THERMAL PERFORMANCE OF KENAF COMPOSITE BY IES SIMULATION

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This report is submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Thermo-Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this project report entitled "Thermal performance of kenaf composite by IES simulation" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermo-Fluids).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

Increase room temperature on a hot day can cause discomfort to the occupants. Measures to reduce the room temperature include installing thermal insulation. Thus, the project was carried out to study the thermal performance of composite kenaf as thermal insulation for buildings. The project was started by selecting some of the composite kenaf. Kenaf composite 4060, kenaf composite 5050, kenaf composite 6040 and kenaf composite 6040 NaOH selected for this project. Thermal conductivity for each composite was tested. The software used for this porject is Integrated Environmental Solutions. Two insulation which are rock wool and wood strands was added to the project as a comparison for kenaf composite. The simulation results showed kenaf composite 4060 is not effective as heat insulation because the thermal conductivity is more than 1.00 W/m.k. Other thermal insulation managed to reduce building heat and use less energy for air conditioning systems.

ABSTRAK

Peningkatan suhu bilik pada hari yang panas boleh menyebabkan ketidakselesaan kepada penghuninya. Langkah untuk mengurangkan suhu bilik termasuk memasang penebat haba. Justeru, projek ini telah dijalankan untuk mengkaji prestasi therma bagi komposit kenaf sebagai penebat haba untuk bangunan. Projek ini dimulakan dengan memilih beberapa komposisi komposit kenaf. Komposit kenaf 4060, komposit kenaf 5050, komposit kenaf 6040 dan komposit kenaf 6040 NaOH dipilih untuk projek ini. Setiap satu komposit diuji kekonduksian terma. Perisian yang digunakan ialah Integrated Environmental Solutions. *Dua penebat ditambah dalam projek ini sebagai perbandingan iaitu rockwool dan lembar kayu. Hasil simulasi menunjukkan komposit kenaf 4060 tidak efektif sebagai penebat haba kerana kekonduksian terma lebih dari 1.00 W/m.k. Penebat haba yang lain berupaya untuk mengurangkan haba bangunan dan menggunakan tenaga yang sedikit untuk sistem penyaman udara.*

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In addition, I would also like to thank to various people for their contribution to this project in giving me the information and their support.

Finally, I wish to thank to my beloved parents for their support and encouragement throughout the completion of this project.

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LIST OF ABBEREVATIONS

CO_2	Carbon dioxide
IES	Integrated Environmental Solutions
MARDI	Malaysian Agricultural Research and Development Institute
LTN	Tobacco Board of Malaysia
PUR	Polyurethane
PIR	Polyisocyanurate
MDI	Methylene diphenyl diisocyanate
EPS	Expanded polystyrene
XPS	Extruded polystyrene
HVAC	Heating, Ventilating and Air Conditioning
CFD	Computational Fluid Dynamic

LIST OF SYMBOL

λ	=	Thermal conductivity
R	=	Thermal resistance
l	=	Thickness/length
m	=	Mass

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Lately, the promptly increasing consumption of composite components in automotive, construction, and other mass production industries, has been concentrated on sustainable and renewable reinforced composites. This focus encompasses an extensive variety of shapes and materials from synthetic to natural, in order to accomplish the demands of manufacturing composites with preferred properties. The integration of reinforcements, such as fibers and fillers into composites affords a means of spreading and refining the properties of the composites that meets the necessities of most engineering applications. Consequently, these enhancements will be associated with economic gains, such as small production costs and small resin consumption .

Hence, the needs for natural fiber reinforced composites have improved drastically over the past few years, for various marketable applications in the industrial sector. These types of composites present various benefits compared to artificial fibers, for example low tool wear, low cost, low density, availability, and biodegradability (Nishino et al, 2003). The most common plant used in applications are bast fibers, such as jute, flax, kenaf, sisal and hemp (Kozlowski et al, 1999). One of the explanations for this increasing focus is that natural fibers have a greater specific strength than glass fiber but same specific modulus. With these properties and low cost sources, these natural fibers hypothetically proposed required specific strengths and modulus, at a lower cost of manufacturing. Many natural fibers can be used as composites, but regularly in applications that involve low stress. Some of the fibers are obtained by processing agricultural, industrial, or consumer waste.

In this report, the composite of one of natural fiber will be discussed which is kenaf. Kenaf, *Hibiscus Cannabinus L* is an annual herbaceous plant growing up to 1.5-3.5 m tall with a wooded base. The stems are 1–2 cm diameter, often but not branched. The leaves are 10–15 cm long, variety in shape, with leaves near the core of the stems being deeply lobed with 3-7 lobes, while leaves near the upper of the stem are shallowly lobed or unlobed lanceolate. The flowers are 8–15 cm diameter, white, yellow, or purple; when white or yellow, the middle is still dark purple. The fruit is a capsule 2 cm diameter, holding a few of seeds. The fibers in kenaf are found in the bast (bark) and core (wood). The bast make up 40% of the plant. "Rough fiber" separated from the bast is multi-cellular, consisting of numerous individual cells held together (Paridah et al, 2011).

The individual fiber cells are about 2–6 mm long and lean. The cell wall is thick (6.3 µm). The core is about 60% of the plant. It also has thickness of ≈38 µm but short (0.5 mm) and thin-walled (3 µm) fiber cells (Nanko et al, 2005). Paper pulp is formed from the whole stem, and thus contains two types of fibers, from the bast and from the core. The pulp quality is same with hardwood.

1.2 PROBLEM STATEMENT

Building is a climate modifier for humans. Most designers today focus on functions in

the buildings and leave the issue of human comfort conditions to engineers who use mechanical systems to modify the interior environment. Energy and CO_2 emissions are influencing factors in the global warming phenomenon. One alternative in the solution of these problems is reducing energy consumption by using insulation materials in the building envelope. Insulation materials provide many benefits to the building, such as reducing energy consumption, increasing comfort, ease of installation, light weight, and low cost. The buildings in cities usually use mechanical air-conditioning systems for thermal comfort in occupied spaces. This requires producing electrical energy to support the demand. This is an important factor contributing to CO_2 in the environment which in turn raises temperatures, example, the Green House Effect and Heat Island. Most buildings in hot, humid climates have been designed without considering for materials and insulation. This is an important reason why heat influencing the temperature inside the building usually includes the heat gained from the outside air and the building's envelope, especially if the roof is directly exposed to sunlight all day.

Inappropriate selection of material can cause the external heat to escape into the building, which, in turn, requires more energy to cool down the building. The proper application of insulation will reduce the heat transmission into the building and the heat gain during the hottest period of the day (Pongsuwan, 2009). This is one alternative to help in solving energy and environment problems. The proposed material for the insulation is kenaf composite.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To determine the thermal conductivity values of kenaf composite.
2. To perform a simulation of thermal performance of kenaf composite by using IES software.
3. To determine the energy saving with using kenaf composite
4. To obtain the comparison of thermal performance kenaf composite insulator with synthetic insulator.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Obtain thermal conductivity of kenaf composite from other researchers.
2. Conduct the simulation of building embed with kenaf composite insulator by using IES software.
3. Do the simulation for synthetic insulator for comparison to kenaf insulator.

CHAPTER 2

LITERATURE REVIEW

2.1 KENAF

2.1.1 Overview about kenaf

In few years back, the enthusiasm of researchers and engineers has converged on utilizing plant fiber as optimal and economically as could be expected under the circumstances to deliver great quality fiber-strengthened polymer composites for many industrial application. It is a result of the accessibility and has prompted to the improvement of auxiliary materials rather than conventional or man-made ones. Natural fiber are originally from animals, plants and mineral sources which can be categorized as appeared in Figure 2.1. The utilization of natural fiber as mechanical components and parts expands the ecological supportability of the parts being built, particularly the automotive market. In the building and construction industry, the enthusiasm in natural fiber is more on insulation properties.

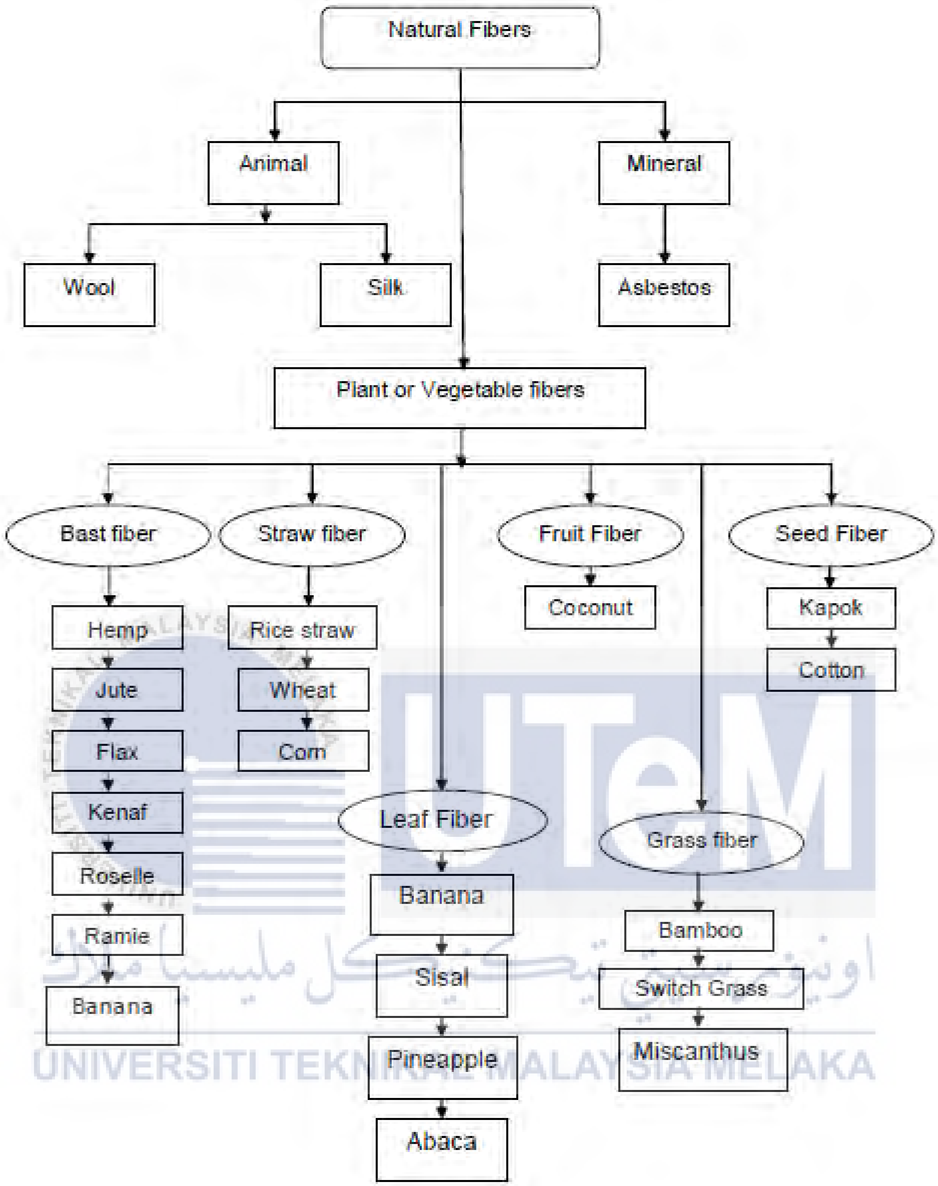


Figure 2.1: Classification of natural fiber

Scientific classification	
Kingdom	Plantae
(unranked)	Angiosperms
(unranked)	Eudicots
(unranked)	Rosids
Order	Malvales
Family	Malvaceae
Genus	Hibiscus
Species	H. cannabinus
Binomial name	
Hibiscus cannabinus L.	
Synonyms	
Abelmoschus congener Walp.	
Abelmoschus verrucosus Walp.	
Furcaria cannabina Ulbr.	
Furcaria cavanillesii Kostel.	
Hibiscus malangensis Baker f.	
Hibiscus vanderystii De Wild.	
Hibiscus vitifolius Mill. No. illeg.	

Figure 2.2 Classification of kenaf plant

Kenaf or Hibiscus cannabinus is a types of hibiscus plant. Kenaf can that can be found in southern Asia. Nonetheless, the origin of kenaf is obscure. The fiber got from kenaf is called as kenaf fiber. Kenaf fiber is comparative with jute fiber. Both fiber practically identical in characteristic. Forenames of kenaf are Bimli, Bimlipatum Jute, Ambary, Deccan Hemp, and Ambari Hemp. There are a few colors of the kenaf blossom, white, bit yellowish, or dark purple.

