June 2007 Technical Series 07-111

Field Testing of Valved Soffit Vent Performance in Protecting the Roof and Attic in Strong Winds

INTRODUCTION

Wind pushing through soffit vents into the roof space can entrain fine snow or even heavy rain, soaking the ceiling. The push can also pressurize the roof space, adding to the outward-acting pressure differentials caused by the wind's "suctions" over the roof. In extreme winds, the roof sheathing can lift off, gables blow out, and the ceiling (already soaked) can be forced down.

Valving the soffit vents can help avert all that: place valves to hang open to most air movement but quickly "blow closed" against strong winds, preventing ruinous entry of snow or rains. Such valved soffit vents ("VSVs") should also prevent wind pressurization of the roof space, and more: they should depressurize it. Only the vents facing the low pressure leeward and "separation zones" away from the wind remain open; the open vents keep the roof space depressurized near equilibrium with the low pressures outside them. This depressurization counteracts the outside "suctions" above and beyond the roof, reducing or even nullifying the outward-acting differentials. That helps keep the roof sheathing on, the leeward gable intact and the ceiling up. That's the concept.

Until now, VSV performance in depressurizing roof spaces has been verified analytically and by 1:15 scale model testing in wind tunnels and on moving vehicles, as briefly reviewed next. The objective of this project is to explore full-scale "real world" VSV performance by monitoring a house roof space in strong winds.

RESEARCH PROGRAM

Engineering testing of scale model houses mounted on automobiles was done in 2005. As pictured in Figure 1, the set-up allows roof space pressures to be recorded (against pitot tube measurement of static and velocity pressures in front of and above the roof) at speeds up to 140 kph. The main findings are recalled below, to help fill in gaps.

Figure 1 Model House Being Mounted for Airstream Testing
Pitot tube is visible at top of photo, above and forward of gable roof peak. The house stance can be adjusted to any angle "to the wind." The twin manometers are mounted inside off the sun visor. Observer: Peter Russell, P.Eng

How do actual house roofs respond to strong, gusty winds, with normal soffit vents and valved ones? Candidate houses were first sought in Ontario's windy Point Pelee region, with the University of Windsor agreeing to help. No suitable house and willing householder could be found, however, even with extensive legwork by CMHC as well as UW. Finally giving up on the opportunity to capture Pelee's winter gales, the researchers turned belatedly to Nova Scotia and then Newfoundland, where the chances of full gales persist into spring and summer. A rather ideal house was located in Pouch Cove, just north of St. John's (with yeoman assistance from the local representative of IRAP, NRC's Industrial Research Assistance Program), Figure 2. A local research team with some related experience undertook to instrument and conduct the pressure monitoring project—despite the late notice and their backlog crush of other commitments.

Canada

CMHC SCHL
HOME TO CANADIANS

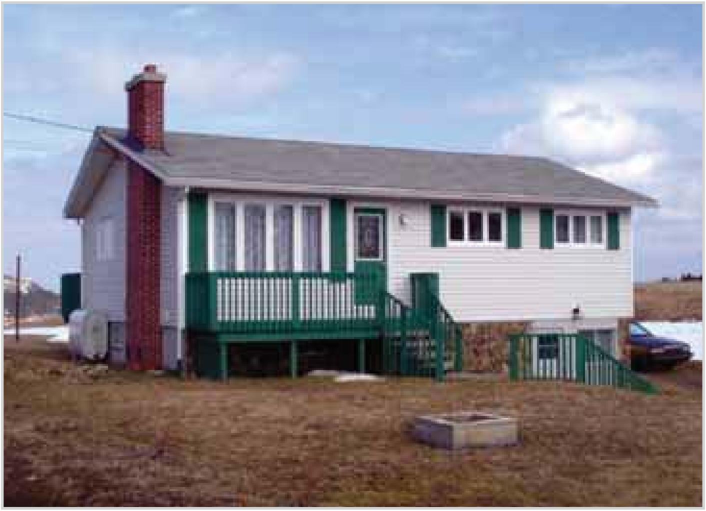

Figure 2 **Pouch Cove House.** Looking north at the front of house; chimney on east end. House plan is 26 × 36 ft. The roof sheathing is tongue-and-groove boarding, probably air-leaky especially where protruding over the gables.

