TOWN OF WESTBOROUGH, MA

WESTBOROUGH FIRE STATION
EXTERIOR ENVELOPE REPAIRS

September 2001

Maguire Group Inc.
225 Foxborough Boulevard
Foxborough, MA 02035

The Westborough Fire Station was inspected by Maguire Group Inc., principally to assess the exterior envelope conditions of the original 1888 building and to make recommendations for repairs. The exterior walls of the original building are in immediate need of repair to preserve the integrity of the exterior walls and to prevent possible injury from falling brick.

Maguire has provided the following existing conditions report along with recommendations for repair. A cost estimate has been provided in order to fully assess the recommendations in terms of available funding and the future plans and needs of the Fire Station.

Because the Fire Station is located within the Downtown Business District, it falls under the advisory of the Downtown Westborough Design Review Board, and ultimately the appropriate permitting authorities. While the 1888 Fire Station is not a significant historical structure because of the many violations to the existing structure due to additions, renovations and alterations, it is nonetheless located in the "Historic District" of Downtown and theoretically falls under the guidelines of historic preservation as established by the local Historical Commission. Regardless, neither the Federal nor the State Historical Commission has any jurisdiction, unless grant funding is utilized for repairs to the building. Our recommendations, however, have taken into consideration the efforts of the Westborough Design Review Board and the Westborough Historical Commission to preserve the heritage of the Village Center by minimizing "removal or disruption of historic, traditional or significant uses, structures or architectural elements as set forth by the Design Guidelines."

The recommendation provided is the most economical and least disruptive solution that meets the immediate needs of the Fire Station and falls in line with the preservation intent of the "Historic District." Maguire Group Inc. is available to review and discuss the recommendations and to assist the Fire Station as necessary in implementation.

The Westborough, Massachusetts, Central Fire Station, located at 42 Milk Street in the center of town, was originally constructed in 1888. Additions, renovations and structural repairs and upgrades have kept the Fire Station operational and serviceable throughout the years. This report concerns the original masonry walls, and the following general description of the building provides background for our field observations and resulting recommendations.

The 1888 structure has brick composite, load-bearing, unreinforced walls and heavy timber framing, with the exception of the floor decks of the apparatus bays which were replaced with concrete joist slabs in the early 1900's. The framing systems of the upper floor, the attic level and hip roof are hung from and supported by the masonry composite walls. Buildings of this era were constructed primarily as masonry fabrications. These older masonry systems were intended to support the floor loads incrementally as they rose to the wall tops. In this structure, the ground floor is supported by the foundations. The typical wall thickness of 3-wythe (3 brick widths) supports the second floor and steps to a 2-wythe thickness at the attic level. There is decorative dentil corbelling at the top of the walls and hose tower. A painted metal cornice gutter system encases the junction of the wall and roof for the entire perimeter of the building. Granite banding, along with granite window headers and sills accentuate the brick facades.

The following discussion of historical brick and mortar provides a basis for appropriate design selection, implementation and compatibility of 1888 brick construction with modern brick and mortar.

Historical Brick

Historically bricks were manufactured in several grades for use in various locations. A manual on the subject published in 1899 (eleven years after the construction of the Fire Station) lists and describes brick as follows:

Common Brick: Brick which was intended for constructional, and not for ornamental purposes, and had no special pains taken in their manufacture.

Stock Brick: Brick which was hand-made and intended for face work; greater care was taken in the manufacture and burning than with common brick; used extensively for the outside facing of factories, machine shops, etc. In the Eastern states, these bricks were sometimes called *face* brick.

Pressed Brick or Face Brick: Brick made in a dry-press machine, or that have been repressed; usually very hard and smooth, with sharp angles and corners, and true sides and beds; cost from two to five times as much as common brick, and were usually laid only in the face of the wall.

All three of these brick types appear to be present in the masonry of the Fire Station. The manual goes on to describe a number of qualities that good brick should have, including strength.

Strength and Quality of Brick: The transverse strength of a brick is quite as important as the crushing strength. A good brick, 8 inches long, 4 inches wide, and 2½ inches thick, should not break under a center load of less than 1,600 pounds, the brick lying flat, supported at each end only, and having a clear span of 6 inches and a bearing at each end of 1 inch. A first-class brick will carry 2,250 pounds in the center and not break.

