ANALYSIS OF THE WIND EFFECT ON THE CANOPY STRUCTURE

FATIN SUFINA BINTI ABDUL RASHID

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UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

Frequently in Malaysia number of damage due to wind storm are occurred. Canopy is widely used by Malaysian. However, the number of canopy damage was some of the most severely occur in Malaysia. No version of the predominant standard and commentary for wind load design in Malaysia introduced for the the first time for the open canopy. In this study the typical type of canopy are identified. Both cases are examined with wind load in order to identify the possibility of wind speed that can cause damage to canopy. From the result it is show that if wind speed 11m /s the failure of the canopy will occur. It can be conclude that canopy structure will be failure easily. For the record at Malaysia Meteorology Department, it show that during thunderstorm wind speed are recorded about 18m/s. Future study need to be calculated in order to implement the understanding of canopy due to wind load.

ABSTRAK

Di Malaysia kerap kerosakan berlaku yang disebabkan oleh ribut angin berlaku. Kanopi digunakan secara meluas oleh rakyat Malaysia. Walau bagaimanapun, bilangan kerosakan kanopi adalah antara yang paling teruk berlaku di Malaysia. Tiada versi standard yang utama dan ulasan bagi reka bentuk beban angin di Malaysia diperkenalkan buat kali pertama untuk kanopi terbuka. Dalam kajian ini, jenis kanopi yang biasa digunakan dikenalpasti. Kedua-dua kes akan diteliti dengan beban angin untuk mengenal pasti kemungkinan kelajuan angin yang boleh menyebabkan kerosakan kepada kanopi. Dari keputusan itu menunjukkan bahawa jika kelajuan angin 11m / s kegagalan kanopi akan berlaku. Ia boleh membuat kesimpulan bahawa struktur kanopi akan gagal dengan mudah. Untuk rekod di Jabatan Meteorologi Malaysia, ia menunjukkan bahawa semasa ribut petir kelajuan angin direkodkan kira-kira 18m / s. Kajian masa depan perlu dikira untuk melaksanakan pemahaman kanopi disebabkan beban angin.

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W	Resultant of dead load of the structural (kN)
H	Horizontal force (kN)
Ay	Reaction on the support
By	Reaction on the support
V	Wind speed (m/s)
Mw	Overturning moment due to wind
M_{DL}	Resisting moment due to DL for overturning
u	Coefficient of friction
F	Sliding force (kN)
Ff	Friction force

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND OF STUDY

Wind related disaster may cause social impact and were some of the most severe in our country. Almost all of these disasters resulted from the combined effects of strong wind and accompanying water hazards due to heavy rain and storm surge. Information on the wind load pressures acting on open canopy structures is still lack. On the other hand, a large number of those structures suffered catastrophic damages due to windstorm. Wind hazards, which include tornadoes, hurricanes, , and other windstorms, are threats to almost 50 states, causing high levels of , deaths, business interruption, property damage and injuries. Hurricane Floyd hit the coast of South Carolina on September 15, 1999, causing $6 billion in damage and killing 51 people. 19 states the week of May 4-10, 2003, recorded 384 tornados touched down resulting in 42 fatalities.

There is no version of the predominant standard and commentary for wind design in Malaysia introduced for the first time the issue of open structures. In this research, I address the problem using a numerical simulation using SAP. With the use of SAP, parametric studies further explore different plan geometries. The obtained extreme values were implemented on two case studies of collapsed open canopy structures, due to windstorm. Previous researchers in Malaysia had made several studies. There are several factors are founded to contribute damage to building component found from the study made. During design stage, there are lacks of consideration due to wind effect thus concluded as the most factors of the failures.

With the use of structural analysis software, the structural members suffering extreme stresses, were identified and compared with the actual collapsed structures on the case studies selected. Structural design procedure is suggested for the analysis of open canopy structures and is implemented on each of the cases studied.

1.1 PROBLEM STATEMENT

Design of canopy has traditionally been carried out using simplified method of analysis. Because the method based on simplified analysis, they cannot provide engineer with all the desired design information and only provide limited indication. In 13 august at Malacca, the flying object from canopies had hit and kills 3 patrons of night markets. This is because there is no version of the predominant standard and commentary for wind design in Malaysia introduced for the first time the issue of open structures.

