AN EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF THE MODIFIED CONNECTION OF OVERHANG ROOF STEEL CLADDING SUBJECTED TO STATIC LOAD

FATIN HUWAINA BINTI ABDULLAH

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2021

AN EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF THE MODIFIED CONNECTION OF OVERHANG ROOF STEEL CLADDING SUBJECTED TO STATIC LOAD

by

FATIN HUWAINA BINTI ABDULLAH

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)

(CIVIL ENGINEERING)

School of Civil Engineering
Universiti Sains Malaysia

August 2021

Appendix A8

UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2020/2021

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: An experimental investigation on the performance of the modified connection of overhang roof steel cladding

Name of Student: Fatin Huwaina Bt Abdullah

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

Signature:

Date : 3rd August 2021

Endorsed by:

(Signature of Supervisor)

Name of Supervisor:
PROF. IR. DR. TAKSIAH A.MAJID
Date:
4 / 8 / 2021

Approved by:

(Signature of Examiner)

Name of Examiner: DR. MUSTAFASANIE M. YUSSOF
Senior Lecturer
School of Civil Engineering
Universiti Sains Malaysia

Date: 05.08.2021

ACKNOWLEDGEMENT

Alhamdulillah, with blessing from Allah S.W.T, I have successfully completed my thesis. First and foremost, I would like to express my gratitude to my supervisor of this project, Prof. Dr. Taksiah A. Majid, for the valuable guidance and advice that have helped me complete this project on time. Her willingness to help me from the beginning of the project with lots of ideas and opinions has motivated me through this project. I am also grateful for the research grant 1001/PWAM/8014023 that helps me financially to complete this project.

Besides that, I also would like to extent my gratitude to Mr. Tan Leng Luik, postgrad student under Prof. Taksiah supervision for his kindly cooperation in providing many information, knowledge, advice, and assisting me during the experimental work. Without his help, I will not be able to complete this thesis.

Next, I would like to acknowledge the staff and technician staffs of School of Civil Engineering especially Mr. Mad Fadzil Ali from structure lab who willing to teach and help me setting up the apparatus for my project. I would like to thank some of my friends who were willingly to be my assistant and supporting me during the lab work.

Lastly, I would like to thanks to my beloved parents for helping and supporting me in this study in term of spirit and financial. Without helps from all the particular that I have mentioned above, I am might unable to accomplish my project and facing a lot of difficulties throughout this project. All the guidance and advice made my project run smoothly until completion. I appreciate all the support and help during this thesis.

ABSTRAK

Kajian terhadap kesan ke atas beban angin ke sambungan kepingan bumbung dan purlin menjadi tumpuan kajian semasa. Kegagalan bumbung didapati bermula di bahagian juntaian bumbung disebabkan oleh pergolakan yang dihasilkan daripada angin yang kuat. Walau bagaimanapun, kajian terdahulu terhad kepada bangunan yang tidak berkejuruteraan tanpa juntaian bumbung terutamanya rumah luar bandar di kawasan utara Semenanjung Malaysia. Dalam kajian ini, ukuran panjang juntaian rumah diperoleh dari kaji selidik rumah luar bandar. Kajian eksperimen menggunakan ujian tarik untuk mensimulasikan kesan beban angin pada ciri rumah pedalaman terutamanya juntaian bumbung. Oleh itu, kajian ini dijalankan untuk mengkaji daya tarikan melalui kapasiti pada sambungan kepingan bumbung dan purlin. Ujian telah dijalankan pada dua jenis bumbung iaitu, bumbung beralur dan trapezoid. Kayu jenis jelutong yang diklasifikasikan di bawah kumpulan kekuatan 6 digunakan sebagai purlin dan beban angin dihasilkan melalui mesin hidraulik. Dalam kajian eksperimen, dua jenis ketebalan kepingan bumbung digunakan iaitu 0.18 mm untuk bumbung beralur dan 0.23 mm buat bumbung trapezoidal. Sampel bumbung dibuat dengan beberapa jenis pemasangan iaitu sebagai sempel kawalan, sempel yang diubahsuai menggunakan cara pertama iaitu dengan penambahan serpihan bumbung dan sempel yang diubahsuai menggunakan cara kedua iaitu dengan penambahan serpihan bumbung dan kayu bersaiz kecil. Berdasarkan keputusan daripada kajian eksperimen, didapati bahawa sempel yang diubahsuai menggunakan cara pertama dan kedua mempunyai daya tarikan maksimum sebanyak 2.10 kN dan 2.304 kN berbanding sempel kawalan iaitu 0.942 kN dan 1.138 kN dan maksimum daya yang dikenakan sebanyak 4.91 kN dan 6.367 kN berbanding sempel kawalan iaitu 2.74 kN dan 2.804 kN bagi bumbung beralur dan trapezoidal. Oleh itu, didapati bahawa sempel yang diubahsuai dapat menambahkan kekuatan bumbung.

