



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**STUDY OF GLASS TINT EFFECTIVENESS AS HEAT  
RESISTANT IN BUILDINGS**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

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## **APPROVAL**

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirement for The Barchelor of Degree of Mechanical Engineering Technology (Maintenance Technology) with Honour. The supervisory is as follow:

.....

(Project Supervisor)

MR KHAIRIL AMRI BIN KAMARUZZAMAN

## ABSTRAK

Dalam iklim Malaysia lembap dan panas, semua bangunan perlu untuk memasang filem tetingkap untuk kaca tingkap dan kaca pada permukaan bangunan yang mendapat cahaya matahari langsung. Ia adalah kerana filem tetingkap direka untuk menyerap atau memantul sinaran solar, untuk mengurangkan penghantaran solar melalui kaca tingkap. Lampiran filem tetingkap solar di kaca dapat mengawal cahaya dan haba penembusan dan untuk menapis cahaya Ultra-Violet (UV). Kesan pengurangan haba mengurangkan permintaan penyejukan penghawa dingin, sekaligus menjimatkan penggunaan elektrik. Dalam kajian ini, objektifnya adalah untuk menyiasat beberapa bahan-bahan daripada filem tetingkap dan fungsi mereka dan untuk membandingkan antara beberapa jenis filem tetingkap dari segi keberkesanan untuk menentang haba. Eksperimen ini menggunakan empat jenis filem tetingkap yang berbeza menggunakan tiga sampel bagi setiap jenis iaitu Filem Warna, Filem Sputtered, Filem Automotif dan Filem Bangunan telah dilaksanakan di bilik pensyarah yang dipilih di Factory 3, Kampus Teknologi UTeM. Keputusannya telah direkod dan dibandingkan untuk membuat graf dan analisis. Dua pengiraan telah dilakukan iaitu pemindahan haba dan beban haba berdasarkan purata data dari kajian. Pengiraan dilakukan untuk membezakan keberkesanan filem tingkap untuk menahan haba dari masuk ke dalam bilik untuk mencapai kesejahteraan manusia dengan memilih filem tingkap dan penyesuaian udara yang bersesuaian. Keputusan diperolehi dari kajian ini telah menunjukkan Filem Bangunan ialah filem tingkap yang paling baik yang membantu menahan panas diikuti oleh Filem Sputtered, Filem Automotif dan yang terakhir adalah Filem Warna.

## ABSTRACT

In hot humid Malaysia climate, all buildings are necessary to install window film for their glass windows and glass facades that getting direct sunlight. It is because the window film is designed to absorb or reflect the incident solar radiation, in order to reduce solar transmission through window glass. The attachment of solar window film on glazing is able to control light and heat penetration and to filter out Ultra-Violet (UV) light, whilst causing the least influence on the building users. The heat reduction effect reduces the cooling demand on air conditioning, thus cuts down the electricity consumption. In the present study, the objectives are to investigate several materials of window film and their functions and to compare between several types of window film in terms of the effectiveness to resist heat. The experiment using four difference types of window film with three samples of each types which are Colour Film, Sputtered Film, Automotive Film and Building Film has been performed at a selected lecturer's room in Factory 3, Technology Campus UTeM. The results have been recorded and compared for making graphs and analysis. Two calculations have been done which are heat transfer and heat load based on the average of experiment data. The calculation was performed to distinguish the effectiveness of the window film to resist heat from enter the room in order to achieve a human comfort by selection the convenient window film and suitable air-conditioner sizing. The result obtain from this experiment have shown the Building Film is the most excellent window film that help to resist heat followed by Sputtered Film, Automotive Film and the last is Colour Film.

# DEDICATION

To my beloved parents, Mr Abdul Garapar @ Zakaria Bin Hasan and Madam Saemah Binti Othman

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Alhamdulillah, all thanks should be praise to Allah as He help and ease me so much to complete this project successfully. This research project won't be complete without people surrounding me who give a lot support and help.

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**LIST OF ABBREVIATIONS, SYMBOLS AND  
NOMENCLATURES**

PET	-	Polyethylene Terephthalate
UV	-	Ultra-Violet
Low-E	-	Low-Emissivity
IR	-	Infrared
NIR	-	Near infrared ray
GPS	-	Global positioning system
TESR	-	Total Energy Solar Rejected
VLT	-	Visible Light Transmittance
Na <sub>2</sub> CO <sub>3</sub>	-	Sodium Carbonate
CaCO <sub>3</sub>	-	Calcium Carbonate
BTU		British Thermal Unit

# CHAPTER 1

## INTRODUCTION

### 1.1 INTRODUCTION

In today's world, glass has been widely used as a structural building material. Most of the commercial buildings have large area of glass as their outer wall, windows or doors. Focussing on windows, usually a tempered glass is use. Tempered glass is defined as strengthened glass that has been heated or use chemicals to increase its strength. The tempered glass nature at normal temperature is usually elastic and brittle. Although, its strength and toughness rely on the load duration and the residual stress state (Cossavella, Morcant, Panait & Yvonnet, 2007). Tempered glass is quite popular glass because it has many advantages which make it likely to be used in many homes and commercial building projects.

