WIND INDUCED VENTILATION IN SHIELDED BUILDINGS

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A quantitative assessment of air motion induced in shielded buildings is important in the planning of buildings for achieving high rates of air movement for cooling in hot and humid climates and avoidance of draughts in cold climates. This paper desc ribes wind tunnel investigations on the shielding effectof buildings for the simple case of a group of buildings comprising of identical blocks placed in parallel rows. Other aspects like influence of cross ventilation through the shielding building and the variations in the relative heights of buildings are also considered. The variation of available wind speeds inside the shielded building in relation to its distance from the shielding building is discussed and the optimum distances of separation for maximum and minimum shielding effect brought out.

It is observed that the available wind speed in shielded building reduces to minimum value when semidetached houses are separated by distances 3H and long rows of houses by 5H. The shielding effect is significantly minimized if the distance between two parallel rows

of houses is 8H for semidetached houses, and 10H for long rows of houses.

In blocks of different heights the shielding effect may also be reduced by locating the building of greater height on downstream side.

Introduction

Air movement is an important consideration in the design of buildings. Its assessment before construction helps architects and planners in funcitonal design and planning of buildings. The studies reported by several investigators[1-4] make it possible to predict the amount of air motion in buildings which are directly exposed to the incident wind. However, because of the change in flow characteristics of oncoming wind, this data can not be made use of for estimation of probable air motion in buildings which are shielded by other neighbouring buildings. Though the studies on air flow around groups of buildings have been reported by several workers[5-6], very little information[7] is available on air flow indoors. Therefore, the present study was carried out to provide data on availability of air motion inside shielded buildings. With the development of the science of town planning, innumerable plans are in use these days. The paper covers the normal practical case in which blocks are arranged in parallel rows.

Experimental set up

A low speed wind tunnel[8] having a test section 2.4 m. wide and 1.8 m high was employed for this study. As the maximum shielding effect occurs for normally incident wind, models of houses with double room depth /W/ were arranged in two parallel rows and kept with their longer side perpendicular to the wind stream in the tunnel. The lengths of the blocks /L/ were 1.5 and 5 times their width, the former representing the case of semi-detached houses while the latter is that of long row of houses.
Wind speeds were measured in the central room located on groundfloor with the help of an omnidirectional hot wire anemometer. The investigation embraces the following:

Blocks of equal height

In this case the building models were all of the same width but of different height. The heights were 0.4 W, 0.8 W and 1.2 W. The rooms were provided with openings on opposite walls and cross ventilation was facilitated. The spacing between the rows of blocks was varied from 0.5 to 8 times the block width. Wind speeds were first measured in a block directly exposed to the incident wind, and the value was used as a reference, in terms of which were expressed the wind speeds in shielded buildings. The results depicted in Fig 1 indicate that in case of blocks having semidetached houses with H/W = 0.4, the available wind speed in the shielded block increases rapidly as the distance between shielded and shield-ing building approaches to about three times the block width /8H/; beyond that the increase is comparatively smaller. For greater values of H/W, i.e., H/W = 0,8 and 1.2, the indoor wind speed first increases and attains a maximum value for spacing equal to 0.7 W /0.85 H/ and 2W /1.6 H/ respectively. Further increase in spacing causes a reduction in wind speed which becomes minimum for spacing equal to 2.5 W/3H/ and 4W/3.3H/ respectively.

As the shielding building is moved farther away, the air motion in shielded building increases rapidly and slowly thereafter. The findings are, obviously, explicable on the basis of the variation in pressure difference /Fig.2/[8] measured between the two centrally located points on the openings on the two sides of shielded model. It was noted during the pressure measurements, that while the pressure difference changes from the +ve to -ve, it fluctuates on both sides of zero value. This shows that near this point, the pressure increases alternately on the windward and leeward sides of the shielded building. Due to rapid changes in the direction of pressure difference, turbulences are set up in the air enclosed in the room and wind speeds as high as 30% of that in the unobstructed building are achieved. The direction of air flow is also reversed at this point. For greater spacing between the blocks, the flow in both the blocks is in the same direction, but for less spacing the air flow through the leeward blocks is in the opposite direction to that through the windward blocks.

