International Journal of Civil Engineering Research.
ISSN 2278-3652 Volume 7, Number 2 (2016), pp. 105-115

http://www.ripublication.com

Study of Wind Pressure on Tall Building Due to Change in Relative Position of Interfering Building

Ritika Pundhir[1] and Nilesh Barde[2]

[1]Management Student, Advanced Construction Management,
National Institute of Construction Management and Research, Pune, India.
Email: pundhir.ritika22@gmail.com

[2]Management Student, Project Engineering Management,
National Institute of Construction Management and Research, Pune, India.
Email: nilesh.barde47@gmail.com

Abstract

Wind loads on grouped tall buildings can be different from that of an isolated building due to effects of neighboring buildings which is popularly known as 'Interference Effect'. Shielding or amplification of forces may take place due to interference. Interference effects were first pointed out in 1934 and the same gained importance after collapse of three cooling towers at Ferry bridge power plant situated on river Aire near Ferry bridge in England in 1965. Earlier investigations have been done on interference effects of tall buildings under wind actions which are focused on the wind induced interference effects between two buildings using wind tunnel experiments. In this paper, change in pressure coefficient along the height of the building under consideration known as principal building is studied in isolated condition as well as in interference condition by changing the relative position of interfering building which is identical to principal building. Incident wind angle is also varied. Both along and wind interference effects are studied in this paper.

Keywords: Tall Buildings, Wind Pressure Coefficient, Interference Effect, along and across wind interference effects.

INTRODUCTION

Wind loads on grouped tall buildings can be different from that of an isolated building due to effects of neighboring buildings which is popularly known as 'Interference Effect'. Shielding or amplification of forces may take place due to interference which can be ascertained by detailed wind tunnel studies as well as using advanced computational tools. Interference effects, first pointed out by Harris(1934) and Bailey & Vincent(1943) and gained importance after collapse of three cooling towers at Ferry Bridge Power Plant in1965.

When a building is located in an urban area, it is exposed to a wind of different characteristics then wind over an open terrain. Neighboring structures may either increase or decrease the flow induced forces on building, depending mainly on geometry and arrangement of these structures, their orientation with respect to the direction of the flow and terrain conditions. Therefore, this effect, commonly known as Interference must properly be assessed by designers and planners. The main parameters affecting interaction between adjacent buildings are the types of terrain, size and shape of the building, the incident wind direction and last but not least the building arrangement and spacing.

Wind is one of the important loads to be considered while designing tall buildings. The structural designers while designing such buildings refer to relevant code of practices of various countries dealing with wind loads [ASCE:7-02 (2002), AS/NZS:1170.2 (2002), BS-EN 1991-1-4 (2005), IS:875-Part 3 (1987)]. However, available information regarding wind pressure coefficients and wind force coefficients is limited to isolated condition of buildings only. No information is available in connection with interference effect. Designers are, therefore, left with the option of either going for wind tunnel investigation or assuming arbitrary values of wind loads in case of interference.

So far as studies on interference effects between tall buildings are concerned, few publications are available. Kim et al. (2011) investigated interference effects between two square building models for local peak pressures on principal building with different height ratios of interfering buildings. Hui et al. (2013) studied interference effects between two rectangular building models for local peak pressure coefficients for parallel and perpendicular arrangements.

In this paper, change in pressure coefficient along the height of principal building is studied in isolated condition as well as in interference condition by changing the relative position of interfering building which is of same size and height as of principal building. Incident wind angle is also varied. Pressure coefficient is studied in both along and across wind directions.

METHODOLOGY

The cross-sectional shape of prototype tall building considered in this study is square shape. The dimensions of the models are shown in Figure 1. Pressure measurements are made on the rigid models. Model scale is taken to be 1:400 and wind speed scale is 1:5. Reference wind speed and turbulence wind intensity at model height is 8.0 m/s and 20% respectively. Many pressure points are made on the models for measurement of wind pressures

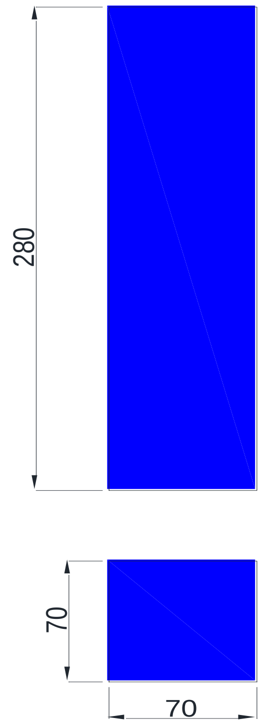

Figure 1: Cross-sectional dimensions and height of prototype building (mm)

Both Principal and Interfering Building models with square geometric plan shape. Dimensions and other experimental details are given in Table 1.

