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DETERIORATION OF MASONRY CAUSES AND PREVENTION

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ABSTRACT

Increasing attention is being focused on the durability of the materials forming cladding assemblies.

This attention is a direct result of the very high costs now associated with the repair and maintenance of our portfolio of ageing buildings and by the widely differing philosophies applied by architects, building scientists and builders to design, construction and restoration work in terms of materials, procedures and assumed life expectancies.

Localized deterioration of masonry in the form of delamination and crumbling of the masonry units themselves is a common occurrence with failure happening either randomly or at specific repetitive locations.

The relationship between masonry deterioration and both cold weather air exfiltration and the presence on the face of the masonry of melt water from perched accumulations of snow and ice will be examined.

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The applicability of today's testing methods as referenced in the CSA and ASTM standards will be reviewed and the merits of the procedures now widely used in Europe will be briefly discussed in relation to temperature gradient conditions typically existing in a masonry wall.

The different categories of masonry deterioration will be briefly discussed together with repair options.

INTRODUCTION

Research is normally undertaken by government agencies and academic institutions without integrating the financial and managerial considerations in the equation in terms of cost effective durability.

The Canadian Standards Association is currently undertaking the publication of a Canadian standard on "Guidelines on Durability in Buildings". As a member of that committee I can attest to the emphasis made by the committee members regarding avoidance of the premature failure of building components. To have an acceptable level of durability in masonry the end product must function for the service life of the structure without incurring unpredictable costs.

It is essential that the needs of building owners and managers be integrated with the growing fund of knowledge now available regarding the performance and life expectancy characteristics of differing design details and materials to construct a masonry cladding with predictable repair and maintenance requirements and a predictable life expectancy in the context of the implementation of the appropriate program of maintenance work.

This integration process is applicable to our ageing buildings since the maintenance and repair of the masonry cladding of many of our high rise buildings must be co-ordinated with other considerations including cash flow and building management, maintenance of resale or rentable value and, in terms of the occupants, maintenance of a desirable environment.

CATEGORIES OF DETERIORATION

Deterioration of masonry generally fits into one of the following categories:

- Predictable
- Predictable with hind sight.
- Unpredictable environmental conditions
- Construction or material defects

- Latent defects in the cladding assembly.

The first category of deterioration is unavoidable, predictable and acceptable with a flexibility in the timetable of the maintenance work required to respond to the gradual deterioration that allows building managers the leeway of not only choosing between pro-active and re-active maintenance but also of adjusting expenditures to suit year to year fluctuations in the availability of funds for maintenance work.

The other four categories are all avoidable and result in unexpected expenses which may be sufficiently high.

PREDICTABLE

Masonry is a composite assembly of masonry units and mortar which is supported vertically and, with respect to panels and veneer, horizontally and which may be reinforced.

For masonry to accommodate annual cycles of thermal movement without hairline cracks developing in the joints the mortar should be weak. In order for the mortar to be durable and resist gradual erosion of the outside surface by weathering it should be strong. This creates a contradictory dichotomy that is normally addressed by the provision of a medium strength mortar that satisfies neither requirement.

As a result masonry with time generally develops hairline cracks in the joints accompanied by the gradual erosion of the exposed mortar surface making eventual maintenance inevitable.

PREDICTABLE WITH HIND SIGHT

The configuration of the building envelope dictates requirements regarding control joint locations and metal flashing and sill details.

It is often difficult both to select the appropriate number of joints and to correctly locate them particularly since it is appropriate to minimize the number of control joints to that required for satisfactory performance since initial cost, appearance and future maintenance costs are all relevant considerations in the design of a building envelope.

As a result self made control joints may develop making necessary the repair of the masonry and construction of control joints at these locations.

Localized deterioration of masonry may occur in the form of discolouration resulting from concentrations of rainwater pouring down the face of the building at locations determined by the configuration of the masonry or the size and configuration of the metal flashings and sills.

This may be avoided by careful attention to detail at the design stage with scrupulous attention being paid to such items as the size, shape and location of drip channels.

Perched accumulations of snow and ice on sills, ledges and wall tops creates the potential for melt water to run down over the face of masonry during periods when the air temperature is hovering around the freezing point. This will result in the surface layer of masonry being subjected to repeated cycles of freezing and thawing while in a saturated condition which frequently causes localized progressive deterioration of the masonry units in the form of spalling and delamination of the face.

The solution is to replace the damaged masonry units and change the service environment to prevent a repetition.

UNPREDICTABLE ENVIRONMENTAL CONDITIONS

A hostile micro environment created by design or construction deficiencies is excluded from this category which addresses the general environment created by the weather and localized changes in environment created by unique events.

