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THE WETTING OF WALLS BY RAIN

by

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PREFACE

Water is by far the most troublesome agent in building. It is almost always involved in the degradation of materials, particularly when they are exposed to the weather. The degree of saturation of masonry is an important factor in determining the damaging effects of freezing. Rain penetration is a continuing problem. In view of these and other considerations in the design of buildings, it is important to know more about the distribution of rain over building surfaces. Measurements made with the aid of rain-collecting cups on two buildings, one in Ottawa and one in Halifax, are now reported.

Mr. Ritchie in Ottawa and Mr. Davison in Halifax are research officers with the Division. Both of them have been engaged in studies of various aspects of masonry over a number of years.

Ottawa
January 1969

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Associate Director.

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Important Canadian building problems, including moisture penetration, efflorescence on masonry, frost damage and excessive dimensional changes, occur as a result of the wetting of walls by rain. The degree to which a wall is wetted may be expected to depend on many factors, including the geographical location of the building, the direction the wall faces and the extent to which the wall is shielded by other buildings and objects.

The state of knowledge concerning the onslaught of rain on buildings was reviewed by Lacy in 1965 (1), who described methods used to measure the intensity of wetting of walls by means of rain gauges and presented the results of measurements involving several buildings. Because of the nature of the flow of air around buildings during rain storms, non-uniform wetting of walls occurs. Casual observations of walls after rains frequently show this to be the case, certain areas, usually those near the top, obviously being much damper than the remainder of the wall. In addition to providing a review of information on the intensity of rainfall on walls, Lacy also considered compiling maps of driving rain index to indicate variations with geographical location in the degree of severity of the exposure of walls to rain.

The purpose of this report is to describe a study made of rain falling on the walls of two buildings, one located in Ottawa, Ontario, the other in Halifax, Nova Scotia. The buildings are occupied by the Division of Building Research and the Atlantic Regional Station, respectively, of the National Research Council. The walls of the former building are constructed of hollow clay tiles with an exterior finish of painted stucco; the Halifax building is faced with sandstone slabs. Only the east wall of each building was studied. Rain-collecting cups were attached at several locations on the wall surface and "run-off" gauges were installed along the base of the wall to collect rain water running down the wall surface.

RAIN GAUGES

The rain-collecting cups, rectangular metal boxes with an open face measuring 8 in. by $2\frac{1}{4}$ in., were attached to the wall with the longer dimension in the vertical direction. The depth of the box was such that the open face was 2 in. from the wall surface. Rain entering the box fell into a trough at the base from which it drained through a plastic tube to a collecting bottle. The run-off gauges, thin rectangular metal boxes 12 in. long, a $\frac{1}{2}$ in. wide and 4 in. deep with an open top, were attached and sealed to the wall with the long dimension horizontal. Water flowing down the wall surface entered the open top of the gauge, and was drained through a plastic tube from the bottom of the gauge into a collecting bottle. A rain cup and a run-off gauge are shown in Figure 1.

Six rain cups were mounted on the wall of the Ottawa building. This wall, 92 ft long and 14 ft high, is the east wall of a penthouse forming the third storey of the building, the remainder of which is two storeys high. The floor area of the penthouse is smaller than that of the remainder of the building, and the penthouse walls adjoin the roof of the lower part of the building on the east side and elsewhere (Figure 2). The top of the east wall of the penthouse is 45 ft above grade.

The rain cups were attached to the wall near its top and bottom, a cup being located 1 ft from the top of the wall and another directly beneath it, but 5 ft above the base of the wall. Two such pairs of cups were located 6 in. from each end of the wall and another pair was located 18 ft from the north end. A free-standing cup, placed 10 ft in front of and at the same height as the bottom cup of the middle pair, was also included in the study. A run-off gauge was attached to the wall beneath the lower rain cup of each pair, but located 1 ft laterally from it.