Table 1: Geometric Dimensions and Details of Principal Building Model

Plan Dimensions of Building Unit (B) (Unit- mm x mm)	70 x 70
Height of building Unit(H) (Unit- mm)	400
Flow Conditions: Urban Wind Exposure (α)	0.27
Model Scale	1:400
Wind Speed Scale	1:5
Reference Wind Speed (m/s)	8
Turbulent Intensity at Model Height (%)	20

An interfering building with similar dimensions is also considered for the study of interference effect.

Table 2: Details of interfering building with its relative position

Plan Dimensions of Building Unit (B) (Unit- mm x mm)	70 x 70
Height of building Unit(H) (Unit- mm)	280
Relative Spacing (Unit- mm) In tandem In oblique (45°)	 105, 420 149, 594
Wind Angle (Θ) In tandem In oblique (45°)	 0°, 180° 45°, 215°

Change in pressure coefficient along the height of principle building is studied by changing the relative position of interfering building and incident wind angle. Pressure coefficient is studied in both along and across wind directions.

LOCATION OF PRINCIPAL AND INTERFERING BUILDING

As shown in figure 2, four different faces of principal building are given four names, front, back, left and right respectively. For study of interference condition of interfering building in tandem and oblique, pressure coefficient on front and back faces gives the along wind response and left and right faces gives across wind response. Four positions of interfering building are considered as shown by a black dot in figure 2 which are named as Case a, Case b, Case c and Case d. B represents the width of principal building.

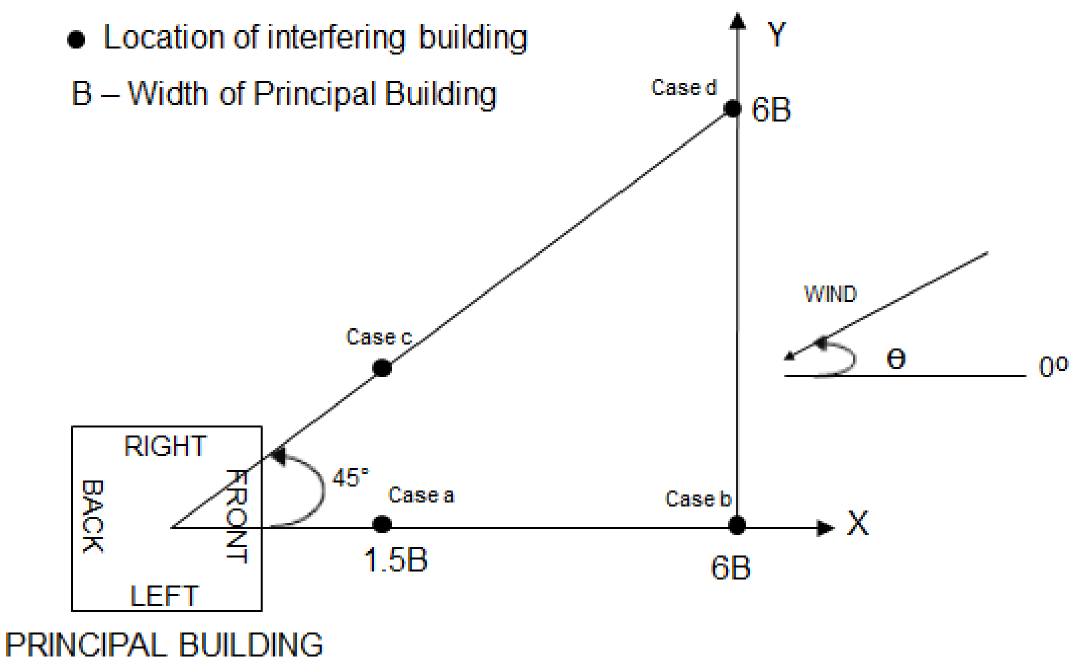

Figure 2: Principal and Interfering Building Location

RESULTS AND DISCUSSIONS

The results consist of variation of Pressure Coefficient (Cp) for with the height Tall Principal Building. Initially a tall building namely Principal Building with square plan shape has been considered and Pressure Coefficient (Cp) is obtained at different incident wind direction. Then Pressure Coefficient (Cp) on Principal Building is obtained by considering adjacent building namely Interfering Building with different position of interfering building with respect to principal building and different incident wind angle (θ). The Height of each Building Unit is 280mm and Plan dimensions of tall building unit are as shown in Table I.