Kenaf has straight and branchless stalk. Kenaf stalk content an internal wooded center and also an external fibrous bast near the center. The stems of the kenaf produce two types of fiber, bast and center. Bast is a rougher fiber in the external layer. Kenaf center fiber is a finer fiber in the core. Kenaf plants develop in 100 up to 1000 days.

2.1.2 History of kenaf plant in Malaysia

Understanding the potential outcomes of economically usable product coming from kenaf, the National Kenaf Research and Development Program has been made to create kenaf for conceivable new industrial harvest in Malaysia. The administration of Malaysia has distributed around RM12,000,000 for research and further advancement of the kenaf-based industry in the ninth Malaysia Plan (from 2006 to 2010) in acknowledgment of kenaf as a commercial crop.

Kenaf began to be planted by Malaysian Agricultural Research and Development Institute (MARDI). In Kelantan as well in Terengganu, Tobacco Board of Malaysia (LTN) has planted a ton of Kenaf. In Malaysia, kenaf develops rapidly, ascending to statures of 3.66m to 4.27m in duration of below a half year. Different reviews demonstrate that kenaf yields up to 6 to 10 tons of dry fiber per acre section of land every year. Upon reap, the whole kenaf plant is handled in a mechanical fiber separator same like a cotton gin.

2.1.3 Kenaf Bast

The individual bast fiber are up to 0.005 m long averaging 0.0026 m long and 0.02 m in diameter. Bast pulp, bit related to softwood pulp, has exact rigidity, however more noteworthy tear quality and bulk fiber; accordingly it could substitute softwood pulp. Pulping kenaf fiber (center and bast) can enhance environment because the growth require small quantity of fertilizer. Despite the fact that the kenaf bark fiber were once only considered for use as a cordage fiber, now, its have extra uses for industrial usage. These incorporate utilization in car dashboards, as an “additional in man-made fiber”, corrugated medium, injection molded and extruded plastics. Kenaf bark fiber are presently in commercial usage in other ecologically benevolent products like fiber yard mats impregnated with grass seed, and splash on soil mulches for use along highway or construction sites to keep soil disintegration from water and wind. The stalk of the kenaf comprises of two distinctive fiber types. The outer fiber is called bast and comprises about 40 % of the stalk's dry weight. The refined bast fiber length 2.6 mm and the whiter, inner fiber is core and comprises 60% of the stalk's dry weight.

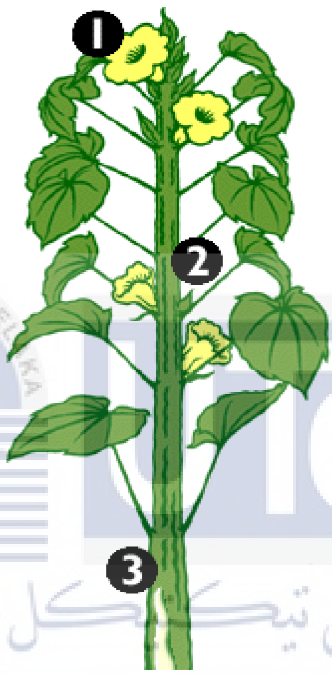


Figure 2.3: Parts of Kenaf Plant (1) kenaf flower, (2) kenaf bast (3) kenaf stack

2.1.4 The usage of kenaf

Kenaf plant grown for almost 40 centuries in Sub-Sahara where its leaves are devoured by human and animal. The bast fiber is utilized for cordage and the woody center of the stalks blazed for fuel. The fundamental usage of kenaf fiber is the fabrication of the product like the product that produced using jute. In Texas, Louisiana, and California, 3,200 acres lands of kenaf were developed at 1992, and utilized for animal bedding and feed. Emerging uses of kenaf fiber incorporate the designed wood, insulation, and clothing.

Kenaf seeds yield a plant oil that is edible and high in cancer prevention agents. The kenaf oil is also used for beauty care products, industrial lubricants/ointments and as additional bio-fuel (Pill et al, 1995).

2.1.5 The Benefits and Drawbacks of Natural Fiber Including Kenaf

Natural fiber, for example, kenaf have driving points of interest contrasted with conventional reinforcement materials, for example, glass fiber as far as expenditure, the ability to recycle, abrasiveness, and biodegradability. The fiber reinforced composites relies on the fiber matrix interface and the capacity to transmit stress from matrix to fiber. The benefits of natural fiber over old-style strengthening materials, for example, glass fiber are low density, minimal cost, globally harmless and incredible physical properties. Natural fiber composites, for example, combination kenaf and polypropylene have been useful in cars parts (Shibata et al, 2005). Other than, natural fiber additionally give the benefits of strength properties, durability, thermal properties, diminished instrument wear, simplicity of detachment, lessened skin and respiratory irritation, enhanced energy recovery furthermore biodegradability. Wood fiber strengthened polypropylene composites have properties exact to conventional glass fiber strengthened polypropylene composites. Many points of interest in utilizing kenaf fiber. Since an innovation of isolating kenaf center and bast has been produced, many plausibility of utilizing the entire kenaf plant or some parts of it. Kenaf production is less cost and less time consuming than other crude yields. Kenaf fiber could be exploited as strengthening material for polymeric composites (substitution of glass fiber). Kenaf bast fiber has unrivaled flexural quality associate with its astounding elasticity that settles on it the material for an extensive variety of extruded, molded and non-woven products. Todays, natural fiber reinforced polymers have become more prevalent in automotive and construction industry. It is demonstrated that kenaf has turned into a significant natural fiber for both industrial and modern applications.

The fundamental trouble of natural fiber in plastics is it may not moisture/wet proof. It could impact in dimensional adjustments of the fiber that may prompt to cracking of the composite and degradation of mechanical properties. Numerous chemical treatments have been utilized to increase the mechanical performance of the natural fiber by many researchers before.

2.2 Composite

The composite materials are artificially materials produced using at least two fundamental materials with altogether different compound or physical properties and stay partitioned on a macroscopic level. Matrix and reinforcement are two sorts of constituent materials. At least one portion of each type is required. A synergism produces material properties inaccessible from the individual main materials, while the unfathomable assortment of matrix and strengthening materials permits the engineer to pick an ideal combination for the product. Designed composite materials must be shaping. An assortment of molding methods can be utilized by outline prerequisites. The main factors for this type of combination are the natures of the chose matrix and strengthening materials. One more imperative component is the gross amount of material to be created. Large quantities can be utilized to legitimize high capital costs for snappy and mechanized assembling technology. Little production quantities are obliged with insignificant capital consumptions yet greater work and tooling expenditure. The physical properties of composite materials are generally orthotropic and not isotropic in nature. The sturdiness of composite panel will frequently be affected by the directional arrangement of the applied forces.

2.2.1 Matrix

The matrix material supports and encompasses the strengthening materials by maintaining their relative positions. The matrix holds fiber together. The fiber are solid, yet, delicate. The matrix can absorb energy by deformation under force or stress. The matrix increases toughness and durability to composite. While fiber have good tension quality, normally they have very bad compression quality. The matrix gives more compression strength to the composite. The matrix material need be introduced to the reinforcement before or after the process of mold. The fusing event will occur during molding. Depending upon the nature of the matrix material, this fusing event can happen in numerous ways such as solidification from the melted state or chemical polymerization.

2.2.2 Reinforcement

Reinforcement or strengthening in a composite can be particulate or fibrous. An extensive variety of both types of reinforcement is accessible for production of composite material however a large portion of the significant advancements as of late have been in the region of fibrous reinforcement. It confer the distinct physical properties and also mechanical properties to boost matrix properties.

2.2.3 Fiber Reinforced Composite

The fiber reinforced/strengthened composite materials can be separated into short fiber reinforced materials and continuous fiber reinforced materials. Continuous strengthened materials will always constitute a layered or covered structure. The woven and continuous fiber styles are ordinarily accessible in an assortment of structures, being pre-impregnated with the given matrix (sap), dry, unidirectional tapes of various breadths, harness silks, and sewed. The short and long fiber are ordinarily utilized in molding. Always in the form of chips, pieces, and irregular mate. The fiber is inserted in matrix keeping in mind the end goal to make the matrix sturdier than before. Fiber-reinforced composites should light and stronger than steel. This implies composites can be utilized to make cars lighter, and subsequently a great deal more fuel effective. This implies they will produce less and less pollution, as well.

2.3 The Performance Terms

2.3.1 Heat Transfer

Heat exchange or heat transfer is the trade of energy between at least two or more physical system. The rate of heat transfer is dependent upon the temperatures systems and the properties of the superseding medium (Çengel et al, 2015).Radiation, convection and conduction are the three fundamental methods of heat transfer. The movement of energy in form of heat, is a procedure by which a system's inner energy is changed, henceforth is essential in the First Law of Thermodynamics. Conduction is otherwise called diffusion, but not to be mistaken for dispersion related to a fluid. Heat transfer from high temperature to lower temperature, and that is governed by the Second Law of Thermodynamics. This process changes the interior energy of both cold and hot systems. Heat transfer will happen in a course that increases the entropy of the collection of systems. Transfer of heat finished when thermal equilibrium is reached, and soon thereafter all included bodies and the environment achieve the quite exact temperature. Thermal expansion is change in volume because change in temperature.

2.3.2 Thermal Conductivity

Thermal conductivity measures the ease with which heat can travel through a material by conduction. Conduction is the main form of heat transfer through insulation. It is often termed the λ (lambda) value. The lower the figure, the better the performance. It is measured in watts per degree Kelvin.

2.3.3 Thermal Resistance

The thermal resistance defines the resistance a material / substance in conducting heat or thermal energy. It also characterizes exactly how safe a material / substance is according to heat energy. Thermal resistance of the materials are reciprocals with thermal conductance of the materials and can be derived from thermal conductivity times the thickness of the materials / substances. Further thickness means less heat flow and so does a minimal conductivity. A wall layer with a high thermal resistance, is a good insulator and vice versa. ("Thermal resistance", n.d.)

2.3.4 Specific Heat Capacity

The common meaning of specific heat capacity of a material/substances is the size of heat required to lift temperature of 1kg of the material/substance by 1°C or 1K. A good insulator has a great specific heat capacity since it requires some time to assimilate more heat before it warmings up (rising temperature) to exchange the heat ("Specific Heat", n.d.).

2.3.5 Density

Density is the unit of compactness of a materials / substance. It is mass (or 'weight') of a material for each unit volume of a material / substance and is measured in kg/m^3. A high density material augments the overall weight and is an aspect of 'high' thermal mass and 'low' thermal diffusivity ("the definition of density", 2016).

2.3.6 Thermal Diffusivity

The thermal diffusivity measures the capacity of a material to conduct thermal energy with respect to its ability to 'keep' thermal energy. It portrays how effortlessly heat diffuses all through material. For example, common metals transmit thermal energy quickly (cold to touch) though wood is a moderate transmitters. Bear in mind, insulators have low thermal diffusivity.

2.3.7 Embodied Carbon (Embodied Energy)

Embodied carbon actually is a key idea in adjusting the global warming gases in producing the material which preserved through the lifetime of the insulation despite the fact that embodied carbon is not a part of the thermal performance of an insulation material. Embodied carbon is regularly considered as amount of gases discharged from fossil fuels and used to create energy expended between the extractions of crude material, through the manufacturing process to the factory (Hammond, G.P.,et al, 2008). The science of embodied carbon is as yet advancing - in this manner, solid and reliable information is hard to get for this time being.

2.3.8 Vapor Permeability

Vapor permeability the degree of material that allows the entry of water through it. Vapor permeability measured when rate of vapor exchange through a unit zone of level material of unit thickness incited by a unit vapor weight distinction between two definite surfaces under definite temperature and humidity conditions. Thermal insulation is usually characterised as vapor permeable or non-vapor permeable. Often referred to, erroneously, as 'Breathing construction', walls and roofs so termed are characterized by their capacity to transfer water vapour from the inside to the outside of the building – so reducing the risk of condensation. (Dupont, 2016).

2.4 Insulation materials and their properties

Thermal insulation is the drop of warmth/heat transfer between objects in thermal contact. Thermal insulation can be accomplished with particular methods or processes, as well as with appropriate object and materials. Thermal insulation gives a region of insulation in which thermal conduction is lessened or thermal radiation is reflected instead of consumed by the lower-temperature body.