A similar arrangement was made on the east wall of the Halifax building which is 183 ft long and 30 ft high (Figure 2). A penthouse on the building has walls which rise 5 ft above the height of the main walls. Four rain cups were attached to the east wall, located in pairs at each end of the building, 1 ft from the corners. The upper cup was 1 ft from the top of the wall, the bottom cup 6 ft from the base of the wall. A run-off gauge was attached to the wall beneath each pair of cups but displaced laterally 1 ft. A fifth rain cup, placed on a rack on the penthouse roof, was 40 ft above the base of the wall.

RESULTS

The amount of rain collected in a particular cup naturally varied greatly from rainfall to rainfall depending on its intensity. In general, rainfall at Halifax is more intense than that at Ottawa and the amount of rain collected in the cups at the former place was therefore greater than that obtained at Ottawa.

At both Halifax and Ottawa there was a significant difference between the amount of rain collected in the top cup and in the corresponding cup near the base of the wall, the former frequently catching several times the amount caught by the latter. The relative amounts are depicted in Figures 3 and 4. On several occasions, however, particularly at the Halifax building, more rain was caught in the lower cup than in the higher one. The variation in the amount of rain caught in the upper and lower cups probably depended on the wind speed and its angle with the wall, as well as the geometry of the building, but the manner in which they influenced the results is not known. Another factor which affected the results was that on a few occasions the tubes joining the cups to the collecting bottles became plugged up.

At both Ottawa and Halifax the amount of rain collected differed at the various locations along the wall. More rain, for example, was generally caught in the cups near the north end of the wall at Halifax than near the south end, while at Ottawa the reverse was generally the case.

A rain cup at Halifax mounted on a rack on top of the penthouse usually caught about the same amount as the top cups on the wall. Similarly, the amount caught by the free-standing cup at Ottawa, 10 ft from the wall surface, corresponded generally to that caught by the cup mounted on the wall behind it at the same height.

The differences in the amount of rain caught in cups along the wall was reflected in the amount of water collected by the run-off gauges. At Ottawa the gauge near the south end of the wall generally collected appreciably more water than the others; at Halifax the reverse was generally the case, the gauge at the north end collecting more than that at the south end. This situation may reflect not only differences in the amounts of rain hitting the wall directly above the gauges but also possible lateral movement of the film of water flowing down the wall surface, the film being deflected by the wind's pressure. Because of the water-absorptive capacity of the walling material, a certain amount of the rain falling on the wall would be absorbed by it, thus reducing the amount flowing into the gauge. The absorptive capacity of the wall is not constant. It is at a maximum value when the wall has had an opportunity to dry completely before again being wetted, and at a minimum value when it is nearly saturated from a previous rain.

CONCLUSIONS

Measurements with rain cups attached to the walls of two buildings indicated that when these walls were wetted by rain the degree of wetting was highly irregular. A particularly marked difference was noted in the amount of wetting received by the upper part of the walls and that received by the lower portion, the upper part generally being subject to much more intense wetting. The results of this study may therefore account for the frequent occurrence of masonry materials being damaged near the top of walls while apparently sound at lower levels, since the rate of decay of a masonry material from frost action, chemical interaction, and crystal growth depends in large measure on the amount of moisture in the material, especially when freezing is the agency of decay.

Measurements of "run-off" from wetted walls reflected the differences in wetting which occurred across the walls and also indicated that a considerable portion of the rain was absorbed by the wall before it could flow down the surface and enter the gauge.

REFERENCE

(1) Lacy, R.E. Driving-rain maps and the onslaught of rain on buildings. Ministry of Technology, Building Research Station, Paper 54, Research Series, Great Britain, 1965.

