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by

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J. I. Lawson

THE USE OF ASPHALT SHINGLES for the surface covering of roofs has become so widespread in Canada, and their performance is generally so satisfactory, that any unusual experience with them is worthy of special study. Such an opportunity presented itself to the Division of Building Research, National Research Council, in May 1951. On the 6th and 7th of that month severe wind-storms swept the Ottawa Valley and caused considerable damage to shingled roofs, especially within the City of Ottawa. It was decided that a thorough investigation should be made of the nature and extent of damage and the causes of the widespread failures in shingle roofing. The task of investigating the damage done by the storm was entrusted to Mr E. W. Glenesk, and the author.

Wind Velocities

On May 6 the wind reached a velocity (one-hour duration) of 47 m.p.h. from 2 to 3 p.m. with a maximum gust velocity (10 minutes' duration) of 62 m.p.h. at 3.30 p.m. From 10 a.m. to 9 p.m. on May 6 the direction of the wind was south-westerly. From then until the early morning of May 7 the direction was north-westerly, changing to westerly and continuing in that direction until the evening, at which time the velocity had dropped to normal. Thus the most severe wind came from a south-westerly direction. No rain fell during the wind-storm.

Table I, which has been prepared from data received from the Meteorological Division of the Department of Transport, sets forth on a monthly basis the maximum velocities of one-hour duration and the maximum gusts of ten minutes' duration during storms which have occurred during the past five years.

From this table it will be seen that during the past five years, on two occasions only has the severity of the subject storm been exceeded and that storms approximating it in intensity and having gusts in excess of 40 m.p.h. have occurred on sixteen occasions.

The average wind velocity at Ottawa has been exceeded at 97 of the 162 weather stations reporting wind data in Canada. It may, therefore, be assumed that methods and

TABLE I

MAXIMUM WIND VELOCITIES IN OTTAWA*: 1945 TO 1950

Maximum Velocity for One Hour per Month

OTTAWA (A)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1945	25	35	35	40	41	21	24	29	30	37	30	29
1946	34	54	31	44	26	27	28	25	28	30	35	42
1947	34	29	32	32	36	33	26	26	32	26	27	35
1948	32	35	31	29	26	25	29	26	23	28	36	27
1949	36	30	27	26	28	28	26	22	39	34	25	30
1950	48	32	33	26	47	–	–	–	–	–	–	–

Maximum Velocity for Ten-Minute Period per Month

OTTAWA (A)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1945	29	35	–	41	41	–	29	35	35	41	35	35
1946	35	63	35	46	29	29	41	29	35	35	41	46
1947	41	35	35	35	41	41	29	29	35	29	29	41
1948	35	25	35	35	29	29	35	29	29	35	35	29
1949	48	35	29	29	29	29	33	41	41	35	35	35
1950	52	41	35	29	–	–	–	–	–	–	–	–

*Readings: Uplands Airport

procedure that will produce satisfactory roofing in the Ottawa district will be equally satisfactory in at least one-half of the weather districts in Canada. Meteorological charts which define these areas will be found in the "Climatological Atlas of Canada" published jointly by the Meteorological Division of the Departments of Transport and the Division of Building Research of the National Research Council.

Installation of Asphalt Shingles

Before dealing with the survey of the damaged roofs, it may be well to review the accepted regulations and standards which are applicable to the laying of asphalt shingle roofing. The manufacturers of asphalt shingles usually include a sheet of instructions, presented graphically as well as in text, which are complete and leave no room for uncertainty on the part of the builder.