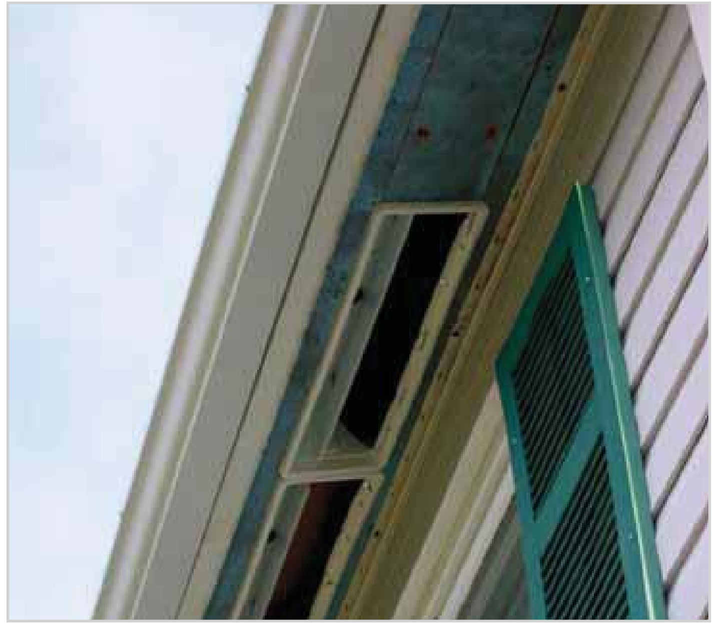

Figure 3 **VSVs Installed.** Hanging open.

Following delays in acquiring suitable instrumentation, the team set up monitoring and ran first trials of the normally vented house on June 5th, 2006. Rectangular soffit vents had been cut into the unvented plywood soffits preparatory to the trials. The VSV crew (the author and householder—a retired physics professor, as a most helpful coincidence) then installed handmade VSVs (Figures 3 and 4), June 13th through 15th. They were able to observe breeze effects while they worked, and also met with the research team June 16th to discuss the project and request basic corrections for the monitoring set-up.

The research team proceeded to monitor again on June 21st with VSVs operative, and on July 3rd with VSVs taped open to act like normal soffit vents. All captured wind events were similar in direction and strength, that is, end-on to the house (SW and WSW) and about 37 kph with 60 kph highs. Unfortunately, no strong broadside winds were monitored.

More unfortunately still, essential errors were not redressed in this rushed work. Ignoring established procedures for measuring wind loads on/in buildings, the team measured all "pressures" only against house indoor pressure as the zero datum. However, the indoor pressure itself was not measured, so there was no way to determine actual pressures, that is, the wind-induced differentials relating to static pressure. Nor could the measured pressures be related to each other with confidence, in that the arrangement of external pressure taps was flawed and not corrected.

It was pointed out that winds would likely strongly depressurize this well-sealed house with its high flue; the datum itself could be strongly and variably negative. Accordingly, the researchers returned to conduct further trials in September, in one of which the indoor pressure itself

Figure 4 **VSVs Installed.** Blown closed. These first full-scale valved soffit vents are "working mockups" made from plastic window planters with light "corroplast" valves. They proved too noisy despite having soft rubber bumpers.

was related to outdoor ambient (static, barometric) pressure, yielding a rough correction to be applied. (That correction was itself obtained rather crudely: a barometer was calibrated against the on-site weather station's barometer, and then placed indoors alongside the sensors' datum location.) Further, all exterior pressure taps were made good, so the roof space pressures could now be related with more confidence to the exterior pressures outboard of the vents.

FINDINGS

A brief review of the model test findings, especially the "car tests" (Figure 1) helps in assessing the field tests' intent and limited findings:
1) End-on winds depressurize the roof space substantially—and essentially equally—through normal soffit vents as well as valved ones.
2) Under "slanted" winds, the valved vents substantially depressurized the roof space whereas normal vents left it neutral or just slightly depressurized.
3) In the "worst case" exposure, broadside winds (which would include hip-roofed houses in most winds, if vented on all sides), the roof space was pressurized in the normally vented condition, whereas the valving reversed that, depressurizing the roof space beneficially. All of that is in accord with calculated pressures taken from the knowledge base of exterior pressure regimes (from University of Western Ontario and elsewhere).

In the Pouch Cove project, the VSV crew—householder and author—were able to observe the following during their work on site, June 12-14th. (In addition to end-on breezes—southwesterly and westerly—there were hour-long periods of slanted and broadside breezes at different times, generally northerly and once from the south. Excepting momentary gusts, none of these were judged to exceed 15-25 kph):

- In end-on breezes, the valves fluctuate mildly in gusts and eddies but essentially remain open to the low pressures below them. The valves make essentially no difference where end-on winds flow freely around a rectangular-plan house which presents little interference.
- In broadside breezes, the windward valves close and stay closed where speeds are palpably 15-25 kph or more. Here, the valves do full duty: no wind entry occurs at speeds that could entrain rain, or even fine snow. The leeside valves hang limply open, with and without mild fluctuation; the roof space remains open only to the depressurized regimes bordering those vents.
- In appreciably slanting breezes and gusts the more windward valves close too. Wherever there's an inward-acting pressure differential (which would include where protrusions such as in L, T or H-plan houses interfere with wind flows along the sides) the valves have a job to do, and appear to do it just as in the model tests.
- Even gentle gusts on the windward and around the house ends can cause the valves to cycle shut-open fairly freely—and too noisily, despite their soft rubber bumpers.