Results pertaining to long row houses /Fig.3/ indicate that available wind speed in shielded building decreases as the spacing is increased to about 0.75W. As the distance apart is further increased, the variation of indoor wind velocity follows the same trend as observed in semidetached houses. The pressure measurements on shielded building /with a typical plot shown in Fig.4/ indicate that for spacing less than 0.75 W the pressure on windward side is greater than that on leeward side. Therefore, for this location of blocks, the flow of wind in leeward building will be in the direction of main flow. As the spacing is further increased, the flow in shielded building gets reversed till the spacing is about 4W, beyond which the pressure on windward face exceeds that on leeward face, so that the wind flows in the same direction in both the blocks.

Effect of closing the openings in windward row

In this case cross ventilation existed only in the houses of leeward row while those in windward row had windows only on the windward side. To study the effect of curtailing the air flow through the wind facing building on the air motion in the interior of shielded buildings, indoor wind speeds were measured in two typical cases, viz, H/W=0.4 and H/W = 1.2 of semidetached houses. Observations were compared with the results obtained in earlier case and are shown in Fig.5. It is seen that in case of blocks with H/W=0.4, the available wind speed is reduced when spacing is less than 1.75W and is increased for greater spacing by closing the windows of windward blocks. In blocks of larger height /H/W=1.2/, the curtailment of air flow through shielded building helps increasing air motion in shielded building when the distance between the blocks is small /2W in this particular case/. With the further increase in spacing, the wind speed first decreases and then increases and thus the trend is similar to that observed in earlier case. It is thus seen that in case of low buildings shielding effect is more pronounced when the wind facing block is devoid of cross ventilation and buildings are located closer together. But in case of buildings with height to with ratio greater than unity, the curtailment of wind flow through the shielding building reduces the shielding effect even when buildings are nearer together.

Blocks of different heights

The relative height of shielded and shielding buildings also governs air flow patterns. Its influence on air motion in shielded building was studied for two cases, viz /i/ by raising the height of leeward building keeping height of the windward one fixed and /ii/ by raising the height of windward block, keeping the height of leeward one fixed. The results of the former are shown in Fig 6. It is observed that the general trend of variation of available wind speed with spacing is almost independent of the relative height of the two buildings, but the value of wind speed increases with the increase in the ratio of the height of leeward to that of windward building. The increase is comparatively greater for buildings located closer. It is thus seen that the shielding effect of a building is reduced by locating the building of greater height on leeward side.

The effect of increasing the height of shielding building over the leeward building is depicted in Fig.7. It is seen that for the shielded building with H/W=0.8, the increase in height of shielding building does not produce any significant change in the trend of variation of indoor wind speed with the spacing; but the speeds achieved are increased when spacing is less than 3.5W and also when it is greater than 4W, otherwise the value remains almost unaffected. It is also noted that when both the blocks are of equal height, i.e., H=0.4W, an increase in spacing produces an increase in the wind speed available in shielded building, but when the height of windward block is 0.8 W or 1.2W /i.e., two or three times the height of leeward building/ the increase in spacing produces a change in wind speed in a way it would have occured when height of leeward was also 0.8 W or 1.2 W. Thus it is seen that the general influence of building separation on air motion in a shielded building depends mainly on the dimensions of shielded building depends mainly on the dimensions of shielding building while the value of available wind speed depends on the dimensions of both the buildings and the spacing between them.

the rows of semidetached houses and 10H for long rows of houses. When buildings are located close together, the curtail-ment of wind flow through windward building increases the shielding effect in low buildings but reduces it in buildings with height-width ratio greater than unity. In the case of building groups comprising blocks of different height, the shielding effect may be reduced by locating buildings of greater height on leeward side. Thus having known the prevailing wind direction, the information covered in the paper may be made use of by the planners in proper planning and layout of groups of buildings in relation to desired air motion to suit the requirements typical of their climate.

