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DEBUNKING MASONRY MAINTENANCE

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ABSTRACT

Maintenance of university masonry façades typically requires a higher standard of care than most commercial buildings in order to preserve their distinctive appearance and the enduring sense of pride among students, faculty, and alumni. One would expect maintenance intervals to be short, and repair costs for these signature buildings to be exceedingly high. However, the evolution from mass masonry wall construction to insulated cavity wall construction—along with combinations of brick, stone, precast, terracotta, fenestrations, and metal panels—has changed the way facades perform. It has also introduced new maintenance challenges that are not always related to the age of the structure and have less to do with the maintenance of the masonry than other components of the facade. Moreover, the demand for improved energy efficiency and the higher cost of masonry construction leaves less room in the budget for structured façade maintenance. A proactive approach was taken to research historic and standardized masonry maintenance guidelines, develop a questionnaire to determine anticipated university building service life expectations, poll other universities for their best maintenance practices and the funds allocated for maintenance, and share the combined data with all participants. Detailed experiential questions were also included on a variety of issues including systemic building envelope leakage and premature façade failure. Thirteen universities completed the questionnaire with detailed comments and typical practices. The responses indicated that universities take a reasonably proactive approach to building inspection and monitoring but a more passive approach to the planning of façade restoration intervals. Clearly defined tracking procedures that balance the inspection effort with the rate of deterioration may significantly improve the budgeting of repairs. It was also determined that masonry facades are usually expected to remain serviceable between significantly longer maintenance intervals (50 to 75 years) than previously reported industry maintenance intervals (25 years).

KEYWORDS: *maintenance, façade, masonry, stone, brick, mortar, tuck-pointing, service life, university, inspection*

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INTRODUCTION

Masonry maintenance intervals and anticipated repair costs have long been the subject of debate in the construction industry. It is generally accepted that masonry is a durable cladding material that, if properly constructed and maintained, is a logical choice for buildings that are designed to have service lives in excess of 100 years or more. But how frequently must masonry be maintained and what types of maintenance activities are anticipated within the service life of the masonry wall are questions not well understood or agreed upon.

One such industry publication that speaks to the expected durability of masonry wall components is the current BIA Technical Note 46 on "Maintenance of Brick Masonry" (2005). Table 1 of this document lists "various building materials and the estimated time before repair may be needed, given normal exposure conditions" [1]. According to this table, brick used in walls is estimated to serve for more than 100 years before repair; however, mortar in walls is only estimated to serve for 25 years or more. Based on this, one might expect brick masonry mortar would need to be repaired three to four times over a 100-year service life. Repairs listed for deteriorated mortar in Technical Note 46 include surface grouting of the mortar joints or repointing of the joints. Both of these methods of repair are labor intensive and expensive to perform, leading many to believe that the anticipated maintenance costs for brick masonry could potentially be quite high, often a large fraction of what it costs to construct a new facade.

However, Technical Note 46 can be traced back to its predecessor, Technical Note 7F on "Moisture Resistance of Brick Masonry – Maintenance." The second printing of this publication in January 1987 presented a table very similar to Table 1 of Technical Note 46. In it were listed "various building materials and their estimated life expectancies with normal weathering" [2], and it listed similar values for both brick and mortar used in walls of 100+ years and 25+ years, respectively. Curiously, the first printing of the 7F Technical Note in February 1986 was virtually identical in many ways to the second printing roughly 11 months later. However, one significant difference between the two versions was that the estimated life expectancy of mortar in walls was also expected to be 100+ years, making it similar in performance to the brick materials [3]. It is unclear why this publication was so radically changed; however, the implications of such a change on the anticipated maintenance costs for masonry are significant.

One such possible reason for the perceived increased maintenance frequency could be the transition from mass masonry wall construction to cavity wall construction in the last half century. These thinner veneer type systems would naturally be subjected to greater extremes of temperature and moisture variation across the wall thickness than would monolithic multi-wythe wall systems and, therefore, may be expected to weather more aggressively. There are also a variety of differences between the components and construction practices making it difficult to directly compare maintenance issues between the two wall systems. The changes in the environmental conditions that the masonry is subjected to from one locale to another make it further difficult to establish consistency of the mortar service life, since colder climates would be expected to have more aggressive freeze/thaw cycling to which the masonry would be subjected. The number of variables between the types of systems and the service conditions make establishing a direct relationship between time and deterioration nearly impossible.

