERIFICATION

The approved injection engineer shall conduct nondestructive verification of CIF penetration. Verification shall consist of pulse-echo, infrared thermography, microwave radar, or through-wall pulse velocity nondestructive measurements conducted throughout the injected area. The injection engineer shall determine the number and location of such tests by a random statistical process. Approximately 10 percent of the injection area is to be tested to verify injection quality.

Nondestructive measurements and visual inspection by the engineer shall confirm the presence of CIF in the wall and adhesion of CIF to existing masonry. Where confirmation cannot be made or evidence of incomplete adhesion is found inspection holes shall be drilled to verify CIF by borescopic examination. Locations where CIF is not to the satisfaction of the injection engineer shall be re-injected.

Results of quality verification testing shall be kept in a log book showing areas inspected, how areas were chosen for inspection, equipment used, results of nondestructive tests, and actions

taken at locations found to be in non-compliance with these specifications. The logbook should be keyed to a plan view of the floor level, room number, and elevations view of the walls with areas inspected drawn on the elevation views of the walls.

CIF Specifications
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