Acknowledgement

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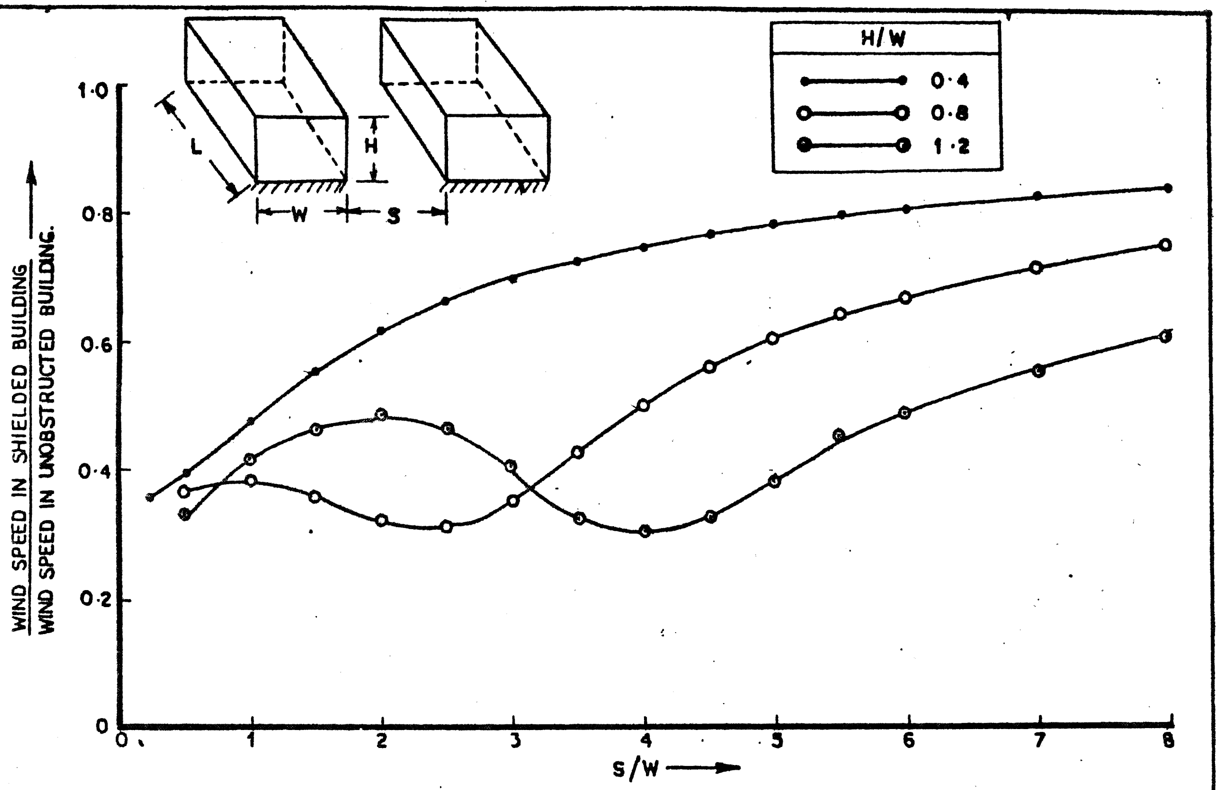

FIG.1 EFFECT OF DISTANCE OF SEPARATION ON WIND SPEEDS IN SEMIDETACHED HOUSES.