ABSTRACT

The study of effects on wind loading to the roof cladding and purlin connection become the focus of the present study. It is found that the failure of roof cladding initiated at the overhang roof due to turbulence created form the strong wind. However, the previous studies are limited to the non-engineered building without overhang roof mainly the rural house in northern region of Peninsular Malaysia. In this study, the typical overhang roof length was obtained through rural house survey. The experimental study using simple pull-through, and pull-out test was performed to simulate the wind loading effect on rural house features especially at overhang roof. Therefore, the study is conducted to investigate the pull-through and pull-out capacity on cladding to purlin connection of rural house. The tests were conducted on two types of claddings namely, corrugated and trapezoidal roof cladding. The purlin used timber type Dark Red Meranti which classified under strength group 6 and the wind loading was applied via hydraulic jack machine. In the experimental work, two different thickness of cladding is used, which is 0.18 mm for corrugated steel cladding and 0.23 mm for trapezoidal steel cladding. The specimen is built with different types of assembly, namely control sample, modification 1, with the addition of roof cladding strap and modification 2, with the addition of roof cladding strap and small size wood. Based on the result from the experimental work, it can be identified that both specimen in modification 1 and 2 are having higher value of maximum load cell nail, 2.10 kN and 2.304 kN compared to 0.94 kN and 1.138 kN from control sample and maximum applied load, 4.91 kN and 6.367 kN compared to 2.74 kN and 2.804 kN from control sample for corrugated and trapezoidal roof cladding. Therefore, it can be concluded that the modification in the roof connection can increase its strength.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

Cataclysmic events are a worldwide issue. Windstorm is an illustration of a catastrophic event sorted under geophysical danger (Shaluf and Ahmadun, 2006). Malaysia is situated in tropical areas where substantial downpours happen practically the entire year. During the inter monsoon season, windstorms are most common in Peninsular Malaysia's northern regions. The inter monsoon cycle is divided into two stages. The principal stage starts from month of April to May while the subsequent stages are from October to November. According to Jayasinghe et al. (2018), when encounters the largest wind load, the most vulnerable part of a house is the rooftop. Roof openings would result from strong wind on a low-rise house, causing more structural damage (Dai et al. 2020). Localized high suctions and large pressure variations cause the majority of roof damage. Almost all houses in Malaysia's rural areas have non-engineered roofing systems. These houses' roofs are prone to failure as shown in Figure 1.1, and various forms of roofing failure can be predicted (Zaini et al.2019).

Figure 1.1 Roof damage during windstorm event

1.2 Problem statement

There have been several reports of wind damage incidents in recent years, which have been widely documented in the media. These occasions have carried genuine inability to the rooftop structure where it typically started at cladding and purlin connection. As of late, there is one case revealed by New Straits Times paper on 30th October 2020 including windstorm occasion happened at Kuantan, Pahang. The windstorm has ripped through residential neighbourhoods in the area causing several homes' roofs to be swept away. Around 37 premises were reported damaged during the event that lasted about an hour starting from 8pm. The occasion has caused structural damage to number of houses such as damaged roofs and broken ceilings which resulted in rain damaging the furniture inside the house as shown in the Figure 1.2.

Figure 1.2 Roof damage in Indera Mahkota Dua, Kuantan (New straight times, 30 October)

In provincial area, majority of the houses comprise of non-engineered low-rise buildings. During the strong wind event, this type of house can be easily affected, and, in some cases, the damages are severe. Thus, this kind of issue need to be further study especially at cladding and purlin connection. An experiment regarding of the connection of overhang roof steel cladding has been purposed to encounter this issue. In this experiment, a typical dimension of roof structure for rural house is needed. Several modifications regarding the connection of overhang will be purposed and the performance of the modified connection will be analyzed accordingly. Furthermore, the type of failure of roof will be identified and discussed throughout this study.

1.3 Objectives

This experiment is intended to study the potential failure load capacity of the modified cladding to purlin connection and is focusing on the following objectives:

1) To identify the typical overhang roof dimension of rural house
2) To analyze the performance of the modified connection of overhang roof steel cladding
3) To compare the type of failure of roof considering pull-out and pull-through capacity of cladding to purlin with the modified connection.

1.4 Scope of work

The focus of this study is mainly on the experimental investigation pertaining to the type of failure of roof cladding to purlin connection which are either pull-out failure or pull-through failure by considering the overhang roof part for the rural house. This study consists of two key works: first, a survey of the rural home, and second, an experimental work. The survey work is conducted in northern region of Peninsular

Malaysia, which is in Pulau Pinang. The data collection from the survey work will then be used in deciding the dimension used during the experimental works. Based on the information gathered, the experimental work is using two type of roof claddings, known as corrugated and trapezoidal. Both roof claddings are widely used in rural houses in Malaysia as they are relatively cheap and easily available in most of the hardware stores. The thickness of the corrugated steel cladding and trapezoidal steel cladding used are constant throughout the experiment which are 0.18 mm and 0.23 mm, respectively. This experimental work is using a timber with a low strength group namely (SG6) for the purlin with the size of 50 mm x 50 mm and an umbrella head nail as the connector of the steel cladding to the purlin. In this study, the roof structure is modified at the connection part by some addition of roof strap and a small size of timber with specified arrangements.

