

Statistics and analysis of typhoons landing and failure mechanism of coastal low-rise buildings in China

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ABSTRACT: In order to reveal the status of typhoon landfall in China coastal areas, the coastal areas and frequency of typhoon landing were compared with the statistical analysis in the paper for nearly 50 years; combined with the wind pressure of low-rise buildings under typhoon in China's coastal, structures damage of low-rise buildings were investigated. The results show that, the southwest coast of Guangdong landfall the largest number of typhoon landing, while the coastal areas of Fujian and Zhejiang have larger number of strong typhoons; turbulence great impact on surface air pressure; it was also found that the high suction pressure zones occurred around the windward roof edges at a wind azimuth of 45° , and wind pressure along the roof corner just behind the roof ridge. The results of the present study are expected to be useful for the future development of a simple approximate formula for the low-rise buildings of the coastal area for design use.

KEYWORDS: Typhoon ;Low-rise buildings; Hurricane; wind pressure; failure mechanism.

1 INTRODUCTION

A full-length paper should have a short introduction. This should state the reasons for the work, with brief reference to previous work on the subject.

Typhoon (tropical storms and strong tropical storm) is an extreme climate which originated in tropical ocean between latitudes $5^{\circ} \sim 20^{\circ}$ and have great destructive, belonging to one of the severe natural disasters. The intensity of typhoon is one of the largest sea area in the Western Pacific, typhoon frequently attacks in China's coastal areas, China is also one of the few countries most severely affected by the Typhoon [1].

Wind resistance capacity of coastal residential wall in China is 12-level design, the strength design value of the walls are about 327kg/m^2 , and negative pressure of roof about 43kg/m^2 . Positive wind pressure of super-typhoon "SaoMai" reached $510 \sim 900\text{kg/m}^2$, roof negative pressure up to $67 \sim 118\text{kg/m}^2$, which greatly exceeded the design limit value of the low-rise buildings at china coastal, Typhoon "SaoMai" caused heavy casualties, which collapsed 39,000 houses and killed 144 people in Zhejiang Province [2~3]. Previous wind statistics show that the damage of low-rise buildings caused losses were more than half of the total losses. Therefore, researching of low-rise building on wind resistance possesses important practical significance [4~7].

2 NEARLY 60 YEARS LANDED IN COASTAL AREAS OF CHINA TYPHOON

Fujian ,Guangdong and Zhejiang Provinces ,suffered most landing typhoons during the past 60 years from 1950 to 2011.Most of the landing typhoons originated from northwest Pacific at east of Philippine, with northwest path as the main track. On the average, 5 typhoons every year landed or impacted china coast areas during the past 60 years, with a relatively big inter annual change and slight upward trend. Most of the impacting typhoons mainly occurred in July to September, showing a normal distribution with August as the centre.

we can see the following conclusions:

(1) Number of landing Typhoon from 1949-2006 in coastal marine areas of Guangdong were a total of 211 typhoons, each year average 3.64, followed by Hainan Province, 135 typhoons, the average was 2.33.But in the 5 years, total of 46 of Landfalling typhoons from 2007 to 2011, the average annual number of 9.2 typhoons.

(2) Compared to 1949-2006 strong typhoon data for more than 50 years, number and frequency of strong typhoons nearly 5 years landing and affecting along the coast appear Increasing trends in china.

Extensive disaster investigation shows that:

(1) Improper location: many houses built in the Typhoon-prone landed in empty fields, the region of villages and towns, offshore marine and upwind or higher ground, when the Typhoon landed, the geographical landform withstand wind loads of very large, very easily lead to collapse or damage of low-rise buildings.

(2) Improper design: wind damage of low-rise buildings of 1 or 2 independent houses account for a large proportion.

(3) Improper construction: construction of residences is not code for building construction, without structural design basic concepts of security, poor construction program, construction technology and construction techniques ,which led to the current poor quality of residential houses in coastal areas, and cause poor wind resistance capacity.

3 STUDY ON THE FAILURE MECHANISM OF COASTAL RESIDENTIAL WIND

According to the damage investigations,most damage to houses was restricted to the envelope of building, in particular to roof sheathing,which indicate that an improvement in wind resistance of the building's envelope will result in a significant reduction in overall economic losses.Failure mechanism of houses along the coast storms due to the Typhoon-prone area residential dwellings along the coast a large number of broad, each time the storms as a result of the economic problems, and also the essential problem facing social and political stability, so there is a need for low-rise buildings in storms damage mechanism of further scientific research.



Fig.1 Hurricane of a low-rise building in China coastal areas

Figure 2 show that[11], most damage to houses was restricted to the envelope of building, suggesting that coastal dwellings destroyed upwind wind-related, and roof more easily damaged than the walls.

