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Influence of Plan Dimension Ratio of Enclosures on Indoor Air Motion

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The results of a study on the impact of variation in the ratio of plan dimensions of an enclosure with fixed floor area and fenestration size on the wind induced air motion indoors are presented. It is observed that so long as the window is not extended over the entire wall length and wind is incident within 45° to the normal to the window, the average indoor wind speed in a square enclosure is greater than in rectangular enclosures irrespective of their shape (deep or narrow), However, when the window covers the entire wall length, a deep enclosure shows better ventilation performance. Wind speeds achievable in a deep rectangular enclosure are almost equal to those obtained in a narrow enclosure when the length to width ratio is 2.

THE size of an enclosure is usually selected on the basis of the space requirements in the light of the activities of the users. Enclosures may be designed in any shape, but generally a rectangular plan is adopted because of the ease of construction and some other economic design considerations. In the case of a rectangular plan, a given floor area may be made from different values of the two sides of the plan. A variation in length to width ratio causes a change in the functional efficacy of the enclosure in respect of various environmental parameters, such as heat, light, ventilation, acoustics, etc. Gaudill and Reed[1] studied the influence of room depth on the wind speeds achievable along the main air stream. The present study was aimed at investigating quantitatively the influence of the length-width ratio of enclosures on wind induced air motion in the occupancy zone indoors.

Experimental Procedure

The study was carried out on 1/30th scale models of enclosures having an arbitrarily fixed floor area of 100 m^2 and 3 m height. Identical windows having a total area of 10 m^2 were provided on opposite walls of the models to facilitate the cross-flow of wind. An omnidirectional hot wire anemometer was made use of for determining the distribution of air speeds indoors. Observations were taken at symmetrically located 15 points at a plane passing through the sill level of the windows. Measurements were made for angle of incidence of wind varying from 0° to 90°. Tests were conducted in a low speed wind tunnel[2] having a free speed of about 2 m/sec. To investigate the influence of length to width ratio on the availability of air motion indoors, experiments were conducted on models having length width ratios 1,2,3, 4 and 5. The ventilation performance of narrow and deep enclosures was examined by locating the windows on longer and shorter walls respectively.

Results and Discussion

Narrow enclosures — In this case, the length of the wind facing wall was greater than the length of the adjacent wall of the enclosure. An increase in length width ratio reduces the distance between the inlet and outlet openings and produces a change in the air flow pattern indoors. The results depicted in Fig. 1 show that increase in the length of the enclosure from 1 to 3 times the corresponding width causes a reduction in the average indoor wind speeds for angles of incidence lying between 0° and 45°; but for greater values of incident angles, there is an increase. It is also noted that for length-width ratio greater than 3 (i.e. for 4 and 5) the air motion indoors is always less than that achievable in a square enclosure. It is attributable to the fact that in narrow enclosures, the incident air stream has to travel less distance before reaching the outlet and less volume of room air is entrained.

Deep enclosures — The enclosures were provided with openings on shorter walls, with one of them facing the incident wind. The results presented in Fig. 2 indicate that variation in length to width ratio from 1 to 2 causes a reduction in the average indoor wind speed. This is true for all orientations of the enclosures with respect to the incident wind. A similar effect is observed for enclosures having length-width ratio 3 and 4 as compared to a square model, but the quantitative variation in the average indoor

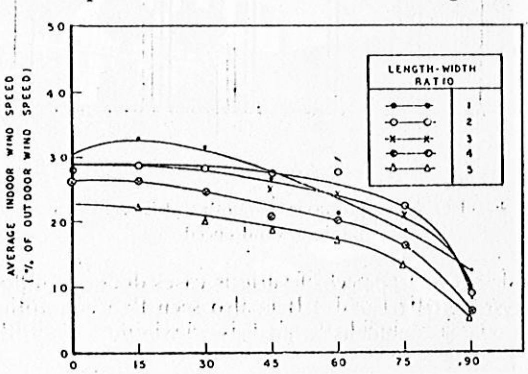

Fig. 1 — Effect of variation in length-width ratio on average indoor wind speed in narrow enclosures