2.4.1 Performance

The most important aspect of an insulation material is its performance – that it consistently provides the designed for resistance to the passage of heat throughout the lifetime of the building. Though the insulation manufacturer's published performance expectations will be an essential guide, other factors associated with the 'real-life' installation of the material need to be considered as part of the design process.

i. **Easiness in installing** – the ultimate performance will be determined by how effectively a builder can install a material using conventional skills. For example, insulation slabs need to be installed so that no gaps result either between adjoining slabs, or between the slabs and other construction components that form part of the overall insulation envelope, such as rafters or joists. Any gaps left over will enable the passage of air and result in a reduction in performance.

ii. **Shrinkage, compaction, settlement** – Some materials are likely to suffer a degree of dimensional instability during their installed life. In many instances this is anticipated and can be overcome through careful design and installation methods. In all other instances, the specifier should seek guidance concerning associated risks from the insulation manufacturer – particularly where materials have not had an established record of installed performance.

iii. **Moisture/dampness proof** – some insulation materials will endure a degradation of performance when wet or soggy. In the event that dampness is a high risk (< 95% relative humidity), then an appropriately resistant material should be specified.

2.4.2 How insulation works

Two characteristics of insulation:

i. The insulation material's natural ability to inhibit the transmission of heat &

ii. The utilization of pockets of trapped gases (natural insulants).

Gases have low thermal conduction properties contrasted to liquids and solids, thus makes a nice insulation material in the event that they can be trapped. With a specific end goal to enlarge the productivity of a gas (for example, air) it may be hindered into little cells which cannot adequately exchange transfer heat by natural convection. Convection includes a bigger bulk flow of gas pushed by buoyancy and temperature differences, and it doesn't function admirably small cells where there is little density distinction to drive it. In foam materials small gas cells or bubbles emerge inside the structure; in fabric insulation, such as wool, small flexible pockets of air happen normally to become gas cells.

2.4.3 Type of Insulation Materials and Properties

There are many kind of thermal insulation in the market. Below are the example of the thermal insulation and their properties

Table 2.1: Properties of thermal insulation

Type of insulation	Thermal Conductivity (W/m.k)	Thermal resistance 0.1 m (K·m^2/W)	Specific Heat Capacity J/(kg.K)	Density kg / m^3	Thermal diffusivity m^2/s	Embodied energy MJ/kg	Vapor permeable
Wood fiber	0.038	2.60	2100	50	n/a	n/a	Yes
Cellulose	0.038 - 0.040	2.632	2020	27-65	n/a	0.45	Yes
Wool	0.038	2.63	1800	23	n/a	6	Yes
Hemp	0.04	2.5	1800 – 2300	25 - 38	n/a	10	Yes
Hempcrete	0.06	1.429	1500 – 1700	275	n/a	n/a	Yes
Cellular glass	0.041	n/a	1000	115	n/a	n/a	No
Straw	0.08	4.37 at 35 cm	n/a	110 - 130	n/a	n/a	Yes
Glass mineral wool	0.035	2.85	1030	±20	1.6×10^{-6}	26	Yes
Rock mineral wool	0.032 – 0.044	2.70 – 2.85	n/a	n/a	n/a	n/a	Yes
H2Foam Lite	0.039	n/a	n/a	7.5 - 8.3	n/a	n/a	No
Phenolic foam	0.020	5.00	n/a	35	n/a	n/a	No
Polyurethane	0.023 – 0.026	4.50	n/a	30 - 40	n/a	101	No
EPS	0.034 – 0.038	3.52	1300	15 – 30	n/a	88.60	No
XPS	0.033 – 0.035	3	n/a	20 – 40	n/a	88.6	No
Aerogel	0.014	3.8 for 50mm	1000	150	n/a	5.4kgs / CO^2 per m^2	No

2.5 Thermal conductivity of kenaf composite

Table 2.2 shows the thermal conductivity (k) for kenaf composite. The thermal conductivity decreased with increasing fibres contents. Polyurethane is a very effective insulating material, due to its foam structure. However, the kenaf fibres were more capable of acting as insulators and as a barrier for the heat transfer through the composites. Increasing the amount of kenaf fibres reduced the thermal conductivity due to the micro structure of the fibres. In addition, all natural fibres including kenaf fibres contain several components (cellulous, hemicelluloses, and lignin) that bind to each other and give the fibres a specific microstructure that makes them similar to composite materials. It is the binding between these natural components that allows the kenaf fibres to work as a heat barrier. The thermal conductivity of the sodium hydroxide treated kenaf fibre composite was 38.15% greater than the thermal conductivity of the untreated kenaf fibre composite, for the same fibre content. The NaOH treatment removes practically all non-cellulose components except waxes. By the dissolving lignin some pores are formed on the fibre surface. This improves the contact area between the fibre and the matrix, which may have increased the thermal conductivity of the treated bio-composites (Sameer Ibraheem et al, 2011).

Table 2.2: Thermal conductivity results for kenaf-polyurethane composites.

Weight contents (%)	Thermal conductivity (k)
40/60	0.5320
50/50	0.0685
60/40	0.0535
60/40 NaOH-treated Kenaf	0.0865

2.6 Previous studies on building simulation

Computer simulation for buildings and structure has become inexpensive and promising in both research and industry amid the most decades with fast advance of computer industry and also key progression of computational methods. Simulation and computational method cover an assortment of aspects of building for instance ventilation performance forecast, whole building energy and thermal load simulation, indoor acoustic simulation, lighting and daylighting demonstrating, building data displaying, and life cycle investigating of buildings and structures (Wang et al, 2016).

CHAPTER 3

METHODOLOGY

3.1 Literature review

Journals, articles, books or any materials regarding the project will be reviewed. The essential scope that need to be review are kenaf, the composite, types of insulation board, and building simulation.

3.2 Simulation

Simulation of the thermal performance of kenaf composite will be made based on the information contribution from the estimation by utilizing IES (Integrated Environmental Solutions) software. IES is driving in 3D performance analysis programming that is utilized to design many energy efficient buildings over the world. The technology is sustained by integrated consulting services and today its abilities are extending from use on individual structures and buildings to helping create sustainable urban communities. Revealing hidden expenditure, energy and carbon savings, the technology and consulting services support smarter energy-efficient choices across new building ventures, building operation and renovation of existing one.

3.2.1 Sections in IES simulation

There are contains 8 section:

i. Section 1 ModelIT

ModelIT is the module to oversee building geometry. This section can be utilized to make and alter geometry to represent straightforward massing models or extremely detailed room by room full building designs.

ii. Section 2 SunCast

SunCast analyzes how sunlight gains impact the building. It permits the client to envision the sun oriented radiation on the façade and inside surfaces, and evaluate the viability of shading strategies. These effects are additionally measured as far as heat gains and energy consumption to help optimize shading design once integrated with ApacheSim. This segment will demonstrate to the client industry standards to setup the model to make the visualizations and how to play out the simulation for the thermal and energy analysis.

iii. Section 3 ApacheSim

ApacheSim is the thermal simulation instrument in the IES. ApacheSim shows the dynamic associations between the building, the outer atmosphere, the inner loads and processes, and the building mechanical systems. It is equipped for incorporating information from the other Virtual Environment modules to investigate sun radiation, daylight harvesting, natural wind currents, and extremely detailed HVAC system performance. This section will demonstrate client the essentials of room thermal properties, how to perform simulations and audit results to survey the advantage of including the sun oriented shading.

iv. Section 4 FlucsDL

Flucs DL permits the client to compute point by point illuminance and sunshine factors on any surface in the model or on specified workplanes (e.g. the tallness of a work area). This section will demonstrate to the client best practices to run simulations to associate the amount sunshine accessible with or without the shading overhangs.

v. Section 5 Radiance

Radiance uses advanced ray tracing as opposed to the radiosity method to generate photorealistic renderings (luminance – what the eye sees and illuminance – what the surface sees) that account for surface textures, room components and furniture, and the impact of multiple bounces of light. This section will show the user how to generate images to calculate the quantity of daylight (in foot-candles) and predict occurrences of glare.

vi. Section 6 MacroFlo

The MacroFlo module allows for air movement due to wind and buoyant effects to be accounted for in the thermal simulation. This section will show the user how to define operable windows in the model and assess how natural ventilation will impact the space.

vii. Section 7 MicroFlo

MicroFlo analyzes air movement in greater detail using a computational fluid dynamics (CFD) model. CFD produces highly visual outputs, and is valuable for assessing complex air patterns and temperature distributions in a space. In this section, the performance of naturally ventilated room on a typical day when external temperatures are comfortable will be analyze.

viii. Section 8 ApacheHVAC

ApacheHVAC offers great flexibility in defining HVAC equipment and controls systems. A user can either start with a predefined system configuration or create customized systems by assembling a series of components and specifying the control strategies. This approach allows users to model a wide range of common system types, or highly customized systems. The HVAC equipment and controls simulation is fully integrated with the solar, daylight, dynamic thermal and macroscopic airflow simulation. All of this1results in very effective representation of the complex interactions between the building, climate, internal loads, and the HVAC systems.

3.2.2 Common design and analysis by IES simlation

Common design and analysis scenarios can be performed by using IES simulation:

i. Geometry Editing

Modify the design by adding additional windows to the model and creating shading overhangs.

(VE-Pro Module = ModelIT)

ii. Solar Analysis

Create images and movie files to visualize the sun's path and solar gains inside the building and quantify the impact of solar control features such as overhangs and vertical fins.

(VE-Pro Module = SunCast)

iii. Thermal Analysis

Perform several simulations to assess variations on the design, and review the results in tables, graphs, and 3D visualizations.

(VE-Pro Modules = SunCast, ApacheSim)

iv. Daylight Analysis

Perform simulations to create a foot-candle map on the floor plan, and create photo-realistic 3D renderings.

(VE-Pro Modules = FlucsPro, FlucsDL, LightPro, Radiance)

v. Natural Ventilation Analysis

Assess the performance of natural ventilation using operable windows. Results will demonstrate effectiveness of natural ventilation through a full year simulation. Additionally a detailed "snapshot" will show the complex air movement and temperature distribution using an advanced computational fluid dynamics (CFD) model. (VE-Pro Modules = Macroflo, Microflo, ApacheSim)

vi. HVAC Systems Simulation

Introduce the component-based HVAC system modelling interface for advanced energy simulations.

(VE-Pro Modules = ApacheHVAC, ApacheSim)

3.2.3 Segment used for simulation

For this project, ApacheSim section will be use. ApacheSim is a dynamic thermal simulation program based on first-principles mathematical modelling of the heat transfer processes occurring within and around a building. Other scenarios such as changing the wall construction materials, reducing internal gains, adding skylights, or testing alternate shading options. ApacheSim explicitly calculates conduction, convective, and radiant heat transfer effects using hourly weather data. Calculations are performed at shorter time intervals to account for dynamic impacts on surface temperatures, and air temperatures which can be used for load analysis, energy analysis, and thermal comfort analysis.

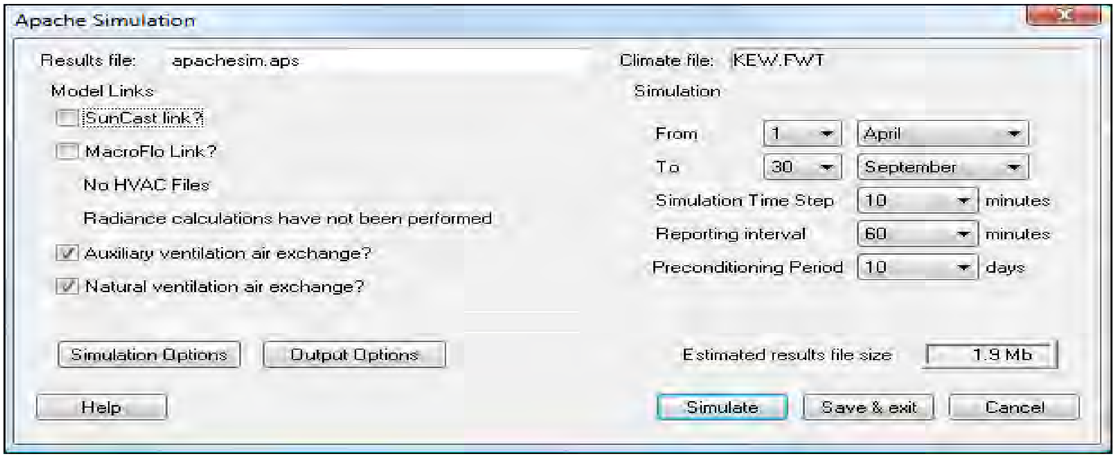


Figure 3.1: Interface for ApacheSim

3.1 There are seven data requirements for thermal applications :

i. Site Location and Weather Data

Data on the global location of the building and the climate to which it is exposed are specified using the program APlocate. The location data includes the latitude and longitude of the site, together with information about the local time zone and any summertime clock adjustment. The weather data covers the requirements of both the heat loss and heat gains calculations and the thermal simulation program. For the heat loss calculation the weather data takes the form of a single outside winter design temperature. For the heat gains calculation the data provides hourly dry-bulb temperatures, wet-bulb temperatures and solar data for one design day per month. For thermal simulation the weather data is more extensive and is stored on a simulation weather file.

ii. Constructions

The material composition of the walls, windows and other elements of the building fabric are described using the program APcdb (Apache constructions database manager). APcdb provides databases of materials and constructions which may be imported into the building and edited as necessary.

