FAILURES OF ROOF STRUCTURES CAUSED BY WIND UPLIFT FORCES

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Special dedication to my father, mother and family members that always inspire, love and stand beside me, my supervisor, all personnel at the Civil Engineering Faculty, UTM and my beloved friends

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ABSTRACT

The weakness of the tying down systems between the structural elements has been identified as the main cause of the failure of light roof structures due to uplifting pressure from the wind. These weaknesses have caused part of the roof structure being blown off during thunderstorms. This project report presents the results of a study carried out to evaluate the load carrying capacities of joints for zinc/asbestos sheeting to purlin, purlin to rafter and rafter to roof beam in the frame structure for light roof construction. The capacities of these joints were determined from laboratory tests on respective samples and also from previous related tests. Comparisons were made with the calculated pressures from the wind and hence the pulling out forces exerted on each type of joint on modeled buildings representing the low and high rise houses located areas similar to those which experienced failure. Details of the structural configuration and types of joints adopted were within the range found in actual construction. The result show that the number of tying down points between members within a specified area of roof and the depth of penetration of the nails at three points currently adopted are inadequate. They are only sufficient to sustain forces exerted by the wind speeds of up to wind speeds of up to 10m/s and 50m/s in low and high rises building respectively. It was also proposed that the pitches between purlin and also between rafters in the present construction be reduced in order to achieve more connection points.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Roof design has been established when people started to build their own shelter in order to protect themselves from weather conditions and from wild animals. Designing a house with a proper roof system is necessary to provide safety, privacy and comfort to the dwellers and give certain degree of aesthetic value.

All building such as low-rise residential houses or high rise development must incorporate the roof system in their superstructure. Therefore, a complete building consists of several components such as roof frame, wall frame, finishes and roof connection and roof covering. Each element is designed to provide special characteristic to the building, which not allows water to penetrate and deteriorate the interior wall and cause severe damage to the building. The roof is built as a cover and function as insulation to the building.

As the purpose of having a complete and proper shelter is to provide protection, comfort and privacy to the dwellers or families. It is necessary for the house to be adequately designed and sturdily constructed to withstand the forces of nature such as strong winds, rains and thunderstorms from causing damages to critical house main component i.e the roof system and its assembly members from the damaging effect of especially wind speed uplifting effect.

Therefore, when there was occurrence of strong wind or thunderstorm, the roof structure should be able to resist the pressure from the wind and protect the roof from being flown away from its tying points. Many cases of roof structure failures have been reported every year which resulted in the loss of property value in a disaster of thunderstorms.

1.2 Problem statement

Roof structure will be damaged due to wind uplift pressure because the forces acting on the roof are larger than the capacity of the roof connection. Occurrence of this condition mostly affected the residential houses that used wood frame trusses with conventional nail connection and light roof sheeting such as zinc and asbestos.

The number of connections tying the roof component plays important roles where each connection has a capacity of pull out resistance which contributes to the overall performance of roof system. In design, the number of connection is important but when in the construction the number of nail is limited to four which the number of tying down points between the roof sheeting and purlin is just enough to tie the frame but not sufficiently strong to withstand wind resistance or wind uplift pressure.

Damage to roof structure due to wind forces particularly those in the category of light roof system have been reported regularly. In these cases part of the whole of the roof structures were blown away by high wind during thunderstorms. The failures were due to failure in the tying down systems between the roof structure elements, which is the roof sheeting to purlins, purlins to rafter as well as rafter to roof beams. This indicates that current design and construction practices provide limited resistance to uplifting by the wind. Consequently the present roof system needs to be revised and further improvement to the design must be adopted which has been the main objective of the research.

1.3 Objectives of study

The general aim of the investigation was to determine the performance of various connections between elements in the roof structure in relation to failures due to uplifting pressure from the wind and more specific terms, the objectives of the study are as follows:-

a) To review the types of connections between roof sheeting and purlin, purlin to rafter and rafter to roof beam currently used in the light roof construction;
b) To evaluate the resistance or the capacity of each type of joint or tying down points in (a) against the uplifting force exerted by the wind;
c) To determine the maximum wind speed at which the present construction of light roof structures is able to sustain the resulting uplifting forces;
d) To suggest recommendations to current practice of light roof structures construction to prevent failures caused by strong wind

1.4 Scope of study

The study was carried out within the following scope:-

(i) The analysis of wind load in this research was carried out in accordance with CP3: Chapter V: Part 2: 1972, Code of Basic Data for the design Buildings;

(ii) The recorded wind speed that had caused failure of roof structures ranged 24m/s to 42m/s and in this study the wind speed of 10m/s – 50m/s was considered;

(iii) Calculation of wind forces was carried out on the building model of low rise and high rise to represent single storey house and apartment/flat respectively. The parameters of frame spacing, roof dimension and type of roof used were identical to those normally found in practice. Site assessment was conducted to determine these information's.

(iv) The results of uplift pressure are used to estimate the pullout force at each particular point and compared with provided resistance calculated from available established experimental data.

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CP3: CHAPTER V-1972, Part 2: *Code of Basic Data for the design of building* Chapter V: Loading, BSI