One of the tempered glass benefits is reducing the risk of injury due to its nature of breaking into small, circular pieces instead of sharp, jagged shards. Besides that, tempered glass window is easy to clean up if it breaks because of the glass break into blunt and small pieces. The small glass pieces of tempered glass can be vacuumed to ensure all pieces have been cleaned up. Tempered glass has high durability and surely not easy to scratch and damage. The tempered glass is the good choice for windows, windshields and other projects that desired high durable glass. Applications of tempered glass include windows in vehicles, entrance doors, shower and tub enclosures, squash courts, patio furniture and skylights.

The window is part of any conventional building wall system. Windows provide visual, thermal, and affect air quality. The requirements for windows in buildings are to provide the occupants with a view, daylighting, privacy, and protection from glare (Svetlana, 2007). Windows that applied with windows film give more comfort to buildings. Benefits of the windows film are including reduced cooling energy costs by reducing excessive solar heat gain, enhanced reduction in cooling energy, reduced glare reduced fading of carpets, furnishings due to the UV-blocking ability of films and give privacy for building occupants when using reflective or dark films (Steve, 2007).

Nowadays, air conditioning system has become a necessity to residential buildings, commercials and industrial sector especially in hot and high humidity climates. This is because air conditioning system is functioning to maintaining thermal comfort particularly in indoor area (Chua et al., 2012). Referred to the sunlight as a light source of buildings, windows will give an advantage to electricity consumption savings for lighting. However, it will give the bad impact that is high electricity consumption for cool a building. Therefore, window tint or its other name, window film is necessary to protect windows building as a shading devices. Window film is a polyester product composed of one or more layers of coated or chemically treated. It is typically made of Polyethylene Terephthalate (PET). Most films are used as an interior surface of a glass window in a home, commercial building, or car, they also have a scratch resistant coating on the outer surface to protect the film.

## **1.2 PROBLEM STATEMENT**

Malaysia climate is quite warm because Malaysia is located in South-East Asia and on the equator. The countries along the equator generally experience equatorial climate that has average temperature at about 30°C during the day. According to Malaysia Meteorological Department, the characteristics of climate of Malaysia are uniform

temperature, high humidity and abundant rainfall. Direct sun radiation is one of the most significant cooling loads is admitted through the windows. Based on these condition, cooling demand on air conditioning of a building is high and taking more times to cool that lead to high electricity usage. Therefore, direct sun radiation through the window should be prevented by the appropriate application of shading devices (Schuman, Rubinstein, Papamichael, Beltran, Lee, Selkowitz, 1992).

The window film in buildings is one of the shading devices that necessary to filter heat from the sun. The attachment of solar window film on glazing is able to control light and heat penetration and to filter out Ultra-Violet (UV) light, whilst causing the least influence on the building users. The heat reduction effect reduces the cooling demand on air conditioning, thus cuts down the electricity consumption. (Chunying, Junyi, Tin-Tai & Zhongzu 2015). According to Prof. Dr. Mohd Zobir Hussein (ITMA-UPM), most of the modern buildings built using lightweight construction materials technology with low thermal mass. This is a major source of indoor temperature. Modern buildings are more likely to rise without control due to the heating temperature of the environment.

Since time immemorial, the shading device is a paired component of the window. Proper application of the shading device is important in window systems (Svetlana, 2007). A traditional shading device to block solar and heat from sunlight was applied. Curtain from fabric is attached to a window. The fabric helps to minimize direct light and heat from outside especially from the sun during a day. Many houses, hotels, chalets and other buildings use curtains to block and minimize direct light and heat. Besides that, the curtain function as decorations and to beautify the building interior. However, industrial sector and commercial buildings such as offices, shopping malls and skyscrapers it is inconvenient to use curtain for their windows. All these buildings prefer to use window films to protect and block heat glare and solar from the sun. The use of window film help to reduce electrical consumption to cool the large area in the buildings. The answer for overheating through windows is to indicate solar control

glass or applied window film, however, even the best solar control glass performs not better than a glass applied with window film (Watts, 2017).

### **1.3 OBJECTIVES**

1. To investigate several materials of window film and their functions.
2. To compare between several types of window film in terms of the effectiveness to resist heat.

