

# Evaluation the Effect of Projection on Wind Pressure Low High Rise Buildings

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**ABSTRACT:** This paper describes the effect of external projections of the building on wind pressure distribution towards the windward wall of the buildings. It is noted that horizontal projection located above in stagnation zone produces insignificant change in the wind pressure at points underneath the projection and reduces the pressure at the wall surface above the projection. Contrary to this, horizontal projection below the stagnation point enhances the pressure at points above the projection and course reduction in pressure at location below the projection. A vertical projection provides right at the edge of the wall enhances wind pressure at points close to the wall end, but a projection located slightly away from the wall edges causes reduction in wind pressure at points between the projection and the edge of the wall.

**KEYWORDS:** Buildings, Wind pressure, Projections, and overhang in buildings

## I. INTRODUCTION

The bulk of the data on wind pressure distribution on buildings available in literature is the yield of large number of wind tunnel studies on wind pressure measurements on isolated models with smooth surfaces. However, buildings have rarely smooth wall surface and provision of some sort of protrusion there from is quite common. It is, therefore, pertinent to know whether the wind pressures determined on models with smooth wall surface are truly representative of those acting on prototype buildings adorned with external projections. An exploratory type of study on the effect of mullions on the wind pressure distribution on a two-dimensional building model ( $H \gg W$ ) exposed to uniform flow conditions was carried out by Leutheusser in 1970. The results indicate that for the wind blowing normal to the front face, the suction on side walls increase for closely spaced ribs, while for the widely spaced ribs, the suction on side walls remains almost unaffected. On the other hand, the pressure coefficient on windward wall for widely spaced ribs increases and becomes heavily negative at the corner while pressure on the front wall with closely/spaced ribs is not so much affected by these ribs.

In 1970, Roshko conducted studied concerning the effect of surface roughness modelled by mullion like grooves on wind pressure action on A circular and prismatic cylinders an aeronautical wind tunnel. It was reported that in the presence of mullions, the pressure distribution on sharp edged objects also depends on the Reynolds number. In 1971 Standen et al., using flat plate boundary layer theory, deduced that the scale of mullions should be the  $4/5$  power of the overall geometric scale of the model. For example, for a geometric scale of 1:400 the mullion scale should be 1:120.

In 1974 Newberry and Eaton reported that provision of several balconies on a result in the creation of a series of pockets of pressure across the windward wall. Because of this, pressure coefficient values should be slightly enhanced for wall adorned with balconies.

Based on the results of full scale as well as wind tunnel tests, Templin and Cermak in 1976 reported that the primary regions affected by the presence of mullions were the sides of the building on which the main flow reattached after separating from the upwind corner. The effect of mullions was mainly to reduce the magnitude of mean and root mean square pressure. Only slight suction increases occurred in the separated regions of the flow, between the first and second mullions on the side wall.

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In 1977, Arens studies the effect of wind on energy consumption in buildings and presented a schematic diagram of pressure distribution on the face of a high-rise apartment block with balconies. It is demonstrated that the positive and negative local pressures at the top and bottom of the balcony space exceeded the total pressure which can cause substantial air leakage through the joints of doors and windows.

In 1988, Stathopoulos conducted studies on the effect of uniform roughness and of balconies on wind pressure distribution on walls of an enclosure for different directions of incident wind. It was found that the uniform roughness reduces  $C_{p\text{mean}}$  and  $C_p$  minimum buy a small amount except for the edge region of the windward wall, which experience higher suction for greater roughness. Presence of balconies on windward wall reduced the positive pressure near the top of the wall, while balconies on side walls produce a reduction in the suction. The + ve and - ve pressures are further reduced due to provision of walls on the balconies. However, variation in the width of the balconies from 2 to 4 meters does not alter the pressure distribution. It is also reported that for low buildings, the appurtenances did not show any pronounced effect on wind pressure on walls except at the edge area for  $90^\circ$  azimuth where some high suctions were observed. In 1990 Stathopoulos reported a study concerning effect of mullions or vertical ribs of different kinds on the local wind pressures on building cladding. It is stated that mullions induce adverse wind effects at wall edges. For tall buildings, mullions induce significant suction increases for wind incident at  $105^\circ$ . Different geometries of mullions in the corner area do not release these high suctions on the wall edges, unless a mullion is attached at the edge as an extension to the wall. For low buildings with mullions, significant suction increase has also been registered for the critical wind direction ( $105^\circ$ ).