Constructions are built up from layers with specified thermophysical properties and widths. In the case of glazing constructions the layer properties include solar transmittance, absorptance and reflectance characteristics. Construction details may be passed between projects using a Construction Template.

iii. Profiles

Profiles provide the means for describing the time variation of input variables. They are used to specify how quantities such as casual gains, ventilation rates and set-points vary over the hours of the day, the days of the week and the months of the year. 'Formula profiles' allow inputs to vary in response to room or external conditions arising during simulations. Profiles are managed by the program APpro.

iv. Internal Gains

Information on heat gains from occupants, lights and equipment is required as input to heat gain calculations and thermal simulation. Heat gains may be sensible or latent, and sensible gains are characterized by a radiant fraction. The magnitude and types of these casual gains, together with profiles to indicate their time variation, may be specified individually for each room or incorporated within a Room Thermal Template.

v. Infiltration and Ventilation

Infiltration and ventilation rates for rooms are specified by assigning them a maximum value and a profile. Ventilation rates can represent either mechanical or natural ventilation. The source of the ventilation may be outside air, air from another room or air at a specified (possibly time-varying) temperature. Like casual gains, air exchanges may be incorporated within a Room Thermal Template. These pre-specified air exchanges may be supplemented by natural and mechanical ventilation air flows calculated dynamically at simulation time by the programs MacroFlo and ApacheHVAC.

vi. Plant and Controls

Where rooms are conditioned by heating, cooling, humidification or dehumidification systems the characteristics of these systems must be specified. The specifications for room control include set-points, heating and cooling capacities and radiant fractions, together with profiles defining periods of plant operation. These parameters form part of the Room Thermal Template data. In the case of thermal simulation, these idealised room control parameters may be overridden by detailed HVAC system models constructed in ApacheHVAC.

vii. Heating and Cooling Zones

In the Thermal view, rooms may be grouped together into Heating Zones and Cooling Zones for the purpose of aggregating results from a calculation or simulation.

Simulation

i. Simulation Period (From, To)

Specify the dates for the first and last days of the simulation.

ii. Simulation Time Step

Specify the time step to be used in the simulation. A time step of 10 minutes is suitable for most building simulations. Smaller time steps may be necessary to capture the detail of control operation in simulations involving ApacheHVAC.

iii. Reporting Interval

Specify the time interval at which require results to be recorded. The reporting interval must be greater than or equal to the time-step and not less than 6 minutes. A reporting interval of 1 hour is satisfactory for most simulations. A shorter interval allows to examine simulation results in more detail.

iv. Preconditioning Period

A period of preconditioning is necessary to ensure that the building enters the simulation period in a realistic thermal state. Preconditioning is necessary because of heat storage in the building fabric. For lightweight buildings a preconditioning period of 10 days is sufficient. For heavyweight buildings as much as 30 days or more may be needed. The appropriate period of preconditioning may be established by increasing the number of preconditioning days until the effect of further increments produces a negligible change in the first day's simulation results.

v. Save & Exit

Save the simulation settings.

vi. Simulate

Run the simulations.

vii. The Results File

The Results File (which has extension *.aps) is used to store simulation results for later viewing in Vista. By choosing a name for this file the user will be able to keep it separate from results from other simulation runs. The estimated size of the results file is shown at the lower right of the dialogue.

3.3 Analysis and proposed solution

Obtain the comparison of thermal performance kenaf composite insulator with synthetic insulator.

3.4 Report writing

A report on this study will be written at the end of the project.

CHAPTER 4

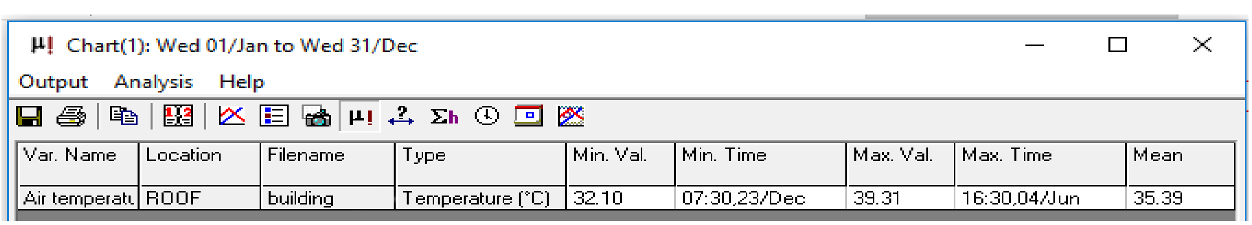
RESULT AND DISCUSSION

4.1 SIMULATION RESULTS

The simulations results consist of four type of kenaf composite insulator which are kenaf composite 4060 insulator, kenaf composite 5050 insulator, kenaf composite 6040 insulator and kenaf composite 6040 NaOH insulator. Also the result for rock wool insulator and wood strand insulator were taken for comparison.

4.1.1 Kenaf composite 4060 insulator

The minimum value of air temperature is 32.10 ^{o}C at 7:30 am at 23 December. The maximum value of air temperature is 39.31 ^{o}C at 4.30 pm at 4 June. The mean temperature for this insulator is 35.39 ^{o}C.



Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	building	Temperature (°C)	32.10	07:30,23/Dec	39.31	16:30,04/Jun	35.39

Figure 4.1: Result of air temperature for kenaf composite 4060 insulator

From the psychrometry chart, dry bulb temperature and wet bulb temperature for kenaf composite 4060 insulator is 23.00 °C and 22.69 °C respectively.

Data Point Properties

Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.44	22.69	97.34	67.48	22.57	0.867

Figure 4.2: Result of psychrometry chart for Kenaf composite 4060 insulator

The minimum value of total energy is 0.9323 kW at 7:30 am at 1st January. The maximum value of total energy is 3.8141 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 1.8110 kW.

Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		building4060.a	Power (kW)	0.9323	07:30,01/Jan	3.8141	15:30,02/Mar	1.8110

Figure 4.3: Total energy for kenaf composite 4060 insulator

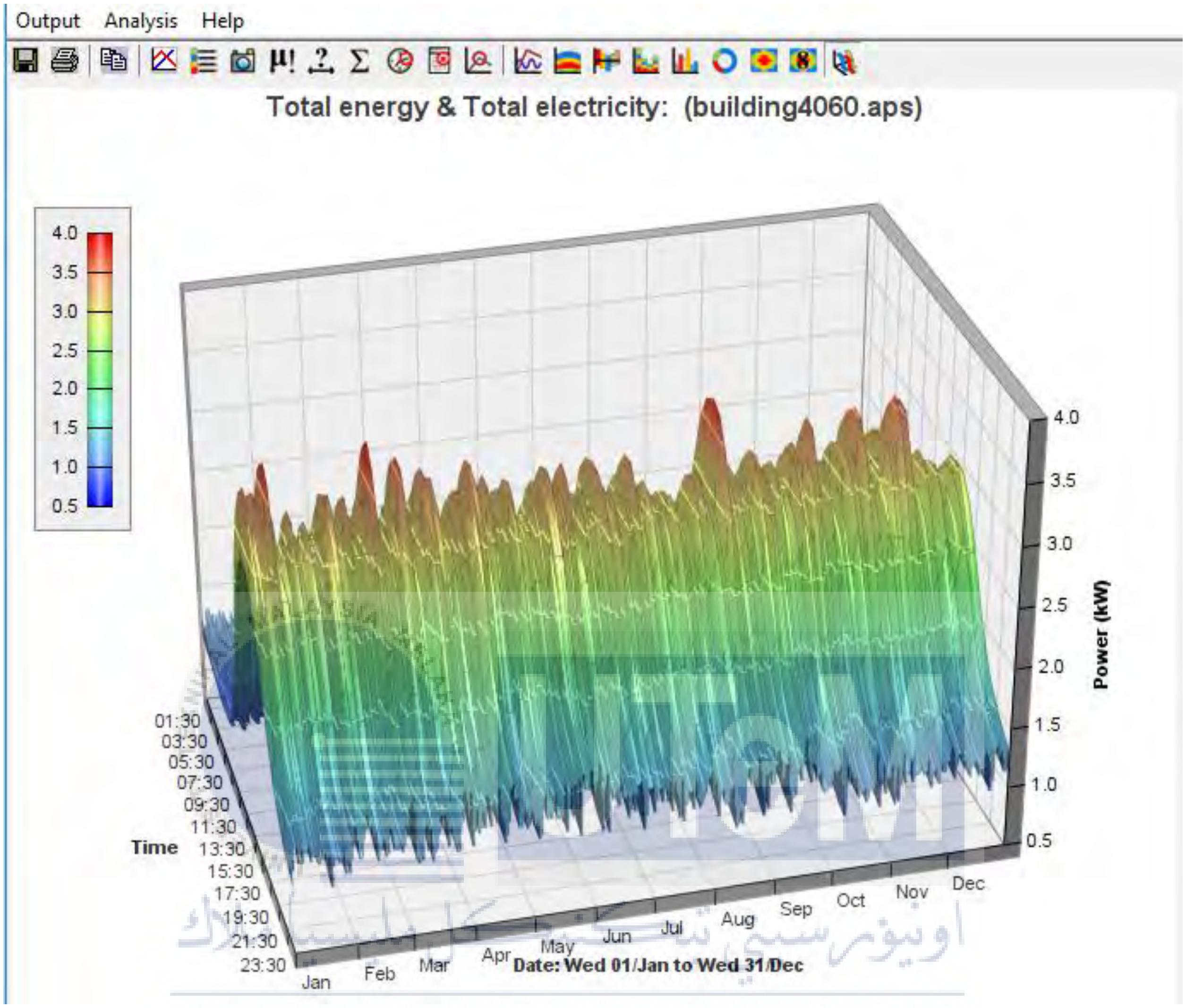
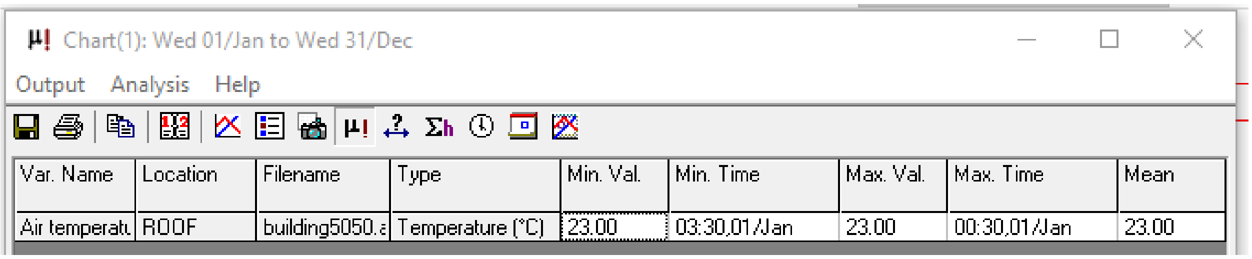


Figure 4.4: Graph of total energy against time against date for Kenaf composite 4060 insulator

4.1.2 Kenaf composite 5050 insulator

The minimum value of air temperature is 23.00 ºC at 3:30 am at 1st January. The maximum value of air temperature is 23.00 ºC at 12.30 am at 1st January. The mean temperature for this insulator is 23.00 ºC.



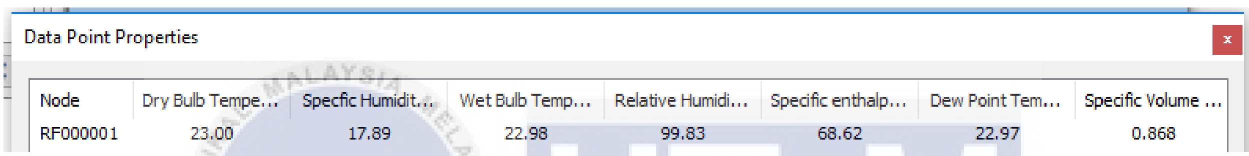
Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	building5050.a	Temperature (°C)	23.00	03:30,01/Jan	23.00	00:30,01/Jan	23.00

Figure 4.5: Result of air temperature for Kenaf composite 5050 insulator

From the psychrometry chart, dry bulb temperature and wet bulb temperature for kenaf composite 5050 insulator is 23.00 °C and 22.98 °C respectively.