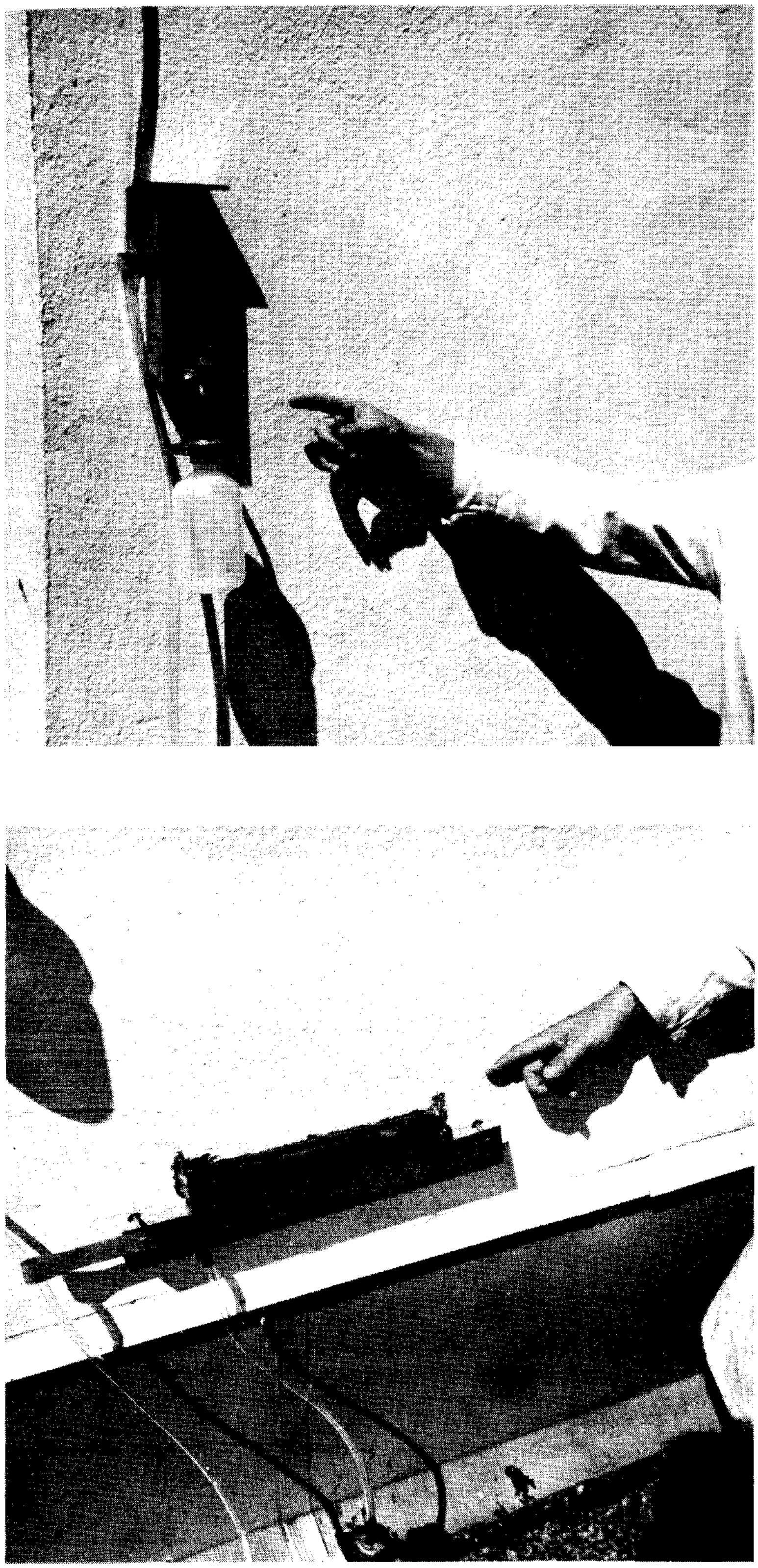

Figure 1. Rain cup (top) and run-off gauge on the wall of the building in Ottawa.