Unique conditions such as physical impact, fire, earthquake or tornado will, in one brief moment, create havoc with previously stable and durable masonry creating the need for extensive repair work.

Progressive chemical contamination resulting from airborne or rainborne pollutants may result in the surface deterioration of masonry requiring a repair methodology that may vary from a one time, permanent repair of the masonry and prevention of a recurrence of the problem to a continuing program of preventative or re-active maintenance work made necessary by the contamination.

DESIGN, CONSTRUCTION OR MATERIAL DEFECTS

Design defects may result from the inexperience or carelessness of the designer or from lack of knowledge regarding the performance characteristics of the building under design and the materials specified.

Performance problems with masonry cladding may occur due to a lack of knowledge of the long term behaviour of a particular design.

At one time horizontal control joints were not routinely incorporated into the masonry cladding high rise residential buildings despite a general awareness among engineers that the height of the concrete from a 20 storey building would shrink by about one and a half inches during the first 5 to 10 years due to creep of the concrete and also that the floor slabs would deflect significantly at mid span for similar reasons.

This created spalling and buckling problems in the brickwork that were costly to repair and in the 1980's reached almost epidemic proportions in relation to buildings constructed in the seventies.

A review of the National Research Council Building Digests extending back over the years reveals a polarity of opinion regarding whether the advantages of ventilating a cavity outweigh the disadvantages.

This is by far the greatest factor influencing the cost of masonry repair and maintenance work.

Construction defects rarely result in the catastrophic failure of masonry but rather cause progressive deterioration; commonly in the form of the breaking down of the masonry units, resulting in work being required both to repair the masonry and address the cause of the problem.

Deficiencies in the air or vapour barrier in a building envelope create a potential for water vapour to exfiltrate from the interior of the building and into the masonry where it may condense during periods of cold weather and accumulate to an extent that deterioration of the masonry is caused by freeze/thaw cycling.

A similar problem is created by rainwater accumulating in the unfilled cores of bricks creating a supply of water to saturate the centre of the brick during subsequent periods of freeze/thaw cycling.

During periods of freezing and thawing, masonry may deteriorate on the exterior face due to the presence of snow or ice melt water, on the interior face due to the presence of condensed water vapour and in the middle of the wythe due to rainwater trapped in the cores.

Deterioration of this type is commonly due to design or construction defects combining with a masonry unit that is not capable of remaining durable in the environment created by the defect.

While the Canadian criteria for freeze thaw durability is relatively rigorous, it is questionable as to whether the laboratory test conditions are an acceptable representation of field conditions.

European countries are increasingly adapting unidirectional freeze thaw procedures that rapidly test clay products unidirectionally in a repeatable and automated procedure.

The test procedure utilizes a thermoelectric semiconductor which when subjected to a direct current, cools on one surface and heats up on the other surface. When the polarity is reversed, the heating and cooling surfaces also reverse.

The application of this procedure results in test conditions in which one face of the test specimen remains frozen while the other face alternatively freezes and thaws. A procedure more closely duplicating field conditions than the standard North American freeze-thaw test.

Sometimes the introduction of a new product line will create its own time dependent problems associated with a lack of durability in a normal service environment.

The introduction in the seventies of bricks with a glazed exterior finish created a potential spalling problem which did not become evident for many years.

LATENT DEFECTS

The final common cause of deterioration of masonry is latent defects associated with some other component of the wall assembly than the masonry but on which the masonry is forced to rely for its own satisfactory performance.

Wall assembly designs vary quite remarkably in the extent to which they are able to accommodate design errors or omissions, construction defects and lack of knowledge regarding the performance of the composite assembly without detriment to the performance of the masonry with some designs being highly sensitive.

It is the highly sensitive combinations of materials and design features that create the greatest potential for lack of masonry durability resulting from performance failure of some other component of the assembly.

For example the masonry veneer cladding to structural steel stud framing is in the author's experience, remarkably sensitive both to workmanship and to the performance characteristics of the steel studs and connections.

There are well documented cases of complete failure of this type of assembly for complex reasons related to the philosophy governing this design methodology.

CONCLUSIONS

Masonry is a time proven material capable of remaining attractive and durable for centuries with the execution of only a minimal amount of predictable maintenance work.

Recent history in Canada has been marred by design and construction abuses which combined with early Building Code omissions to cause large numbers of localized masonry failures with a few catastrophic failures creating a climate of doubt regarding the suitability of masonry material for applications for which, in fact, it is eminently suitable.

The observance of good design practices when combined with the selection of the appropriate masonry product for the use to which it will be put and the maintenance of a high quality of construction confirmed by a program of quality assurance inspection and testing work should assure trouble free masonry with a durability comparable to that exhibited by 17th, 18th and 19th century European masonry.