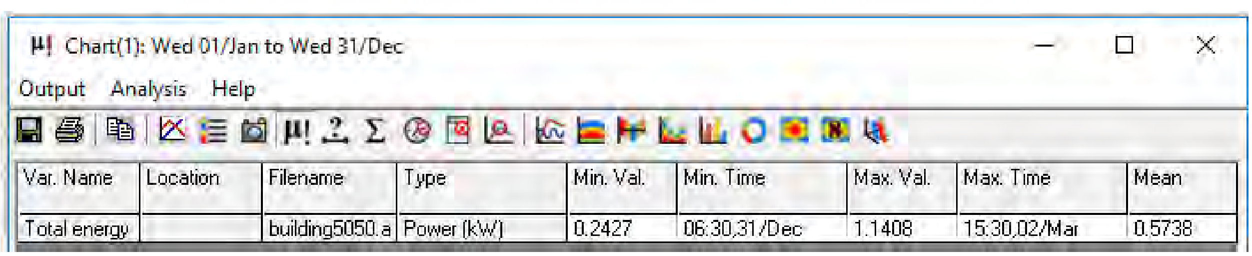


Data Point Properties

Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.89	22.98	99.83	68.62	22.97	0.868

Figure 4.6: Result of psychrometry chart for Kenaf composite 5050 insulator

The minimum value of total energy is 0.2427 kW at 6:30 am at 31 December. The maximum value of total energy is 1.1408 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 0.5738 kW.



Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		building5050.a	Power (kW)	0.2427	06:30,31/Dec	1.1408	15:30,02/Mar	0.5738

Figure 4.7: Total energy for kenaf composite 5050 insulator

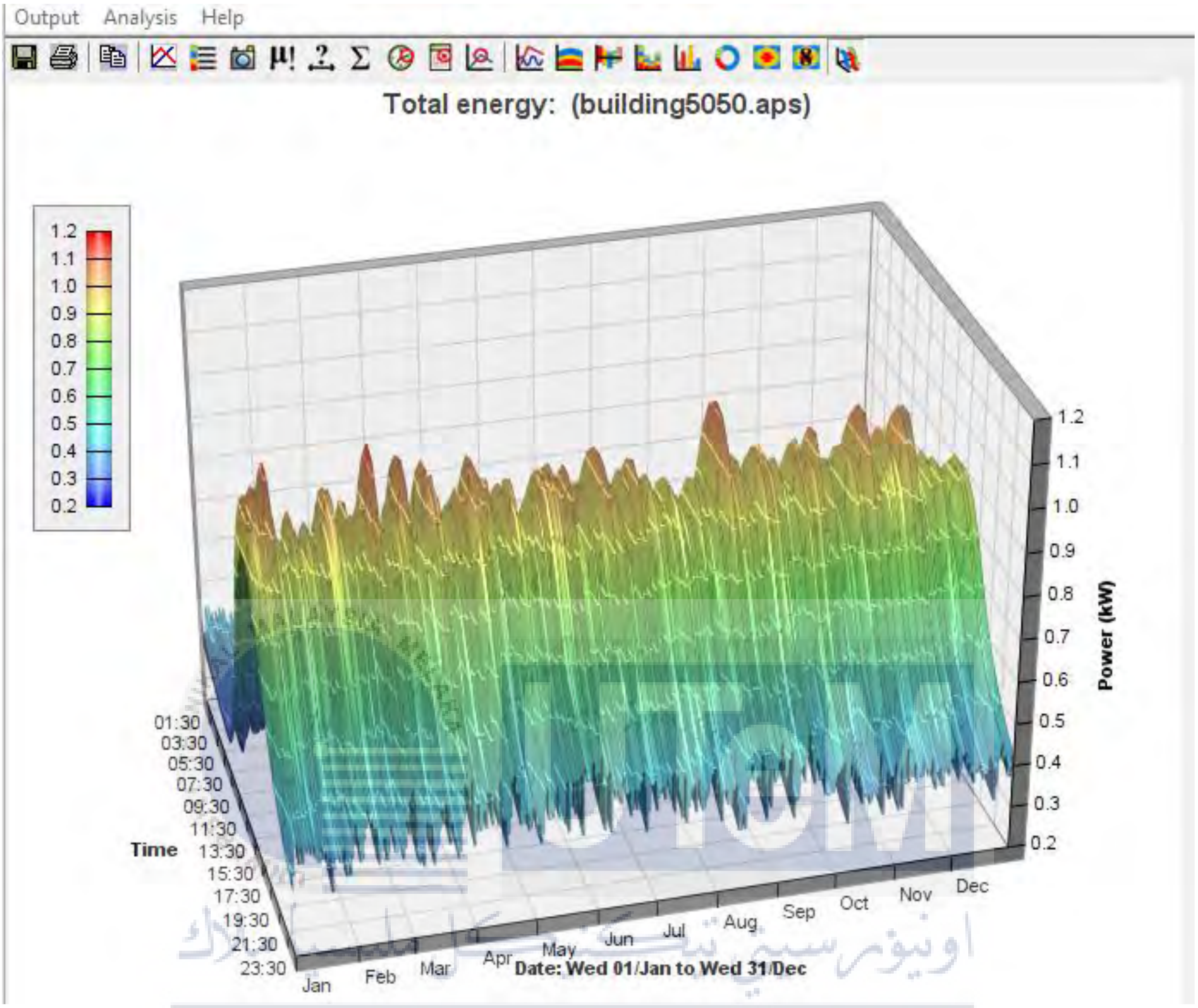


Figure 4.8: Graph of total energy against time against date for Kenaf composite 5050 insulator

4.1.3 Kenaf composite 6040 insulator

The minimum value of air temperature is 23.00 ºC at 10:30 am at 13 January. The maximum value of air temperature is 23.00 ºC at 1.30 am at 1 January. The mean temperature for this insulator is 23.00 ºC.

Chart(1): Wed 01/Jan to Wed 31/Dec

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	building6040.a	Temperature (°C)	23.00	10:30,13/Jan	23.00	01:30,01/Jan	23.00

Figure 4.9: Result of air temperature for Kenaf composite 6040 insulator

From the psychrometry chart, dry bulb temperature and wet bulb temperature for kenaf composite 6040 insulator is 23.00 ºC and 22.98 ºC respectively.

Data Point Properties

Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.89	22.98	99.83	68.62	22.97	0.868

Figure 4.10: Result of psychrometry chart for Kenaf composite 6040 insulator

The minimum value of total energy is 0.2606 kW at 6:30 am at 31 December. The maximum value of total energy is 1.0881 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 0.5627 kW.

Chart(2): Wed 01/Jan to Wed 31/Dec

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		building6040.a	Power (kW)	0.2606	06:30,31/Dec	1.0881	15:30,02/Mar	0.5627

Figure 4.11: Total energy for kenaf composite 6040 insulator

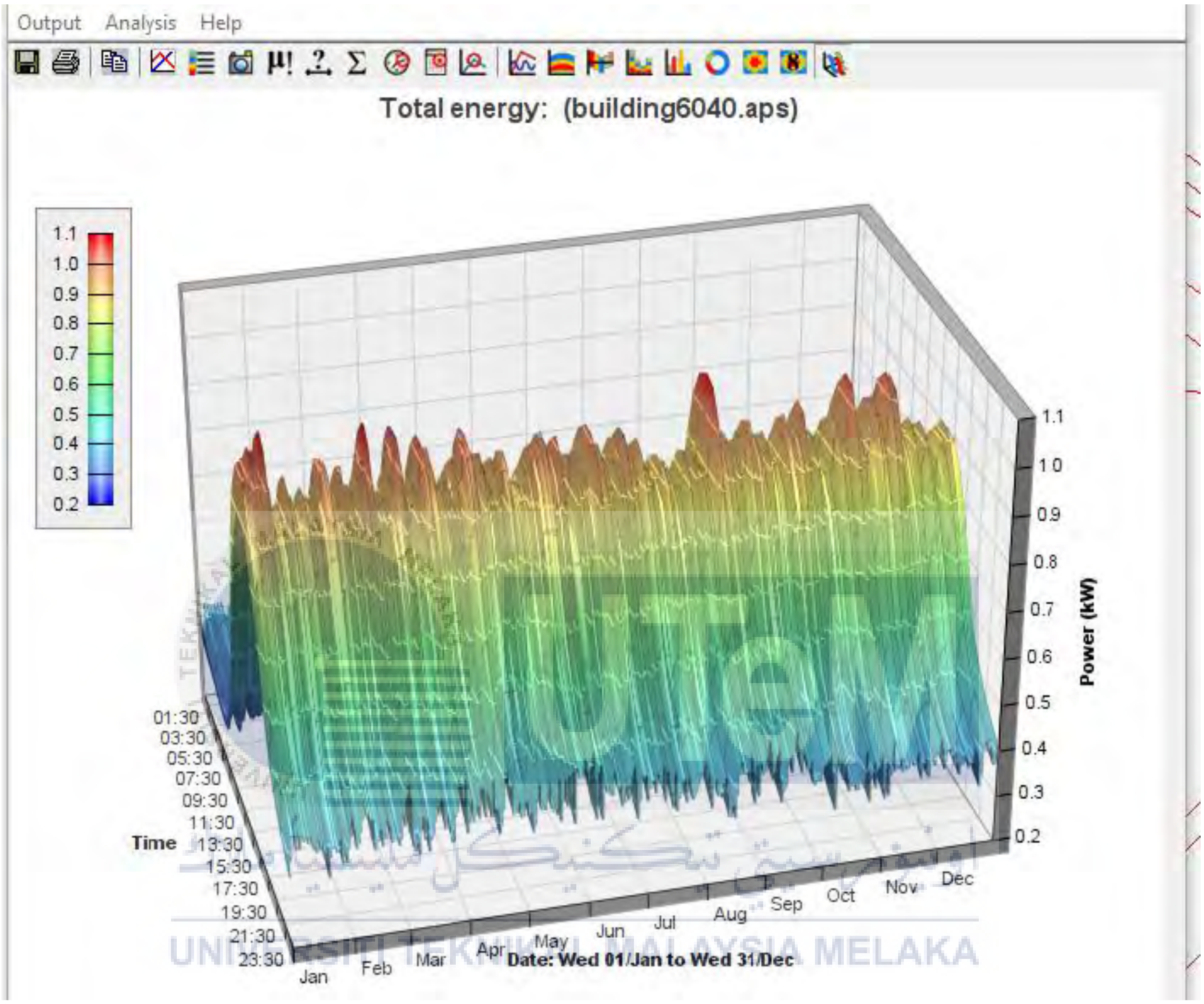
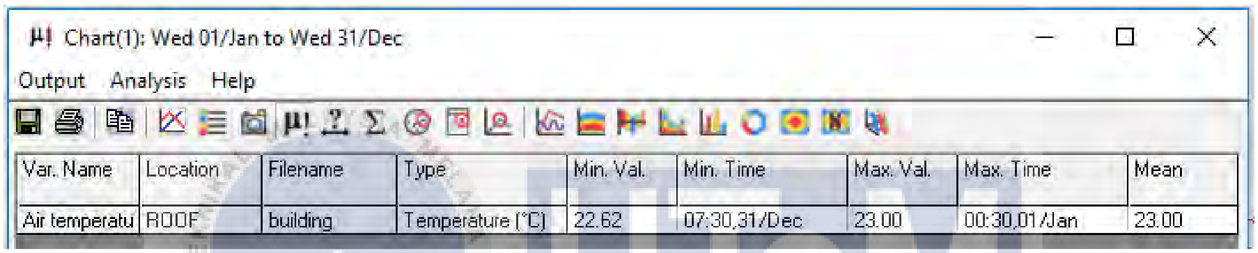


Figure 4.12: Graph of total energy against time against date for Kenaf composite 6040 insulator

4.1.4 Kenaf composite 6040 NAOH insulator

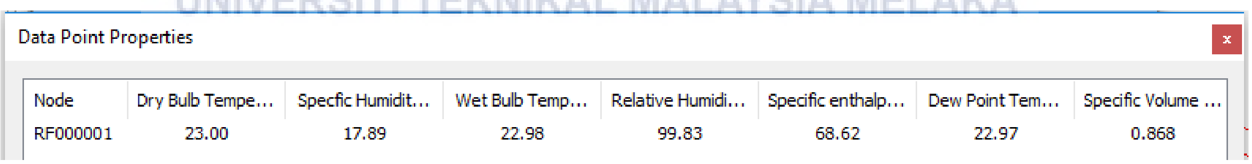
The minimum value of air temperature is 22.62 °C at 7:30 am at 31 December. The maximum value of air temperature is 23.00 °C at 12.30 am at 1 January. The mean temperature for this insulator is 23.00 °C.



Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	building	Temperature (°C)	22.62	07:30,31/Dec	23.00	00:30,01/Jan	23.00

Figure 4.13: Result of air temperature for Kenaf composite 6040 NaOH insulator

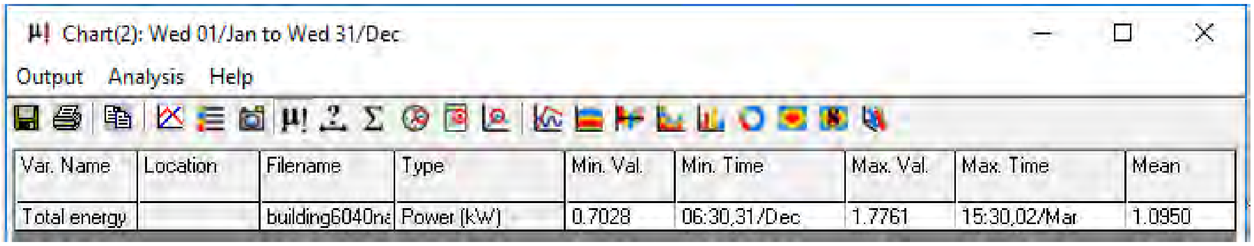
From the psychrometry chart, dry bulb temperature and wet bulb temperature for kenaf composite 6040 NaOH insulator is 23.00 °C and 22.98 °C respectively.



Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.89	22.98	99.83	68.62	22.97	0.868

Figure 4.14: Result of psychrometry chart for Kenaf composite 6040 NaOH insulator

The minimum value of total energy is 0.7028 kW at 6:30 am at 31 December. The maximum value of total energy is 1.7761 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 1.0950 kW.



Chart(2): Wed 01/Jan to Wed 31/Dec

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		building6040na	Power (kW)	0.7028	06:30,31/Dec	1.7761	15:30,02/Mar	1.0950

Figure 4.15: Total energy for kenaf composite 6040 NaOH insulator

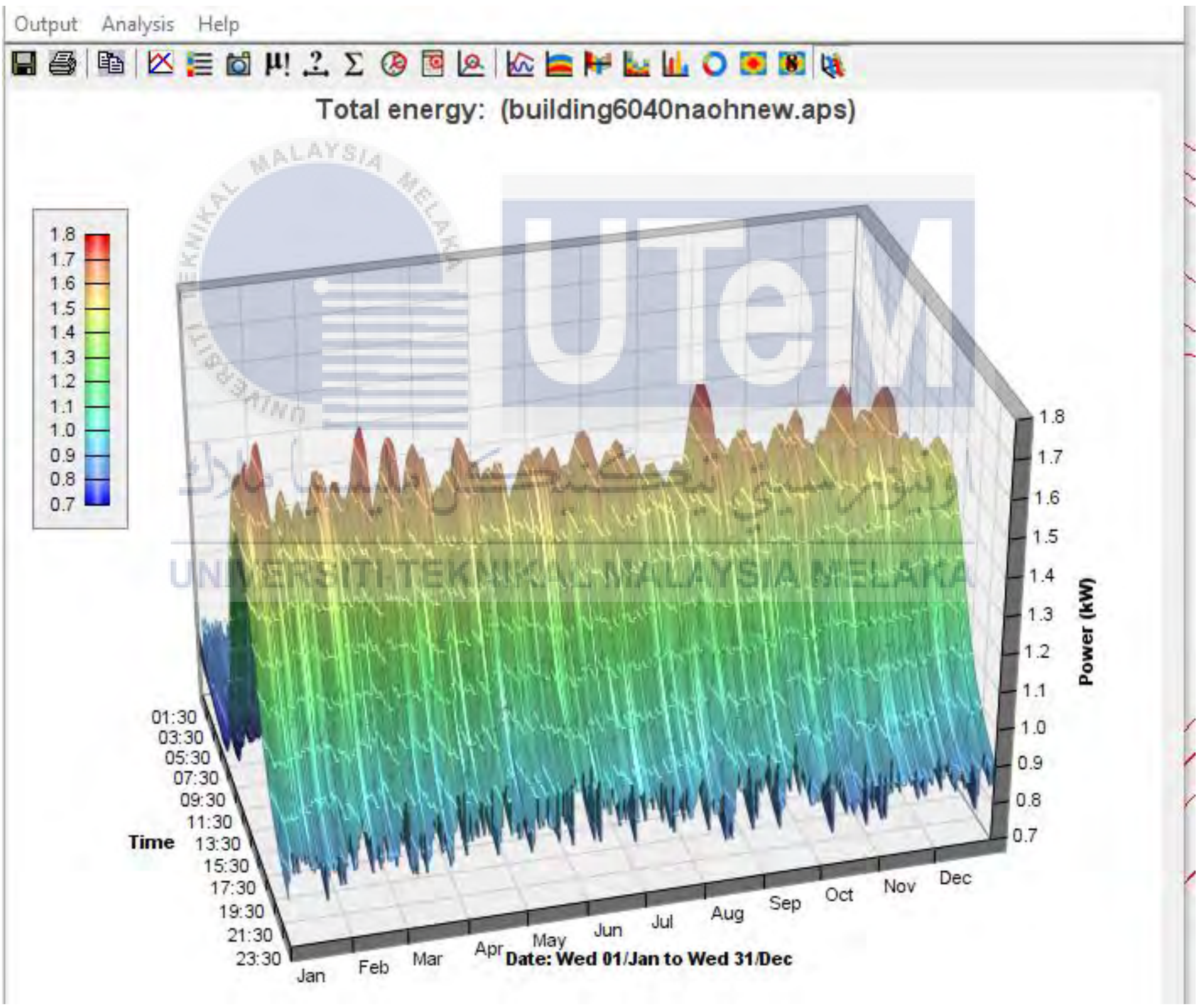


Figure 4.16: Graph of total energy against time against date for Kenaf composite 4060 NaOH insulator

4.1.5 Rock wool insulator

The minimum value of air temperature is 23.00 °C at 1:30 pm at 3rd February. The maximum value of air temperature is 23.00 °C at 12.30 am at 1 January. The mean temperature for this insulator is 23.00 °C.

Chart(1): Wed 01/Jan to Wed 31/Dec

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	buildingrockwc	Temperature (°C)	23.00	13:30,03/Feb	23.00	00:30,01/Jan	23.00

Figure 4.17: Result of air temperature for rock wool insulator

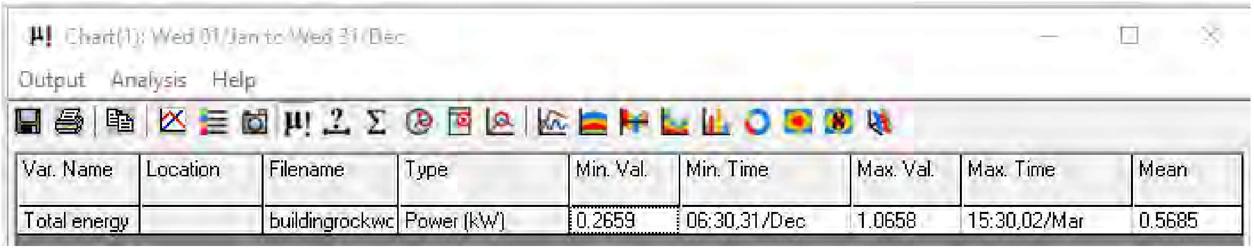
From the psychrometry chart, dry bulb temperature and wet bulb temperature for rock wool insulator is 23.00 °C and 22.98 °C respectively.

Data Point Properties

Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.89	22.98	99.83	68.62	22.97	0.868

Figure 4.18: Result of psychrometry chart for rock wool insulator

The minimum value of total energy is 0.2659 kW at 6:30 am at 31 December. The maximum value of total energy is 1.0658 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 0.5685 kW.



Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		buildingrockwc	Power (kW)	0.2659	06:30,31/Dec	1.0658	15:30,02/Mar	0.5685

Figure 4.19: Total energy for rock wool insulator

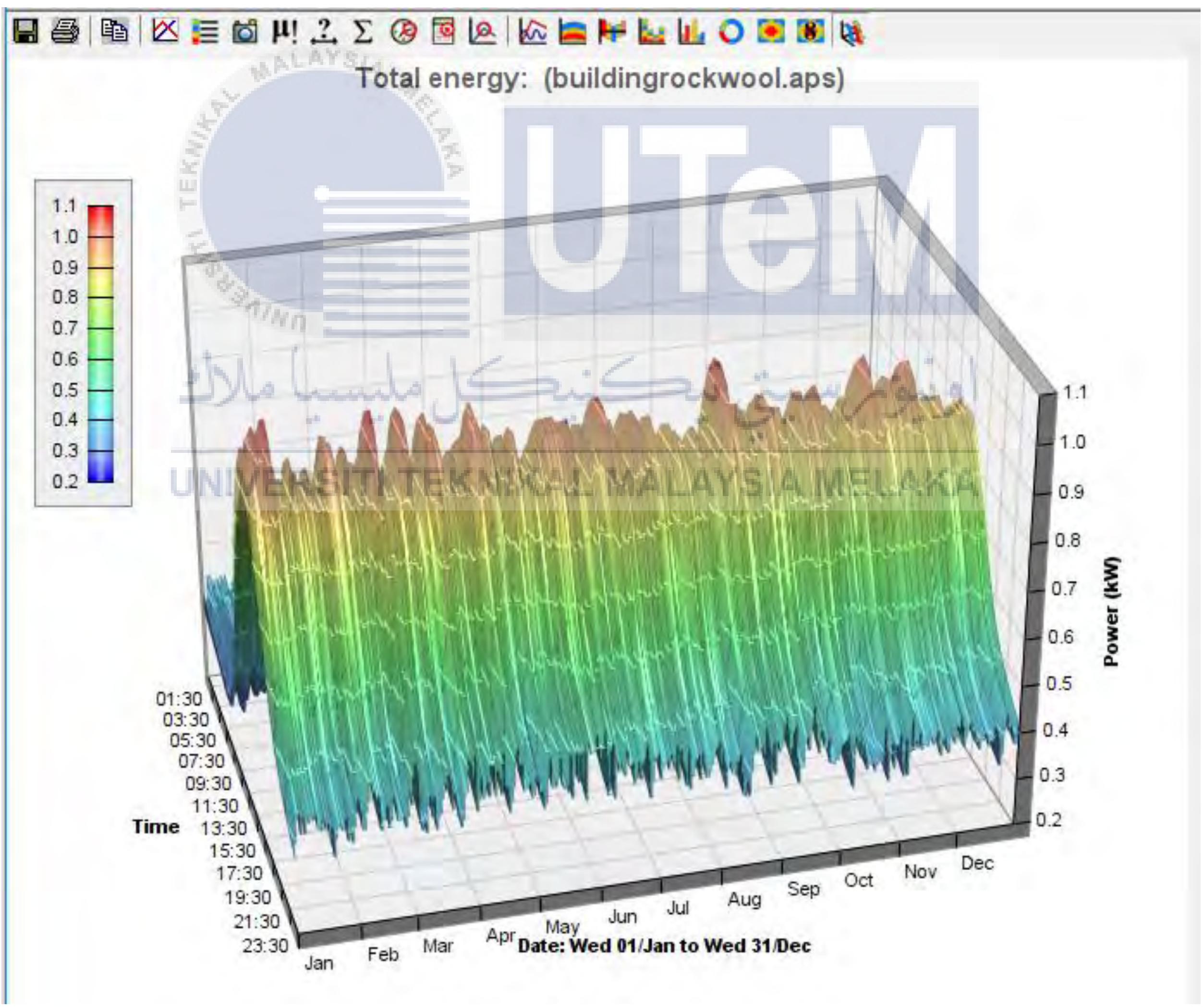
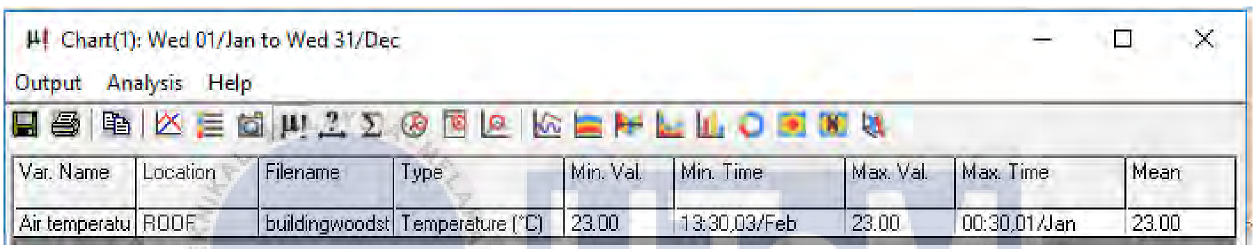


Figure 4.20: Graph of total energy against time against date for rock wool insulator

4.1.6 Wood strand insulator

The minimum value of air temperature is 23.00 °C at 1:30 pm at 3 February. The maximum value of air temperature is 23.00 °C at 12.30 am at 1 January. The mean temperature for this insulator is 23.00 °C.