Among these instructions, as applying to 3-in-1 asphalt shingles, are the following:

The pitch of the roof should be 4 inches or more to the foot;

Roof boarding should be flat and true and so nailed that it will not curl or warp;

The flashing strip at eaves and along the rake of gables should extend not more than ⅜ inch beyond the wood fascia;

A starting strip of slate surfaced roll roofing at eaves should be at least 18 inches wide and not less than 6 inches wider than the projection of the eaves;

An underlay consisting of one ply of asphalt waterproof breathing paper over the entire roof should be lapped not less than 2 inches;

First course of slate surfaced shingles laid at eaves over the roll roofing;

Six nails per 3-in-1 shingle applied ½ inch above the top of the cutouts and 1½ inches from the end of shingle and from the centre line of the cutouts;

Nails shall be large-headed galvanized or aluminum roofing nails 1¾ inches long when laying over old shingles and 1 inch long for new work; and

If exposed to extremely severe winds, butts should be cemented down with a 1-inch spot of asphalt plastic caulking cement under the centre of each tab.

Other instructions relating to ridges, valleys, and chimneys are included but are not repeated here as they have no bearing on the damage caused by the storm.

The following stipulations are extracts from the two principal sets of building regulations in Canada:

CMHC Standards

a) Material shall be laid in accordance with the manufacturers' directions;
b) Asphalt felt shingles shall weigh not less than 210 pounds to 100 square feet of roof surface; and
c) Slope of roof shall be not less than 6 inches in 12, except that on Vancouver Island and lower coastal regions of the B.C. mainland, the slope may be not less than 5 inches in 12. (In CMHC Building Standards, 1954, it is stated that a pitched roof shall have a slope of not less than 5 inches in 12.)

National Building Code (1953)

a) The minimum head lap shall be 2 inches;
b) There shall be two nails for each tab. The nails shall not be placed at the head of the slot;
c) Where experience shows it to be necessary the administrative official may require shingle butts to be cemented down;
d) The minimum nominal weight per square and the maximum exposure shall be 210 lb. and 5 inches respectively. With special types of shingles these restrictions are somewhat relaxed.

Field Study

Before beginning the investigation in the field, useful information as to the location and general extent of the failures in various areas was obtained from the City Architect's Office and from the Head Office and the Ottawa Branch Office of Central Mortgage and Housing Corporation. On completion of the survey a local firm of insurance adjusters was interviewed. They stated that as a result of the storm between 500 and 600 claims had been filed and that the amount of the claims averaged approximately $20.00 per claim. It was estimated that at least one in every 15 to 20 asphalt shingle roofs in the area had suffered some visible damage due to the wind-storm.

On examining the damaged houses it was found that, with a few exceptions, they had all been built during the previous five years and that they were located in all parts of the City and district where extensive new housing had been built during that time. With few exceptions, the damage to any one roof was not extensive.

In the majority of cases the failures had occurred at the eaves or ridge, but there were many cases of damaged areas in the general field of the roof and a few failures on the roofs of dormers. Roofs having a low pitch, 20 to 30 degrees, appeared to be more susceptible to damage than those having a slope of 40 to 45 degrees. All damaged slopes had a southerly or westerly exposure.

As nearly all of these houses were built under the provisions of the National Housing Act, a restriction had automatically been applied on the use of shingles under 210 pound weight per 100 square feet. The great majority of the shingles examined were 210-pound 3-in-1 shingles of the thick butt type on which nearly all manufacturers had standardized under war-time controls. Some houses, however, were roofed with 210-pound shingles of the flat type, that is, of the same thickness from top to butt.

Many shingles were examined and no defects due to manufacture were found. Failure could not, therefore, be attributed to this cause. The failures appear to have been progressive. The butt of a poorly laid shingle on being lifted by the wind exerted a lifting effect on the shingles above it and this action continued from shingle to shingle. The resulting flapping of the tabs of the shingles caused tearing at the cutouts and even at the point of nailing by pulling over the nail heads.

Findings from Survey

It would appear that the failures can be attributed to one or more of three causes: negligence in preparing the roof to receive the shingles; improper nails and nailing;

and faulty workmanship. On comparing the results of the survey with the Manufacturers' Instructions for Application and with the building regulations quoted, it was found that the instructions and regulations relating to the preparation of roof surfaces, to nailing and to workmanship had been violated in every roof examined in one or more particulars.

