DEVELOPMENT OF A RAIN SCREEN SYSTEM FOR ADHERED MANUFACTURED STONE

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ABSTRACT

Due to recent changes in the Building Codes for Coastal regions there is a need to develop cladding systems which implements a drain screen system. To meet this new requirement, existing concrete stone cladding systems had to be modified to incorporate wood strapping to create the drainage space. Though initial impressions were the issue was simplistic, treating the façade as a system revealed it to be a complex problem. It was imperative the system be able to withstand the wind loads of coastal applications while at the same time still being flexible to not have permanent displacement of the stone and therefore façade failure. This paper outlines the development process of determining the system, iterative testing of the system and interaction with CCMC to come to a final application technique.

OVERVIEW

The performance of cladding systems has always been a major topic of discussion. The concept of a rain screen versus drain screen versus face sealed, being the focal point of that discussion. Regardless of the design used, the ultimate requirement is durability. Recognizing that there is indeed a difference in durability of products and systems from both design and geographic points of view, the Canadian governing bodies have implemented a requirement for a drain screen system for claddings for coastal regions in the National Building Code.

In the Canadian system for Federal evaluation of a product or system, the Canadian Centre For Construction Materials (CCMC) provides a technical guide for the means to assess the proponent's product or system. Since the Building Code does not specifically address the performance requirements of a cladding system, CCMC's Technical Guide for Adhered Manufactured Stone using a Strapped System, stipulated the wind load, impact and physical properties requirements. Ideally, the specified parameters reflect what occurs in real situations and expected loadings. Since the design is stipulated to be a drain screen system, water penetration testing was not required. As such any penetration into the stud space would be the result of a deficiency in the secondary line of defense, not a failure of the cladding.

Since Manufactured Stone claddings have had a long and good history, ideally it was necessary to find a means of meeting the requirements of the CCMC guideline, without compromising the tried and true system. It had to be understood that taking a historical system which was working well and make significant changes to meet those criteria, would have a significant effect on market. Therefore the products, i.e. the stone and mortars, had to remain the same.

WHAT TO TEST

Since the market in question was residential and normally of detached or semi-detached construction, the base wall construction, and the focus of CCMC's technical guide, was for wood stud and wood sheathing (OSB or plywood).

The task therefore was to find a wall assembly that would be similar to what is currently accepted in the market place

Further complications to developing a suitable wall system were; geographic variations in construction techniques, the total number of stone geometries manufactured and the variations in joint styles and types between the stones. Previous comparisons had been made of stone sizes and the differences were found to be minimal.

In terms of geography, the primary difference was determined to be the use of plywood versus oriented strand board (OSB) as sheathing. Similarly, the differences in the joint mortar application were considered to be of minimal effect on strength contribution and therefore a uniform joint width flush with the face of the stone was used. Ultimately the assemblies had to meet the minimum requirements of the National Building Code.

The final assembly therefore would need to be flexible enough to withstand some deformation, yet strong enough to withstand the pressure differentials to be imposed.

A matrix was developed outlining the possible combinations of materials to achieve a workable solution. The materials were readily available and installed using a normal construction practice. Of some controversy was the means of strapping. Since practices varied somewhat geographically from ripping plywood or OSB, to using dressed thin lumber, the decision was made to correspond to the means most cost effective on site, which was the ripping of OSB sheets to approximately 75mm widths.

The final assemblies therefore consisted of; wood framing, sheathing, 30 minute building paper, strapping at varied spacing, various laths and normal stone application using type "N" mortars. See Table 1.

	Specimen 1	**Specimen 2**	**Specimen 3**	**Specimen 4**
Studs	Wood 16" OC	Wood 16" OC	Wood 16" OC	Wood 16" OC
Sheathing	3/8" (11mm) OSB	3/8" (11mm) OSB	3/8" (11mm) OSB	3/8" (11mm) OSB
Sheathing Fastening	Min per code	Min per code	Min per code	Min per code
Weather Resistant Barrier	30 min Bldg Paper	30 min Bldg Paper	30 min Bldg Paper	30 min Bldg Paper
Strapping Material	3/8" treated Ply, ripped 1.75"	3/8" treated Ply, ripped 1.75"	3/8" treated Ply, ripped 1.75"	3/8" treated Ply, ripped 1.75"
Strapping Fastening	6" Spacing, 1 " Penetration into Studs, Galv Staples	6" Spacing, 1 " Penetration into Studs, Galv Staples	6" Spacing, 1 " Penetration into Studs, Galv Staples, Ctr Strapping fasteners not to penetrate through sheathing	6" Spacing, 1 " Penetration into Studs, Galv Staples, Ctr Strapping fasteners not to penetrate through sheathing
Strapping Spacing	16" OC	16" OC	8" OC	16oc
Lath Material	Non Ribbed 2.5lb 60 min paperbacked	Ribbed 2.5lb 60 min paperbacked	Non Ribbed 2.5lb 60 min paperbacked	3.4lb raised rib, paperbacked
Lath Fastening	6" Spacing, 1 " Penetration into Studs, Galv Roofing Nails	6" Spacing, 1 " Penetration into Studs, Galv Roofing Nails	6" Spacing, 1 " Penetration into Studs, Galv Roofing Nails	6" Spacing, 1 " Penetration into Studs, Galv Roofing Nails

Table 1 – Test Assembly Matrix

The test panels for the wind loading were required to be 3.2m by 3m with variant sizes of sheathing within that space. The panel for the impact testing was required to be 1220mm by 1220mm.