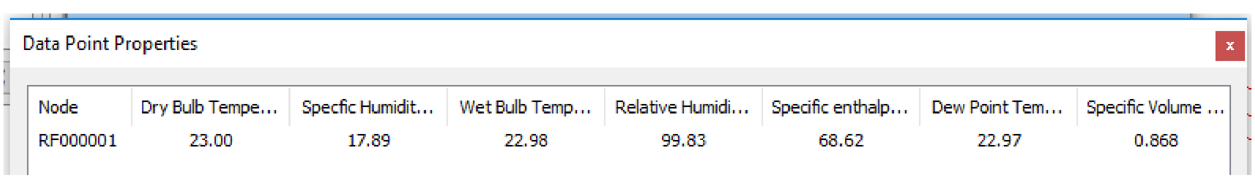
Chart(1): Wed 01/Jan to Wed 31/Dec

Output Analysis Help

Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperatu	ROOF	buildingwoodst	Temperature (°C)	23.00	13:30,03/Feb	23.00	00:30,01/Jan	23.00

Figure 4.21: Result of air temperature for wood strand insulator

From the psychrometry chart, dry bulb temperature and wet bulb temperature for wood strands insulator is 23.00 °C and 22.98 °C respectively.

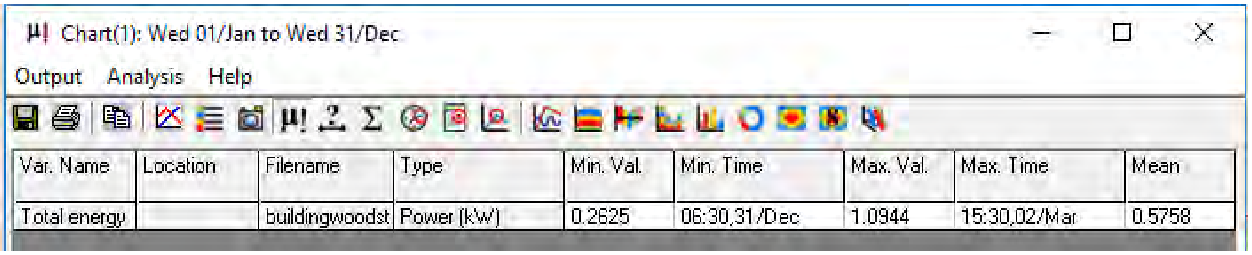


Data Point Properties

Node	Dry Bulb Tempe...	Specfic Humidit...	Wet Bulb Temp...	Relative Humidi...	Specific enthalp...	Dew Point Tem...	Specific Volume ...
RF000001	23.00	17.89	22.98	99.83	68.62	22.97	0.868

Figure 4.22: Result of psychrometry chart for wood strand insulator

The minimum value of total energy is 0.2625 kW at 6:30 am at 31 December. The maximum value of total energy is 1.0944 kW at 3.30 pm at 2nd March. The mean total energy for this insulator is 0.5758 kW.



Var. Name	Location	Filename	Type	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Total energy		buildingwoodst	Power (kW)	0.2625	06:30,31/Dec	1.0944	15:30,02/Mar	0.5758

Figure 4.23: Total energy for wood strand insulator

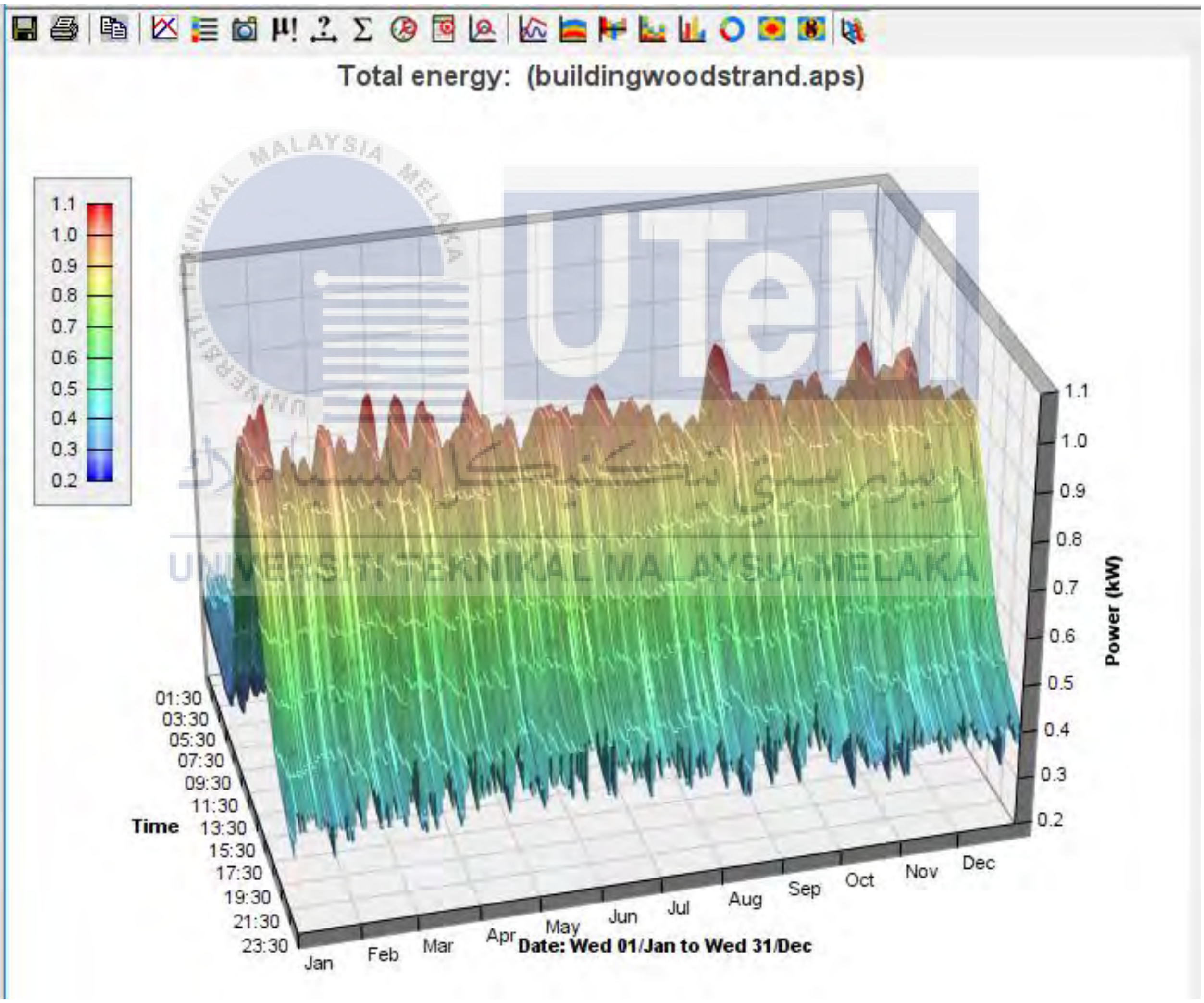
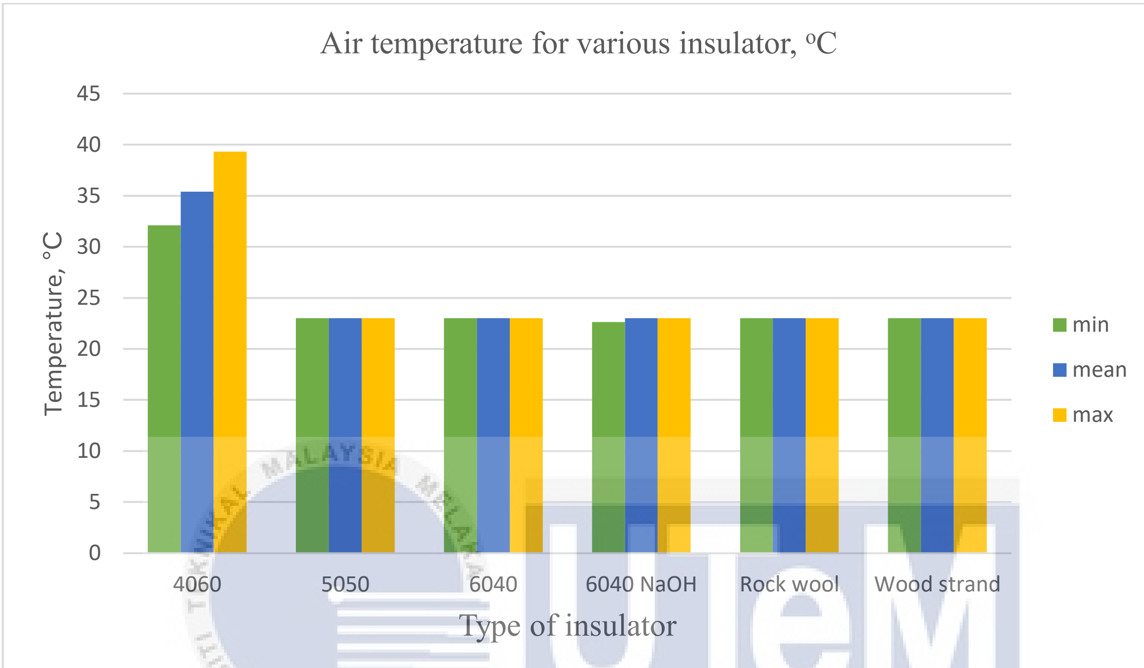


Figure 4.24: Graph of total energy against time against date for wood strand insulator

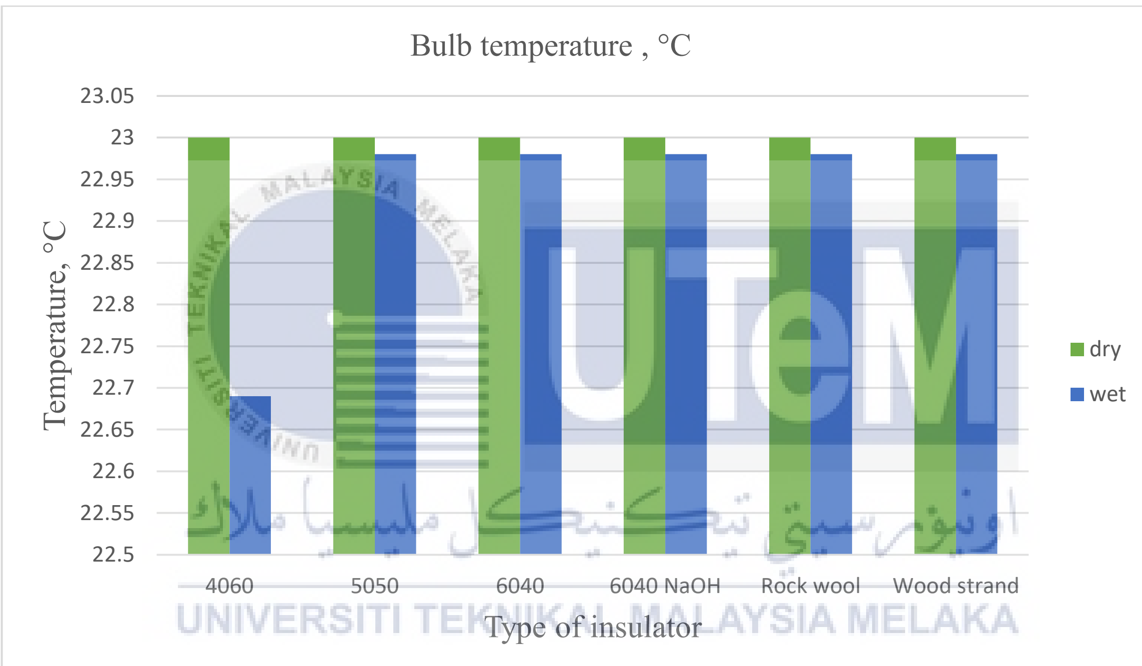
4.2 DISCUSSION AND COMPARISON



The graph shows the value of air temperature of the building by using various type of insulator. Different trends can be seen for kenaf composite 4060 while air temperature from other insulator shows insignificant changes.