1.2 OBJECTIVES

1. To analysis wind load effect on canopy structure.
2. To determine wind speed that caused failure to the canopy structure.

1.3 SCOPE OF STUDY

To achieve the objective of this project, scopes have been identified in this research. The scopes are analysing the design of open canopy structure using SAP. This includes simulation on canopies 6m x 6m and 3m x 3m. The study shows how overturning and moment will affect the structure. For the beginning, studying the tutorial from tutorial is a must before I'm starting my open canopy analysis.

1.4 EXPECTED OUTCOME

1. The study will provide an analysis wind load on canopy structure.
2. The study will provide further knowledge about effect on canopy due to wind load.

CHAPTER 2

LITERATURE REVIEW

2.0 WIND ENGINEERING

Wind engineering education is still quite unusual, and most engineers have a working knowledge of use of local codes and no more education about wind engineering. The area to which engineers understand building aerodynamics is thus frequently directly related to the complexity of the code with which they are known.

It is now common for overseas engineers to work on projects in countries with which they are unfamiliar. Many engineers will use the wind design codes with which they are familiar to gain an initial estimate of loads at the initial design stage. Obviously to do this, it requires the input of a site specific wind speed consistent with the code being used. This can have a significant impact on the design process if the use of a different code during initial design leads to significantly different results to the local code which will most likely have to be used for design submissions then. To understand the limitations of any design codes that may be used, it is therefore important for design engineers.

According to the definition given by Jack, E. C. 1975, "The rational treatment of the interactions between wind in the atmospheric boundary layer and man and his works on the surface of earth is best the definition of Wind engineering". It is of a multi-disciplinary nature and includes consideration of the following topic – meteorology, wind structure in the atmospheric boundary layer, wind climate, numerical and physical modelling of atmospheric flow fields, bluff-body aerodynamics, vehicle aerodynamics, wind tunnel tests, full scale measurements, computational fluid dynamics, wind loads on buildings and structures, wind effects on transportation, wind energy production, atmospheric dispersion of pollutants, wind erosion, sand and snow drifting, windbreaks, urban planning, pedestrian wind environment, natural ventilation, wind actions and effects on long-span bridges, wind-structure interaction, aero elastic and chaotic phenomena, wind storm disaster assessment and reduction, insurance and re-insurance policies, wind codes and standards, vulnerability of structures under wind loads etc."

Current practice for the determination of wind pressures on structural elements, wind velocities, or overall wind forces on structures, and interaction of wind with other meteorological elements such as rain, dispersion of pollutants in the urban or open environment, is mainly by measurements in boundary layer wind tunnels simulating the principal features of atmospheric flow processes and conditions.

2.1 WIND UPLIFT

Wind uplift is a major concern for anyone who manufactures designs or installs roofing products whether for life safety, code compliance, or insurance. Pressure is exerted against the building as the air pushes against the sides and moves up and around the building is occur when wind hits a building. When the pressure below a roof is greater than above it, wind uplift will occur. This can happen from many different ways but is usually because pressure increases inside a building from air pressure build up or pressure above the roof system decreases by high air flow (wind). The roof could potentially lift off the building when wind uplift is greater than the system was designed for.

Wind is a great complexity of phenomenon because of the many flow situations arising from the interaction of structures with wind. Wind is composed of a multitude of eddies of rotational characteristics carried along in a general stream of air moving relative to the earth's surface and varying sizes. These eddies give wind its turbulent character or gusty. From interaction with surface features the gustiness of strong winds in the lower levels of the atmosphere largely arises. The average wind speed over a time period of the order of ten minutes or more tends to increase with height, while the gustiness in certain ways tends to decrease with height.

According to Baskaran et. al. 2012, “A common factor in roof failures is wind forces, which inflict considerable damage every year, even to new roof structures. Metal roofs are a popular low-sloped roof assembly.” Recent evidence suggests that designing structures and components, such as roofing, to withstand the damaging effects of the wind is an important aspect of engineering. During the 1970's and 1980's, many research studies were conducted using wind tunnels to measure the forces of the wind on various types of structures. Wind velocities, roof slope, the location of the structure, roof height, roof shape are factors that caused uplift pressure on roofing. The increased pressures inside the building caused by wind entering through openings are considered, as well as the "suction" forces of wind passing over the roof.

