

**11b. Wind Load.**—Various formulas and rules have been presented in the past for the purpose of determining wind pressure upon a plane surface normal to the direction of the wind.

In the past, reliable results were believed to be given by the Duchemin formula, derived by a French army officer, Col. Duchemin, from experiments made in 1829. This formula is

$$P_n = P \frac{2 \sin \alpha}{1 + \sin^2 \alpha}$$

in which  $P$  = unit pressure in pounds per square foot on a surface perpendicular to the direction of the wind,  $P_n$  = component of pressure normal to the roof, and  $\alpha$  = angle which the inclined surface makes with the direction of the wind. Since this formula has been widely used in the past, illustrative problems are provided in which it is applied.

Probably the most authoritative source of information at the present time is the *Final Report* of Sub-Committee No. 31, Committee on Steel, Structural Division of the American Society of Civil Engineers. This report, published in the *Transactions* of the Society, Vol. 105, p. 1713, 1940, recommends as follows:

(1) As a standard wind load for the United States and Canada the Sub-Committee recommends a uniformly distributed force of 20 lb. per sq. ft. for the first 300 ft. above ground level, increased above this level by 2.5 lb. per sq. ft. for each additional 100 ft. of height, no omission of wind force being permitted for the lower parts of the building by reason of alleged shelter. Special wind-force specifications should be formulated locally for areas that are definitely known to be subject to hurricanes or tornadoes.

The foregoing recommendation applies only to those surfaces which are perpendicular to the direction of the wind, the wind being assumed to act horizontally. It has been recognized for some time that suction may exist for certain inclinations of a plane surface on the windward side and for all inclinations on the leeward side as well as for surfaces parallel to the wind. With respect to this effect, the report states:

(2) For proportioning the wind bracing of tall buildings it is not necessary to divide the wind force into pressure and suction effects, although this should generally be done for structures with rounded roofs, for mill or other buildings with large open interiors, and for walls in which large openings may occur. The effects of possible high local suction should be investigated in relation to secondary members and the attachment of roofing or siding.

## STRESSES IN FRAMED STRUCTURES

(3) For plane surfaces inclined to the wind and not more than 300 ft. above the ground, the external wind force may be pressure or suction, depending on the exposure and the slope. For a windward slope inclined at not more than 20 deg. to the horizontal, a suction of 12 lb. per sq. ft. is recommended; for slopes between 20 and 30 deg. a suction uniformly diminishing from 12 lb. per sq. ft. to zero; and for slopes between 30 and 60 deg. a pressure increasing uniformly from zero to 9 lb. per sq. ft. For the leeward slope, for all inclinations in excess of zero, a suction of 9 lb. per sq. ft. is recommended.

(4) It is recommended that for a flat roof a normal external suction of not less than 12 lb. per sq. ft. should be considered as applied to the entire roof surface.

(5) On walls parallel to the wind it is recommended that an external suction of 9 lb. per sq. ft. should be considered.

### Special recommendations for rounded roofs are:

(6) For roofs that are rounded or may be represented roughly by a circular arc passing through the two springings and the eaves, the wind force will depend not only upon the exposure and the ratio of rise to span of the equivalent circular arc but also upon whether the springings are elevated above the ground or are on the ground. Where the surfaces considered are not more than 300 ft. above ground level the recommended external wind force is as follows:

(a) On windward quarter of the roof arc, when the roof rests on elevated vertical supports and where the rise ratio is less than 0.20, a suction of 12 lb. per sq. ft. is recommended; and for a rise ratio varying from 0.20 to 0.60, a pressure increasing uniformly from zero to 12 lb. per sq. ft., or alternatively, for rise ratios between 0.20 and 0.35, a suction varying uniformly between these limits from 12 lb. per sq. ft. to zero is recommended. For roofs springing from the ground level a pressure, for rise ratios varying from zero to 0.60, uniformly increasing from zero to 11.4 lb. per sq. ft., is recommended.

(b) For the central half of the roof arc, where the roof rests on elevated vertical supports, with rise ratios varying from zero to 0.60, a suction uniformly varying from 11 lb. per sq. ft. to 20 lb. per sq. ft. is recommended; for roofs starting from ground level, a suction of 11 lb. per sq. ft., regardless of the rise ratio, is recommended.

(c) For the leeward quarter of the roof arc, for all values of the rise ratio greater than zero, a suction of 9 lb. per sq. ft. is recommended.

In addition to wind forces acting on the external surfaces, the report further recognizes the existence of internal wind forces of pressure or suction as stated below:

(7) Even for buildings that are nominally airtight, internal wind forces of either pressure or suction may exist, varying from 3 to 6 lb. per sq. ft. and depending on whether the openings are generally in the windward or in the leeward surfaces. Large internal pressure may arise due to the breaking of windows in the windward side of buildings by reason of flying gravel from the roof or other objects carried by the wind. Still larger internal forces of pressure or suction may arise when the windward or leeward side of a building is completely open. The Sub-Committee recommends that for buildings that are nominally airtight an internal pressure or suction of 4.5 lb. per sq. ft. should be considered as acting normal to the walls and the roof. For buildings

## GENERAL THEORY

with 30 per cent or more of the wall surfaces open or subject to being open, an internal pressure of 12 lb. per sq. ft. or an internal suction of 9 lb. per sq. ft. is recommended; for buildings that have percentages of wall openings varying from zero to 30 per cent of the wall space, the recommendation is an internal pressure varying uniformly from 4.5 to 12 lb. per sq. ft. or an internal suction varying uniformly from 4.5 to 9 lb. per sq. ft.

With regard to the determination of the final design wind force in any specific instance, the following is quoted from the report:

(8) The Sub-Committee recommends that the design wind force applied to any surface of a building be a combination of (a) the aforementioned appropriate external wind force and (b) the appropriate indicated internal wind force.

(9) Where a series of roofs exists in one building, one roof being nominally masked by another, the structure as a whole should be designed for the full wind load on the first roof and for 80 per cent of the wind load on the other roofs. Any one roof should be designed for the full wind load.

(10) When wind surfaces are more than 300 ft. above the ground, the external and internal wind forces should be scaled up in the proportion that the prescribed wind force on plane surfaces normal to the wind fixed by recommendation (1) at the level under consideration bears to 20 lb. per sq. ft.