When Interfering Building is in Tandem

Case a: In figure 3, it can be seen that pressure coefficient is much lesser in interference condition as compared to isolated condition when interfering building is placed at a distance of 1.5B i.e., Case a (B is the breadth of principal building) at 0° wind direction. Shielding effect is seen in this case in both along and across wind response.

When wind direction is 180°, firstly there is shielding due to interference in both along and across wind response as it can be seen in figure 4 and then amplification of pressure coefficient takes place above the height of 220 mm on principal building model.

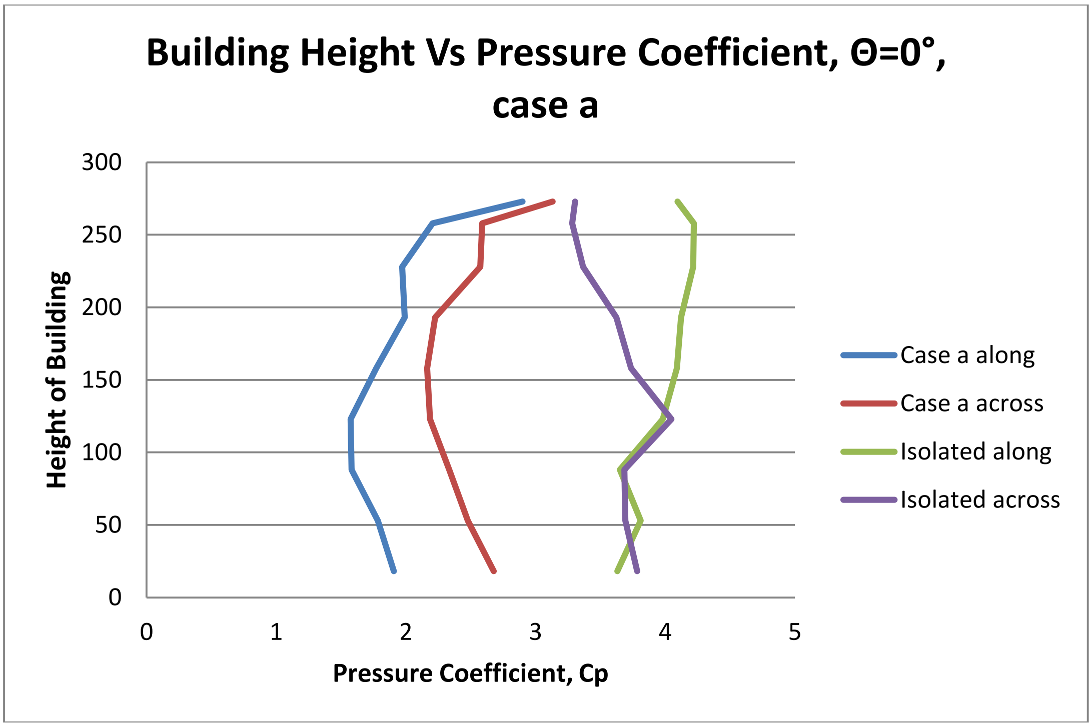

Figure 3: Variation of Pressure Coefficient along Building Height Considering Case a and Θ = 0°