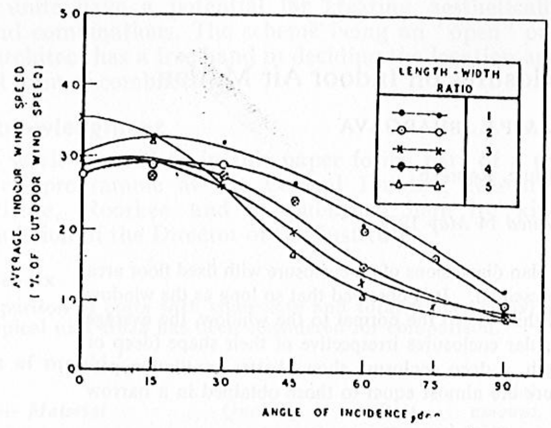

Fig. 2 — Effect of variation in length-width ratio on average indoor wind speed in deep enclosures

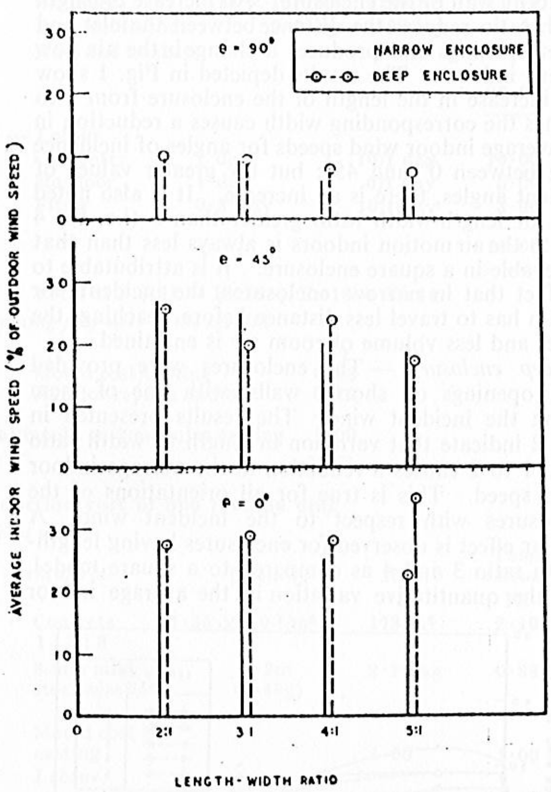

Fig. 3 — Effect of variation in length-width ratio on average indoor wind speed

wind speed in respect of various cases does not follow any systematic trend. It is also seen that air motion for normally incident wind is maximum when the length of the enclosure becomes 5 time the width. It is because the width of the window is almost equal to the corresponding wall length and air flows over the entire area of the enclosure. Thus, it is seen that for most of the practical cases, air motion indoors decreases on increasing the length-width ratio of the enclosure.

Comparative performance of narrow and deep enclosures — It is interesting to compare the functional efficiencies of narrow and deep enclosures having the same floor area and window sizes in respect of the air motion available indoors. To accomplish this, the average indoor wind speed in each enclosure was compared for two cases, viz. (i) windows located on the longer sides and (ii) windows located on the shorter sides. The results pertaining to various enclosures are presented in Fig. 3. It is seen that for normally and tangentially incident wind, the air motion achievable in a deep enclosure is almost identical with that in a narrow enclosure of similar dimensions. It is true for enclosures having length not exceeding 3 times their width. For higher values of length-width ratio, the air motion indoors is better for deep enclosures. It is also noted that when wind is incident at 45°, deep and narrow enclosures have identical air motion for plan dimension ratio 2 or 5. However, better ventilation occurs in a narrow enclosure when this ratio is 3, and in a deep enclosure when it is 4.

Conclusions

(1) For winds incident within 45° on either side of the normal to the window, the average indoor wind speed in narrow enclosures decreases as the length width ratio rises above unity.

(2) Except in cases where window covers the full wall length, air motion in deep enclosures is less than that in a square enclosure, but ventilation in deep enclosures having windows extended over the entire wall is better than that in a square enclosure.

(3) A deep enclosure and a narrow enclosure having identical dimensions with length to width ratio 2 show practically similar ventilation performance, but the deep enclosures function better as regards air motion indoors, when their length is 5 times the width.

Acknowledgement

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