In order to best evaluate the reasonableness of the purported 25+ year service life of mortar, one should look for the actual performance conditions of a variety of buildings with various construction and service conditions and determine how frequently masonry walls are maintained and what activities are performed to repair them. One such source of this data would be the buildings of university and college campuses, where buildings are predominantly masonry clad with the majority of the facades clad in brick and a significant percentage clad in stone. These buildings also often vary in age, construction, and service environment. The most important trait that sets higher education buildings apart from the building inventory of private owners is the desire of a university or college to maintain its inventory in superb condition to preserve an aesthetically pleasing environment; to preserve an enduring sense of place and pride among students, faculty, and alumni; and to further its prestige and reputation among its peers. This necessitates façade preservation and building service life for a university building to be at a higher level than typical commercial buildings, and in many cases, university structures are of historic significance.

SURVEY OF HIGHER EDUCATION BUILDINGS

The conditions of brick and stone facades vary considerably around most campuses and in general, are not necessarily comparable with regard to the age or exposure of the building. The evolution of masonry wall construction since the earliest campus buildings, such as the Wren Building on the campus of William & Mary, built more than 300 years ago, has been significant, especially in the last half century. The push for more economic and energy efficient wall systems has changed virtually everything about the way the first masonry buildings were constructed. Stone and brick were initially used in the foundation elements of many of the earliest campus buildings, and walls were generally constructed as a monolithic or "mass" masonry system with multiple wythes of interlocking brick or stone. With time, construction of masonry facades moved toward cavity wall or veneer type construction with masonry laid over a back-up material of concrete, concrete masonry, or occasionally steel stud framed walls. Veneer construction is the most common configuration of masonry facades, encompassing the majority of campus buildings. The early veneers slowly evolved into insulated cavity walls which are now typical construction for modern inventory, to improve the energy efficiency of the building. The different types of masonry wall construction have specific design features and behaviors that give them very different performance levels from a maintenance perspective. Added to that are differences in specific design detailing, construction trade practices, wall materials, and construction quality, that yield a host of variables, making prediction of the maintenance intervals of individual building facades challenging, especially on a campus wide scale.

The authors performed a survey of 13 universities from the Northeast to the Southeast areas of the United States. The surveys were sent to the Facilities Departments responsible for constructing and maintaining the campus buildings, inquiring on common practices and experiences for masonry maintenance and expected life cycles of masonry façade components. The survey consisted of 43 questions, predominantly multiple choice, on a number of topics including:

- Composition of the building inventory
- Structure and size of the maintenance department
- Budgets for maintenance
- Inspection practices and frequency
- Common façade problems
- New construction practices
- Expected life cycles of masonry façade components

The results of this survey were compiled and shared with the participating universities in an effort to determine best practices for masonry inspection and maintenance intervals. The information obtained was also combined with information obtained from literature published both in the United States and in Europe regarding the anticipated service life of masonry wall systems to establish a reasonable estimate of time between significant maintenance intervals. Several trends were established from the data returned in the surveys:

Roughly 70% of the respondents held a building inventory of more than 100 buildings, but less than half of the respondents had more than 8 million square feet or more, indicating some universities have generally larger buildings with more square footage per building. All respondents had predominantly masonry facades in their inventories, but only three had more stone than brick facades.

Most universities responded that they anticipated either a 50 or 100-year service life from the buildings in their inventory. One university indicated that buildings designed as world heritage historic structures that would continue to be preserved and renewed as needed were expected to have service lives greater than 100 years, but the majority of buildings were realistically in the 50 to 100-year category. Some student housing was considered to be 25 years.

The number of personnel directly involved with building inspection and employed by the universities varied widely among the respondents, and many departments had different approaches to inspection. More than half indicated that less than 10 personnel are involved with building inspections. Two responses stated that more than 50 personnel are involved with inspection, indicating a more broadly cast responsibility for building inspection. With regard to repair, the maintenance staff typically employed to maintain building facades was normally less than 25 personnel, and about half of the respondents used less than 10 employees.

Annual building maintenance budgets correlated directly with the size of the university. The seven largest universities all had \$10-\$50 million budgets, and five of the smallest universities were all less than \$10 million budgets. The majority of the universities spent less than 1% on façade inspection; however, a few universities spent a disproportionately larger amount of their budget on inspections. Most universities spent less than 5% of the maintenance budget on repairs, a smaller group spent 5-10%, and two universities spent more than 10% on façade repairs.