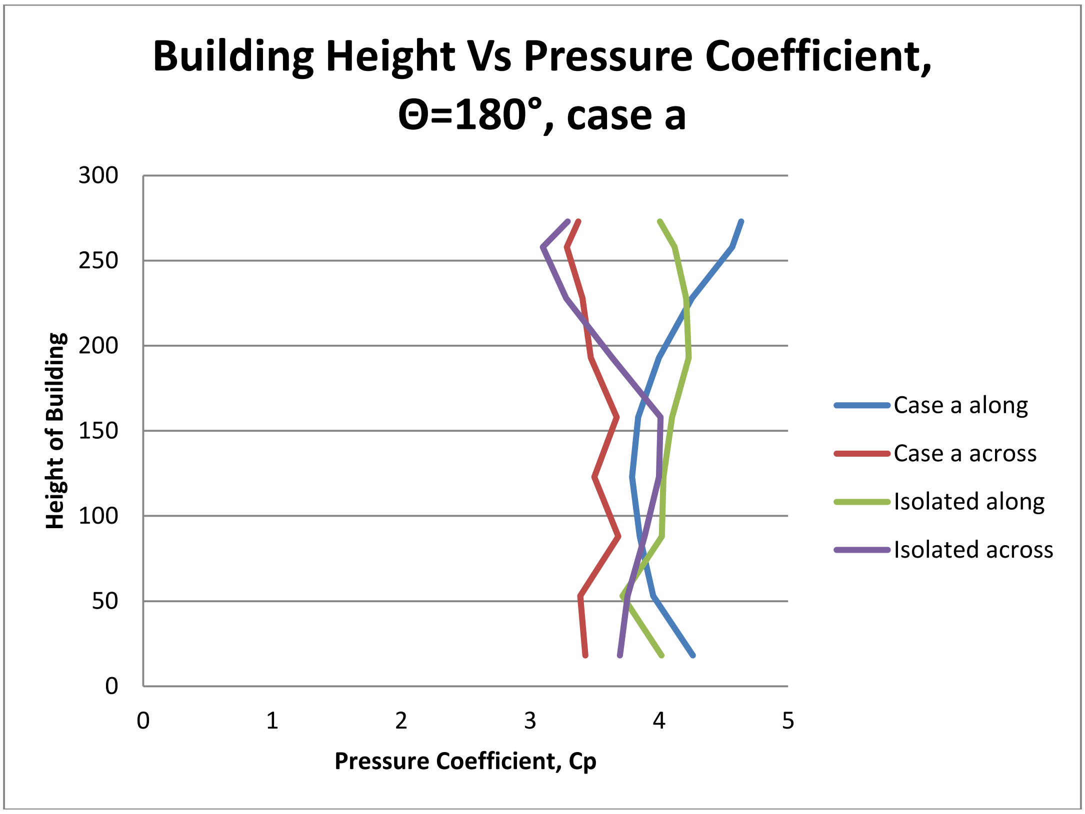

Figure 4: Variation of Pressure Coefficient along Building Height Considering Case a and Θ = 180°

Case b: Variation of pressure coefficient with the height of the principal building when interfering building is placed at a distance of 6B (B is the width of principal building) at wind direction at 0° can be seen in figure 5. It can be found that there is a considerable reduction in the pressure coefficient on principal building due to interference throughout the height of the principal building in along wind response. However there is a slight increase in Cp above the height of 230mm in across wind response.

A similar condition can be seen at 180° wind direction for the same case (figure 6). There is a shielding effect due to interference throughout the height of the building in along wind response while there is a slight increase in Cp above the height if 230mm in across wind response.

