James Cook University

SCHOOL OF ENGINEERING AND PHYSICAL SCIENCES

Response of pierced fixed metal roof cladding to fluctuating wind loads

Thesis submitted by

David James Henderson BEng(Hons)

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In memory of my father,

R. D. Henderson

17 Sept 1939 – 4 Nov 2008

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Statement on the contribution of others

This thesis included the following contributions of others:

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Abstract

The roof of a low rise building (e.g., house, industrial shed) is subjected to intense fluctuating wind pressures during a tropical cyclone. A failure of the building's roof is not only a life safety issue but also impacts greatly on the community's resilience during and after wind storms.

Low cycle fatigue cracking of roof and wall cladding, fixings, and supports during tropical cyclones is a complex process, where small changes in load, geometry or material properties can significantly affect the fatigue performance of the cladding system. Investigating the performance of the building envelope when subjected to cyclonic winds is of importance to the manufacturing and construction industry, and standards communities. A better understanding of the fatigue mechanisms of cladding systems will provide industry with a means to optimise the cladding design and to improve the assessment of vulnerability of building stock.

The research was conducted to analyse the performance of light gauge but high yield strength corrugated metal cladding subjected to cyclonic wind loads. The experimental methods involved tensile coupon tests and static point load tests as well as static pressure, cyclic pressure and dynamic wind pressure tests on double 900 mm span 0.42 mm BMT G550 corrugated cladding specimens. The air pressure tests, including the simulated cyclonic wind pressures, were carried out by using a Pressure Loading Actuator (PLA) that was able to apply a positive and negative (suction) pressure via an air-chamber. Reactions in the X, Y and Z directions were measured at the cladding screws, along with lateral movement of the screws and crack growth in the cladding under the range of fluctuating loads.

Wind tunnel test data and full scale measurements show that the wind pressures are highly fluctuating and temporally and spatially varying across the building envelope. Yet the line load testing and typical product testing applies the "same load" to all fasteners in the test specimen. The thesis has shown, by measuring fastener reactions to point loads applied at various points across the cladding, that there is minimal influence on the reaction in one screwed crest to an adjacent screwed crest, justifying the assumption of applying a uniform load across the test specimen.

Different shaped cyclic pressure traces, such as sinusoidal, sawtooth and spike were used. The numbers of cycles to failure for these pressure traces with similar load cycle ranges showed it was the peak load per cycle and load ratio that governed number of cycles to failure and not the RMS of the trace or the duration of the peak.

The application of fluctuating pressures representing wind loads enabled the assessment of cladding response to these dynamic pressures and a comparison to cyclic load tests. Cladding crack patterns generated with the simulated wind trace from the PLA were similar in shape and length to crack patterns reported in damage surveys and the loads at which the claddings deformed and buckled, were of similar magnitude to those in the cyclic load tests. Analysis of the applied fluctuating pressures and resultant screw reactions showed that the cladding specimens responded in a quasi-static manner. That is, there was no resonance in the cladding from the fluctuating pressures.

A Damage Index metric based on S_{max}-N cyclic test data is proposed that could be used as an indicator of extensive cladding damage and possible cladding failure for generated cyclonic traces. The DI could also be used to indicate possible crack initiation for crease type cracks following low intensity cyclone crossings.

The outcomes of this study have demonstrated (a) the relevance of the experimental basis of the current test standard (i.e., L-H-L), (b) the improved resilience of the building envelope if designed to the L-H-L standard over the previous test criteria, (c) potential areas to be strengthened in current building stock, and (d) the need for increased design pressures on cladding elements in the Australian Wind Actions Standard.

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