To perform the experiment, a complex arrangement and intense laboratory set up and equipment are needed such as wind tunnel and airbox to replicate the wind pressure that will be exerted on the roof connection. Therefore, in order to reproduce the same outcome in this study, the hydraulic jack testing is used, and associated steel frame assembly is produced. Five numbers of Lateral Vertical Displacement Transducer (LVDT) together with a 5 kN load cell is attached to the roof cladding to identify numbers of parameters such as the displacement of the cladding when subjected to the static load and the actual fastener load at critical central support.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Recently, the number of wind-related disasters in Malaysia has risen dramatically as a result of windstorm events. Mahendran and Mahaarachchi (2002) said that low-rise structures are more susceptible to damage caused by extreme wind events such as windstorms. As illustrated in Figure 2.1, rural housing in Malaysia is characterized by non-engineered structures and low-rise structures. When subjected to high wind loads, this type of house is vulnerable to destruction (Muhammad et al., 2015). This is because low-rise structures have a low-pitched roof and a poor link in the direction of the uplift load (Mahendran, 1995). Due to the large number of non-engineered low-rise buildings that are unable to withstand high-wind events, this would result in an economic loss due to building damage to the owner.

Figure 2.1 Common rural house in Malaysia (Muhammad et al, 2015)

2.2 Element of roof structure and connection

Roof batten or purlin, roof sheeting or cladding, and rafter are the primary roof structure elements. As illustrated in Figure 2.2, each element plays a unique role in providing external and internal support for the roofing system. Usually, rural houses are non-engineered structures, they were typically built with very little, or no technical engineering input, and they are often the product of varied building traditions and cultures. There are three types of connection in roof structures, namely roof sheeting-purlin connection, roof-wall connection, and purlin-rafter connection. These connections are usually built with a simple nailing of purlin to rafter and rafter to stud walls, Muhammad et al. (2015). In Peninsular Malaysia's five northern regions, Majid et al. (2016) discovered that the majority of rural houses have an overhang roof. This portion of the roof, situated at the roof's edge and protruding outwards, serves to shield the face of the wall during the downpour. However, Zaini et al. (2017) reported that damage at the overhang could occur, especially during a strong wind event due to the insufficient support to prevent the roofing system from uplift.

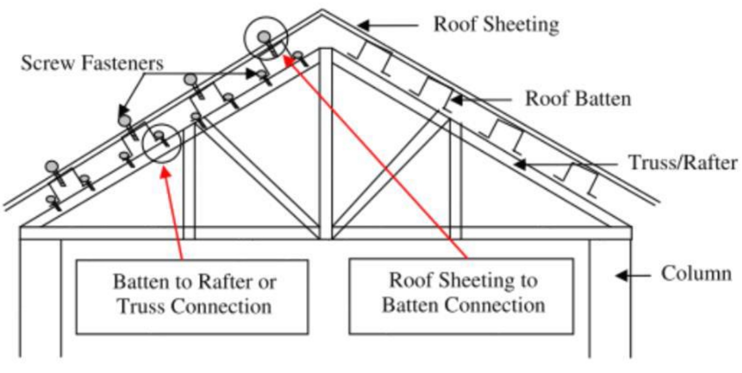


Figure 2.2 Roof structure component (Sivapathasundaram and Mahendran, 2016)

2.3 Failure of roof connection

Extreme wind events, according to Chowdhury et al. (2012), can cause roof link failure and result to significant damage to residential buildings. The most severe failure of the roof link in the roofing system could result in accelerated damage to the entire structure (Mahendran, 1995). Generally, roof link failures fall into two categories: pull-through and pull-out. According to Sivapathasundaram and Mahendran (2016), pull-out failures occur when the fastener is pulled out of the purlin, while pull-through failures occur when the fastener head is pulled through the thin cladding. The failure of the roof cladding to purlin relation is shown in Figure 2.3.

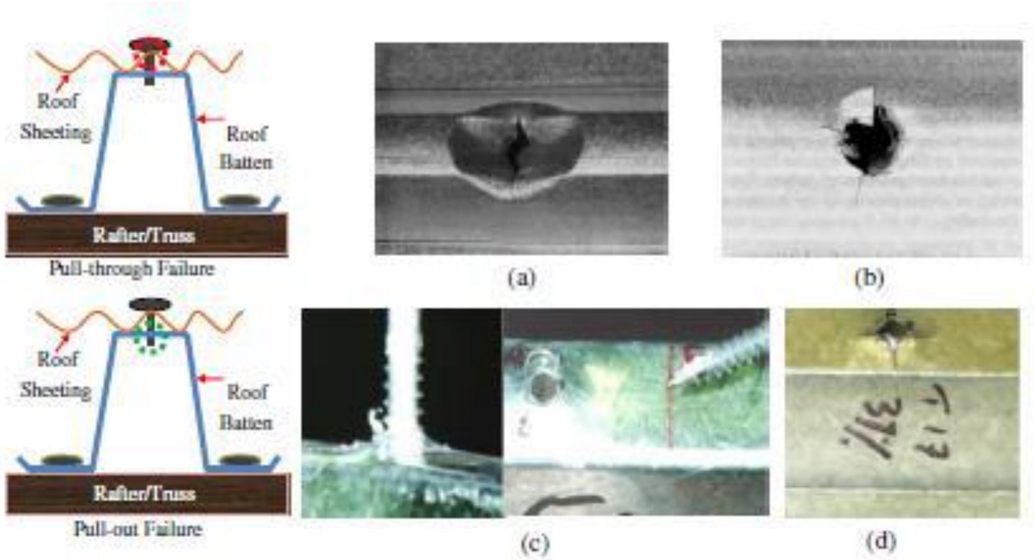


Figure 2.3 Roof purlin connection failures; (a) and (b) pull-through failure; (c) and (d) pull-out failure (Sivapathasundaram and Mahendran, 2016)