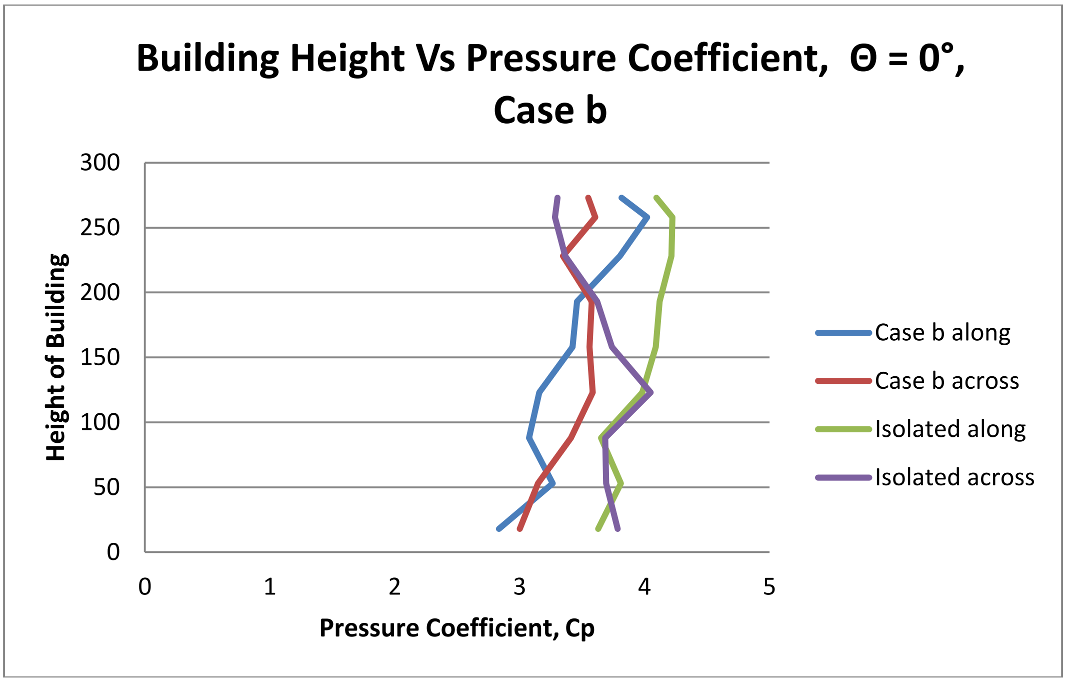

Figure 5: Variation of Pressure Coefficient along Building Height Considering Case b and Θ = 0°

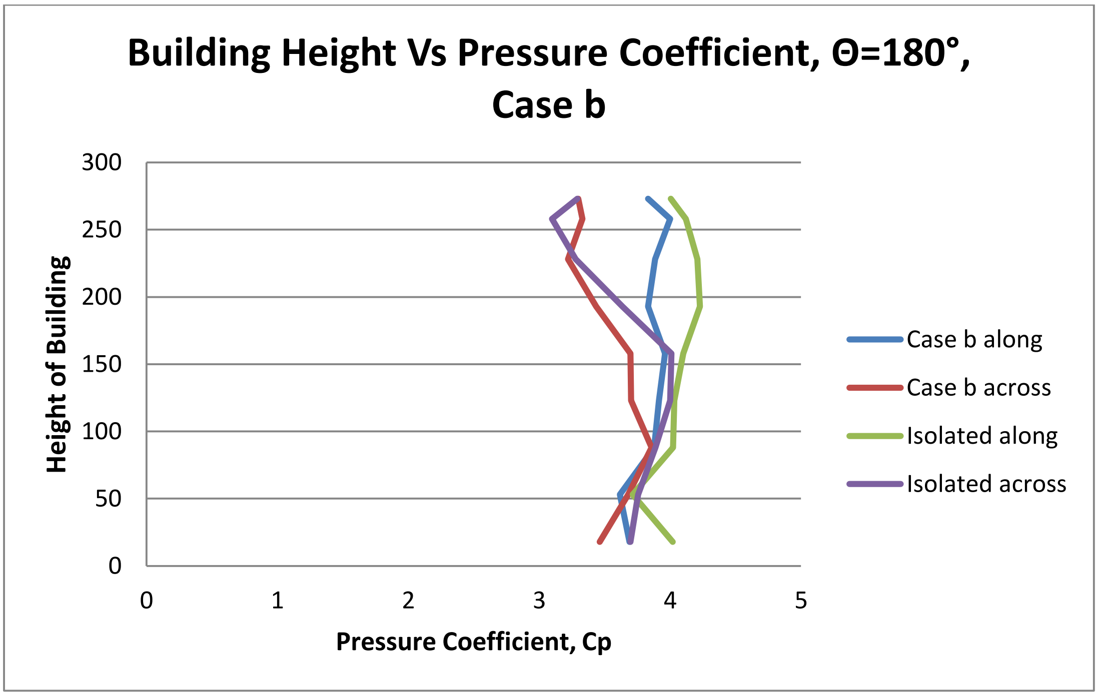

Figure 6: Variation of Pressure Coefficient along Building Height Considering Case b and Θ = 180°

When Interfering Building is in oblique line

Case c: In figure 7, it can be seen that when interfering building is placed in the oblique line (at an angle of 45° with respect to the principal building) nearest to the principal building and wind direction is 45°, firstly, at the lower heights of interfering building, there is shielding due to interference and then there is amplification in the Cp above the height of 190 mm in along wind response. Amplification of Cp takes place above the height of 150 mm in across wind response.

When wind direction is 215°, the amplification of Cp due to interference in along wind response takes place above a height of 140 mm. In across wind response, there is an increase in Cp due to interference above a height of 175mm.