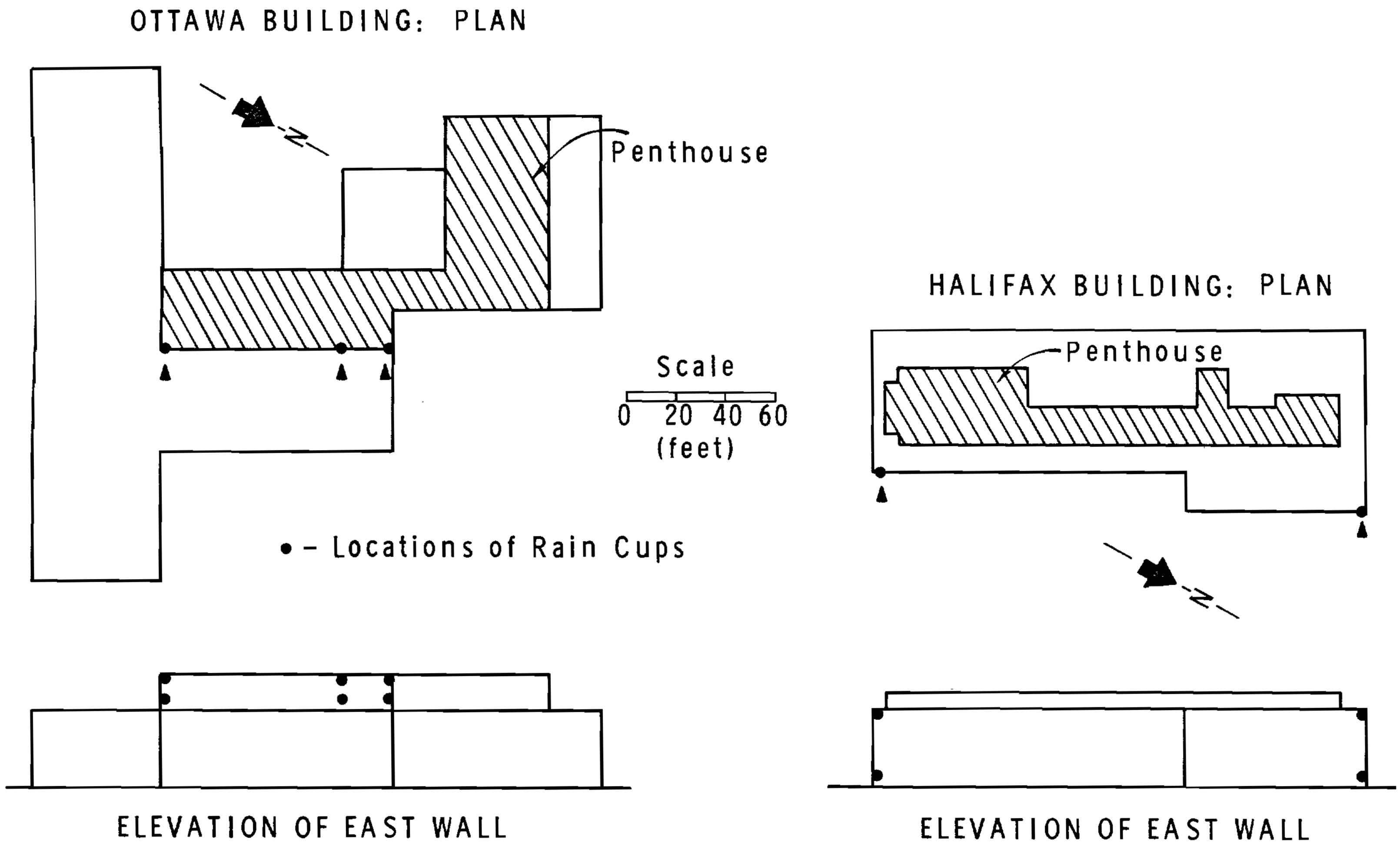

FIGURE 2

PLANS AND ELEVATIONS OF THE BUILDINGS

BR 4098