Modern bricks are, as a rule, much stronger than historic brick. The kiln temperatures are higher, quality control of ingredients is much better, and the brick are much more uniform than their historic counterparts.

- *Minimum Compressive Strength (bricks tested lying flat):*

  Grade SW: five brick average 3,000 foot-pounds per square inch
  Grade MW: five brick average 2,500 foot-pounds per square inch
  Grade NW: five brick average 1,500 foot-pounds per square inch

While the existing brick on the Fire Station may meet the minimum allowable compressive strength of modern brick, problems arise when specifying and attempting to purchase modern brick with this low a compressive strength per square inch. Most bricks sold today have an average compressive strength of 10,000 pounds per square inch or more. Theoretically, modern brick with a strength as low as 2,500 psi is made and should be available, but generally there are long lead times for orders of soft brick.

Despite the difficulties in obtaining brick of such low compressive strength, we highly recommend it. The introduction of a harder brick in the wall assembly will create a hard spot that will not act in the same semi-plastic manner as the rest of the wall. The new work could be a source of future damage unless the new brick is fairly close in compressive strength to the older ones composing the remaining wall area.

The original exterior walls exhibit severe weathering and deterioration. These masonry walls have many open joints, and mortar is missing entirely in areas of the walls. In the areas where mortar is missing, it appears that significant water infiltration and the east-southeast weather exposure are the main culprits. The combined effects of leaks in the cornice gutter system along the perimeter of the pitched roof areas, water trapped and infiltrating the hose tower walls at the metal banding, weathering and lack of wall maintenance, have weakened the mortar materials as the soluble minerals have and are leaching out. This does occur, to an extent, naturally as masonry ages; however, water infiltration and severe weathering exacerbates the process.

A crew from Geisser Engineering worked on July 23, 2001, to remove brick and mortar at several wall locations to examine the depth of deterioration. The mortar condition was good in the lower half portion of the wall. In the upper half of the wall, the mortar was partially or fully disintegrated. The brick appeared in good condition for the full height of the wall. A small diameter hole was drilled in the brick wall to determine the wall thickness. It was observed that the wall is made up of three wythes of brick, for a total thickness of 13 inches. A structural engineer, architect an construction supervisor from Maguire Group were present to observe and examine.

Geisser Engineering visited the site again on August 17, 2001, to drill two 8-inch diameter cores in the brick wall. The purpose of the core drilling was to observe the condition of the brick and mortar in all three wythes and to view conditions in several brick courses. One core was drilled approximately 4 feet above the base of the wall and the second core was drilled about mid-height of the wall. Two wythes of brick were removed by the core drilling. It was observed that the brick and mortar in all wythes of the lower core were in good condition. Examination of the upper core indicated that the brick there was in good condition, but the mortar had mostly disintegrated.

The brick was not tested for structural strength, but because of its age, appearance, hardness and in-place field condition, the types of brick found within the wall are assured to range from 2,000 to 5,000 psi in compressive strength. No structural problems associated with the brick were identified, and thus no strength testing was deemed necessary. There was no evidence of movement of the wall as a unit; however, the exterior wythe in areas is in danger of falling off. There are three distinct locations that are in immediate danger, two areas at the corbelled tops of the east wall, and one area below the northwest corner of the metal banding at the hose tower. In these areas, the mortar has completely disintegrated and is missing. There are also other areas on the original walls that are progressing toward this dangerous condition.

Mortar disintegration will ultimately be the downfall of the original walls. It appears that a significant amount of the lime has leached out of the original mortar, thus the disintegration. Even in areas not exhibiting water infiltration problems, the mortar was found to have lost strength and in the process of decomposing. There was evidence of three different repointing mortars on the original wall. These mortars were all significantly harder than the original mortar. While currently the mortar has enough strength to bond the wall composition sufficiently for the wall to function appropriately structurally, remedial measures must be undertaken to protect and ultimately prolong the life of the original walls.

The exterior wall face will need to be made water-tight, yet breathable. When repointing, it is important to note that the mortar should not be stronger than the brick. Additionally, the existing mortar appears to be a mortar originally with a high lime content. Use of a Portland cement mortar over a lime mortar will trap moisture in the walls and should be avoided.