Preparation of roof surfaces:

i) In every case the flashing strip at eaves and at the rake of gables had been omitted;
ii) In most cases the starting strip for reinforcement over the eaves had been omitted;
iii) In many cases there was no underlay sheet; and
iv) In a few cases there was no underlay sheet, flashing or starting strip.

Nails and nailing:

i) Many of the nails were not corrosion resistant;
ii) A large percentage of the nails were too short, being less than 1 inch long; and
iii) Very few shingles were nailed with the stipulated 6 nails; in most cases there were only 4 nails per strip and in some there were only two or three. A few shingles were found which had no nails at the butt line being nailed only at the upper edge by nails from the shingle above.

Workmanship:

i) In some cases the projection of the shingles at the eaves and rake was too great; being as much as 1½ to 2 inches;
ii) In a few cases the starting shingles were not properly laid or nailed;
iii) In the majority of cases, the nails were misplaced: they were driven through the selvedge instead of through the top of the thick butt or were placed immediately above the cutout instead of being the stipulated 1½ inches from either side: nails driven into the selvedge were pulled through the material or caused it to tear: when nails had been placed at the top of the cutout, many of the shingles had split apart at this point;
iv) Many of the nail heads were driven into the shingle to the extent that the imprint of the hammer head was visible: this had a punching shear effect which materially weakened the shingle;
v) In no case had the tabs been cemented down as recommended for severe exposure; and
vi) In a few cases the ridge shingles were dislodged because of improper lapping or nailing.

Discussion of Findings

Deficiencies in the preparation of the roof surfaces to receive the shingles, although not the principal cause of failure, were indirectly an important factor. The flashing at the eaves and rake reduces the effect of icing which tends to loosen the shingles at the most vulnerable part of the roof. Most of the failures occurred at the eaves or rake of the gables and this may be attributed to the too common practice of projecting the shingles as much as 1½ to 2 inches instead of the stipulated ¼ to ⅜ inch.

Improper nailing was the most general and the most serious fault and would appear to have been the principal cause of the failures. If from any cause a shingle becomes loose, lifting action by the wind will occur. This lifting causes the rigid butt of the shingle to exert considerable leverage on the nails. Unless they are properly placed and firmly driven, this leverage will cause withdrawal. If the nails are placed above the butt in the thin limp section of the shingle, the material will tear at the nail. If they are placed above the cutout in the weakest point of the butt, the shingle will crack and fail at this point.

When a loose shingle is lifted by the wind it acts as a lever on the shingle above. The force of this leverage may be considerable as the ratio of length of butt to overlap is about 6 to 1. This action becomes progressive and may continue from shingle to shingle until the wind subsides.

The "thick-butt" shingle, which was developed to stimulate wood shingles, may be weakened at the cutouts if improperly nailed as is the case with all shingles. When nailed correctly the butt has a satisfactory resistance to bending but nailing above the thickened bond into the thinner upper part reduces the resistance of the shingle to the lifting action of the wind.

"Slab type" shingles which are the same thickness throughout possess considerable elasticity and being thinner than the "thick-butt" shingles offer much less resistance to the wind. They will bend without cracking and so the leverage on the nails is less. Only in the event of extreme lifting would there be any stress on the shingle above. As the shingles are the same thickness throughout, misplacing of the nails (within reason) would have little or no effect. It would seem that this would account for the fact that in the survey no failures were found in this type of shingle.

The main and direct cause of failure was, however, the disregarding of regulations and instructions for application. That 500 to 600 roofs in the Ottawa area were damaged by this wind-storm is impressive even though a relatively small area of each of the roofs was affected. The percentage of shingles damaged to shingles laid was actually very small. It may, therefore, be assumed that had all the shingles been laid strictly in accordance with the regulations and instructions the damage caused by this storm would, in all probability, have been negligible. The study reinforces the vital importance of adherence to the recommendations of the manufacturers of building materials. It also shows the eminent desirability of adequate inspection to ensure good workmanship in house building.