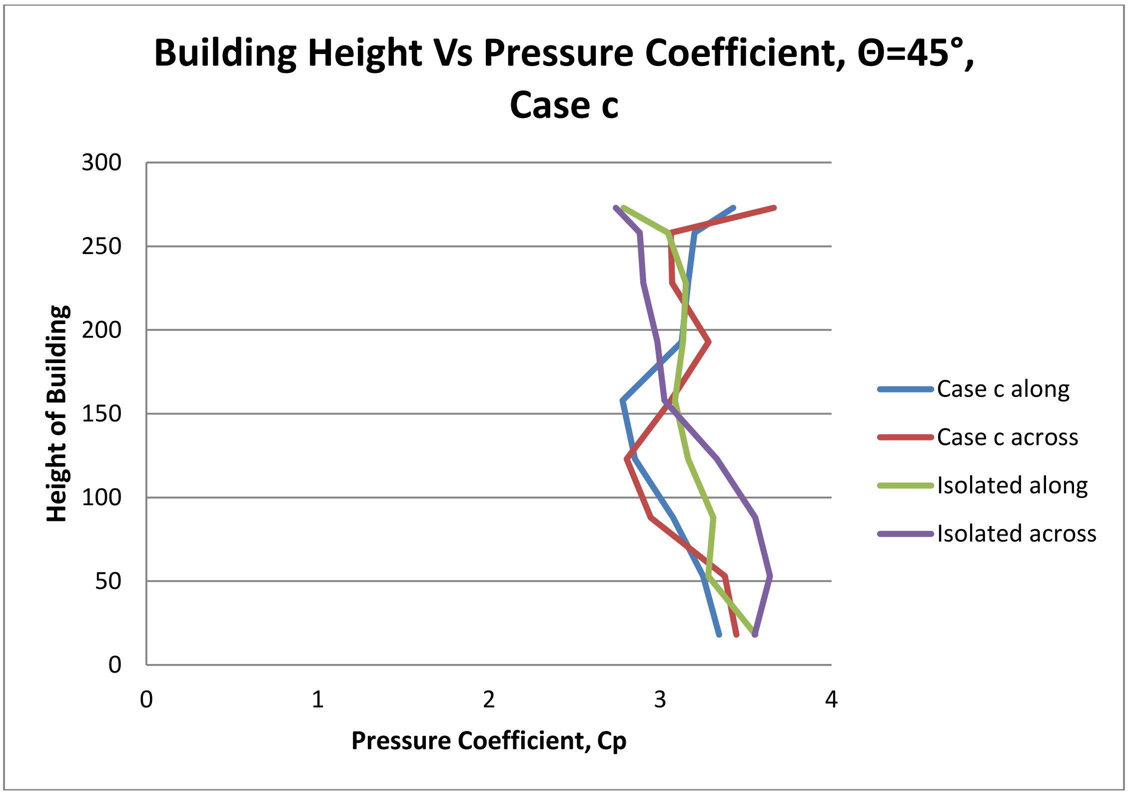

Figure 7: Variation of Pressure Coefficient along Building Height Considering Case c and Θ = 45°