There are several available products specifically designed to stabilize masonry walls where the wythes have debonded either due to deterioration of the existing ties or disintegrated of mortar. One such product is manufactured by Helifix North America Corporation. A company

representative was invited to visit the project site and demonstrate their anchor system and its ability to restore the brick wall in question.

Mr. Patrick Morrissey of Conspec Associates visited the project site on August 28, 2001. He installed 8 mm diameter ties at three critical locations. A 6.5 mm entry hole was drilled through the exterior brick and into second and third wythes of masonry to a depth of approximately 11 inches. The ties were driven into position and recessed by means of a setting tool. These ties structurally bond the three wythes of brick. The recommended tie spacing would depend upon the Code-required design wind load for the project site.

It is Maguire's opinion that stabilizing the brick walls utilizing the spiral ties would provide the most economical and least disruptive solution.

The following repair recommendations are based on the field observations and the test installation of masonry restoration ties.

The brick composition walls, which includes the east wall, hose tower and chimney, should be pinned and stabilized utilizing spiral stainless steel masonry restoration ties previously described in this report. The ties will most likely require spacing horizontally at 24 inches on center and vertically at 16 inches on center.

To prevent further wall infiltration, the existing metal gutters and metal hose tower banding should be replaced with a new two-piece gutter system to match the original cornice profile and new metal banding to match the profile of the original, both flashed appropriately. New membrane flashings and linings should also be provided.

Any spalled, cracked or otherwise damaged brick should be removed and replaced with new brick, appropriately selected. Brick replacement should occur during the repointing phase of work.

The original masonry walls should have all the masonry joints cut out on the exterior and face and repointed with an ASTM Type O mortar. Specifications for this work should emphasize the importance of proper finishing and joint tooling when working with soft mortar. It should also be noted that in areas where repointing occurred in the past, the mortar is much harder and care should be taken to not damage the brick.

Prior to repointing, the walls should be cleaned with a water-based solution with the appropriate chemicals based on testing and approval utilizing a moderate pressure (75 to 150 psi) rinse. This will wash out a significant amount of the loose mortar. This work should be done in warm weather to allow the wall to dry out and avoid significant freeze-thaw damage.

APPENDIX A

COST SUMMARY

COST ESTIMATE
WORK SHEET

Description	Quantity	Unit	Unit Cost	Total Cost
Spiral Ties - 8mm	1,800	Ea	$18.0	$32,400
Cut Out and Repoint Mortar Joints				
East Wall	950	Sft	$24.0	$22,800
West Wall	450	Sft	$24.0	$10,800
South Wall	300	Sft	$24.0	$7,200
Hose Tower	1,250	Sft	$32.0	$40,000
Chimney	200	Sft	$24.0	$4,800
Replace Damaged Bricks	1	LS	$5,000.0	$5,000
Replace Existing Gutter	110	Lft	$50.0	$5,500
Replace Existing Metal Band - Hose Tower	1	LS	$5,000.0	$5,000
Sub Total				$133,500
10% Contingency				$13,350
20% Contractor's OH and Profit				$29,370