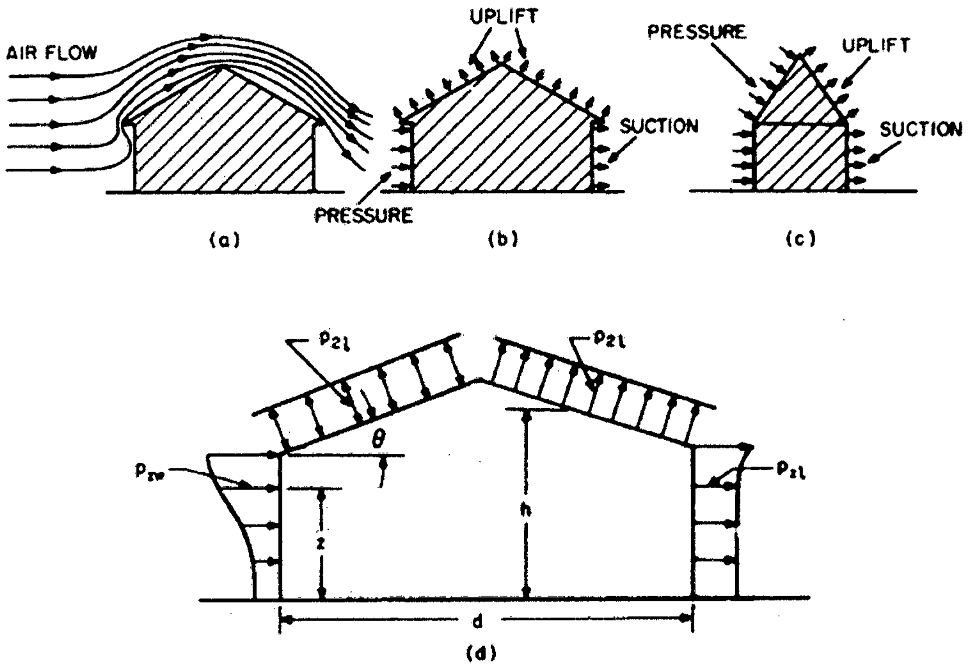

FIGURE 3.1 Effects of wind on a low building with pitched roof. (*a*) Airflow at the building. (*b*) Wind applies inward pressure against the windward wall, suction on the leeward wall, and uplift over all of a roof with slight slopes. (*c*) With a steep roof, inward pressure acts on the windward side of the roof and uplift only on the leeward side. (*d*) Pressure distribution along walls and roof assumed for design of wind bracing of a building.

Figure 2.1: Shows the effect of wind

2.2 OVERTURNING

Structures are subject to lateral forces and we all know that fact. We've seen the awesome Mother Nature at work of power and learned valuable lessons from natural events, such as in 1906 the Great San Francisco Earthquake and Hurricane Katrina in 2005 which is the destructive forces of wind. In construction, building codes throughout the country either require structural engineers to require contractors to build by a prescriptive method of resisting lateral forces or to calculate and design for wind or seismic forces.

Bryan, D. W, et. al. 2007 stated that "When lateral (wind or seismic) forces engage the diaphragm of a structure, it's easy to visualize the force pushing horizontally on the top of the shear wall. Sheathing then transfers the shear from the top of the wall to the bottom of the wall while holding the wall together to resist racking. If the bottom plate of the wall is anchored to the foundation to resist sliding, the far end of the wall will press down (compression force) and the near side of the wall will lift up (tension force)". Recent study says that "Wind forces are generated from natural events like thunderstorms, hurricanes and tornadoes. These winds create forces that attack the integrity of a structure in multiple ways: vertically, resulting in uplift forces, and horizontally, resulting in overturning, sliding and racking forces. Without proper design and construction, these forces can produce structural damage and even destruction." (Structure magazine November 2009)

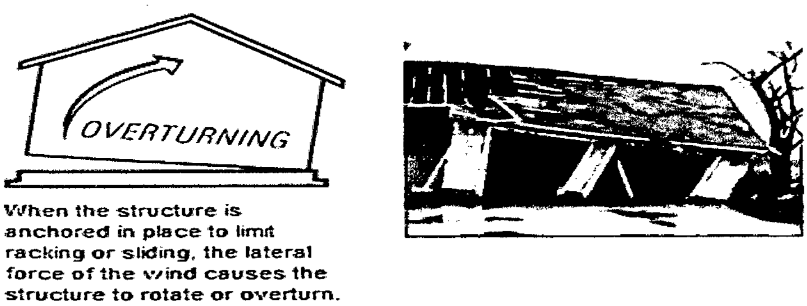

Figure 2.2: An illustration on how overturning occurs.

