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Comparison of Isolated Building Wind Pressure Coefficient Situated On Flat Terrain with That on Rolling Terrain

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Abstract - *Since we are aware of the current scenario that there are many restrictions while constructing in the horizontal direction mainly due to the high cost of land. So an alternative to this is constructive development in a vertical direction in the given land. In the designing of high-rise buildings wind load is considered to be the governing case. Many tools are available for their computation and designing purposes. One of the oldest systems is wind tunnel testing which is highly costly, time-consuming, and requires skill-based knowledge to interpret the result of the test. Using the software for the same purpose can be considered as an alternative and CFD simulation is one such tool for wind analysis and is opted in the present study for its lesser cost and time investment as compared to the wind tunnel testing method. From the literature and research study available there are different cross-section shapes like square, circular, triangular, and hexagonal. These shapes is selected based on previous research study and CFD simulation is carried out.*

Key Words: Aerodynamic, ANSYS Fluent, CFD, Terrain Characteristics, Wind Load, etc…

1. LITERATURE REVIEW

Author	**Year**	**Short descriptions**
Abdollah Baghaei Daemei	2019	The drag coefficient was first calculated on a triangular segment. The triangular model was then given three aerodynamic modifications: chamfered, rounded corner, and recessed, and drag coefficients were measured.
Ahmed Elshaer	2014	The primary goal of this research is to determine the suitability of "CFD" modelling for assessing aerodynamic modification results.
J Abdullah	2018	This research takes into account topographic features such as flat, depression, slope, and valley.
S.K. Verma	2013	An experimental research was performed on a rigid model of a square plan tall building made of Perspex sheet in a closed-circuit wind tunnel under boundary layer flow to study effect on wind incidence angle.
S.K. Verma	2015	The CFD analysis employs the same criteria as the experimental sample. The buildings chosen for this study have an octagonal plan by calculating average wind pressures on the faces of building models, the influence of differing wind incident angles, namely 0º, 15º, and 30º, on wind pressure distribution is investigated.
M.D. Aslam	2017	Four different building forms, namely rectangular, circle, ellipse, and hexagonal, are investigated for three different heights, namely 75 m, 150 m, and 225 m.

2. METHODOLOGY

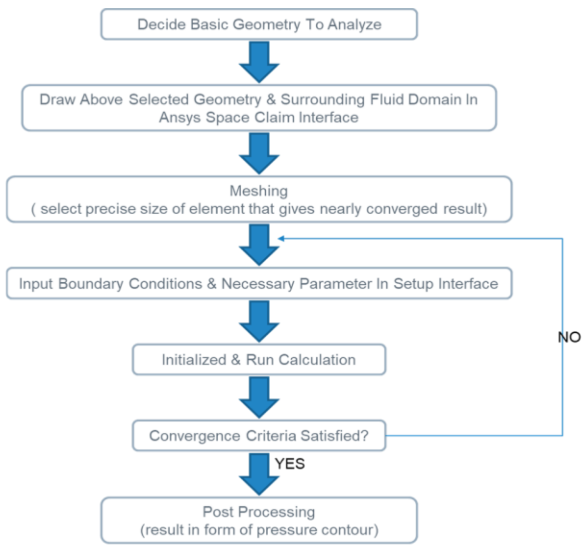

Chart -1: Flow chart

Many studies have been done on wind analysis using CFD considering flat terrain. Very less study have been done on how terrain characteristics such as slope that also affect wind load. Using the CFD simulation tool to predict the flow pattern around an isolated building in wind load analysis considering sloping terrain characteristics. Aerodynamic treatment will be given to shape of the cross-section of an isolated building considering sloping terrain characteristics.

- Cost-effective solution for wind load analysis of high-rise structures.
- To study the effect of terrain characteristic on wind load by comparing it with that of flat.
- For this purpose slope of 5° is taken in the present study.

2.1 Problem Statement

- Building Height Ratio: $3/2 < h/w < 6$ ($h/w = 2.5$)
- Building Plan Ratio: $1 \leq l/w \leq 3/2$ ($l/w = 1$)
- C/S area = 900 m^2 (30m*30m)

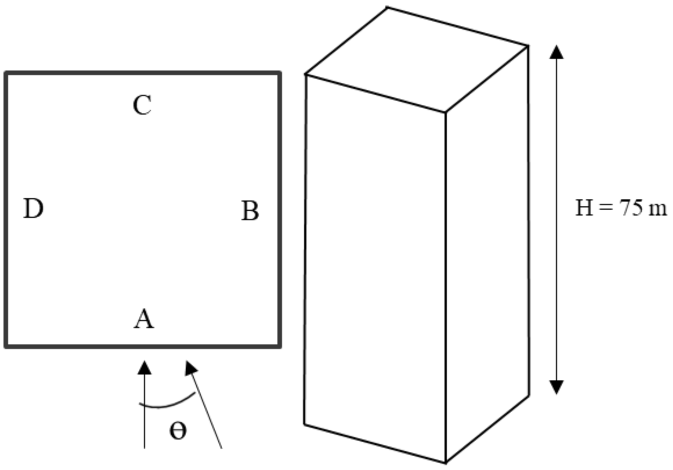

Fig -1: Geometry of problem

Domain created for the study is done from the paper by Jorg Franke [7] which suggested that building is situated at five times the height of building from the domain inlet so that fully developed flow can be achieved and for no backflow or reverse flow condition occurs in the domain and at the back, fifteen times the height of the building is allowed.