$176,220

APPENDIX B

PHOTOGRAPHS

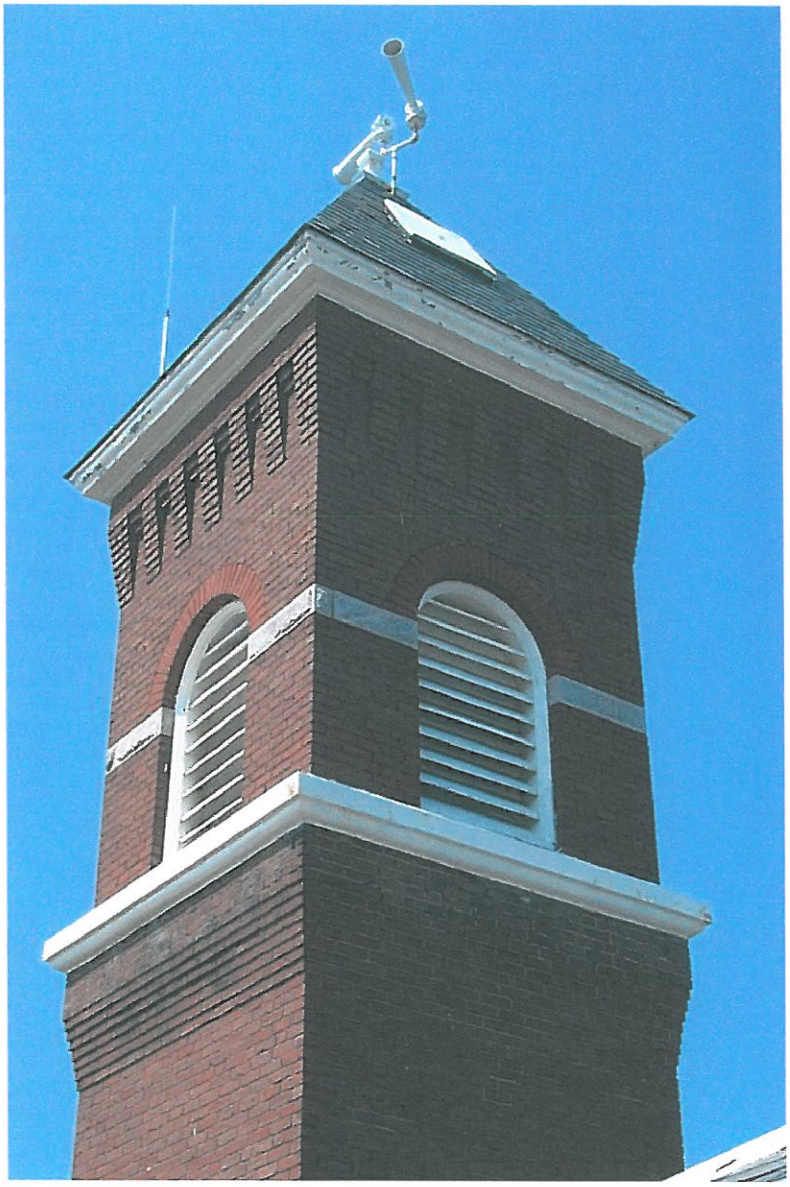
East Wall, Hose Tower and Chimney

Wall deterioration at east wall.

Wall deterioration at hose tower

Wall deterioration at east wall

East Wall



Hose Tower

Chimney

Typical condition of original walls.

Wall deterioration.

Missing mortar typical of original walls.

Dentil corbelling deterioration.

Mortar disintegration.

Deterioration.

Interior wall face at attic.

Brick core at wall base.
Note good mortar condition.

Brick core at wall mid-height.
Note deteriorated mortar.

APPENDIX C

MANUFACTURER'S LITERATURE

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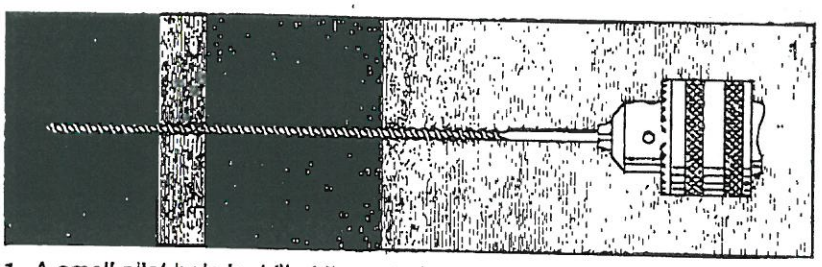
DRYFIX® MASONRY PINNING

The DryFix patented method of masonry stabilization involves simply driving a Helifix stainless steel tie through the masonry, via a small pilot hole, using a unique installation tool. The self-tapping DryFix tie cuts a threaded groove into the masonry as it is driven into position to provide a solid connection between wythes without the use of toxic chemicals, mechanical expanders or rigid rod connections.

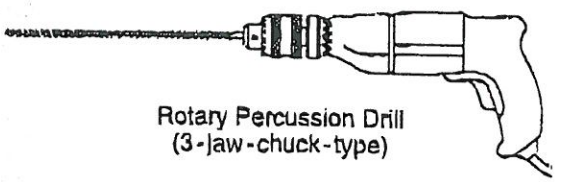
Helifix ties are engineered from austenitic stainless steel and have a unique helical Hi-Fin design. They combine axial strength to withstand all anticipated wind loadings in both tension and compression with sufficient flexibility to accommodate normal building movement.