According to Mahaarachchi and Mahendran (2009), the pull-through of the roof cladding is initiated by the presence of a significant stress concentration around the fastener hole caused by wind loading. As a result, the cladding failed locally near the fastener, creating a sizable hole through which the fastener could pass (Yang and Bai, 2017).

2.4 Post Experimental Work

There are only a few experimental studies that have been performed to model the wind uplift effect on roof cladding. Kretzschmar (2011) investigated the efficiency of roof cladding under uplift loading conditions using an air bag. The uniformly distributed load was simulated by directly applying a pressured air bag to the roof cladding's bottom. However, (Stephen, 2013) reports that the real uniformly distributed load pressure across the entire roof cladding cannot be simulated accurately by the air bag.

Xu (1992) and Xu and Reardon (1993) has applied the line load test method to investigate the behavior of roof cladding. The system is regarded as a cost-effective method of research that is simple to conduct in the laboratory. At mid-span throughout the entire length of the specimen, the band pressure is used to replace the evenly distributed pressure acting on the roof cladding. Although the line load test method is capable of simulating the correct bending moment and reaction force at the central support, it is discovered that the method is predicated on the premise that the test span length equals the design span length.

Mahaarachchi and Mahendran (2009) then conducted an air box examination, concluding that the air box approach is the most effective laboratory method for simulating wind loading on roof cladding. This is because the air box is capable of truly generating and distributing uniform pressure loading distribution across the roof cladding. There are essentially two distinct methods for applying pressure to the air box configuration. It can be accomplished by either using a vacuum chamber in which pressure is removed before the box reaches vacuum or by directly applying pressure to the roof cladding.

2.5 Post Computation Fluid Dynamic (CFD) Analysis

Additionally, Computational Fluid Dynamics (CFD) is used to investigate the behaviour of wind loading operating on roof cladding. This approach is capable of providing a wealth of knowledge about wind-related issues in real time (Deraman et al., 2018). The most advantageous aspect of CFD analysis is the method's ability to predict wind movement around a building under conditions that are very similar to its actual state. However, Deraman et al. (2018) reported that validating experimental data against CFD models can be extremely complex and time consuming.

Irtaza et al. (2015) clearly stated that while numerical solutions such as CFD are relatively inexpensive, they do have some limitations in that pressure taps cannot be easily mounted at the sharp edges at the corner regions of the overhang sections. The mesh arrangement of the model in CFD analysis should be fine enough to allow for efficient computation, as smooth meshing and high-quality meshing produce more accurate simulation results, (Yahya et al., 2017). They also discovered that the existence of an overhang roof increases the likelihood of roof cladding damage. Thus, this research employs experimental work to determine the effect of wind uplift on the overhang roof of a rural home.

2.6 Summary of previous research

In past years, a number of studies has been conducted by researchers regarding to effect of strong wind om roof connection. Table 2.1 shows the summary of the previous research and the findings.

Table 2.1 Summary of previous research

Author(s)/ Year	Finding
Harold et al., 1987	• Strapping and clip angles were 15% and 36% stronger than conventional nail • Extra nailing with serrated nails doubles the strength of the connection • Conventional roof connections are generally adequate to resist extreme wind
Mahendran, 1994	• Strength of connection dependent on type of roofing, thickness, strength and ductility of steel, and type and size of fastener • Behaviour of cladding much dependent on geometry of profile • Thin cladding underwent large cross-sectional distortion and localised deformation around fastener hole when subjected to wind uplift
Mahendran, 1995	• Uplift load path often has the weakest links in form of connection • Uplift loading causes fatigue failures of roofing to purlin connection • Insufficient screws or nails make connection fail under high wind event

Mahendran, and Mahaarachchi, 2002	• Presence of fatigue effects as the pull-out failures occurred after a few cycles of loading at much lower load levels than the static pull-out failure loads • Thicker batten produced small steel bending deformation around hole • Presence of fatigue limit in the range of 25%-35% of static pull out failure load
Sivapathasundaram, and Mahendran, 2016	• Short batten did not simulate bending moment as it not significantly effects the pull through failure • The use of special fastener arrangement allows accurate of actual screw fastener connection behaviour. • Small scale testing result more conservative
Sivapathasundaram, and Mahendran, 2018	• Roof batten with four screw fastener highlight shows slightly effect to the redistribution of applied load among screw fasteners. • High ductility roof improved the distribution of applied load compared to low ductility roof • Overlapping roof batten at connection will increase the pull through capacity and effect of higher bending moment at connection of batten
Qin and Stewart, 2019	• The fragility analysis considered the roof damage due to overloading of cladding-to-batten (CTB), batten-to-rafter/ truss (BTR) and rafter/ truss-to-wall (RTW) connector. • It was found that, if no wall dominant opening exists, the mean proportion of roof sheeting loss and roof truss failures is negligible under a 500-year return period wind speed.