Once the test sample panel construction had been established, the logistics of construction and testing had to be considered. Since curing time of all mortars had to be a minimum of 28 days, it was most efficient to construct all panels at the same time. This however meant that the test buck had to be designed to be able to be moved without compromising the sample. Any rework would immediately create a one month delay in the program. The sample also had to remain air tight. Fortunately the wide dressed lumber needed for placing the panels in the test jig, required little reinforcement in order to make the assembly handleable.

TEST CRITERIA

In order to meet the possible weather effects of the costal regions the criteria laid out by the CCMC Technical Guide, consisted of low pressure cycling to simulate fatiguing of the system and then loading to 2640 Pa in negative and positive directions. The sample was required to not crack or have stones displaced from the surface. Though perceived to be very high, the stipulated pressure related to a wind of 140 kph and is realistic for costal regions which are in the path of hurricanes such as the eastern Maritimes.

Secondary to the wind loading, impact testing of the final assembly was also required. A separate panel was constructed for the impact testing so that there would be no effects from the wind loading. This also resulted in some discussion as to which is the worst case location for the impact; between the strapping where there would be the most flexure but best dissipation of energy or directly over the strapping where the stone won't move but must absorb the full energy of the impact. The impact was provided by a 3 m swing of both hard and soft impact devices. The pass fail requirement allowed for damaged cladding, but there could be no debris falling from the panel due to the impact.

WIND LOAD TEST JIG

In order for the panel to be mounted into the test Chamber, a wood "buck" was constructed as part of the panel and as per the pattern laid out by the Technical Guide. Once curing time of 28 days was complete, the assembly was mounted such that stone faced into the chamber which made monitoring difficult. Failures could only be surmised based on the inability to establish or maintain the necessary pressures. Even once the pressure testing was completed the panel had to be removed to carry out a visual inspection for cracking or stone delamination.

Part of the protocol was the requirement for measuring differential deformation between the cladding and the other system components such as the framing and sheathing. This then necessitated the penetrating of the sheathing which required resealing the holes yet still allow movement of the gauges.

As testing progressed it was evident that the porosity of the masonry assembly was so high that the required pressures were not attainable. A heavy sealant coating therefore had to be applied over the stone to minimize air leakage through the cladding.

RESULTS

In each case the panels were able to withstand the initial cycling pressures and therefore demonstrated relatively good fatigue strengths. Specimens #1 through #3 however, failed under the deformation loads. The pressure at which failure occurred increased as the specimen strengths increased, as would be expected.

As expected, Specimen #4 was able to withstand the deformation pressure without delamination of the stone. This assembly had the heaviest lath and closest spaced strapping. Results therefore appeared to be dependent on the tensile strength and rigidity of the lath, mortar and stone assembly as a total.

The impact testing was carried out under both conditions, between and directly over strapping, with no damage resulting in either case.

DISCUSSION

Clearly the results were not what was expected.

The three dimensional cone shape deformation which occurred during the testing resulted in a rotational component of the forces acting on the cladding and stone. This rotation occurred primarily at the perimeter of the specimens and was verified by the fact that the failures of Specimens #1 to #3 occurred at the perimeter. The stone and mortar was expected to flex outward following a curvature from top to bottom as well as from side to side. This rotation was also a partial cause of failure.

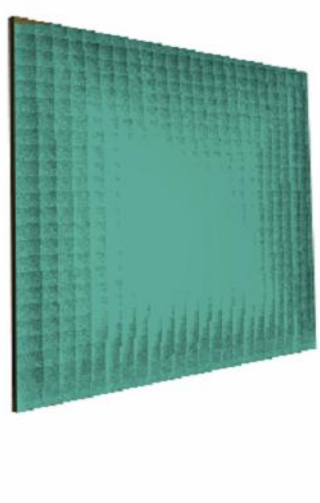

Figure #1- Actual panel deflection shape - 3 Dimensional

In reality a wall assembly is normally restrained at the horizontal and not the vertical interfaces and as such there would not normally be a rotation factor. The vertical interfaces would typically be a control joint where the system is free to move.

Figure #2 – Normal deflection profile - 2 Dimensional

CONCLUSION

The testing showed that the stone and masonry are very permeable to air and therefore the likelihood of the cladding seeing such pressures is unlikely. The pressure differences would normally be borne by the air barrier layer and as such distributed to the substrate. The resultant deformation would therefore be a function of the substrate strength. The cladding would then simply be subjected to the expected deformation of the substrate under the given conditions. The omission of weeping holes also showed that the test did not represent a realistic scenario since the weepers would have permitted some or complete pressure equalization of the drain cavity.

The testing also showed that the code minimums were insufficient for this test protocol since all specimens were constructed to code requirements. Currently the CCMC process does not allow for changing of the protocols for a particular project which is underway. Therefore the results must stand.

Rhetorically, the question remains was the method and criteria reasonable? Future testing protocols of this type should consider actual framing and installation conditions. Further research is also recommended to fully understand the effects of edge restraint on claddings and cladding systems.

Photograph #1 – Test panel with strapping applied

Photograph #2 – Paper backed lath being applied

Photograph #3 – Completed application of paper backed lath

Photograph #4 – Start of scratch coat application of mortar

Photograph #5 – Application of manufactured stone

Photograph #6 – Completed panel

Photograph #7 – Panel mounted against test chamber

Photograph #8 – Typical failure of Panels #1 to #3

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