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STUDY OF THE EFFECT OF NORTH LIGHT OPENINGS ON WIND INDUCED AIR MOTION IN INDUSTRIAL SHEDS

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SYNOPSIS

It is shown that northlight openings are advantageous for air motion in sheds having openings on one wall only; the benefit is of greater magnitude when the wall openings face the incident wind. It is also seen that northlight openings tend to retard the air motion in the working zone when wind blows from south. In cross-ventilated sheds having openings on opposite walls, northlight openings enhance the air motion for wind blowing from E,W, SE and SW directions.

Introduction :

The problem of natural ventilation in industrial buildings with specific reference to the effect of roof openings on air movement at working level was studied by Weston[1]. These investigations pertain to the multibays open plan buildings and do not cover industries having partitions between different bays. These days, a large number of industrial complexes comprising of small scale industries are comming up in this country and a common trend of design is to form isolated sheds by putting full height partitions between different bays of the building. Such sheds are usually ventilated by the natural force of wind. Provision of adequate natural ventilation in these sheds necessitates the knowledge of the influence of disposition of various openings on the availability of air motion in the working zone indoors. Therefore, the present investigation was carried out to examine the effect of northlight openings on the distribution of wind speeds indoors. This will help in determining optimum location of northlight openings for enhancing air motion inside single bay industrial sheds for various directions of outdoor wind.

Mechanism of wind induced air flow in industrial sheds

The flow of wind around a building causes development of excess pressure (+ve pressure) and under pressure (—ve pressure) over the various parts of the building envelope. Wind flows in through the openings located in high pressure region and escapes out through those in the low pressure region. In the case of sawtooth roof building, the pressure distribution on the walls is broadly known[2]; it is +ve on wind facing walls and —ve on leeward walls. However, the patterns of distribution of wind pressure over the roof are not so well defined. The wind flow patterns are complex over the roof because of its typical sawtooth shape.

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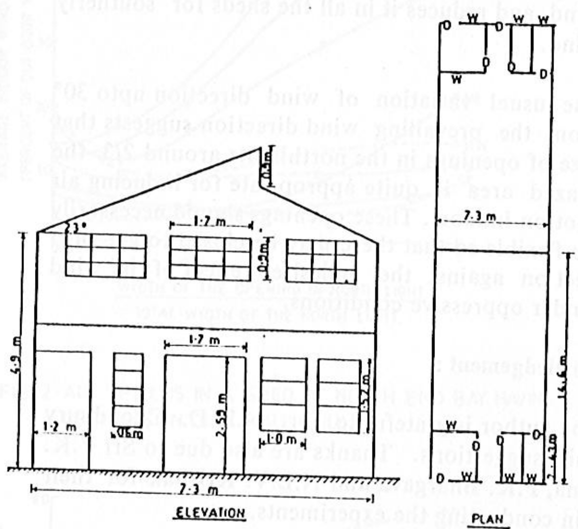
Wind pressure distribution on the roof of each bay varies with the location of bay and the angle of incidence of the wind. Consequently, contribution of a northlight opening to the availability of air motion in the interior of a bay also depends upon the bay location and its orientation with respect to the on blowing wind. A study of these aspects was made and the role of northlight openings was explored straightway by measuring the available wind speeds in the occupancy zone indoors.

Experimental setup:

The study was carried out on a 1/30 scale model consisting of three bays of an industrial building having sawtooth roof. The plan and section of one of



FIG·1·PLAN AND ELEVATION OF A BAY OF SAW TOOTH ROOF SHED.

the bays is depicted in Fig 1. On each end of the bays, provision is made for a sitting room and two bath rooms with a 1.7m wide passage between them. During the experiments, the interconnecting doors between the entry passage and sitting and bath rooms were kept closed. The total area of opening on the two longer walls of the bay is about $25.4m^2$ and the glazed area in the northlight is around $26.8m.^2$ The model was tested in a low speed wind tunnel[1] having air stream velocity of about 5.0m/sec. For convenience of description, the roof lights of the model were considered to face North. The model was oriented in a manner that the wind was incident from E, W, N, S, NE, NW, SE and SW directions. In each case, wind speeds were measured at a plane 1.2m above the floor keeping area of north light openings equal to 0, 1/6, 1/3, 2/3 and total area of the glazed area of roof lights. Such measurements were taken in the bays on south and north ends of the models. This covers the influence of upstream and downstream locations of the shed in respect of the on blowing wind. The study embraces the following cases:

Sheds having windows on one wall only:

Full height partitions parallel to the longer walls, i.e, East and West walls, were provided centrally in all the bays. The enclosures so formed represent sheds having glazed area in the north lights equal to $13.4m^2$ and openings of $12.7m^2$ on one exposed wall only. For this arrangement of openings, the pressure difference across the various wall openings is small and consequently the air motion induced in the sheds is also small when roof lights are completely closed. In such cases provision of openings in northlights has significant bearing on indoor air motion. The results of measurements taken in the west facing shed of the north end bay are shown in Fig. 2. Because of symmetrical locations, these results may also be applied to east facing sheds with a proper consideration of corresponding wind direction. It is seen that for wind blowing from West & North direction, indoor air motion increases by increasing the size of northlight opening. Obviously, roof openings act as inlet for north blowing wind and outlet for westerly wind. The indoor air motion also gets enhanced under the action of oblique wind incident from SW and NE directions when roof opening size exceeds 1/3 and 2/3 of the total size of the northlight respectively. For smaller sizes of northlight openings, the air motion in the working zone is reduced. It is also seen that provision of openings in the roof light retards air motion in the sheds for wind incident from S and NW directions. However, the influence of northlight openings on indoor air motion is insignificant for wind blowing from E and SE. By analogous considerations, it is also found that northlight openings may increase air motion in east facing sheds for wind blowing from SE, E, N and NW directions.

The wind speeds achievable in the west facing shed of south end bay are depicted in Fig. 3. It is observed that indoor air motton increases considerably by increasing the size of northlight openings when wind blows from W and NE directions. A nominal benefit in respect of induced air motion is also achieved for wind incident from E, SE, SW and N directions when roof light openings are larger than 1/3 of the total northlight. Such openings help enhance indoor air motion considerably in situations of NW wind. It is also noted that north light openings do not contribute to indoor air motion for wind blowing from N, but cause a reduction in available wind speeds when wind blows from South. By analogy, it is also observed that except for Northerly and southerly wind, air motion in east facing shed of south end bay is enhanced for most of the orientations when more than 1/3 of north light is kept open.

Sheds having windows on opposite walls

For this study, the partition wall placed in the centre of the bay was removed and the sheds were single bay enclosures with identical openings on east and west walls. Obviously, this is a case of cross ventilation and represent a commonly preferred design for adequate natural ventilation in buildings. The influence of northlight openings on air motion in a cross ventilated northend bay is depicted in Fig. 4. The roof light openings are found to be of distinct advantage only for northerly wind. However, a nominal benefit in respect of air motion is also achieved for wind blowing from E, W, SE & SW directions when openings cover more than 1/3 area of north light. It is also found that when a part of northlight is kept open, the available wind speed is slightly reduced for southerly wind; it however, remains almost unaffected for wind blowing from NE and NW directions. For cross ventilated southend bay, the available wind speeds for various sizes of northlight openings and different directions of incident wind are shown in Fig. 5. It is observed that roof light openings help increase indoor air motion due to the wind from E, W, SE, N and S directions. However, the openings are disadvantageous, in cases of wind blowing from NE and the NW directions. It is also noted that under the action of northerly wind, the enhancement in air motion due to northlight openings is much smaller in south-end bay as compared to that of the northend bay.

Conclusions :

(1) Sheds having openings on east wall only are benefitted due to wind blowing from E or SE direction when openings larger than 1/3 of the glazed area are provided in the northlights; for south end bay the openings are advantageous for NE wind as well.

(2) For northlight openings greater than 1/3 of the glazed area, the air motion is enhanced in sheds with windows on west wall for wind incident from W or SW direction; the increase in indoor air motion in the shed of south end bay is achieved for NW wind also.

(3) Northlight openings larger than 2/3 of the glazed area promote air motion in sheds having windows on East or West wall only for wind blowing from NW and NE direction respectively.

(4) Northlight openings increase air motion in cross ventilated sheds with windows on E and W walls for wind blowing from E, W, SE and SW directions.

(5) Provision of openings in northlights augment air motion in the sheds of northend bay for northerly wind, and reduces it in all the sheds for southerly wind.