2.3 TEMPORARY STRUCTURE

Temporary structures, by definition, "Encompass a wide range of items such as concert and theatrical stages, temporary grandstands and bleachers, temporary roofs and shade structures, tents, public art projects, lighting and speaker towers, and many other facilities. Some building codes require temporary structures to comply with the wind-load guidelines applied to permanent buildings, and others leave this to the discretion of the building official. Accordingly, engineers are designing temporary structures to be strong enough to withstand hurricanes when in fact these structures will be used for only a short period, sometimes just a day or two. (William, B. G, et. al. 2009)

Temporary structures can be built utilizing a wide variety of materials, come in a variety of shapes and sizes, and created for a multitude of purposes. Definitions of what is a temporary structure are quite a few. Sometimes, these structures are required for only a brief period of time, and then they are relocated or dismantled. Their function and existence is temporary. We all see examples of this type of structure on a daily basis such as sports event seating ,exhibition stands, fairground rides, temporary workshops, kiosks, marquees, commercial and industrial units and warehouses. There are many more.

Our local Planning Department will also have thoughts on the definition of "temporary", as in their eyes, it will not require planning permission if a building or structure will be in existence for less than 28 days. Users of temporary structures have the major advantages experienced whether for sport, business, and emergency scenarios educational or military are quicker to build since all the parts can be quickly made (if they are not already in stock), temporary structures are exceedingly quick to dismantle and erect and also they don't need foundations. It is also much cheaper than a conventional building. Lower costs of components used in the construction will save a great deal of money when compared against a conventional building whether you buy outright or rent. Shorter lead times in the stages of planning, designing and building. On versatility side, it's very easy to change the configuration of the structure, or add to it at a later date. It is also very easy to dismantle it or relocate it. (M. G. Hill, 2012)

2.4 SAP2000 SOFTWARE

The SAP is introduce for over 30 years ago and has been synonymous with state-of-the-art analytical methods sinceSAP2000 follows in the same tradition analyse a very subtle, intuitive and user friendly powered by a design tools for engineers working on transportation, industrial, public works, sports, and other facilities and an unmatched analysis engine.

From its 3D object based graphical modelling environment to the wide assortment of analysis and design options completely integrated across one powerful user interface, SAP2000 has proven to be the most useful, integrated, and realistic general purpose structural program on the market today. This intuitive interface allows producing structural models rapidly and intuitively without long learning curve delays. Now you can control and use the power of SAP2000 for all of your analysis and design tasks, including small problems. With powerful built in templates, even a complex models can be meshed and generated. wind, wave, bridge, and seismic loads with comprehensive automatic steel and concrete design code checks per US, international and Canadian design standards can be automatically generate by Integrated design code features.

Advanced analytical techniques allow for step-by-step large deformation analysis, catenary cable analysis, multi-layered nonlinear shell element, Eigen and Ritz analyses based on stiffness of nonlinear cases, velocity-dependent dampers, material nonlinear analysis with fiber hinges, buckling analysis, progressive collapse analysis, support plasticity, energy methods for drift control, base isolators, and nonlinear segmental construction analysis. With options for direct integration and FNA nonlinear time history dynamic analysis, nonlinear analyses can be static and/or time history.

SAP2000 is the easiest, most useful solution for structural analysis and design needs because it can analyse from a simple small 2D static frame analysis to a large complex 3D nonlinear dynamic analysis.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 INTRODUCTION

This chapter provides information on the research methods of this thesis. The analysis using software SAP2000 is a method has been chosen to analysis wind load effect on canopy structure and to determine wind speed that caused failure to the canopy structure. The flow chart will be used to represent the whole process from the beginning of the project until the result is achieved.