In the research team's formal September monitoring runs, with SW and WSW winds end-on to the house, the pressure in the roof space proved essentially the same as the mean outdoor pressures just below the open vents—and did so in the earlier runs too. These outside pressures along the sides parallel to the wind fluctuate rapidly even in steady winds, in the field or wind tunnel—but are always negative. Again, the valves give no advantage in this end-on exposure of a house of simple rectangular plan: valved or unvalved, the vents keep the roof space depressurized in end-on winds.

Depressurized—but to what actual pressure? The twinned barometers indicated that the "reference" indoor pressure of this house was drawn down to approximately 70 Pa below the outdoor static pressure, in 50 km/hr winds from any direction, and as much as 120 Pa in 65-70 kph winds. (Those depressurizations do follow the velocity-squared law, and are believable for this completely gutted/air-sealed/renovated house with projecting flues venting a fireplace as well as the oil furnace with its barometric damper. The householder reports that windows, doors, fireplace damper and attic hatch were closed during all trials.) Accordingly, the 70 Pa offset has been applied to all 50 kph trial results to suggest actual wind-induced pressure differentials. With that rather

Table 1 Field Test Alongside Scale Model Test Findings

Pouch Cove House ~ 50 km/hr, Pv*~ 120 Pa (calculated)			**Vehicle-Mounted 1:15 Model House** ~100 km/hr, Pv ~ 412 Pa (measured)		
2006	Prs* approx	**Prs/Pv***	**Prs/Pv***	Prs* measu-red	2005
Sept 10th Valved[1] →	-70 Pa	**~0.58** $\downarrow$[3]	**0.53** $\downarrow$	-216	←**Valved** July 8th
June 21st **Valved**[2] →	-65	**~0.54** $\downarrow$[3]			
July 3rd **Open Vents**[2] →	-65	**~0.54** $\downarrow$[3]	**0.53** $\downarrow$	-216	←**Open Vents**
Wind Tunnel Test Derivations ~ 100 km/hr, Vp ~ 170 Pa.			**Vehicle-Mounted 1:15 Model House** ~100 km/hr, Vp ~ 412 Pa		
		Prs/Pv*	**Prs/Pv***	Prs* Pa	2005 June 30
Open Vents →		**~0.2** $\uparrow$	**0.20** $\uparrow$	+83	←**Open Vents -** Roof space pressurized above ambient.
Valved → (Based on wind tunnel and field measurements of pressures under the windward and leeward soffits –UWO and other sources.)		**~0.3** $\downarrow$	**0.26** $\downarrow$	-108	**Valved** June 30th Roof space depressurized

*Prs – pressure in roof space, Pascals; Pv – wind's velocity pressure; *The **Prs/Vp** ratio is a standard way of expressing wind pressures on/in buildings, allowing direct comparison of results measured at different wind speeds. *A downward arrow denotes negative pressure, "pulling" down on the roof sheathing; upward denotes positive pressure, adding to uplift. Note 1: Sept 10 run was the only one with exterior pressure taps cut flush with bldg surface. The pressure readings for all three runs have been crudely adjusted (see text) to relate to ambient (static) pressure. 2. While these runs had flapping pressure taps affecting external pressure readings, their roof space taps would be free of such effects. 3. Air leakage would be expected to weaken the depressurization in an actual house roof space vs. the model test results. The Pouch Cove results are likely somewhat optimistic, probably due to the crude correction for static pressure using two barometers.

crude superposition, the wind-induced outdoor pressures under the vents do agree with the knowledge base, and the wind-induced roof space pressures (Prs) agree with their mean values and with scale model results, Table 1.

CONCLUSIONS

Valving the soffit vents to shut against wind/rain entry, while remaining open to low-pressure lee and separation zone "suctions," does appear to work in the field just as in theory and scale model testing. Where normal vents can allow winds to push in ruinous amounts of snow or rain and worsen blow-out forces on the envelope, valving can stop the former and reverse the latter, depressurizing the roof space and thereby reducing the net blow-out forces. The valving can be a simple and effective retrofit. The prototypes are, however, too noisy.

Performance in stronger, gustier winds should be studied, and should include L-plan or similar interferences with wind flows. Final "proof runs" are being set up in a Category 5 "hurricane simulator" program (Forrest Masters, University of Florida). Another house case study, the Mercer Pilot Project, has already been done in Florida, using an improved, quieter "Valved Throat Vent" that installs above any type of vented soffit. (It testifies that sleep-depriving valve noise is still a problem, but a "whisper quiet" valve has now been bench-tested successfully.) More pilot retrofits are being readied.

CMHC Project Manager: Don Fugler

Consultant: Bob Platts
Stormfirma Inc.

Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more ***Research Highlights*** plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642
Fax: 1-800-245-9274

Printed in Canada
Produced by CMHC 14-06-07

65417