### **1.4 SCOPE OF WORK**

In order to achieve the objectives, below are the scopes of this project:

1. This project will be conducted to study on window film effectiveness as heat resistant in a building.
2. Make comparison between four difference types and thicknesses of window film using three samples of each types.
3. Experiment will be conducted at a lecturer's room located in Factory 3, Technology Campus UTeM.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 TYPES OF WINDOW GLASS**

Glass is a hard, brittle, and usually transparent product formed by the fusion of sand with soda or lime. Sand is mix together with waste glass from recycling collections, sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and calcium carbonate ( $\text{CaCO}_3$ ) and heated in a furnace to form a glass. The sodium carbonate reduces melting point of the sand, which helps to save energy during manufacture. The calcium carbonate is added to prevent unfortunate drawback by sodium carbonate produces a kind of glass that would dissolve in water. The end-product is called soda-lime-silica glass that ordinary glass that commonly found around us. Glass is an important segment of virtually all solar heating and cooling systems thus its properties, its qualities, its strengths and its limitations should be completely understood by the designers of such systems (Yellott, 1983).

##### **2.1.1 Tempered Glass**

Tempered glass is extremely strong and regularly utilized for security highlights. If this glass breaks, it will break into little pieces like stone that is harmless to human. The Figure 2.1 shows comparison of broken tempered glass and broken non-tempered glass. This Glass is perfect for decreasing the chance of injury in case of breakage. Tempered glass is ideally utilized as a safety glass where the glazing may be broken out of the frame in an emergency. For example, the side windows of a car

are tempered so that they can be broken away in case of an accident happen. tempering procedures are utilized to strengthen glass in order to render it more secure and more durable. Tempered glass has many specific elements and physical properties which make it indispensable to architects in many situations (Yvonnet et. al, 2007). The tempered glass is not good in heat conductivity, the temperature difference caused a strain and be the key factor leading to the glass breakage shows that the convection has more influence on the temperature rise than the radiation (Mingxuan et. al, 2014).

There are many advantages of using tempered glass as windows glass. One of them is utilized for safety that can reduce the intensity of the accidents that may take place in the building, apart from avoiding any kinds of accidents happen cause by glass in the first place. Besides that, tempered glass is stronger and hence can survive strong weather changes, defend from strong wind pressure, tornado, or heavy rains. Almost all tall buildings such as skyscrapers use tempered glass because it always be experience in heavy wind pressures. Furthermore, the tempering process does not affect the transparency of the glass, it is providing a clear view that is necessary for the window, while maintaining structural stiffness. In other hand, tempered glass still has a little disadvantage that is cannot be recut or drilled once it experienced the tempering process, as this would cause the whole pane to break.



Figure 2.1: Tempered Glass versus Non-Tempered Glass

Source: <http://destinglass.com/tempered-safety-glass>

### 2.1.2 Low-Emissivity (Low-E) Glass

Low-emissivity (Low-E) glass is glass that has a special thin coating that reflects the infrared (IR) portion of light while allowing the visible light spectrum through. This is good because the infrared heat from the sun is reflected away from the building during summer and reflect back the infrared heat already inside the house during the winter. Low-E glass gives enhanced insulation properties and is a decent decision in all climates situations. There have been some concerns about the impacts of Low-E glass on house plants, but it is actually not affected the plants growth because a Low-E glass is designed to just block heat, not light. According to Megan (2012), the Customer Service Manager at Glass-Rite states that a few reviews show that Low-E windows can improve plant growth over clear uncoated glass. The visible spectrum from sunlight is important for plant growth.

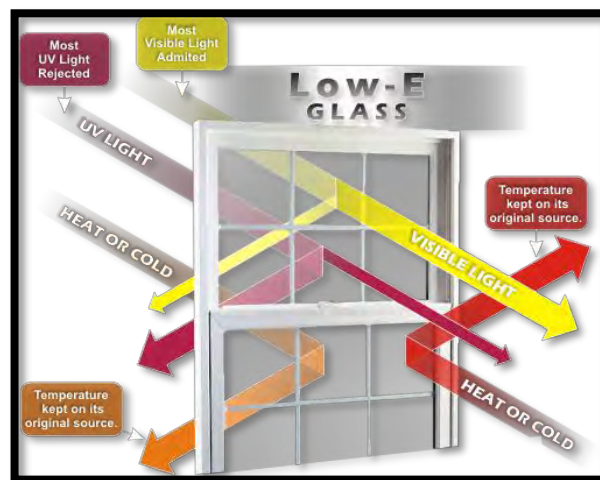


Figure 2.2: Low-E Glass

Source: <http://performancwindowsoftexas.com/low-e-glass/>