(6) The usual variation of wind direction upto 30° from the prevailing wind direction suggests that size of openings in the northlights around 2/3 the glazed area is quite appropriate for inducing air motion indoors. These openings should necessarily be flexible so that these may be closed to get protection against the undesired effect of the wind under oppressive conditions.

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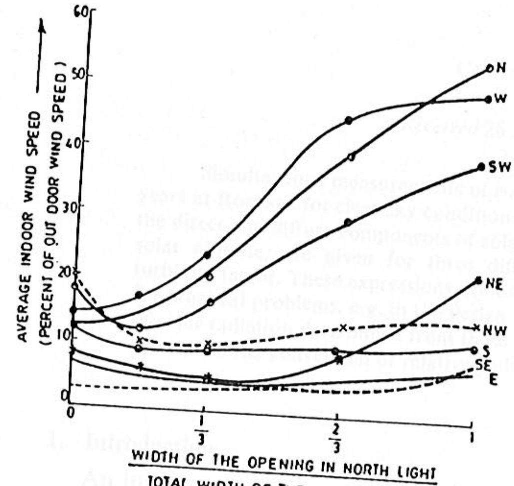
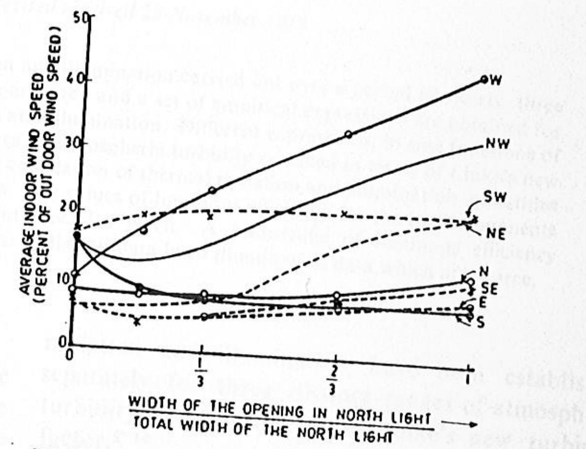
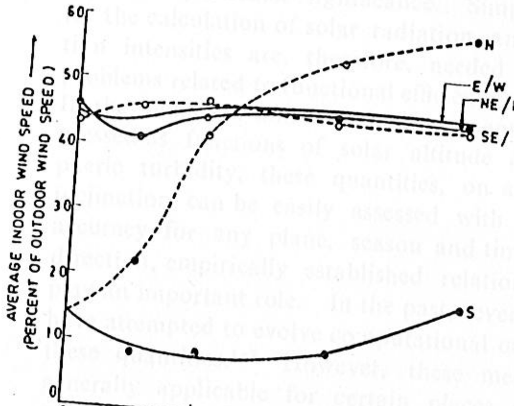


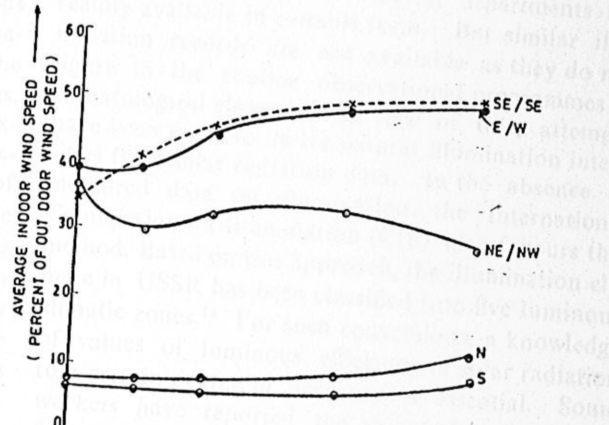
FIG·2· AIR SPEEDS IN A SHED OF NORTH END BAY HAVING OPENINGS ON ONE WALL ONLY.



FIG·3· AIR SPEEDS IN A SHED OF SOUTH END BAY HAVING OPENINGS ON ONE WALL ONLY.



FIG·4· AIR SPEEDS IN NORTH END BAY HAVING OPENINGS ON OPPOSITE WALLS.



FIG·5· AIR SPEEDS IN SOUTH END BAY HAVING OPENINGS ON OPPOSITE WALLS.