The DryFix system provides effective and economical stress-free connection between all commonly used materials in cavity and solid masonry constructions and has been widely used in high rise, domestic and commercial applications throughout North America and other parts of the world.

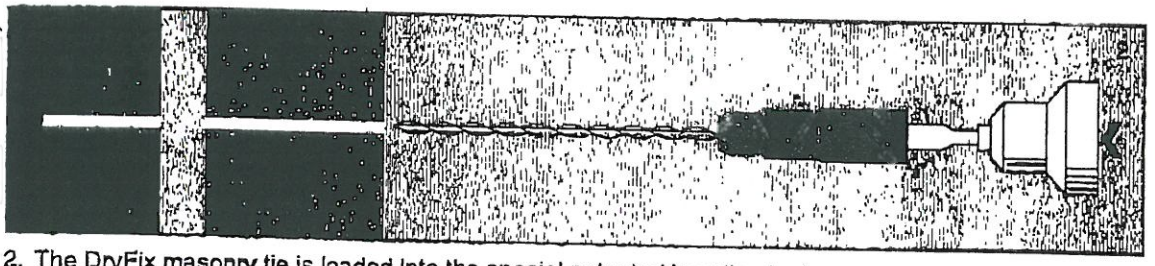
Installation



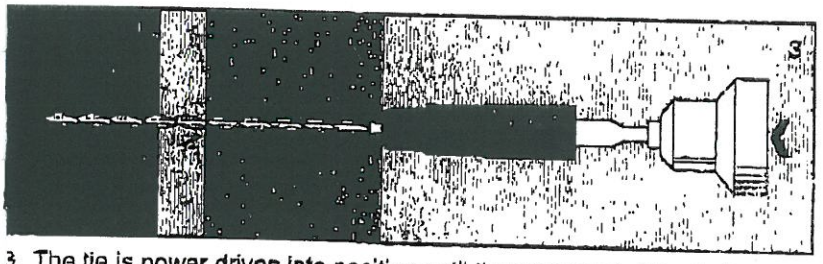
1. A small pilot hole is drilled through the masonry and into the backup material, to a predetermined depth, using a rotary percussion drill (3-jaw-chuck-type).



Rotary Percussion Drill
(3-jaw-chuck-type)

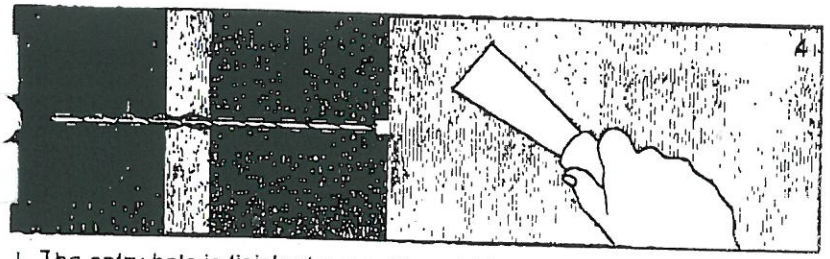


2. The DryFix masonry tie is loaded into the special patented insertion tool which is fitted to an electric hammer drill (SDS type).



3. The tie is power driven into position until the outer end of the tie is automatically recessed below the face of the masonry by the insertion tool.

Hammer Drill (SDS type chuck)



4. The entry hole is finished over with matching materials.

DRILLING TECHNIQUES have been developed to optimize the performance of the DryFix System.

Procedures for drilling are available together with product specifications for typical masonry stabilization problems.

Rotary percussion drilling usually achieves the best results, SDS hammer drilling may be required where masonry material is extremely hard or dense.

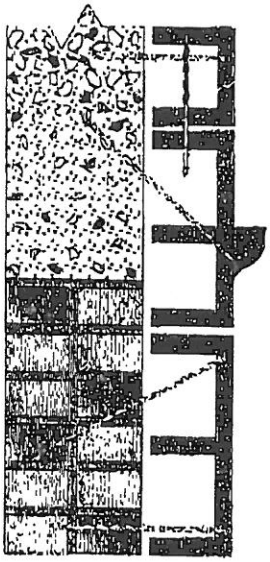
NOTE: The SDS hammer drill is ALWAYS used with the DryFix Insertion tool to set the Helifix tie in place.