It is noted that prior to the investigations carried out by Stathopoulos, most of the available studies related to the effect of external projections on wind pressure distribution on buildings were of an exploratory type and were not carried out in three-dimensional boundary layer flow which is a well-established prerequisite for achieving reliable results through model tests in wind tunnels. Hence for the basic understanding of the effect of horizontal and vertical projections on characteristics of wind flow around buildings provided with projections model studies were carried out in a boundary layer wind tunnel. Findings of these studies and general characteristics of wind flow patterns derived there from have been presented in this paper

## II. DETAILS OF EXPERIMENTAL SETUP

The studies were carried out on a 14x12x10 cm high model in an opencircuit boundary layer wind tunnel having 2.4x1.8 meter high test section. The wind speed profile and variation of turbulence intensity in the free airstream at the location of test model in the wind tunnel. Wind pressures were measured at nine points on one of the longer walls of the model. The positions of these points figure 1 were chosen so as to cover central and corner locations at various heights above the ground level. Pressure holes each about 4 mm in diameter were drilled at each of these points and 25 mm long pieces of stainless steel tube with 3 mm internal diameter were fixed therein. One of the end of each of these tubes was flush with the outer surface of the model while other ends were connected to a pressure measuring system consisting of a scanning box, a digital micro manometer, a personal computer and its peripherals. During the course of observations, the model having smooth surfaces was mounted on the test table of the wind tunnel in a way such that its long side fitted with the pressures measuring tubes was oriented perpendicular to the incident wind stream in the tunnel. Then by giving appropriate command, mean pressures were determined at all the nine points. Similar measurements were also taken after mounting a 10 mm wide and 2 mm thick **perspex** strip on the entire width of the windward wall of the model above and below the observation points at the three levels above the ground. Subsequently, pressure measurements were also taken after mounting the perspex strip over the entire wall height on the two sides of the vertical rows of the observation points. Wind pressure measured at all the nine points were expressed in dimensionless form as follow:

$$C_p = \frac{P - P_s}{0.5 \rho V^2}$$

### Where

$C_p$	=	Pressure coefficient
$P$	=	Measured surface pressure on the model
$P_s$	=	Free stream static pressure
$V$	=	Free mean wind speed at roof level height of the model

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$\rho$  = Density of air

The provision of a horizontal projection under the observation points enhances wind pressure on the wall at points 4,5,6 and also at points 7,8,9 but reduces the pressure at the points marked as 1,2,3. On the other hand a horizontal projection mounted above the observation points causes reduction in wind pressure on the wall at points 4,5,6 and 7,8,9. However, wind pressure at points 1,2,3 is not affected much due to the provision of a horizontal projection over these points. It is also observed that a vertical projection provided in the vicinity of points 2,5,8 does not produce any significant change in the wind pressure distribution on the wall, but the wind pressure at the points 1,4,7 gets enhanced when a projection is located in their vicinity towards the end of the wall. In the latter case, shifting of the vertical projection on the other side of the points 1,4,7 causes significant reduction in wind pressure at the points 1 and 4 and creates suction at the point 7.

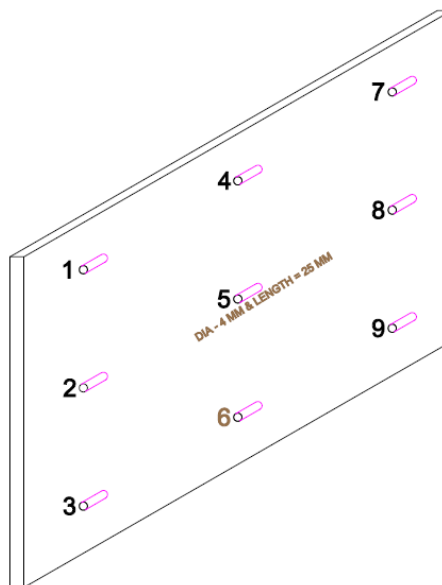


Fig.1. Nine points on longer point

### III. RECOMMENDATION

Your Conference Paper must follow these overall formatting specifications: A critical examination of the results of these studies reveals that external projections do affect the distribution of wind pressure on building surfaces. The extent of variation in magnitude of pressures coefficients on different walls depends, inter alia, on the type, size, location and number of projections, and on the direction and velocity gradient of the incident wind. Theoretical prediction of the quantitative influence of these parameters is difficult and experimental techniques have to be adopted for such predictions. However, based on the existing knowledge of wind flow around buildings and flat plate boundary layer theory, the influence of external projections can be predicted qualitatively as described below; A projection on a wall influences the flow of wind around the building in two ways; (1) it interrupts the free flow of incident wind before its impingement on the wall and (2) it also disturbs the flow of wind over the wall surface. These two events jointly contribute to the changes that are produced in wind flow patterns around buildings due to the projections on walls.

**Wind Flow around a Projection:** The most prevalent projections on buildings are made up of thin reinforced concrete slabs with thickness and width (dimension perpendicular to the wall) varying from 5 to 7.5 cm and 30 to 90

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cm respectively. Projections may cover the full or part of the wall height, or wall width, while mounted vertically or horizontally. For normal incidence of the wind, the projection surface facing the wind has one of its dimension several times greater than the other dimension. Hence a major part of the incident wind, after deflection at the wind facing edges of the projection, flow around its longer sides. In this process, the flow separates at the leading edges and subsequently gets reattached at the surface of the projection. Because of the surface friction, the wind flows the vicinity of the projection slows down, and a boundary layer is developed on the projection surface. As a result of this, the speed of wind striking on an otherwise unadorned wall gets diminished near the projection on the wall and remains almost unchanged at points away from the projection,

**Wind Flow Patterns around Buildings with Smooth Wall Surfaces:** Information on the basic characteristics of wind flow patterns around buildings is already available in the literature. The flow patterns are governed by the ratio of height to width of the frontal projection, and the absolute height of the building is immaterial relative to this ratio. In the case of low buildings ( $L \gg H$ ), flow around the sides is negligible compared to that over the top. A return flow is also set up along the floor because of the adverse pressure gradient created ahead of the wall due to the stagnation on the wall. Thus, a stable eddy with a horizontal axis is formed along the front of the wall at the base. The variation in pressure on the front wall is also small.