When asked how often masonry facades were cleaned or completely repointed, two universities indicated they had a 50-year cycle for re-pointing mortar joints, and two universities indicated that there was a schedule in place for cleaning the buildings. The remaining universities indicated that they only cleaned or repointed buildings when it became necessary. Each university that responded has had some issue with mortar, masonry, or sealants. All but two universities have had to re-clad up to 5% of their buildings due to façade problems. Almost 70% of the respondents have had problems with systemic or widespread leakage on their buildings, while 30% indicated no major leakage problems. The most commonly experienced issues by all universities were:

- Cracked mortar joints (Figure 1)
- Cracked masonry units (Figure 2)
- Failed sealant joints (Figure 3)

Figure 1: Cracked Mortar Joints

Figure 2: Cracked Masonry Units

Figure 3: Failed Sealant Joints

Based on the information obtained from the survey, it is clear that higher education entities provide a reliable source of data for establishing trends with regard to the service life of masonry facades.

INCONSISTENCIES OF PUBLISHED MASONRY SERVICE LIFE DATA

There are many publications available that address the means and methods required for historical preservation work, but specific guidance regarding maintenance of university masonry façades is rare since they have a different set of maintenance issues that land in-between commercial and historic buildings. In general, there is no consensus in the industry with regard to what the service life of a university masonry façade should be, how it should be maintained, and what level of maintenance is required. However, based on the survey performed by the authors, most universities surveyed anticipate a 50 to 100-year service life from their buildings, and most are expecting more than 50 years of service before they begin performing significant maintenance repairs, such as pointing campaigns or recladding efforts.

Many published documents attempt to predict masonry service life (and maintenance requirements) utilizing various theoretical models. However, inconsistencies exist between the different models because of the complexities of predicting environmental factors, exposure, and service conditions for different materials. Moreover, comparing the theoretical models with empirical data adds the variable of façade maintenance variations, with changing programs and ownership, throughout the life of the building.

The previously discussed Brick Industry Association (BIA) Technical Note 46 (2005) estimates the amount of time before repairs should be expected for brick, mortar, plastic flashing, and metal anchor ties to be 100+, 25+, 5-25 and 15+ years, respectively [1]. Based on this, one might expect a re-anchoring, re-flashing, and repointing campaign to be required every 25 years leading to four such major renovations of the façade over an anticipated 100-year service life. Clearly, this is not consistent with most universities surveyed nor is it consistent with the authors' experience in practice. Although no data was previously provided to support these estimates, they are often relied upon in the industry as representative of masonry construction. When making service life comparisons between different cladding systems, this puts masonry at a distinct and unwarranted disadvantage, based on the high cost of such maintenance activities over the service life of the building.

A stone masonry study supported by qualitative data conducted on 140 buildings in Lisbon, Portugal, analyzed the environmental factors that most influence degradation [4]. The study classifies four (4) levels of degradation and recognizes level 3 to be 20% degradation and the service life limit of the cladding. The study concludes that exposure to humidity is the most influential environmental factor toward stone degradation and that façade orientation is directly related to humidity exposure. Furthermore, the study predicts that stone masonry facades in Lisbon, Portugal, have a 90% probability of exhibiting level 3 (20%) degradation and, therefore, reaching their useful service life, in the following number of years and orientation:

- 60-year service life with W/NW orientation
- 63-year service life with E/SE orientation
- 73-year service life with S/SW orientation
- 78-year service life with N/NE orientation

Such information is much more consistent with the anticipated performance of properly constructed masonry systems recognized by the universities surveyed and the authors.

A similar study conducted by the same authors, compares three statistical methods with empirical reference data for predicting masonry service life [5]. The results show estimated service lives of 113, 80, and 73 years obtained using the Graphical Method (GM), Artificial Neural Networks (ANN) and Multiple Linear Regression (MLR), respectively. The ANN and MLR methods fell relatively in line with the empirical reference service life of 77 years to reach a degradation level of 20%.

SUMMARY

While clearly no published consensus of masonry façade service life exists within the industry, it appears from the survey data that the state of practice for many universities and colleges is aligned with this shortcoming, by taking a reasonably proactive approach to building inspection and monitoring and a more passive approach to the planning of façade restoration intervals based on the conditions. As a result, most universities realize much better performance of their masonry buildings than some industry "rules of thumb" imply. While each building is different and service lives of masonry facades will vary, anticipating a single significant renovation of a masonry façade within a 50 to 75-year time period over a 100 year expected service life, would certainly be a reasonable estimate for facility planning strategies based on data available. It is the authors' belief that this same information could easily be projected into other construction projects outside of the higher education realm to provide reasonable anticipated service life predictions for masonry facades.

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