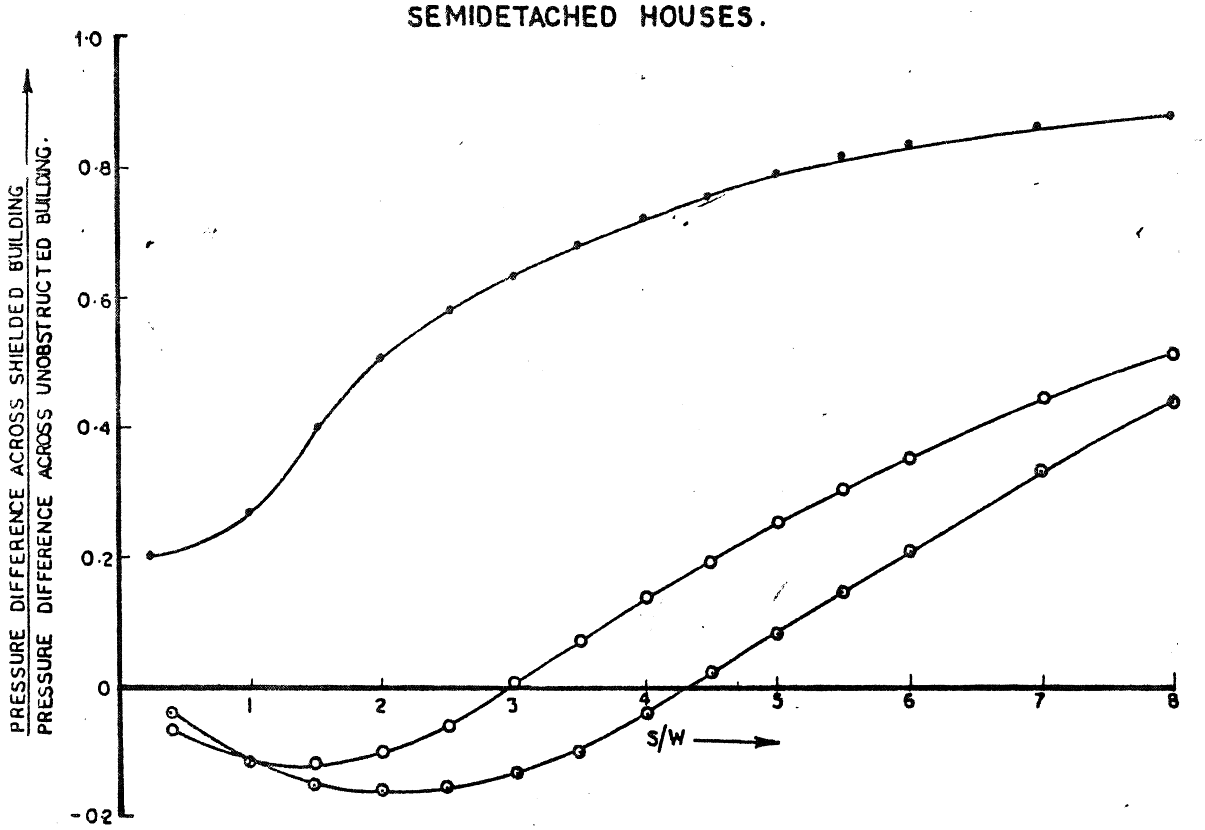

FIG. 2 EFFECT OF DISTANCE OF SEPARATION ON PRESSURE DIFFERENCE ACROSS SEMIDETACHED HOUSES.