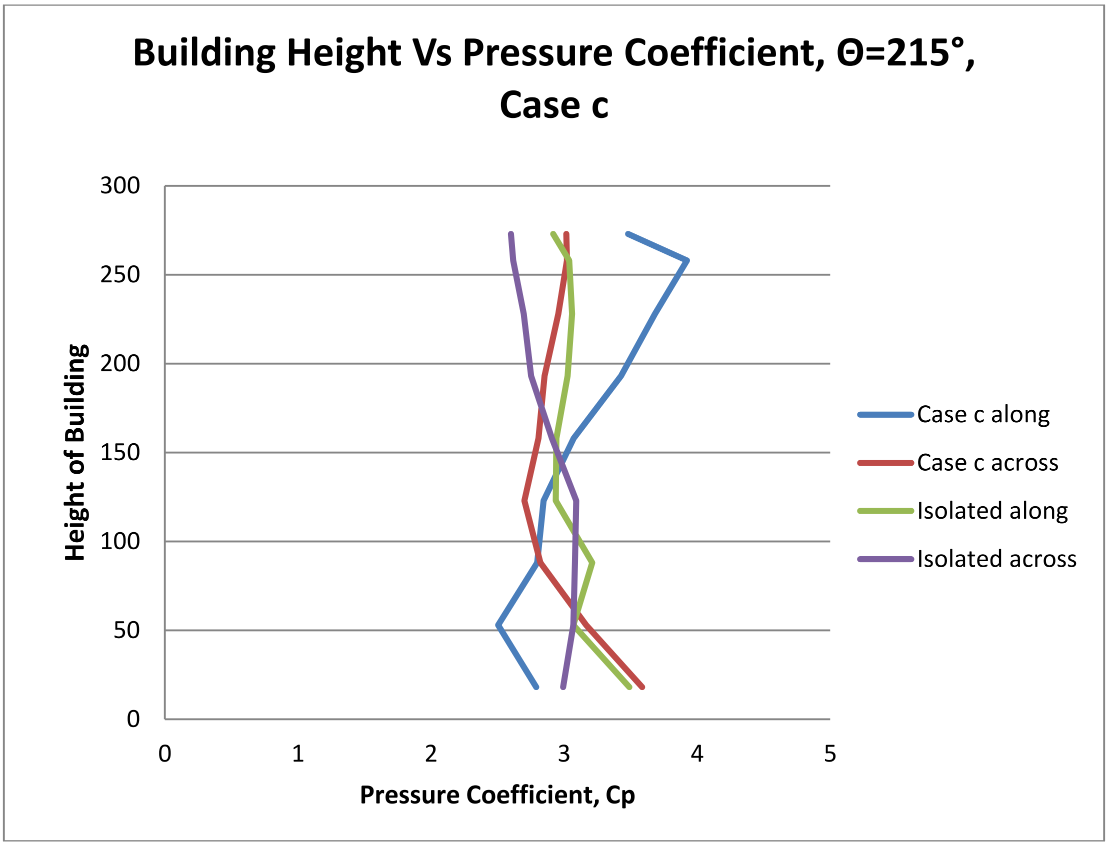

Figure 8: Variation of Pressure Coefficient along Building Height Considering Case c and Θ = 215°

Case d: In figure 9, it can be seen that when interfering building is placed at 6B and wind direction is 45°, there is a total amplification of Cp throughout the length of the principal building in along wind response. In across wind response, amplification takes place above the height of 100 mm.

At 215° wind direction, there is a total amplification of pressure coefficient throughout the height of principal building due to interference in both along as well as across wind directions (figure 10).

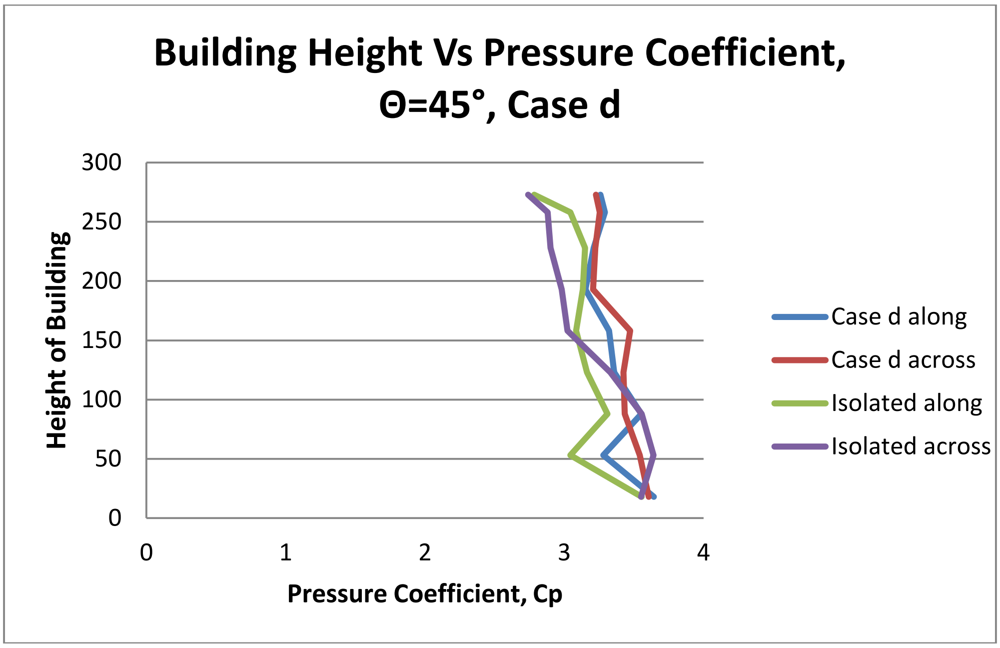

Figure 9: Variation of Pressure Coefficient along Building Height Considering Case d and Θ = 45°