Majid et al., 2020	• The length of the roof overhang produced significant effect on the roof cladding to purlin connection. • Shorter overhang improved the pull-through capacity by increasing the stiffness and reducing the tributary area that accumulate the wind pressure. • The pull-through resistant can be significantly contributed by the cladding thickness.
Siron et al., 2021	• There is a relationship between the overhang length, uplift loading, and deflection. • An increase in the overhang length revealed a lower uplift force underneath the overhanging roof and lower deflection for both cladding profiles. • The maximum fastener reaction force and applied load decreased with increased roof cladding length for both cladding profiles.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The focus of this study is to determine the performance of various modified connections of steel cladding to the purlin at the overhang by using pull-through and pull-out test considering the pull-through and pull-out load capacity. The study comprises of two parts which are rural house survey and experimental work. The survey of rural house took place only in one district in the state of Pulau Pinang, namely Sungai Kechil. The data of the site activities with numbers of houses participating were shown accordingly in this chapter. This chapter comprises of the brief explanation of the preparation of the specimens, the set up and details on the procedure of pull-through and pull-out test. Meanwhile, the experimental work took place in Heavy Structure Laboratory at School of Civil Engineering, Universiti Sains Malaysia. The flowchart of the overall methodology including both survey work and experimental work shows in Figure 3.1. There are in total of four stages involved in this study.