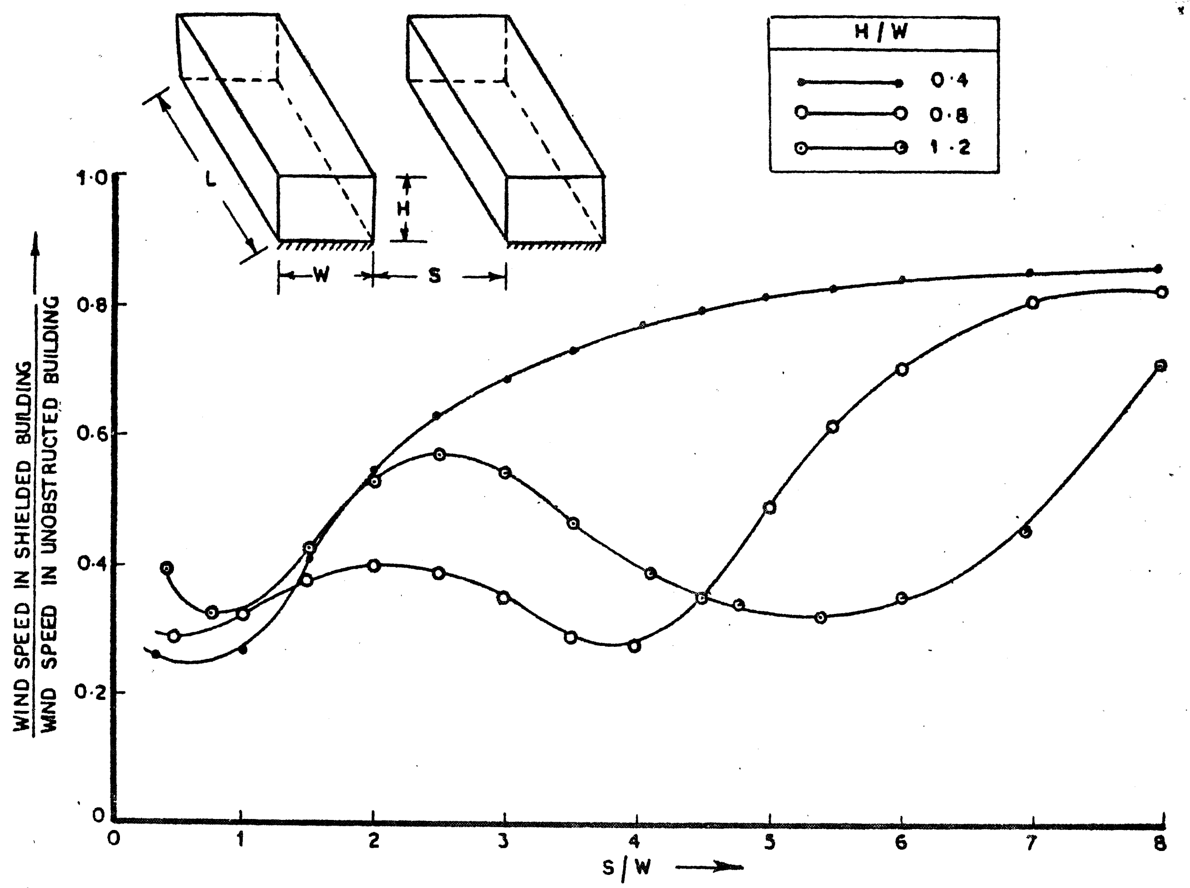

FIG.3 EFFECT OF DISTANCE OF SEPARATION ON WIND SPEEDS IN LONG ROW OF HOUSES.

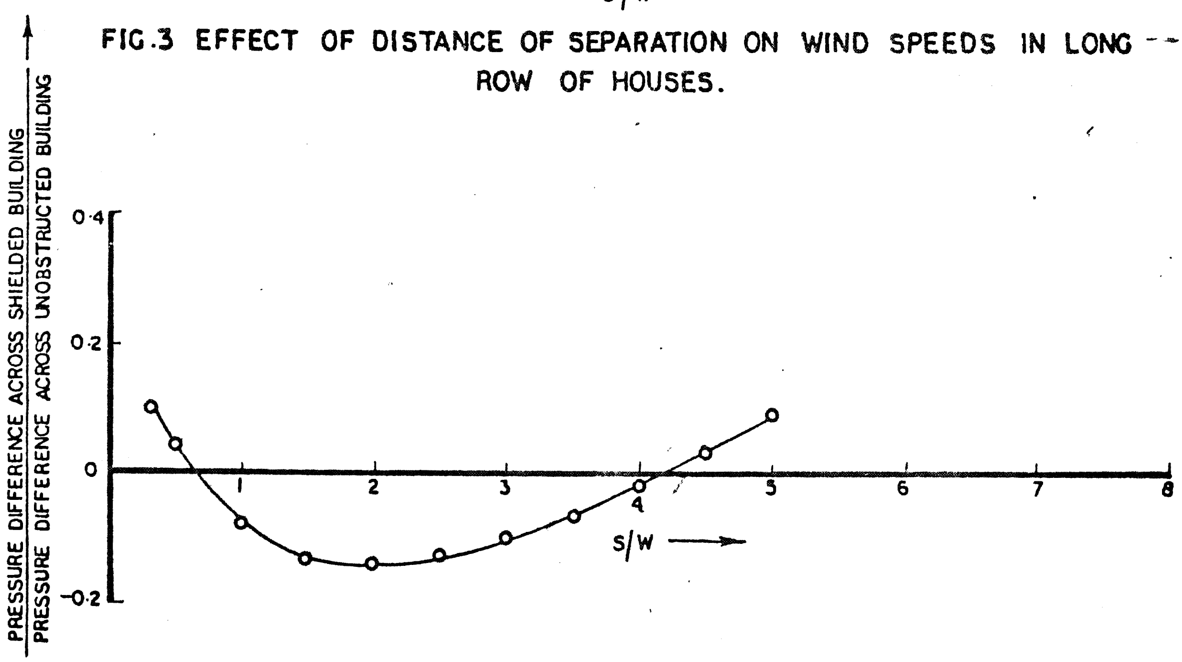

FIG. 4 EFFECT OF DISTANCE OF SEPARATION ON PRESSURE DIFFERENCE ACROSS LONG ROW OF HOUSES.