3.1 FLOW CHART OF RESEARCH METHODOLOGY

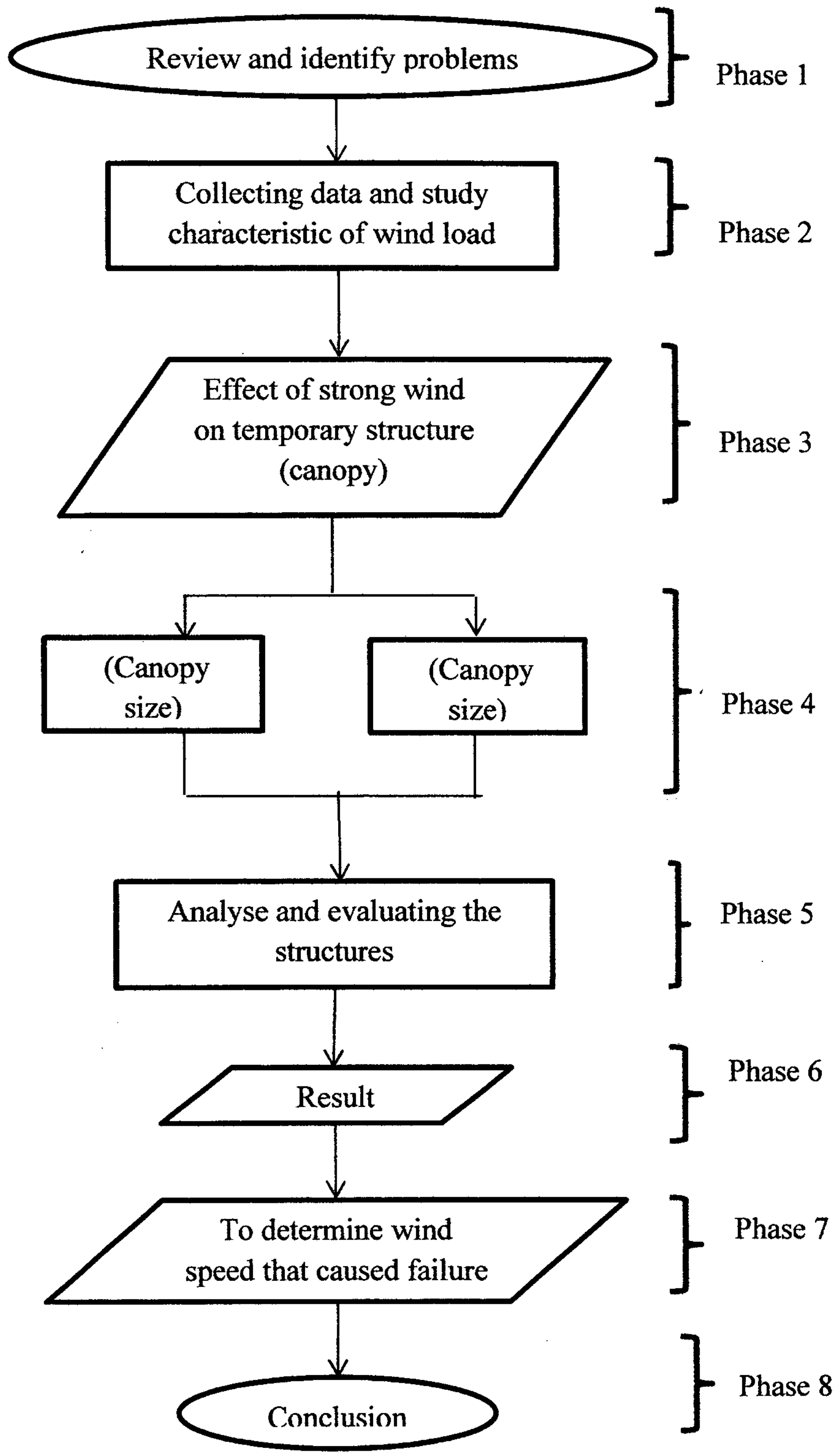

Figure 3.1: The methodology of this study has been summarised in the flow chart.

3.1.1 Phase 1

The aim of the 1st phase is to review and identify problems. Design of canopy has traditionally been carried out using simplified method of analysis. Because the method based on simplified analysis, they cannot provide engineer with all the desired design information and only provide limited indication.

