NUMERICAL INVESTIGATION ON RAINFALL NOISE INTRUSION AND PREDICTION OF RAIN NOISE FOR DIFFERENT COMPOSITE ROOF CONSTRUCTIONS.

LEE SHE JIE

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Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

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"I hereby declared that this thesis is my own work except the ideas and summaries which I have clarified their sources"

Signature: ....
Author : ...Lee She Jie.......
Date : .....16/6/08...........

Specially dedicated to my family, friends and companion

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ABSTRACT

This thesis is focused on the numerical investigation on rainfall noise prediction for different composite roof construction for different rainfall rates, velocity and droplet size. Based from the previous reviewed on the theoretical considerations, a semi-empirical equation was developed to predict the noise level due to rainfall for a range of composite roof construction. For an assumed rainfall droplet size, rainfall rate and rainfall velocity that impacting on the roof panel and then transmitted into a reverberant room condition an empirical constant was proposed which allows the sound intensity level to be estimated. Theoretical studies were based on the concept and mechanism of noise generation on different composite roof installed and roofing material layers construction in an acoustic reverberation room. Basically, the composite roof were laminate the roofing materials to form a single layer of composite but as for roof construction, most of the time that consisted a bare roof and composite roof with different noise control options such that its effect on noise and vibration generated could be determined. Based on the theoretical for semi-empirical equation and the transmission loss, a new numerical prediction is formulated to predict the sound intensity level due to a range of composite roof layer. This numerical prediction was compared with previous works for purpose validation and it was found that the numerical prediction was quite accurate in terms of minimal error. The characteristics of the composite roof materials especially the density and the thickness may influence the transmission loss value. As the density and the thickness increased of the roof material being selected, more sound transmission loss will be obtained and therefore reduced the noise generated inside a room.

ABSTRAK

Tesis ini fokus atas pengajian mekanisme generasi bunyi ke atas bumbung komposit dipasang pada sebuah bilik gema ujian akustik. Mengikut kajian teori sebelum ini, kaedah separuh emporok formula digunakan untuk meramal aras kebisingan hujan berdasarkan kepada beberapa binaan bumbung komposit. Berdasarkan kepada anggapan saiz titisan, curahan hujan dan halaju titisan hujan, pemalar empirik bunyi binaan bumbung berkenaan dikemukakan untuk membolehkan aras keamatan bunyi dianggarkan. Seperti yang diketahui umum, kebisingan dijana oleh hentaman hujan ke atas bumbung adalah disebabkan oleh hentaman getaran secara rawak. Sebagaimana kita tahu, komposit dihasilkan daripada percantuman lapisan bahan material. Dengan ketebalan dan densiti yang sedia ada dalam sifat-sifat tersendiri, maka dapat menghasilkan kesan mengurangkan kebisingan apabila melalui komposit tersebut. Tidak dapat dinafikan bahawa jika ketebalan dan densiti sesuatu bahan itu adalah tinggi, maka tahap mengurangkan kebisingan juga akn tinggi. Persamaan empirikal berdasarkan kepada teori dapat dirumuskan bagi mendapatkan hubungan di antara kebisingan dan getaran ke atas bumbung komposit terhadap frekuensi pusat jalur oktaf sepertiga. Ikhtiar juga dibuat untuk mengesahkan pengaruh redaman ke atas radiasi kuasa bunyi dari bumbung dapat mengurangkan aras halaju getaran. Kaedah saparuh empirik kemudian akan diprogramkan ke dalam database software komputer untuk dapatkan keputusan janaan bunyi dalam bilik gema. komposit dihasilkan daripada cantuman beberapa lapis bahan

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(3.44) $S.I.L_A = 10\log\left(\frac{Q}{Q_0}\right) + 45\log\left(\frac{v}{v_0}\right) + 15\log\left(\frac{D}{D_0}\right)$

$- 10\log(1+0.8709Ms^2) - 5$ 30

(3.45) $S.I.L_A = 10\log Q + 45\log v + 15\log D - 10\log(1+0.8709Ms^2)] - 5$ 30

CHAPTER I

INTRODUCTION

This chapter will introduce the overview and the objective of this project. Besides that, it also includes some problem statement and the scope of this project.

1.1 Overview

In the beginning of this project, it will start with an introduction to the basic concepts and theory of sound. It is important for the engineer to understand the nomenclature and physical principles involved in rain noise transmission of rain impact through metal roofing in order to suggest a rational procedure for rain noise reduction. Furthermore, this project will also examine the alternative method for predicting the noise generated by the raindrop on the metal roofing. This information is required in the design stage of any rain noise control project. Information about the specification and characteristic of the roof material can allow the design of equipment that is quieter in operation through adjustment of the raindrop speed or some other parameter.