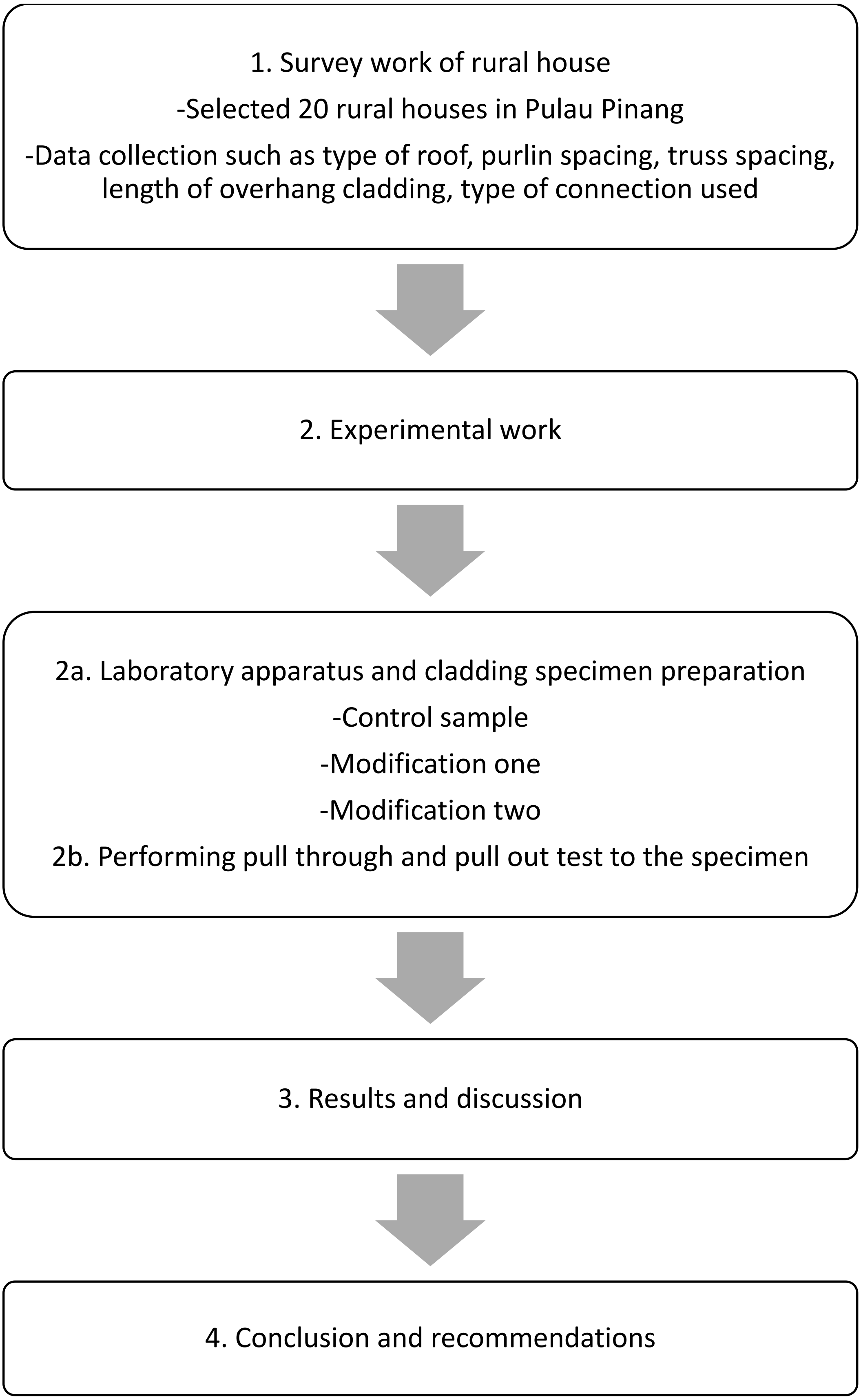


Figure 3.1 Flowchart of the study

3.2 Rural house survey

A survey has been conducted on rural houses with the aim to gather useful information regarding to the roof dimension especially on overhang roof part. The data that has been collected has been used in the experimental work. The area of survey is limited only in one state, namely Pulau Pinang. It was recorded in a study from Wan Cik et al (2014), said that Pulau Pinang is one of three states in Peninsular Malaysia that experiences highest number of damaged houses during windstorm event, along with Kedah and Perak. The survey was conducted in Sungai Kechil, Pulau Pinang (Figure 3.2) with the participation of 20 number of houses.

Figure 3.2 Study area located in Sungai Kechil, Pulau Pinang.

Numbers of information has been collected during the survey, including the dimension of the roof, such as purlin spacing and overhang length. As the survey was conducted to find various information especially on the overhang part, a non-engineered house was selected in order to portray the reality of most of the rural houses in Malaysia, where majority of the houses were not specifically built with certain standard measurements. Therefore, a certain range of data were expected from the survey.

During the rural house survey was conducted, various activities were involved, starting from the site survey, where to find the suitable type of houses to be participating within the requirement of non-engineered rural houses. Next, the process of measuring the dimension of the roof and some other parameters were taking place coherently with the interview participated by the owner of the houses.

(a)

(b)

Figure 3.3 Activities at site (a) measuring roof overhang and (b) interview session with the house owner

The process of measuring the roof dimension was conducted by using two types of equipment, namely measurement tape and handled distance laser meter as shown in the figure 3.4. The data obtained has been recorded under the survey form and the process of rural house survey is completed.

(a)

(b)

Figure 3.4 Measurement tool used during the survey (a) measuring tape (b) handled distance meter.

Based on the information gathered, it is identified that the structure of the overhang roof of the rural house comprises the combination of purlin spacing (PS) and overhang cladding (OC). The first part of the overhang roof is the purlin spacing, it covers the area from purlin to purlin, where usually the first purlin is located at the end of the wall of the building and the second one is away from the building and near to end of the overhang roof cladding. Meanwhile, the second part of the overhang roof covers from the second purlin to the end of the overhang roof cladding, namely as overhang cladding. Figure 3.5 shows the structure of the overhang cladding of one of the houses participated during the survey was conducted.

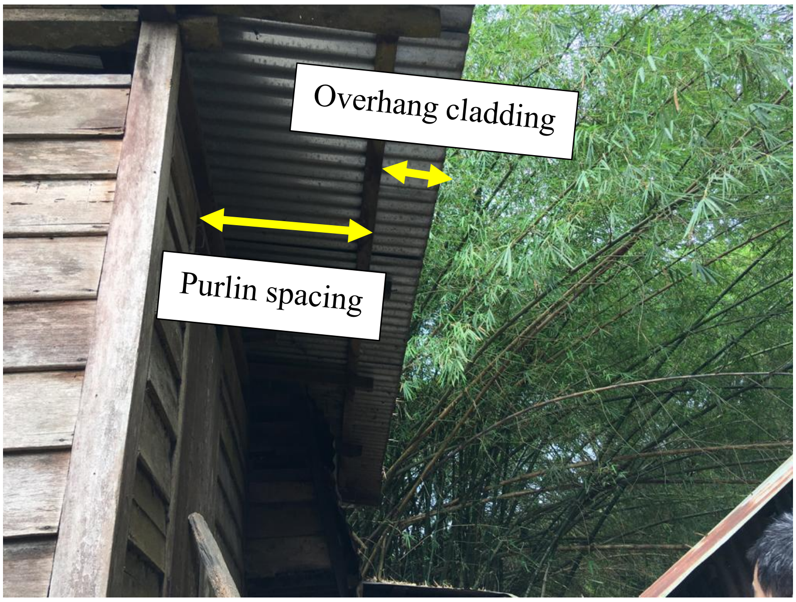


Figure 3.5 Segment of overhang roof which consist overhang cladding and purlin spacing.

3.3 Experimental work

This section comprises the details on the experimental procedures to achieve the aim of the study which is to identify the type of failure of roof considering pull-out and pull-through capacity of cladding to purlin with the modified connection by analyzing the performance of the modified connection of overhang roof steel cladding. The information regarding the material and apparatus used during the experimental work are presented in this section.

3.3.1 Materials and apparatus

The testing specimens includes roof cladding, timber purlin, small size timber and fastener. The testing specimens utilized in this experimental work were supplied by the local supplier from the nearby hardware store. The details on the materials are shown in the Table 3.1.