Features and Benefits

- A one-piece, austenitic stainless steel wall tie
- Quick and easy to install
- Requires only a small diameter pilot hole
- No toxic chemicals or expansion devices involved
- Easily site tested immediately after installation
- Used in all common masonry materials and wood
- Withstands cyclic loading
- Accommodates differential movement between materials
- Combines flexibility with strength
- Does not stress or fracture fragile substrates
- Usable in all weathers, environments, temperatures and seasons
- Minimal special equipment and labor training involved
- Widely used across North America

Standard DryFix® Procedures

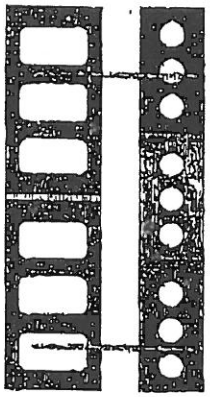
The DryFix techiques below involve different installation procedures, specialty drills and tools. A job-site survey should be carried out prior to start-up to determine material strengths, pilot hole size, appropriate drilling techniques and the correct tie length and optimum spacing. Standard procedures are available for common situations.



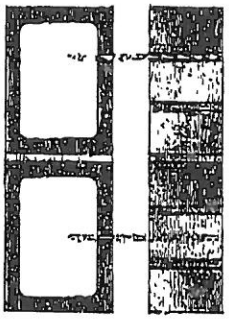
a. Fine terra cotta to masonry

b. Brick to clay tile

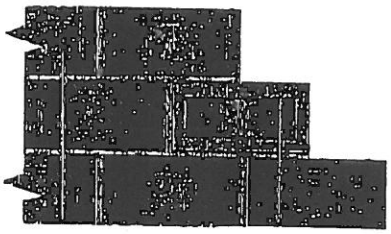
c. Brick to concrete (mortar joint or solid brick)



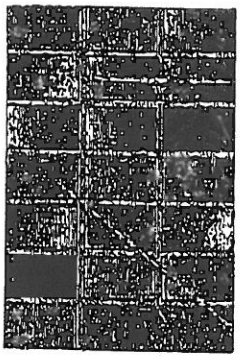
d. Brick to concrete block



e. Brick to concrete block (mortar joint or solid brick)

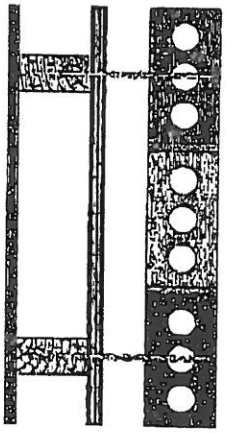


f. Brick multi wythes (Plan)

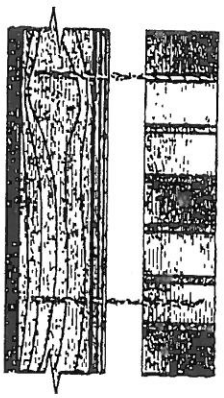


f. Brick multi wythes (Section)

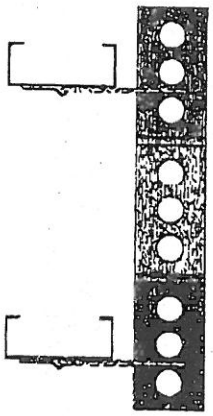
g. Repairing limestone/sandstone or brick arches and lintels



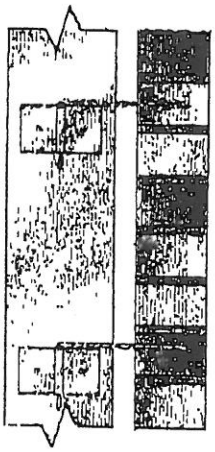
h. Brick to wood stud (Plan) (mortar joint or solid brick)