A study of the rain noise control techniques applicable to rooms will be made by using conventional method to overcome rain impact noise fairly straight forward. These procedures include the use of acoustic treatment of the walls of the room and the use the multilayer of material to make as the roof will reduce the impact force. It is important to determine if acoustic treatment of the metal roofing will be effective or if the offending noise source must be enclosed to reduce the rain noise to an acceptable level.

Concern about problem of noise in the workplace and in the living space has escalated since the amendment of the Walsh-Healy Act of 1969. This act created the first set of nationwide occupational noise regulations (Occupational Safety and Healthy Administration, 1983). In the design of many appliances, such as dishwashers, the designer must be concerned about the noise generated by the appliance in operation. It is important that noise control be addressed in the design stage for many mechanical devices. Lack of proper acoustic treatment in offices, apartment, and classrooms may interfere with the effective functioning of the people in the rooms. Even though the rain noise is not dangerous and not particularly annoying, if the person cannot communicate effectively, then the rain noise is undesirable

1.2 Objectives of the project

This project is to analyze the rainfall noise level when it impacting on the surface of the roof system and transmit through the different material layers to a reverberant room. The main objectives in this project are as following:-

Investigate impact noise on lightweight composite roof

- Predict the relationship between impact noise sound level on selected roofing inside a room subjected to composite roof construction at different rainfall rate.

- Study and identify the method used in programming to generate the result numerically.

1.3 Scopes of the project

This project will investigate the rainfall noise drop on the construction of the material roof layers analysis. The scopes that generally cover in this project are as following:-:

- Familiarize the use of any software package as a tool (Visual Basic)
- Numerical simulation of rainfall noise generated by rainfall on roof structures via programming based.
- Prediction of sound pressure / intensity level generated by rainfall on different composite roofs.
- Validation with available analytical or experimental woks possible at all stages.

1.4 Problem Statement

Nowadays, global warming affect the rain fall rate unstable in certain area of the world. Especially those countries near the tropical rain fall zone. This rain fall may cause the building always face the sound pollution problem during heavy rain. This rain fall noise is affected by high rain impact noise free drop on the metal roof layer and the metal roof material resonates randomly and generates the high level of noise into the room. This noise pollution may lead the communication is difficult to proceed and productivity performance can be affected also.

As an example, Malaysia is one of the country locate in the tropical zone, therefore the rainfall rate is estimated to be 180 to 220 mm/hr, in which the rainfall rate is quite critical. In the certain area of Malaysia such as the city of Kuala Lumpur, most of the building or tower practice tends to favour the construction of roof with lightweight roof construction. However, by using lightweight roof structures in buildings where speech communication is of great importance causes noise due to rainfall impact on roof to be an issue of concern. Lack of proper acoustic treatment in offices, apartment, and classrooms may interfere with the effective functioning of the people in the building.

To overcome this noise pollution during the heavy rain fall, most the roof constructor will design the roof with select high density and thicker roof material so that the noise levels may be reduce. Adding the multiple layers or the composite roof material can reduce resonate of the sound intensity levels. As the high density material can produce a good transmission loss therefore more of the material's engineer are try to develop on this composite engineer material to increase their transmission characteristic of the roof material so that it can perform better solution to solute the rain fall noise pollution problem during the heavy rain.

CHAPTER II

LITERATURE REVIEW

This chapter will introduce a lot of literatures that have been studied and reviewed as a reference which are intimately relative with this project. The construction of the roof system directly influence the rainfall noise level from the out side of the room transmits into the roof layers and finally transmits into the reverberant room.

2.1 Background

A lot of studies had been done by researcher are related to prediction of rainfall drops for different composite roof constructions. However, it is only reviewed fewer studies which were focus on investigate on roof construction system. Although the roof layers construction is different for every country, but the conceptual to calculate the transmission of the rainfall noise through these layers are always same.

According to J.McLoughlin, D. J. Saunder & R.D Ford (1993) conclude that lightweight steel and aluminium roof cladding systems are commonly used in large 'shed' type constructions where cost is often more important than noise considerations. However, the use of these systems in more noise-sensitive environments such as schools, office buildings, conference halls and leisure centres has increased the interest in their acoustic performance. In addition to providing adequate insulation between