In the case of tall buildings ( $L \ll H$ ), the air layer close to the surface is subjected to strong vertical pressure gradient, and a strong flow down the wall results. Near the top of the building the downward flow is superimposed on the natural upward flow caused by the wind deflection at the end. This cause considerable reduction in the quantity of air flowing atop the wall.

**Effect of Horizontal Projection:** The fore-going description of wind flow over the smooth surface of a windward wall demonstrates that the flow is bound to be subjected to modifications when protrusions are provided on the wall. A projection provided in a horizontal plane will not interrupt the wind flow in the lateral direction, but will have an important bearing on the flow in the vertical direction. Since wind flow over the major part of the windward wall of a low-rise building takes place in upward direction above the stagnation point and downwards below the stagnant point, the influence of a horizontal projection on the wind flow pattern will depend upon the distance and location of the projection with respect to the stagnation wall end. This implies that provision of a vertical projection should not alter the pressure distribution at higher levels on the front wall of a high-rise building but a change in pressure distribution at points below the stagnation zone is inevitable.

## IV. CONCLUSIONS AND SUGGESTIONS

A brief review covering salient features of the findings of earlier studies on the effect of external projections on wind pressure distribution on structures has been presented. The available information in conjunction with the flat plate boundary layer theory and some experimental studies on wind pressure measurements on building models fitted with external projections have been used to describe the probable wind flow patterns around the wind facing wall of buildings provided with horizontal and vertical projections. The important conclusions and suggestion of the study are given as below;

1. The influence of a projection on the free wind stream is less pronounced as compared to that on the flow of wind over the wall surface.
2. The effect of a vertical projection depends upon its distance from the wall edge, whereas location, whether above or below the stagnation zone, is the parameter that governs the influence of horizontal projection.
3. A horizontal projection located above the stagnation zone produces insignificant change in wind pressure at points underneath the projection, but causes reduction in the pressure at the wall surface above the projection. Contrary to this, a horizontal projection below the stagnation zone enhances the pressure at points above the projection, and causes the reduction in pressure at locations below the projection.
4. Vertical projections provided right the wall edge result in enhancement of wind pressure near the wall corner, but projections located slightly away from the wall produce a reduction in wind pressure at points between the projection and the edge of the wall.

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## REFERENCES

- [1] Leutheusser, H.J., Influence of architectural features on the static wind loading of buildings, Building Science Series 30, proceedings of Technical Meeting Concerning Wind Loads on Buildings and Structures, National Bureau of Standards, Washington DC, 1970, pp.73-86.
- [2] Roshko, A. On the aerodynamic drag of cylinders at high Reynolds numbers, Proceedings of Seminar on Wind Load on Structures, University of Hawaii, Honolulu, 1970, pp.87-96.
- [3] Standen, N.M., et al. A wind tunnel and full-scale study of turbulent wind pressures on a tall building, Proceedings Third International Conference on Wind Effects on Buildings and Structures, Tokyo, 1971, pp. 199-209.
- [4] Newberry, C.W. et al. Wind Loading Handbook, Building Research Establishment Report, Garston (U.K.) 1974, pp. 58-60.
- [5] Templin, J.T. et al. Wind pressures on buildings: effect of mullions, Technical Report CER 7677JTTJEC24, Fluid Dynamics and Diffusion Laboratory, Colorado State University, Fort Collins, Colo, 1976
- [6] Arens, E.A. et al. The effect of wind on energy consumption in buildings, Energy and Buildings, Vol. 1(1977), pp. 77-84.
- [7] Stathopoulos, T. at el., Wind pressure on buildings with appurtenances, Journal of Wind Engineering and Industrial Aerodynamics, Vol.31 (1988), pp.265-281.
- [8] Stathopoulos, T. at el., Wind pressure on buildings with mullions, Journal of Structural Engineering, ASCE, Vol.116 No.8(1990), pp.2272-2291.
- [9] Ishwar Chand et al., Studies on the effect of mean wind speed profile on rate of air flow through cross ventilated enclosures, Architectural Science Review, Vol. 35, No.3 (1992), pp. 83-88.
- [10] Ishwar Chand, A low speed wind tunnel for studying the problems on natural ventilation in buildings, Indian Journal of Technology, Vol.II (1973), pp.267-271
- [11] Gupta, S. K., Nathani, N. (2016). Thermal Performance of Wall & Roof – Efficiency of Building Materials. International Journal of Science and Research (IJSR), 1354-1357. <https://www.ijsr.net/archive/v5i5/NOV163707.pdf>
- [12] Gupta, S. K., Nathani, N. (2016). Climatic Elements & Their Impact on Building Design. International Journal of Science and Research (IJSR), 2378-2383. <https://www.ijsr.net/archive/v5i5/28051601.pdf>