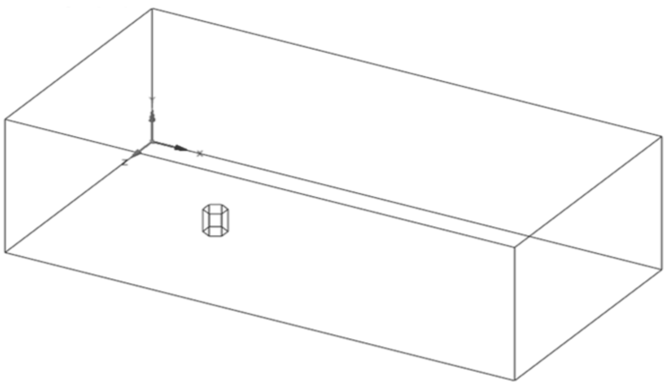

Fig -2: Flat terrain domain

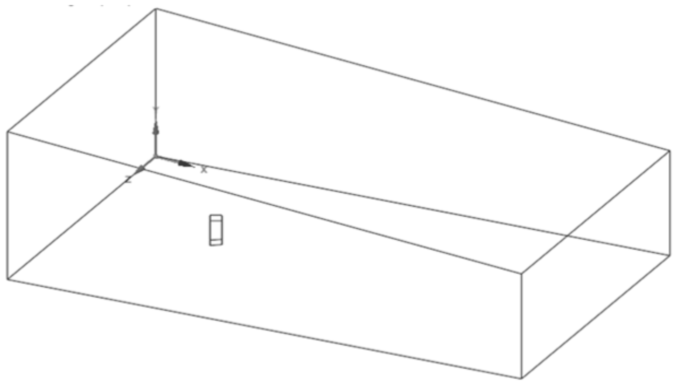

Fig -3: Slopping terrain domain

Steps to run simulation in ANSYS Fluent:

- Open ANSYS 2020 R2 workbench window
- From various available options select ANSYS fluent option
- There are five steps to go through for solving any problem taken in the present study namely wiz. Geometry, Meshing, Setup, Solution, Results
- In the first step namely geometry select space claim interface
- Draw specified geometry and surrounding wind tunnel domain in space claim interface
- Save drawn geometry model and move to next step meshing
- In meshing choose the precise size of the element to discretized whole studied area into a sufficient number of parts which gives nearly accurate results
- In the setup step provide all the necessary and sufficient boundary conditions to solve mathematical up to the desired accuracy in the right manner
- In post processing step get result in the form of pressure contours for global or local coordinate system

Table -1: Input parameters

Element order (size)	Quadratic (20 m)
Model	Realizable k-elipson model
Inlet velocity	39 m/s
Turbulent intensity	5%

3. RESULTS

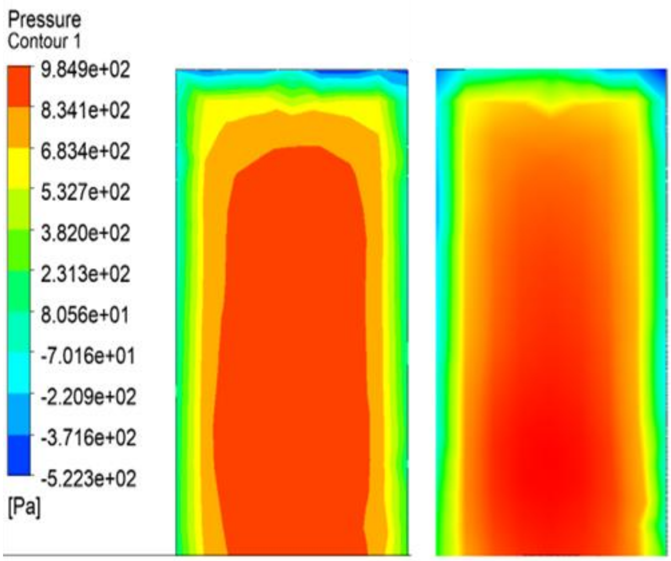

Fig -4: Comparison of pressure contour on front face

Face average pressure coefficient (Cp) is calculated from the equation given below

$$Cp = \frac{P}{0.6\ V_Z^2}$$

Here P is the wind pressure in Pascal & V is the inlet velocity in m/s.

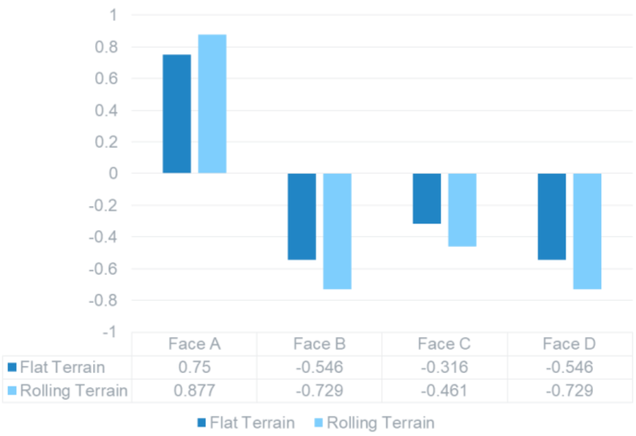

Chart -2: Average face pressure coefficient (Cp)

4. CONCLUSIONS

- At a 0-degree wind incidence angle average face pressure coefficient for rolling terrain as compared to flat terrain increased by 16.93% for square isolated buildings.
- In Square cross-section plan building drag force on rolling terrain 36.10% higher is observed as compared to flat terrain.
- In code there are two cases 1] hill and ridge 2] cliff and escarpment but uniform rolling terrain is also to be considered wherever applicable.
- On rolling terrain, as we go forward wind parallel to slope also contributing to wind above it which cause higher velocity which reduces pressure around an isolated building to some extent but in overall pressure is increased.

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