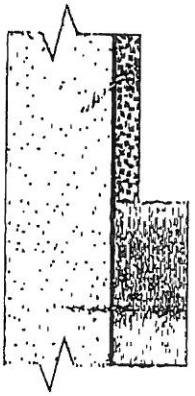
h. Brick to wood stud (Section) (mortar joint or solid brick)



i. Brick to steel stud (Plan). Interior installation



i. Brick to steel stud (Section). Interior installation

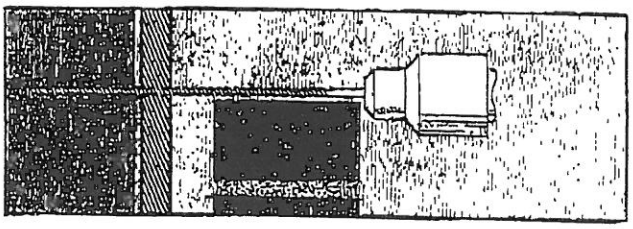


j. Stone, marble or granite panels to concrete

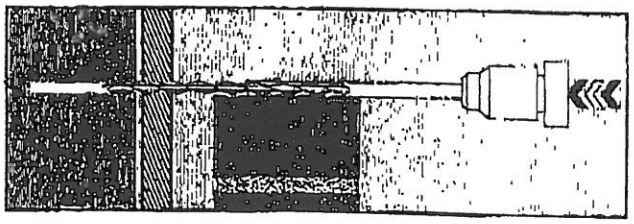
NOTE: Detail 'h' may also be installed from the interior as in detail 'i'

Masonry Refacing / New Construction

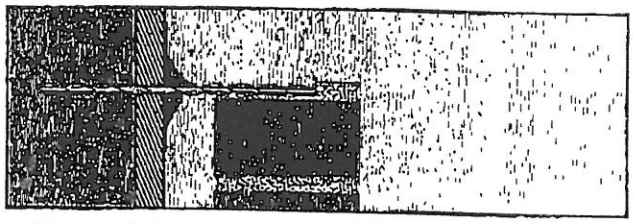
As the new outer masonry wythe is constructed, Helifix ties are installed at a predetermined spacing as specified by the designer.



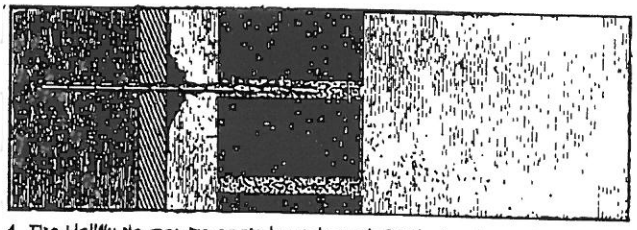
1. A pilot hole is drilled into the backup substrate to a predetermined depth



2. The Helifix stainless steel masonry tie is loaded into the support tool and driven into position.



3 Where required, an insulation retainer is snapped into position over the Helifix tie.



4. The Helifix tie may be angle bent through 90° before being 'wet set' in mortar prior to the next brick course being laid.

Site Testing

Helifix ties can be proof tested immediately after insertion into the backup to check the strength of the connection. The Helifix 675lbf (3kN) load test unit (right) is custom designed for this purpose.

The quick release collet-key is placed over the tie and a test load applied. The gauge gives an immediate direct reading. For quick general testing, the collet-key can be used on it's own with just a manual pull.

Load Test Unit

Load Requirements

The primary function of a wall tie system is to enable the outer masonry to withstand wind loads while allowing differential movement between adjacent layers.

Masonry walls should not be considered as a continuous panel but rather as a series of load sharing units.

In this context Helifix remedial wall ties function as a flexible load sharing device for masonry walls rather than as a rigid anchoring mechanism.

The use of rigid anchoring systems should be avoided as their inability to accommodate normal building movement could lead to wall failure.

A minimum pull-out load of 225 lbf (1kN) will usually be obtained from even the weakest masonry with much higher results from normal materials.

Tie performance in weak masonry is allowed for by reducing the tie spacing thereby increasing the tie density.

