Effect of Hurricane Winds on Elevated Costal Buildings in Galveston, Texas

Siva Vinay Moturi and C. Vipulanandan, PhD, P.E.
Texas Hurricane Centre for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX, 77204-4003
Tel: (713)743-4291 Email Address: smoturi@mail.uh.edu

Abstract

In this study the effect of hurricane wind forces on the typical elevated costal building was investigated and compared with the same building without pedestals. For buildings without pedestals as the slope of the roof is increased the uplift pressures on the roof decreased on the wind ward side. For the leeward side the uplift pressures first increased then decreased up to a certain angle then remained constant. In the elevated costal building up to angle of 30º the downward wind pressure underneath the building was lower than the windward pressure.

1. Introduction

Hurricanes are formed when a well set of revolving winds clock-wise in the southern hemisphere and anti clock wise in the northern hemisphere develop over tropical waters, these are categorized into five types based on Saffir Simpson scale. One of the most important natural effects that must be taken in to account for the design of low rise structures is wind forces especially in hurricane prone areas. In Gulf of Mexico region most of the structure built along costal area can be categorized as low rise buildings used for commercial, residential, industrial and other purposes. In actual wind forces on buildings may fluctuate with time but for most of the structures dynamic effect is small, therefore the wind load is treated as lateral static loads. Wind forces on the buildings are taken to be as acting perpendicular to the building walls and roofs. Both wind pressure on wind ward side and the wind suction on leeward side must be taken in to account. Especially wind suction on the roof creates a serious problem due to light weight of the structure if the roof frame members are not tied to the main building properly. The magnitude of wind pressure and suction depends upon a comprehensive relationship between wind speed, air mass density, building geometry, building dimensions, building stiffness, orientation, location, surrounding area and some other factors.

2. Objective

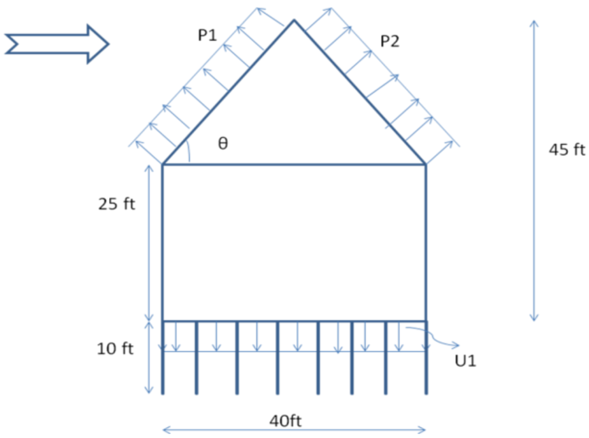
The objective of this study was to quantify the hurricane forces on Costal elevated buildings for various roof configurations.

3. Analyses

For analysis a gable end roof structure of simple geometry without eaves and over hangs was considered. The structure was analyzed for external and internal wind pressures for different roof configurations. The typical dimensions of the building are 60 ft x 40 ft in plan with an eave height of 25 ft and Ridge height of 45 ft, the building was assumed as partially enclosed rigid structure. The structure was located in Galveston Texas with open terrain belonging to structural category of Type II (ASCE 07). The design wind speed was 130 mph. From ASCE 7 -05 the maximum and minimum external pressure coefficients for different roof angles were determined on windward and leeward sides for the walls and roofs. The wind pressures underneath the building was calculated for the wind direction parallel or perpendicular to ridge.

4. Discussions

From the analysis it is observed that as the slope of the roof increases the wind pressures decreased numerically to zero, in then increases in positive direction. For wind direction normal or parallel to ridge the wind pressures on the wind ward side and leeward are calculated by considering the building as flat roof building for angles up to 10 degrees. The angles of roof were selected according to ASCE 07-05 (For gable roof θ<7 and 7<θ<45). For buildings without pedestals it is observed that Pressure P1 decreased numerically from -51.6 to -20.52 psf with positive internal pressures, whereas when negative internal pressures were included the pressure P1 increased from 14.81 to 31.94 psf it was also observed that with the increase in angle the Cp value decreased from -0.18 to zero and then increased to 0.36.When the elevated building was considered the roof pressures on wind ward side and leeward side were almost same as the pressures P1 and P2 in buildings without pedestals except the additional wind pressures U1 underneath the floor. For this case the pressure U1 underneath the building remains constant.



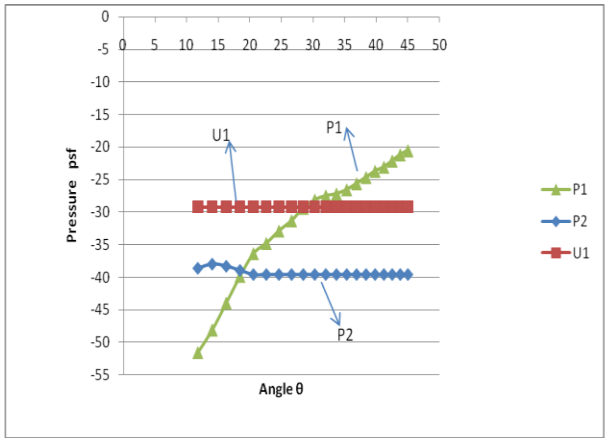


Figure 1: A Typical Elevated Costal Building. Figure 2: Variation of Uplift Pressure with Change in Angle.

5. Conclusions

Based on the study it was noted that there is an increase in the uplift forces as the slope of the roof increases for both buildings with and without pedestals. Due to the limited study on coastal elevated structures the downward forces underneath the buildings are approximations, further investigation is going to be carried out in future for accurate downward/upward forces.

6. Acknowledgement

The study was supplied by the Texas Hurricane Center for Innovative Technology (THC-IT).

7. References

1. ASCE (2005) "*Minimum Design Loads for Buildings and other Structures*". "ASCE 7-05, Reston, Virginia".
2. Mehta, K. C. and Delahay, J. M. "*Guide to the Use of Wind load Provisions of ASCE 7- 02*". ASCE press, Reston, Virginia.
3. Jhon Holmes, "*Wind loading on Structures, Second Edition*", 2007 Taylor and Francis.
4. "Costal Construction manual" http://www.fema.gov/rebuild/mat/fema55.shtm.