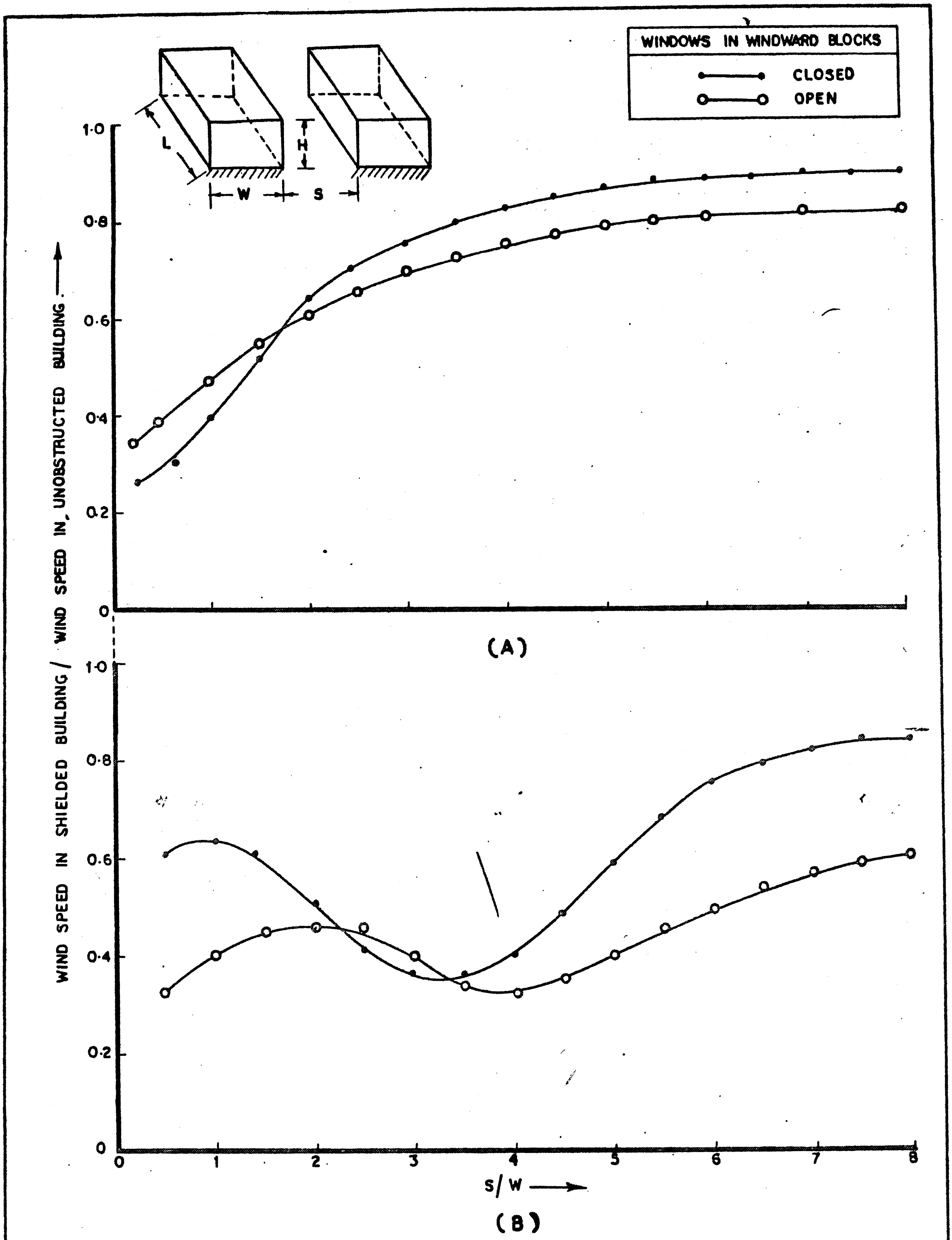

FIG. 5 EFFECT OF CURTAILMENT OF AIR FLOW THROUGH WINDWARD BLOCKS [(A) H/W = 0·4; (B) H/W = 1·2]

