METHODOLOGY FOR TESTING AND CERTIFICATION OF CLADDING, ITS FIXINGS AND IMMEDIATE SUPPORTS FOR APPLICATIONS IN CYCLONIC REGIONS

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Introduction:

As engineers, it is our responsibility to optimise the usage of materials and resources to achieve a desired function for the betterment of society. Consideration of safety, functionality, economy and environmental impact is of great importance. With a detailed knowledge of engineering materials, mechanics, components and systems; engineers can design and construct lean structures. This knowledge is usually achieved through expensive and time consuming research. There are certain well-understood classical engineering principles that - when combined with information from focussed research and testing (prototypes) - could produce some not so accurate but useful information. With the inclusion of a safety factor (factor of ignorance), this information could be used to achieve most intentions and purposes in engineering at a reasonable economy without compromising safety and functionality. Innovation is the only way to improve economy and affordability while improving safety and performance at the same time.

It is common knowledge that the development of an engineering system is a linked process where the weakest link will determine the final performance and capabilities of the system. As such, engineers must make sure that all the linkages are considered with equal attention and executed prudently. The greatest design does not produce a great product if the fabrication or installation of the design is not executed correctly. Installation is an area where attention is required to assure that the design conditions are met. For example, a well designed bolted joint will not perform if not tightened properly or if the correct fastener grade is not used. This may only be assured by implementation of rigorous quality control and auditing processes.

Conservative designs will reduce the chance of failure, but at a cost. Some of the pyramids built several thousand years ago are still standing. However, we can no longer allocate similar magnitude of resources to satisfy a similar need; hence, we do not see construction of pyramids anymore. One can argue that a pyramid is a well designed structure for it has been standing for thousands of years, but it is very hard to argue that it is a well engineered structure. As we learn in engineering, it is the aim of engineers to utilise the available resources (materials, knowledge and labor) to achieve the desired function (safety, performance, life span) in the most reliable and economical way.

In general, the world is moving towards performance based standards. Although, one can argue that in a performance based standard the performance can only be defined for the final system, this argument is too simplistic and far from complete. For example, the performance of a motor vehicle can be defined as "to be able to safely and reliably travel from one place to another at a certain speed..." This performance definition does not require the fastener manufacturer to manufacture a car and test it in a central laboratory in order to prove that the fasteners are fulfilling their function. Breakdown and analysis of the main system performance standard has provided different performance standards for the sub-systems such as fasteners, brakes, engine, transmission, gears etc. Fasteners supplied to the automotive industry need to satisfy only dimension, strength and finish performance requirements, which are tested at the fastener manufacturers quality laboratories.

There is no argument that full scale testing of complete engineering assemblies (systems) will provide the most reliable information and assurance of the performance of such a system under the desired test/field conditions. If engineers took this approach in the development of nuclear weapons, biological advances or space explorations, the repercussions on the world would have been unimaginable! Although academically sustainable, the explicit recommendation for testing cladding, its fixings and immediate supports (e.g. roofing sheets, battens, purlins and fasteners) for fatigue performance under cyclic loading (as introduced by AS/NZS 1170.2-2002 clause 2.5.5) will pose an enormous commercial problem for the associated industries. Simple and innovative test methods that can be applied by individual component manufacturers in order to define the scope of applications for a specific product are of utmost importance to the future success of the construction industry.

Problem Statement.

The inspection of building system failures after severe wind events has identified that some batten/purlin connections had failed while the cladding sheets were still in contact with the battens. These failures were attributed to non-linear fatigue caused by cyclic wind loading. It is understandable that the battens/purlins need to be tested under cyclic wind loading as they will experience (in local areas) almost the full extent of cyclic loading experienced by the roofing sheet and the sheeting fasteners. The fact that all components require the same number of load cycles, in a way, simplifies the process of testing of battens as a part of the cladding system. This observation and analysis probably has led to the inclusion of Clause 2.5.5 in AS/NZS 1170.2-2002: that cladding, its fixings and immediate supports shall demonstrate performance in resisting fatigue loading under the cyclic pressure sequence defined by AS 4040.3.

Testing and verification of cladding, its fixings and immediate supports under cyclic loading will pose several industrial problems. It is common knowledge that totally separate industries are involved in producing the components of a cladding system. For example, fastener manufacturers such as Ajax will have no control over the roofing sheet manufacturer or the batten/purlin manufacturer. Similarly, a cladding sheet manufacturer such as BHP will not have any control over the fastener or the batten manufacturer. To make things worse there are several fastener manufacturers, cladding sheet material manufacturers, cladding sheet manufacturers, and batten/purlin manufacturers. Each cladding manufacturer makes a number of different thickness and configurations of cladding (e.g. Cladding: Custom Orb ®, Trimdek®, Spandek®, 0.42 bmt, 0.48bmt) and each batten/purlin manufacturer markets variations of batten/purlins configurations (eg. Top hat, C, Z, 0.5mm bmt, 0.75mm, 1.0mm up to 6mm etc). Then there are a number of fastener manufacturers marketing large ranges of different fastener concepts (eg. StormFixx®, Corrilok® etc.). Now, it is evident that if a full assembly of cladding, its fixings and immediate supports is to be tested it will form hundreds of combinations and permutations of different components and their parameters.
For example, all the combinations of the parameters such as:

Steel Supplier	BHP, Overseas
Cladding Sheet manufacturer	BHP, Stratco, Robot, Stramit
Sheet Profile	Custom Orb®, Trimdek®, Spandek®, Rolex, Dualclad, MonoClad®
Sheet bmt	0.35, 0.42, 0.48, 0.60
Batten Profile	Top hat, C, Z
Batten size	64x34, 100x65, C100
Material Grade	G450, G500, G550
Batten Thickness bmt	0.48, 0.55, 0.75, 1.0, 1.6, 2.0, 2.5, 3.0, 4.0, 4.5, 6.0
Fastener Cladding sheet to batten	StormFixx®, Corrilok, STD cyclonic washer assembly
Fastener drill point	Steel Point, Tek, Type-17
Fastener Gauge:	12g, 13g, 14g, 15g
Fastener Length	40mm, 50mm, 65mm
Purlin Profile	C, Z, RHS
Purlin Material	G450, G500, G550
Purlin thickness	1.5mm, 1.9mm, 2.4mm
Fastener Batten to Purlin	14g-10x22, 14g-20x22 , timber 12g-11x40 T-17,

need to be tested with all their variations.