3.1.2 Phase 2

The aim of the 2nd phase is collecting data and study characteristic of wind load. The data of canopy structures that has been chosen was recorded. The characteristic of wind load included uplift load, shear load and lateral load.

3.1.3 Phase 3

The 3rd phase involved the study of the effect of strong wind on temporary structure. The structure that has been analysed was 6m x 6m and 3m x 3m open canopy structures. I choose these two structures because they are the common open canopy that use in Malaysia.

Figure 3.2: 3 m x 3 m

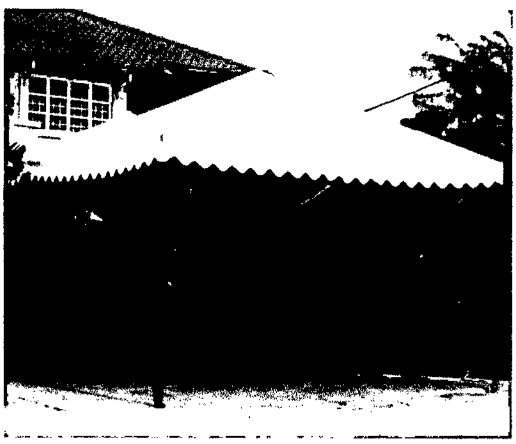

Figure 3.3: 6 m x 6 m

3.1.4 Phase 4

The 4th stage was analysed and evaluating the structures. The SAP2000 is used in the analysis and a couple of manual calculation in determining the wind load.

The types of the materials used are steel with tensile yield strength, 345MPa and tensile ultimate strength, 450 MPa. Wind is caused by differences in atmospheric pressure. When a difference in atmospheric pressure exists, air moves from the higher to the lower pressure area, resulting in winds of various speeds. Therefore, the structures are applied with differences wind load based on the wind speed. The calculation used is based on the Ms 1553:2002 code of practice on wind loading for building structure, section 2.4.1

Refer to the Ms 1553:2002 the minimum wind load design is 0.65kN/m2. The values is decreased till the structures is hit the maximum speed it can resist. If the structures still can resist the minimum wind load design, the values is increased till the structures start to fail. The structures being apply with gravity and uplift force.

3.1.5 Phase 5 and Phase 6

For the open canopies of 3 m x 3 m and 6mx6m first thing I have to calculate the reaction by using various wind speed which are 32, 27, 20, 15, and 10 m/s. From the graph, if the horizontal forces increase, the overturning moment will be increase. The structure will overturn if the wind speed is more than 10m/s. From the table, if the wind speed more than 10 m/s, the canopy structure will tend to slides.

3.1.6 Phase 7

From the investigation, the both structures will start to fail if wind speed is more than 10m/s. a structure must be strong enough to safely support all anticipated loadings and it must not deflect, overturn, tilt, vibrate or crack in a manner that impairs its usefulness.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 REACTION ON THE OPEN CANOPY STRUCTURE

For the open canopies of 3 m x 3 m and 6mx6m first thing I have to calculate the reaction by using various wind speed which are 32, 27, 20, 15, and 10 m/s. All the calculation was done manually.