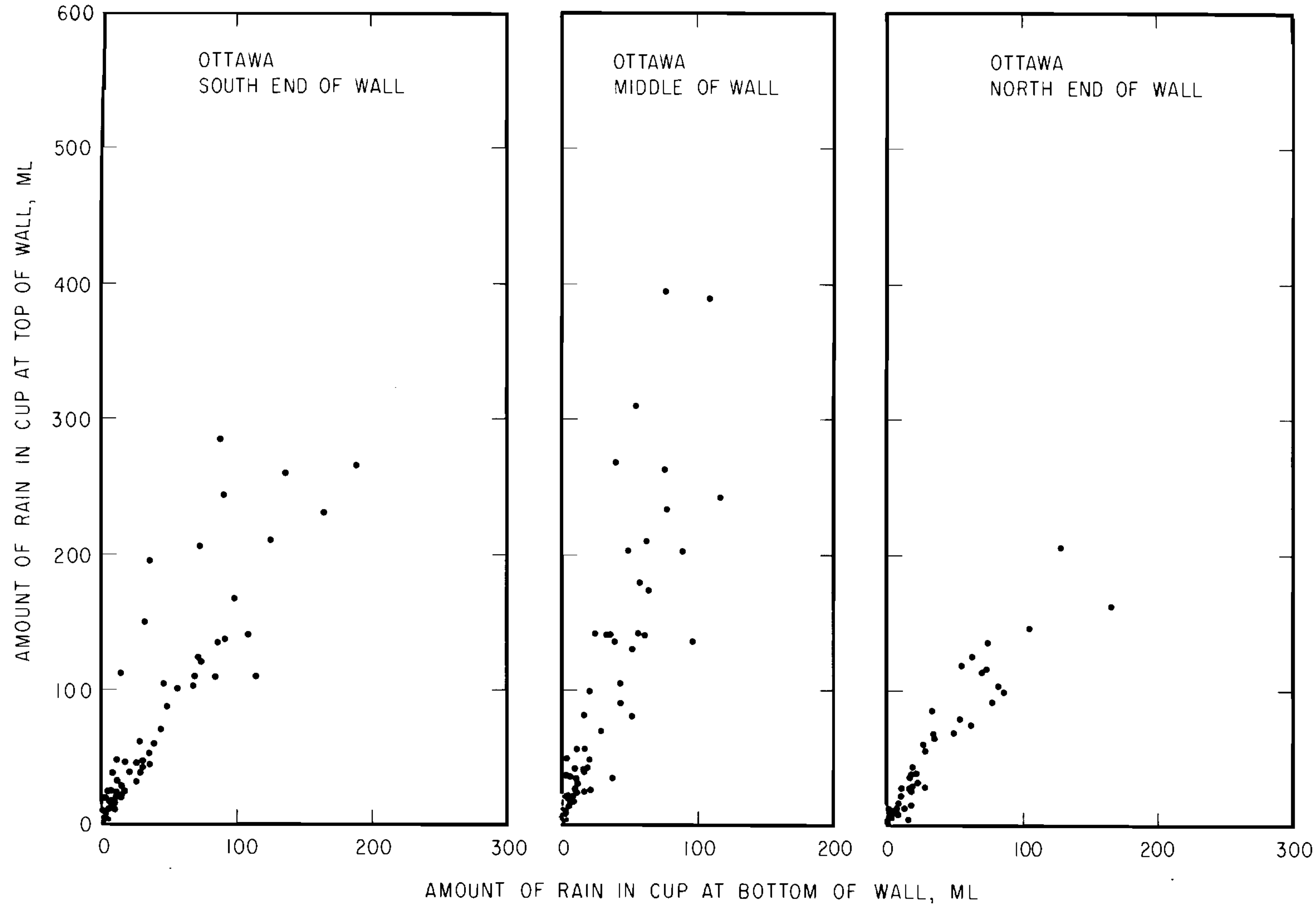

FIGURE 3
RELATIVE AMOUNTS OF RAIN CAUGHT IN CUPS AT TOP AND BOTTOM OF WALL AT OTTAWA