The figures for air temperature of the building showed diverse tendencies. The minimum, the mean and the maximum air temperature of kenaf composite 4060 is 32.10 °C, 35.39 °C and 39.31 °C respectively. On the other hand, the value of air temperature for kenaf composite 5050, kenaf composite 6040, kenaf composite 6040 NaOH, rock wool and wood strand stays at 23 °C for minimum, mean and maximum value. Only minimum air temperature for kenaf composite 6040 NaOH show slight low at 22.62 °C.

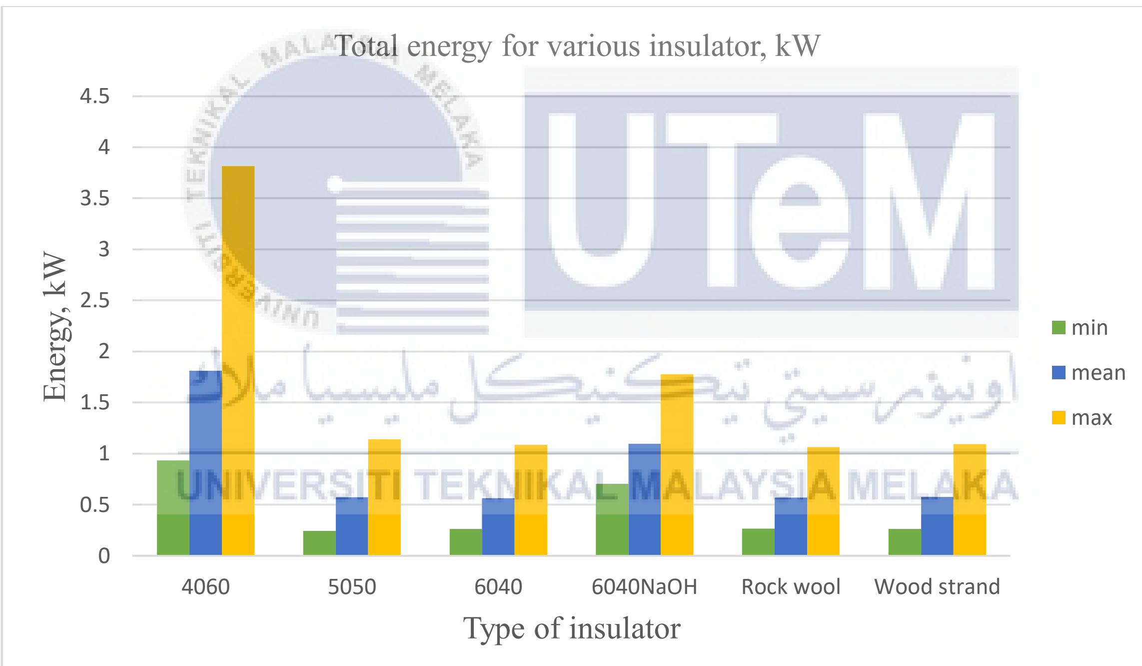
The kenaf composite 4060 insulator shows such value for air temperature because insulator fail to prevent heat from outside to enter thus increasing the temperature of the building. Air conditioning fail to lower the air temperature in the building to 23 °C. Kenaf composite 4060 insulator is not suitable as heat insulator because the value thermal conductivity is 0.5320 W/m.k. Other insulator suitable for the building because the values of thermal conductivity less than 0.1 W/m.k. At this value, heat have difficulty to transfer through the wall of the building. That's why the value of air temperature starting to uniform at temperature 23 °C because the air condition managed to reduce the temperature to that level.



The graph shows the value of bulb temperature of the building by using various type of insulator. Different trends can be seen for kenaf composite 4060's bulb temperature while bulb temperature from other insulator shows insignificant changes.

The figures for dry bulb temperature for all type of insulator maintained at 23.00 °C. On the other hand, the value of wet bulb temperature for kenaf composite 4060 is 22.69 °C while kenaf composite 6040, kenaf composite 6040 NaOH, rock wool and wood strand stays at 22.98°C.

Dry bulb refer as air temperature for a building. For kenaf composite 4060, value of dry bulb temperature is different to air temperature because from this simulation, the value air temperature is collective data for full one year while the dry bulb temperature is data for specific one day. For wet bulb of kenaf composite 4060 have such low value because of simulation factor. Fail to get same value like other insulator because only thermal conductivity less than 0.1 W/m.k managed to maintain dry bulb temperature and wet bulb temperature the 23 °C and 22.98°C respectively.



The graph shows the value of total energy usage of the building by using various type of insulator. The trends for this graph almost same for all type of insulator.

The figures for total energy of the building showed diverse tendencies. The maximum energy recorded is 3.8141 kW for building that use kenaf composite 4060 insulator. The minimum, the mean and the maximum total energy of kenaf composite 5050 insulator is 0.2427 kW, 0.5738 kW and 1.1408 kW respectively. For kenaf composite 6040 insulator, the value of total energy shows slight decrease compared to kenaf composite 5050 in term of minimum, mean and maximum total energy. On the other hand, the value of total energy for kenaf composite 6040 NaOH shows a significant arise compared to kenaf composite 5050 and kenaf composite 6040. Total energy for rock wool insulator and wood strand insulator both shows insignificant changes compared to kenaf composite 5050 insulator and kenaf composite 6040 insulator.

Kenaf composite 4060 insulator have high value for total energy because the energy consumed by air condition system high compared to other yet, the air condition system fail to reduce the temperature to 23 °C because it have high thermal conductivity that make the heat to easily go through the wall. Other insulators managed to maintain temperature of the building to 23 °C by using total energy less compared to kenaf composite 4060 insulator. On the other hand, the total energy for kenaf composite 6040 NaOH insulator show the value slight high compared to other insulator that have thermal conductivity less than 0.1 W/m.k because the simulation for that insulator were done during sunny hot day.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this project, the thermal performance of four type of kenaf composite were successfully simulated using Integrated Environmental Solutions software. Two other insulator, rock wool insulator and wood strand insulator were also simulated to give a comparison for kenaf composite. From the result obtained, the following conclusions are drawn.

i. The thermal conductivity of the composites has decreased with increase in volume fraction of fibers.

ii. At maximum volume fraction of fiber, the thermal conductivity of the composite has varied from 0.0535 W/m.k to 0.0865 W/m.k

iii. Insulator with high thermal conductivity such as kenaf composite 4060 fail to reduce the temperature of the building. Insulator with low thermal conductivity value managed to reduce temperature to certain level.

iv. Building with high thermal conductivity insulator consumed more energy for air conditioning system compared to the building with low thermal conductivity because large amount heat pass through the insulator.

v. Synthetic insulator shows greater thermal conductivity in this simulation.

The result of this study indicate that the natural insulator poses great thermal performance on a par with synthetic insulator. Hence, further research for kenaf composite can be availed in various industries that still rely on synthetic composites.

5.2 RECOMMENDATION

Recommendation for this project is to use different climate. This project is located at Malacca which have tropical savanna climate. So use other climate like rain forest, monsoon, humid subtropical, humid continental, desert, steppe, subartic climate, tundra and polar ice cap can used for future studies. Besides that, the future project can used different building simulation such as UrbaSun, BEAVER, FineGREEN and EcoDesigner Star in ArchiCAD programme at Graphisoft. This project can be improved by using different binder such as Urea-Formaldehyde and Phenol-Formaldehyde and the composition of kenaf-binder can be varied to 55% kenaf 45% binder and 45% kenaf 55% binder. Last but not least, this project also can be tested with other mechanical test such as strength, swelling thickness, tensile stress and bending stress.

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APPENDIX A

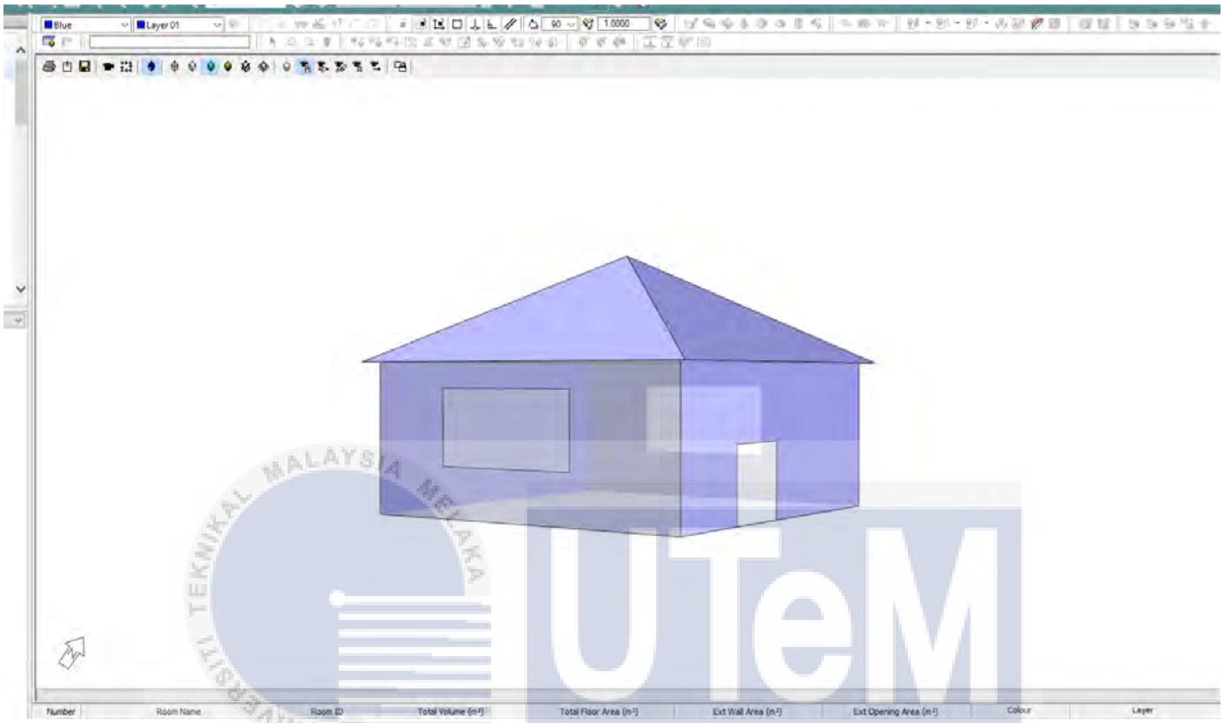

Figure A1: The model of house use for simulation.

Description: 2013 External Wall ID: STD_WAL1 External Internal

Performance: ASHRAE

U-value: 0.3292 W/m²·K Thickness: 208.900 mm Thermal mass Cm: 21.9500 kJ/(m²·K)

Total R-value: 2.8884 m²K/W Mass: 46.9780 kg/m² Very lightweight

Surfaces Functional Settings Regulations

Outside — Emissivity: 0.900 Resistance (m²K/W): 0.0299 ☑Default; Solar Absorptance: 0.700

Inside — Emissivity: 0.900 Resistance (m²K/W): 0.1198 ☑Default; Solar Absorptance: 0.550

Construction Layers (Outside To Inside) System Materials... Project Materials...

Material	Thickness mm	Conductivity W/(m·K)	Density kg/m³	Specific Heat Capacity J/(kg·K)	Resistance m²K/W	Vapour Resistivity GN·s/(kg·m)	Category
[STD_SM1] Rainscreen	3.0	50.0000	7800.0	450.0	0.0001	-	Metals
Cavity	50.0	-	-	-	0.1300	-	-
[STD_EPS] Insulation	81.4	0.0330	20.0	1030.0	2.4667	-	Insulating Materials
[STD_USP] Cement bonded particle board	12.0	0.2300	1100.0	1000.0	0.0522	0.000	Boards, Sheets & Decking
Cavity	50.0	-	-	-	0.1800	-	-
[STD_US1] Plasterboard	12.5	0.2100	700.0	1000.0	0.0595	0.000	Plaster

Figure A2: The interface of the wall layer composition.