Table 3.1 Material properties

No.	Material	Type	Dimension
1.	Roof cladding	Corrugated	690 mm x 1220 mm x 0.18 mm
		Trapezoidal	835 mm x 1220 mm x 0.25 mm
2.	Roof cladding strap	Corrugated	255 mm x 690 mm x 0.18 mm
		Trapezoidal	250 mm x 835 mm x 0.25 mm
3.	Timber purlin	Jelutong (SG6)	50 mm x 50 mm x 1220 mm
4.	Small size wood	Wood composite	12 mm x 22 mm x 925 mm
5.	Fastener	Umbrella head nail	Head diameter: 20 mm Shaft diameter: 3.9 mm

3.3.1(a) Roof cladding

In this experimental work, there are two kinds of roof cladding being utilized, namely corrugated cladding and trapezoidal cladding. The dimension of the roof for corrugated cladding is 690 mm x 1220 mm, meanwhile for trapezoidal cladding is 835 mm x 1220 mm. However, during the testing being conducted, the length of cladding is modified consistent with the length of overhang. These two types of cladding are commonly used in roof construction for the houses located in the rural area. This is due to the reason that these roofs are easy to obtain as they can be purchased in most of the hardware stores, and they are easy to be installed. Figure 3.6 shows two different types of cladding employed in this experimental works. The thickness of corrugated cladding and trapezoidal cladding are 0.18 mm and 0.25 mm, respectively.

Figure 3.6 Two types of roof cladding

3.3.1(b) Roof cladding strap

Roof cladding strap is a modification made from the original piece of roof cladding. Both type of roof, namely corrugated cladding and trapezoidal cladding are used to create roof cladding strap. The roof is cut into a smaller section with dimension of 255 mm x 690 mm for corrugated roof and 250 mm x 835 mm for trapezoidal roof. The strap for corrugated and trapezoidal cladding has different dimension in term of length as the original roof cladding provided by the supplier were cut according to its standard, therefore the straps were cut to fit the original roof cladding. Meanwhile, the width of the strap for corrugated and trapezoidal cladding were cut with almost same measurement with only 5 mm in different, in order to provide similar function to serve the modification purposes. These straps have been used in the experiment for the modification purpose in term of overhang roof cladding connection. Figure of the roof cladding strap for both type of roofs is shown in Figure 3.7.

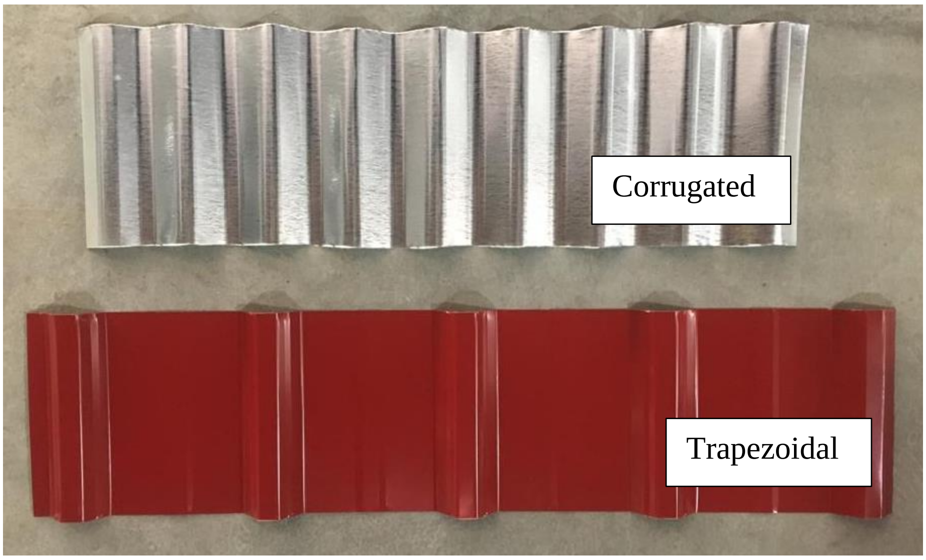


Figure 3.7 Two types of roof cladding strap

3.3.1(c) Timber Purlin

The timber used in this experimental work known as Jelutong, this type of timber is categorized under strength group 6 (SG6). Based on the class of the timber, it is notable that this type of timber is relatively weak. Therefore, it is easy to be purchased due to its low cost. The dimension of the purlin used is 50 mm x 50 mm and the length of 1220 mm as shown in Figure 3.8.

Figure 3.8 Jelutong was used as purlin

3.3.1(d) Small size wood

In this experimental work, a certain type of wood has been used, it is known as wood composite, they are made from recycled wood chips and sawdust. This wood composites can offer various environmental benefits. Therefore, this type of wood is suitable to be used as one of the key materials in the modification of roof connection, as it is also relatively cheap and readily available in local hardware store. The dimension of the timber used is 22 mm x 12 mm and the length of 925 mm as shown in Figure 3.9.

Figure 3.9 Small size wood made from wood composite.

3.3.1(e) Fastener

Umbrella head nail was employed in this experiment as the fastener. It is notable that majority of rural houses in Malaysia used umbrella head nail due to its nature that that made this nail easy to operate and it is also provides more strength to the connection. This umbrella head nail has the diameter of 20 mm for its head 3.90 mm for its shaft. Figure 3.10 shows two type of fasteners used in the experiment to secure the connection between roof cladding and purlin, known as umbrella head nail and modified umbrella head nail. Both umbrella head nail and the modified one, have the identical dimension for its head but it has been altered a little by making a brief thread on its tip so it can be securely attached to the load cell.