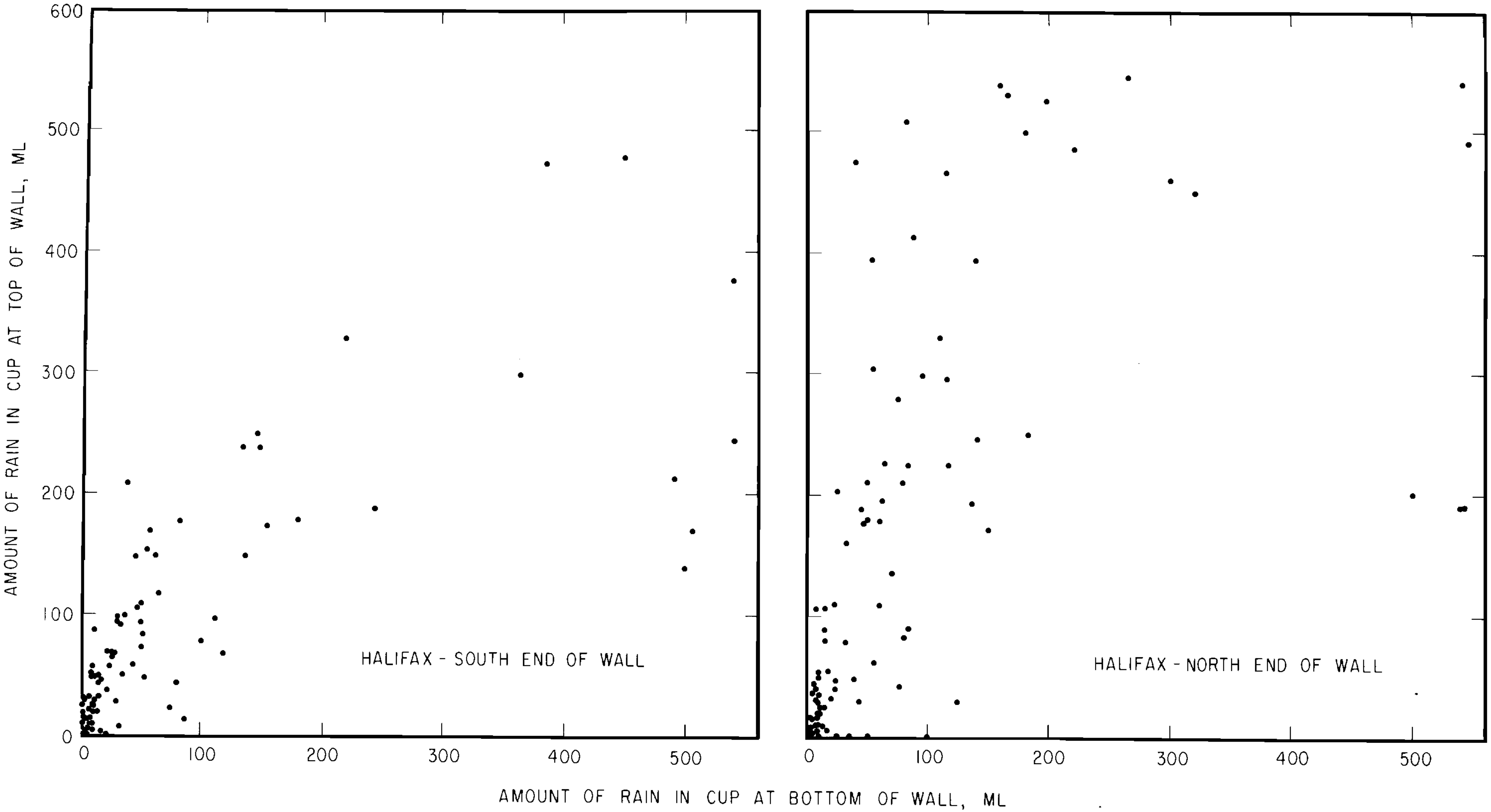

FIGURE 4
RELATIVE AMOUNTS OF RAIN CAUGHT IN CUPS AT TOP AND BOTTOM OF WALL AT HALIFAX