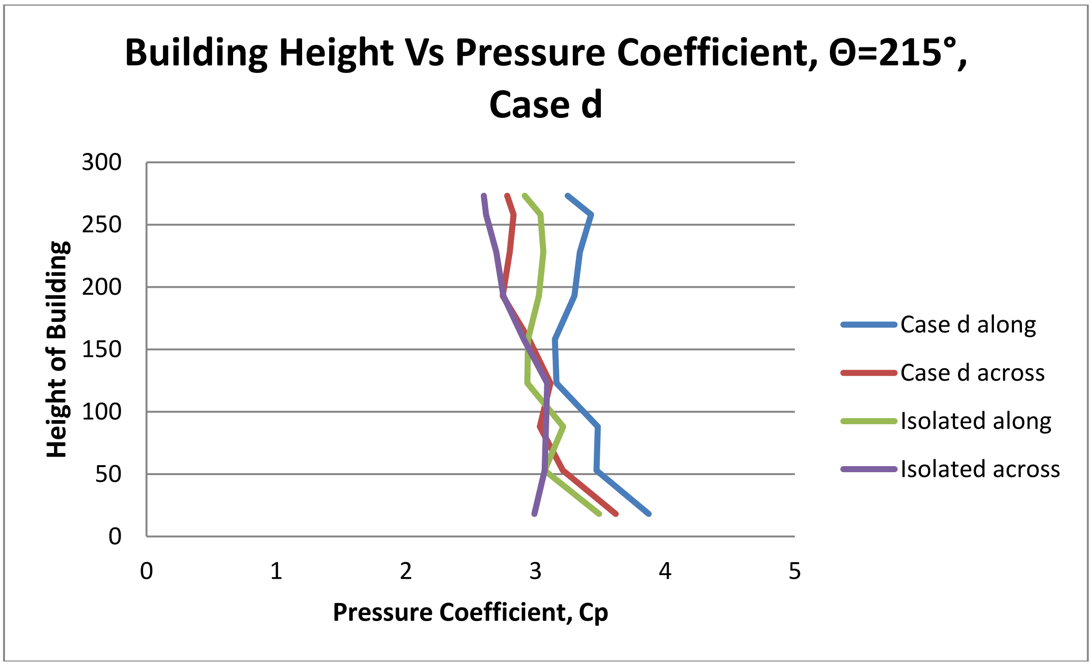

Figure 10: Variation of Pressure Coefficient along Building Height Considering Case d and Θ = 215°

CONCLUSIONS

Following conclusions can be drawn from the study presented in this paper:

1. In the cases described above there is a common phenomenon observed between all the cases i.e., the interfering building provides shielding effect (reduction in pressure coefficient of the principal building in interference condition as compared to isolated condition) at the lower heights of the building, mainly up to 150 mm, and above this height, there is an increase in pressure coefficient due to interference.
2. It has been observed that maximum shielding takes place in Case a at 0° wind direction (figure 2). This is happening due to reason that almost full width of principal building in under direct shadow of interfering building and the wind direction is same as the direction of interfering building with respect to the principal building and hence velocity vectors are not directly striking the principal building and hence wind pressure on principal building reduces. As the value of angle between the principal building and interfering building goes away from Incident Wind Direction (θ), the shadow effect of interfering building reduces on principal building and hence winds pressure on principal building increases gradually.
3. However in Case a, when wind direction is changed to 180°, there is an amplification in the pressure coefficient due to interference above the height of 220 mm in both across and along wind response because at 180° wind direction, the wind hits the surface back face of the principal building directly.
4. In case d, at 215° wind direction, there is a total amplification in the pressure coefficient, throughout the height of principal building due to interference. This case can be considered as the critical case in wind design of structures.
5. In interference condition, when interfering building is placed very closed to the object building on its upstream side, all surfaces of the object building are subjected to suction. With the increase in the spacing between two buildings, suction on windward faces get converted to pressures and suction on leeward surface increases approaching to the values in isolated condition.

REFERENCES

[1] ASCE: 7-02 (2002). “Minimum design loads for buildings and other structures”.

[2] AS/NZS: 1170.2, (2002). “Structural design actions, Part 2 - Wind actions”.

[3] Atul K. Desai, Jigar K. Sevalia, Sandip A. Vasanwala. “Wind interference effect on tall buildings”, International Science Index, Civil and Environment Engineering, Vol:8, No:8, 2014.

[4] Bailey, P. A. and Kwok, K. C. S. (1985). “Interference excitation of twin tall buildings”, J. Wind Engg. and Ind. Aero., 21, 323-338.

[5] IS: 875-Part 3, (1987). “Code of practice for the design loads (other than earthquake) for buildings and structures (Part 3 - wind loads)”.