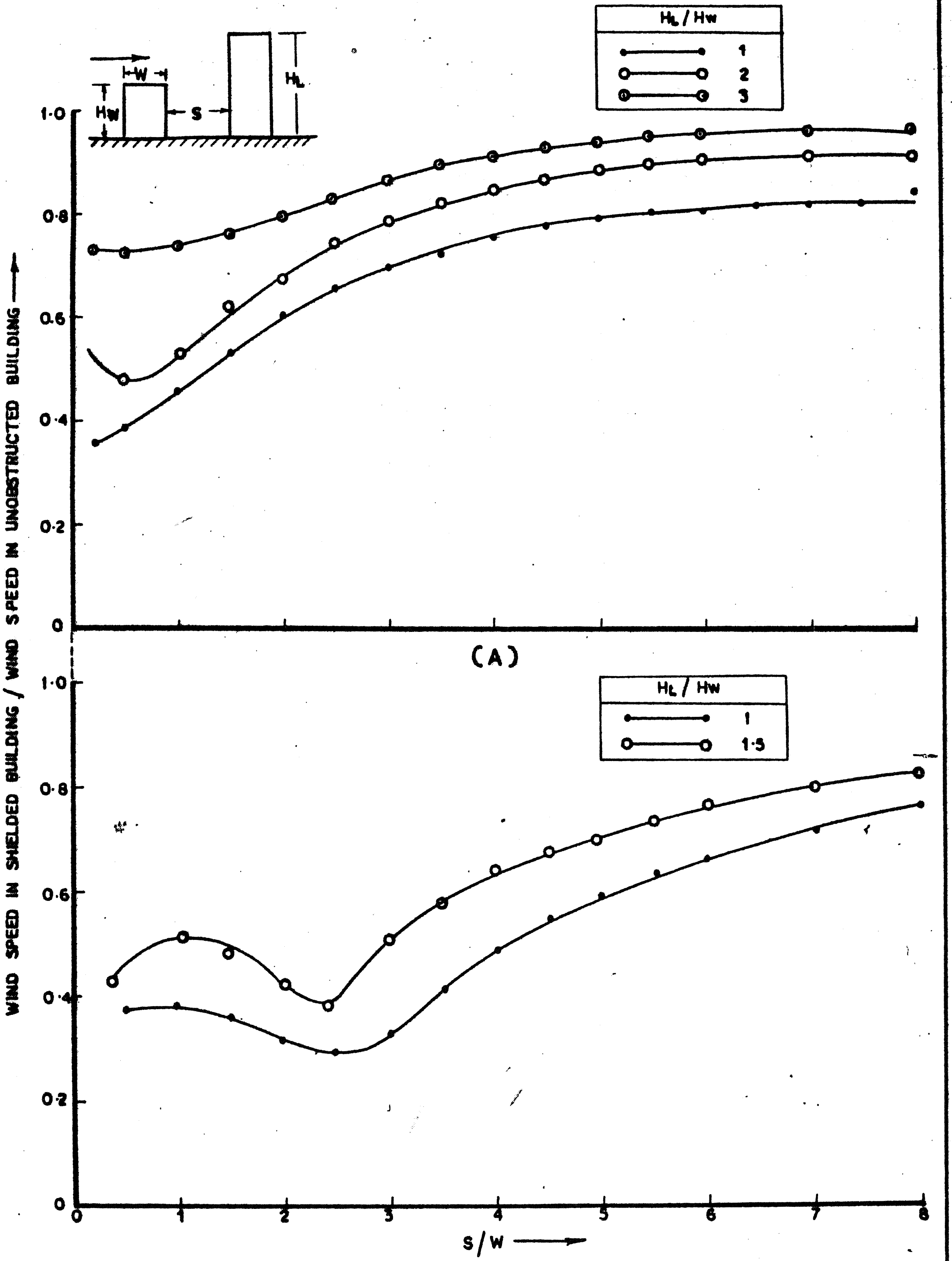

FIG. 6 EFFECT OF INCREASE IN HEIGHT OF LEEWARD BUILDING
[(A) H_W = 0·4 W, (B) H_W = 0·8 W]