(a)

(b)

Figure 3.10 Types of fasteners used in the experiment (a) umbrella head nail and (b) modified umbrella head nail

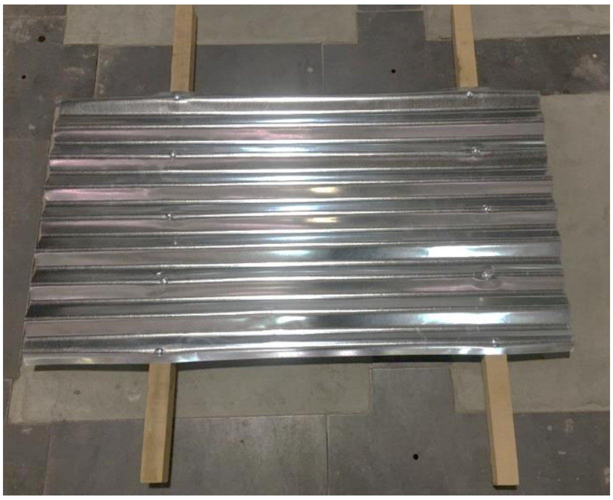
3.3.2 Preparation of sample

In this experimental work, three type of specimen has been prepared, namely control sample, modification one and modification two. Each of the specimens has been assembled in a group of three in order to get the average of the reading during the testing.

3.3.2(a) Control sample

The specimen was assembled according to the real roof construction. The information gathered during the survey of rural houses was used as the guidelines to reproduce the identical structure of roof. Based on the data collection, the overhang cladding is 150 mm, purlin spacing is 750 mm, and the connection used is umbrella nail head. Thus, the roof is being prepared accordingly as shown in Figure 3.11. The result of testing for the control sample will be used as the benchmark in this experiment.

(a)

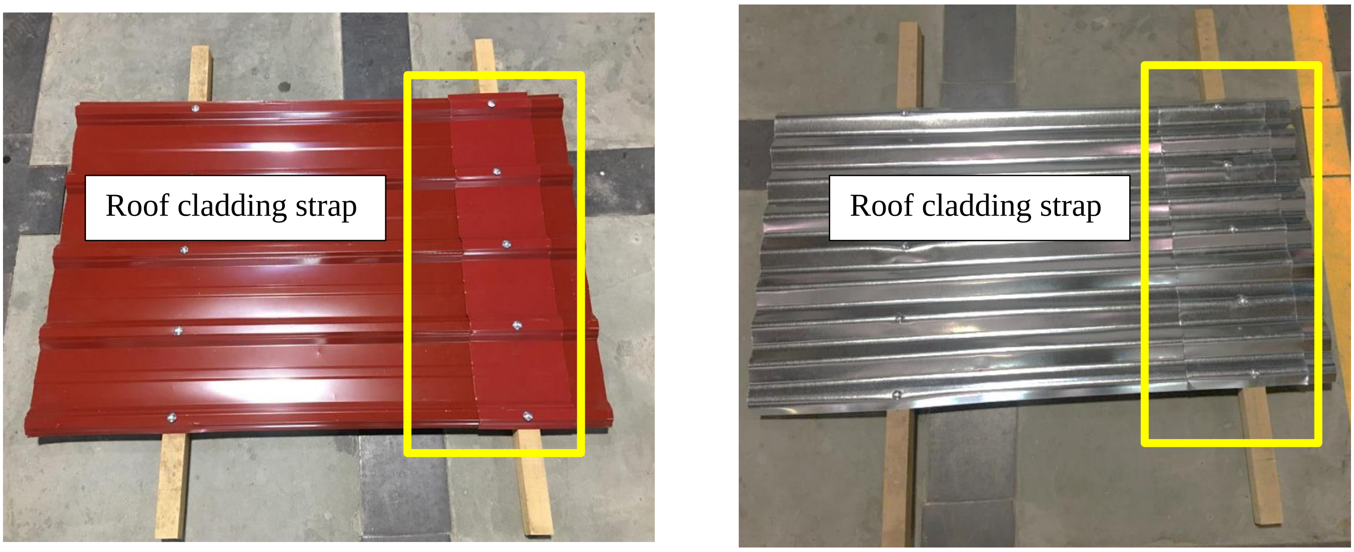


(b)

Figure 3.11 Control sample for both roof type (a) trapezoidal steel cladding (b) corrugated steel cladding

3.3.2(b) Modification one: roof cladding strap

In this experimental work, some modifications were made to the connection of roof cladding to the purlin. The first modification idea was by adding a piece of roof cladding strap on top of the roof cladding. The roof cladding has been laid parallel to the purlin that located near to the overhang cladding and secured by the umbrella head nail. The structure of the roof is basically the same with the control sample, but with the addition of roof cladding strap on top of the roof cladding as shown in the Figure 3.12.



(a) (b)

Figure 3.12 Modification one sample with addition of roof cladding strap for both roof type (a) trapezoidal steel cladding (b) corrugated steel cladding