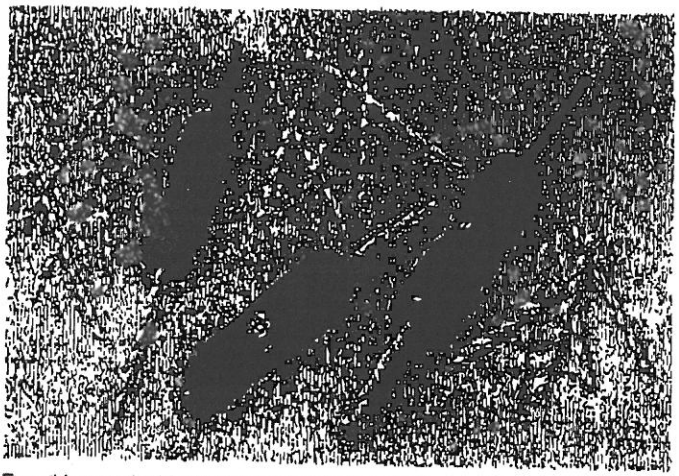
Product Testing

Helifix ties have been subjected to extensive testing in a wide range of materials. Standard data are based upon the test results. However, few, if any, buildings match laboratory conditions and wherever possible site tests should be conducted to determine the physical dimensions of the wall and the pull-out loads achievable. From this information a specification can be produced based upon reality and not theory.

Tie Selection

1. Material: Austenitic stainless steel grade 304. For severely corrosive conditions ties in grade 316 are available.
2. Ties are available in two diameters: 8mm and 10mm.
3. Tie diameter and length are dependent upon the strength of the wythes, the cavity width and the outer wythe thickness.
4. Tie spacing is set to match the anticipated wind loads with the pull-out loads achievable and must take into account any local building codes.

DryFix™ Tools & Accessories



Everything required for the DryFix system is available from Helifix and is detailed in the relevant standard procedure.

For further information contact:

Helifix North America Corporation, 110 Maplecrete Road, Concord, Ontario LK4 1A4, Canada

Toll Free: 888-992-9989

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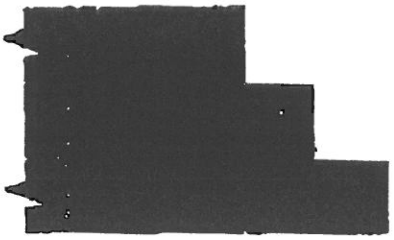

MULTI-WYTHE BRICK

SPECIFICATION

ALL MULTI WYTHE BRICK IS TO BE STABILIZED BY MEANS OF AN 8MM HELIFIX 304 STAINLESS STEEL REMEDIAL WALL TIE BY HELIFIX NORTH AMERICA

INSTALLATION PROCEDURES

INSTALL HELIFIX STAINLESS STEEL TIES INTO THE EXTERIOR MASONRY USED IN A ' **DRYFIX** ' TECHNIQUE AT SPECIFIED SPACING AS PER THE FOLLOWING PROCEDURES:

- A 6.5MM ENTRY HOLE SHALL BE DRILLED THROUGH THE EXTERIOR BRICK AND CONTINUOUSLY DRILLED INTO THE SECOND AND / OR THIRD WYTHES OF MASONRY TO A DEPTH TO BE SPECIFIED BY THE DESIGNER. THIS DRILL PROCEDURE SHALL BE CARRIED OUT BY MEANS OF A HIGH SPEED ROTARY PERCUSSION DRILL (3 JAW CHUCK TYPE)

NOTE: SITE TESTING WILL VERIFY DRILL ENTRY HOLE SIZES AND ANY NECESSARY ADJUSTMENTS MAY BE MADE AT THAT TIME

- THE HELIFIX TIE SHALL THEN BE DRIVEN INTO POSITION AND RECESSED BY MEANS OF A HELIFIX ' **DRYFIX** ' SETTING TOOL MOUNTED ON AN ELECTRIC HAMMER DRILL (S.D.S. TYPE)

NOTE: A ' **DRYFIX** ' SUPPORT TOOL MAY BE REQUIRED WHEN INSTALLING LONGER LENGTHS OF THE HELIFIX TIE INTO DENSE MASONRY UNITS

- PATCH ALL PENETRATIONS TO MATCH EXISTING AS APPROVED BY THE SPECIFIER

ALL RELEVANT DRILL BITS AND SETTING TOOLS SHALL BE SUPPLIED BY :

HELIFIX®

North America Corporation **110 Maplecrete Road, Concord, ONTARIO, Canada L4K 1A4**

Toll Free: 888-992-9989 **Tel: 905-761-0042** **Fax: 905-761-0045** **www.helifix.com**