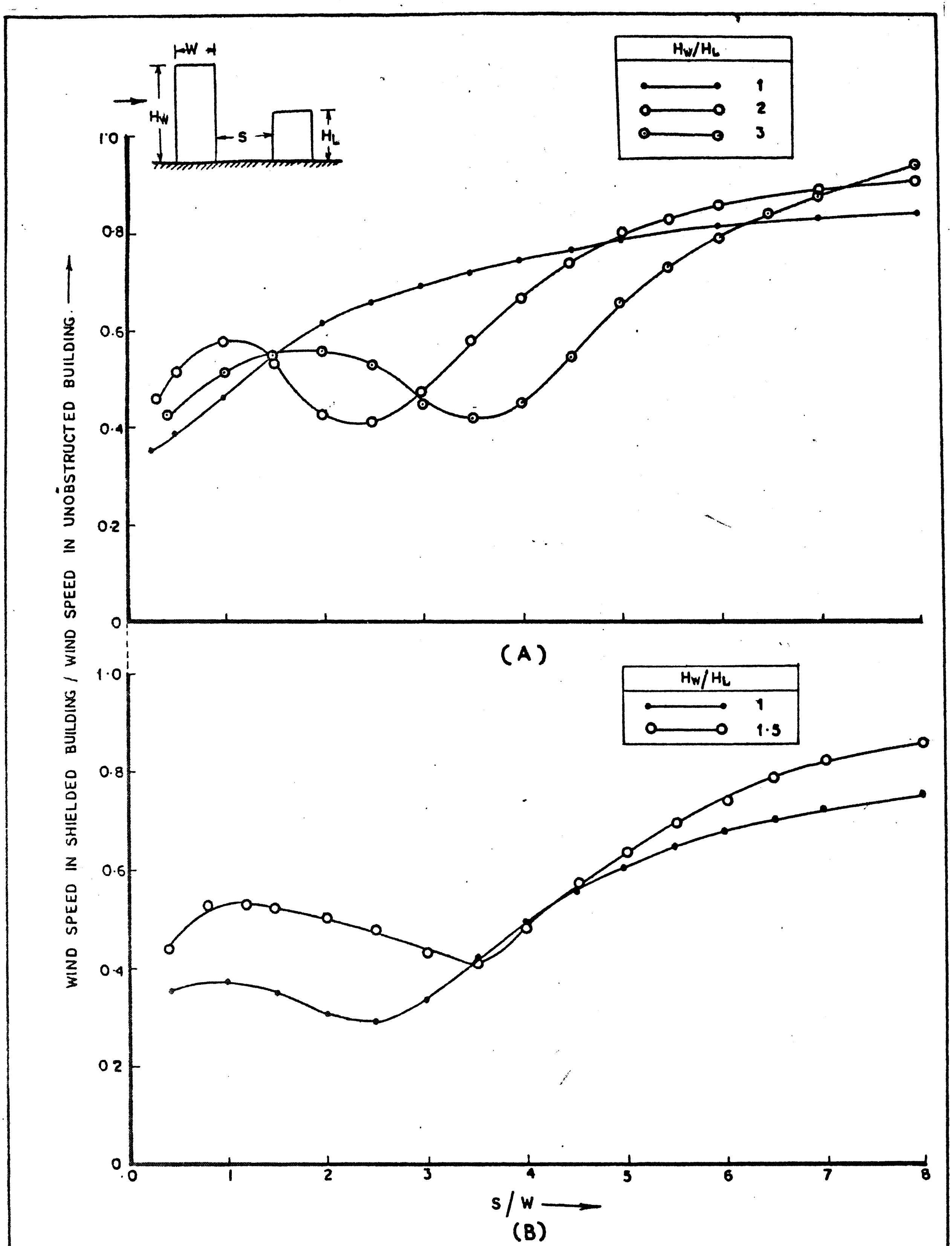

FIG. 7 EFFECT OF INCREASING THE HEIGHT OF WINDWARD BUILDING
[(A) H_L = 0·4 W ; (B) H_L = 0·8 W]