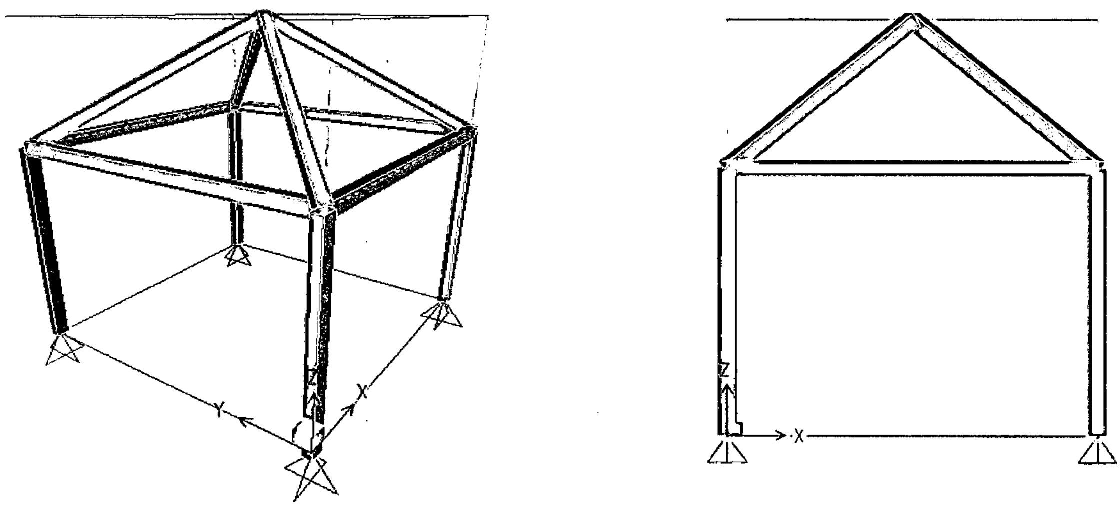

Figure 4.1: An illustration of 3D model and 2D model of open canopy structures using SAP2000.

4.1.1 Reaction on the 3m x 3m Open Canopy Structure

Example on how to calculate reaction on Ay and By on 3m x 3m canopy structure.

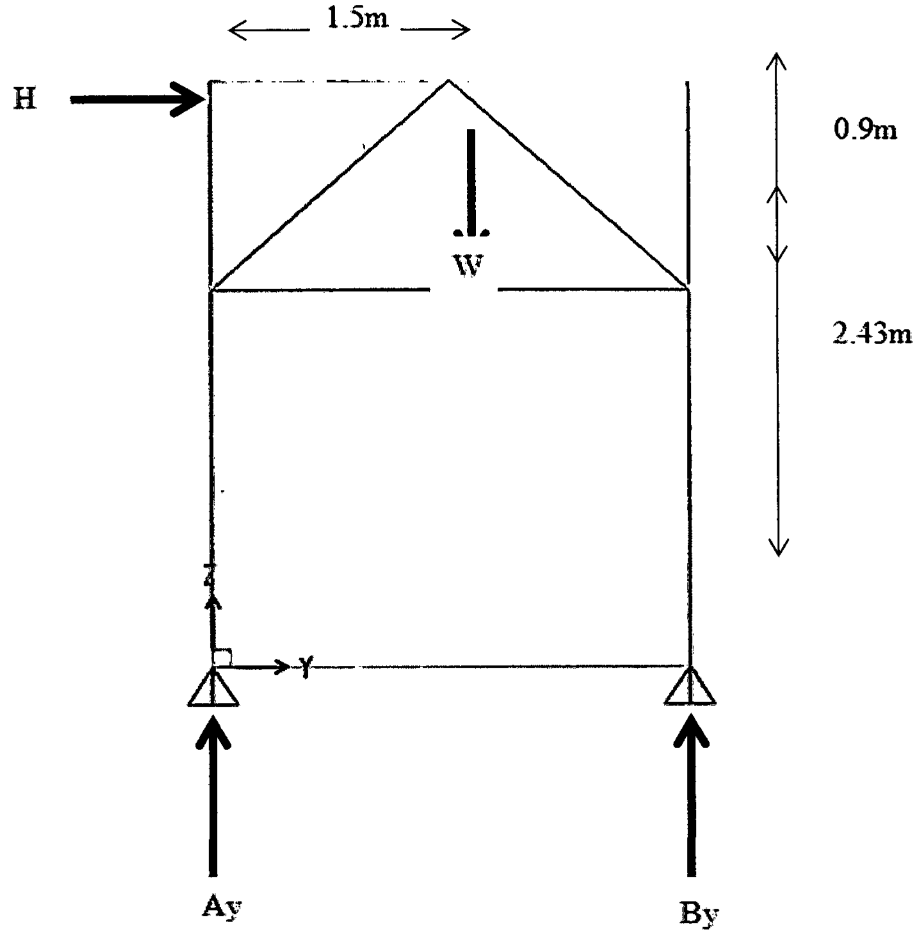

Figure 4.2: Reaction on the 3 m x 3 m canopy

Where,

W = Resultant of dead load of the structural (kN)

H = Horizontal force (kN)

Ay and By = Reaction on the support

V = wind speed (m/s)

1) Design wind pressure

$P = 0.613\ [V]^2 / 1000$

$= 0.613\ [32.5]^2 / 1000$

$= 0.65\ kN/m^2$