With each test costing up to $1000, the real cost of carrying out necessary testing to cover the full range of combinations used in the market will be enormous. Then the problem of commercial responsibility needs to be addressed. Who is going to pay the bill? Who is going to take the responsibility for a failure if certification is given to the combination of components? Is it the fastener manufacturer's responsibility to prove that their fastener will perform with a particular combination of other components? What if a customer wants to change one of the components? Does the fastener manufacturer have to spend more money for testing that particular variation? What if a supplier of another product changes their specification? This will alter the application range for the fastener!
As can be seen, although the proposal is academically sound, it will pose insurmountable problems to the industry and the cost of certified cladding products will skyrocket. This will impact upon the affordability of a building as well as increase the cost of development of innovative solutions, hence hindering progress of society.

Possible Solution?

Using innovative focussed research programs, it is possible to understand the exact function of individual structural elements (e.g. cladding sheet, fastener, batten, purlin and the batten to purlin fastener) in a cladding system. This research will establish effects of these elements on loading and the local stresses and strains, which will subsequently determine the performance under cyclic loading. All possible failure modes as seen from the point of view of each individual component need to be established. For example, if the failure mode is that the head of the fastener is pulling through the cladding sheet, the limitations on immediate parameters such as the following need to be established.

- fastener washer diameter
- fastener washer stiffness distribution
- fastener strength
- head geometry
- local stress/strain distribution on the cladding sheet
- sheet thickness
- material properties
- threshold stresses
- local displacement
- local rotation
- friction characteristics and
- work hardening.

This will provide some guidelines on the limitations of various parameters assigned to individual structural components. More up to date analysis techniques such as non-linear finite element modeling may be used to identify the micro level effects using the results of macro level experiments. Furthermore, local strain gauging and other forms of load, displacement, stress, strain and pressure measurement techniques may also be incorporated in to the prototype test jigs to collect critical experimental information to validate numerical models.

Using fundamental engineering principles, it is possible to evaluate the characteristic local effects (displacement, rotation, loading etc.) experienced by each sub-system and only to simulate such local effects in the evaluation of the sub-system. If necessary, certain safety factors (factors of ignorance) may be included if certain parameters cannot be simulated adequately in a simple sense. With the development of these test methods, the fastener manufacturer only needs to test their product on a specific thickness and grade of a material setup in a specific configuration under a specific loading regime. Similarly the batten manufacturer will have their own performance parameters such as flexural stiffness, rotational stiffness and corrosion resistance, that they can test within their facilities; as will the cladding sheet manufacturer.

As a main component of this research, the critical characteristic performance parameters and their dependencies for each individual structural element will be established. These performance parameters can then be used by their respective manufacturer to evaluate the performance of individual components. The designers can use the same parameters in their design and specification process so that the integrity of the system can be maintained. This will finally define the performance envelopes for each component and hence the whole system. This may sound difficult; however, this is an essential part of innovation needed by the industry in order to make sure that the necessary performance and safety is achieved at an affordable cost.

Furthermore, the responsibility for each component of the system can be delegated to the supplier of that component. The design engineer will take responsibility for using the correct information and specifying the appropriate component. The builder/inspector will make sure that the correct component and the installation procedures are used. This way the responsibility of a failure is well defined. With the understanding of these performance parameters, their envelopes and their impacts on the final assembly, each component manufacturer has a better understanding of the expectations and hence has a better opportunity to develop new and innovative products without interfering with other component manufacturers.

This type of methodology is very common in the aerospace and military industries as the cost and time requirements for full scale testing are prohibitive. In principle, any engineering system could be sub-divided into individual components in terms of their functionality and performance. Although there may be some dependencies between functional elements, for all intents and purposes these dependencies could be characterised by factors of ignorance. The important issue to be mindful about is that the cost of using the factor of ignorance has to be less than the cost of the alternative test method to avoid it. This way the system will be more conservative and satisfy safety and performance requirements but at a lower cost. For a particular application, if the cost of using the factor of ignorance (safety) is higher than the cost of the test to avoid it, the customer has the option to carry out testing for that particular application.

This proposal will improve the commercial viability of products as well as reduce the cost of the products without sacrificing necessary performance. This will also improve competition amongst the market players as the cost of testing may not deter small players entering the market. Most of all, this will help ordinary citizen to get their structures made at affordable costs without sacrificing safety and reliability.

Going Ahead:

It is understood that in order to develop such test methods and parameters, organisations such as AWES, ASI, CSTS have to take a leading role. Funds may be raised through industry contributions to support such comprehensive test/analysis programs in order to develop simplified component test methodology. Technical expertise of the component manufacturers may also be utilised. As this proposal will provide tremendous benefits to ordinary citizens and to associated industries, it may be possible that there could be an opportunity to attract government funding. In terms of engineering, this is feasible and has been successfully implemented in other industries.