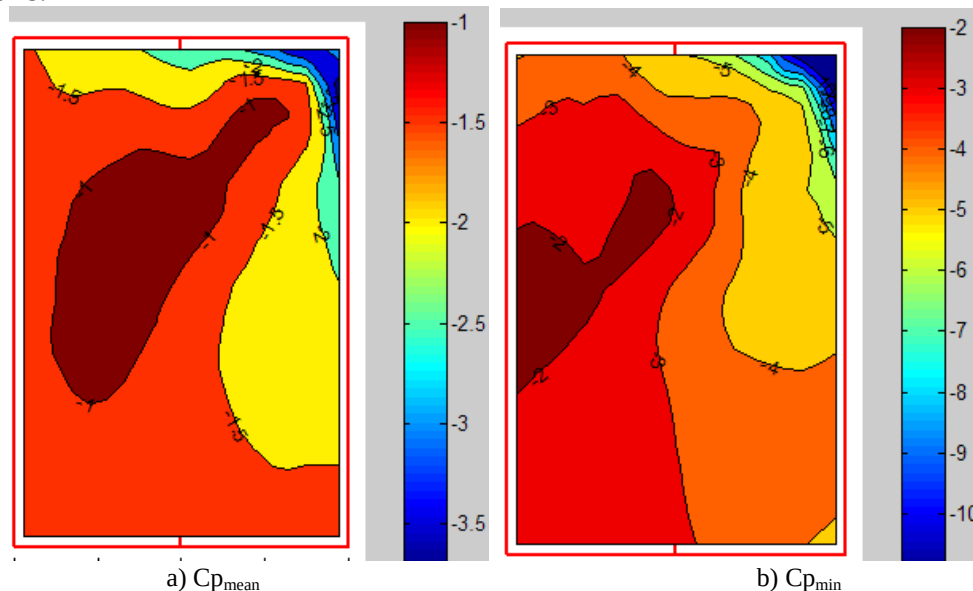


Fig.2 Hurricane of a low-rise building in China coastal areas[11]

The results [8~11] show that, The entire roofs of the full-scale low rise building experience negative mean and minimum pressures regardless of the incident wind direction. The angular position of highest (mean and peak) suction do follow the vortex core position closely. It was found that the high suction pressure zones occur round the windward roof edges. The roof corner just at the windward end of the roof exhibit the highest minimum pressure coefficients. The regions are expected to be the most vulnerable for wind induced roof damage in severe windstorms. Strong suction and high pressure regions on the the leading edges and roof-corner regions were induced by the updrafts and downdrafts of wind flows near the eye of the typhoon. The highest negative mean pressure coefficients observed was -3.34. It occurred at a wind azimuth of 45° , and the corresponding minimum pressure coefficients was -10.64.

CONCLUSIONS

- (1) Some practical considerations and tasks in the development for wind-resistance design of low-rise buildings have been examined in this paper, author suggest that we should increase wind resistance design standard of coastal low-rise buildings in China.
- (2) Strong suction and high pressure regions on the the leading edges and roof-corner regions were induced by the updrafts and downdrafts of wind flows near the eye of the typhoon.
- (3) This article analyzes the main problems in practical construction of the coastal buildings in China, and puts forward improving measures for the improvement of current design of low rise buildings in China coast.

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REFERENCES

- 1 FU Guohong. Study on wind load characteristics and Typhoon-resistant design of low-rise buildings[D]. Hangzhou . Zhejiang University, 2002:1~3
- 2 WANG Wei-guo, WANG Xiu-rong, XU Ying-long. Characteristics of super-typhoon "SaoM ai" and benefits of forecast service. Journal of Natural Disasters, 2008, 17(3):106-112
- 3 CHEN Xiang. Analysis of Devastating "Sangmei" Typhoon No. 0608 in Fujian, Journal of Sub-tropical Resources and Environmen, 2007, 2(3):36-43
- 4 XUE genyuan, YU Shanxian. Damage characteristics of Typhoon Rananim and primary research on typhoon disasters in Zhejiang Province. Journal of Natural Disasters, 2006, 16(4):39-47
- 5 LIU Qiaohui, ZHENG Youfei, SONG Yajie. Statistical analysis of typhoon landing and impacting Fuding area of Fujian Province during 1948-2007. Journal of Natural Disasters, 2011, 20(1):130-134
- 6 SONG Fang-fang, OU Jin-ping. Investigation and analysis of structures damage caused by typhoon "Hagubit". Journal of Natural Disasters, 2010, 19(4):9-17
- 7 XU An, FU Jiyang, ZHAO Ruohong. Field measurements of typhoons according to civil engineering research. Journal of Acta Aerodynamica Sinica, 2010, 28(1):24-32
- 8 LI Qiusheng, DAI Yimin, LI Zheng nong. Surface layer wind field characteristics during severe typhoon "Hagupit" landfalling. Journal of Building structures, 2010, 4(31):54-62
- 9 LI Qiusheng, DAI Yimin, LI Zheng nong. Wind pressures on the building surface during severe typhoon "Hagupit". Journal of Building structures, 2010, 4(31):62-69
- 10 DAI Yimin, LI Qiusheng, LI Zheng nong. Experiment study of wind pressures on a low-rise full-scale building. China Civil Engineering Journal, 2008, 41(6): 9-15
- 11 DAI Yimin, LI Qiusheng, LI Zheng nong. Wind loads on low-rise buildings— Study on variation of near ground wind profiles. China Civil Engineering Journal, 2009, 3(42):44-51