



**PROCEEDING  
INTERNATIONAL CONFERENCE**

THE 1<sup>st</sup>  
WARMADEWA UNIVERSITY  
INTERNATIONAL CONFERENCE ON  
ARCHITECTURE AND CIVIL ENGINEERING

**SUSTAINABILITY  
DESIGN  
AND  
CULTURE**

DENPASAR, OCTOBER 20<sup>th</sup>, 2017



# PROCEEDING INTERNATIONAL CONFERENCE

THE 1<sup>st</sup>  
WARMADEWA UNIVERSITY  
INTERNATIONAL CONFERENCE ON  
ARCHITECTURE AND CIVIL ENGINEERING

# SUSTAINABILITY DESIGN AND CULTURE

DENPASAR, OCTOBER 20<sup>th</sup>, 2017

WARMADEWA UNIVERSITY PRESS  
2017

**Scientific Committee**

1. Prof. Tasuku Tanaka, Ph.D. (Graduate School of Science and Engineering Yamaguchi University, Japan).
2. Prof. Dr. Ir. Agus Taufik Mulyono, M.T., ATU., IPU. (Department of Civil Engineering and Environment, Gajah Mada University, Indonesia).
3. Prof. Wimpy Santosa, Ph.D (Faculty of Engineering Parahyangan Catholic University, Bandung, Indonesia).
4. Dr. Takahiro Ozawa (Center for Remote Sensing and Ocean Sciences (CRoSOS) Udayana University, Denpasar, Bali).
5. Dr. Ir. Ahmad Rifa'i, MT. (Department of Civil Engineering and Environment, Gajah Mada University, Indonesia).
6. Dr. Ngakan Ketut Acwin Dwijendra, ST., MA. (Campus of Bali Design School (STD Bali)).
7. Prof. Dr. Ir. I Wayan Ruma, MT. (Faculty of Engineering Warmadewa University, Denpasar, Bali).
8. Dr. Ir. I Gusti Agung Patu Eryani, MT. (Faculty of Engineering Warmadewa University, Denpasar, Bali).
9. Dr. Ir. I Wayan Parwata, MT. (Faculty of Engineering Warmadewa University, Denpasar, Bali).

**Katalog dalam Terbitan** : Perpustakaan Nasional Republik Indonesia  
The 1<sup>st</sup> Warmadewa University International  
Conference on Architecture and Civil Engineering  
SUSTAINABILITY, DESIGN AND CULTURE  
Denpasar, 2017, ix, 324 pages, 21.0 x 29.7 Cm



Hak Cipta Dilindungi Undang-undang  
UU RI No. 19 Tahun 2002

**Editor** : 1. I Kadek Merta Wijaya, S.T., M.Sc.  
2. Putu Aryastana, S.T., M.Eng., M.Si.  
3. Made Suryanatha Prabawa, S.T., M.Ars.

**Cover Design** : Ni Putu Ratih Pradnyaswari Anasta Putri, S.T., M.Sc.

**First Published** : October 2017

**Copyright** : Warmadewa University Press

**Editor Address** :  
Jalan Terompong No. 24, Gedung D Lantai 2,  
Tanjung Bungkak, Denpasar 80234, Bali  
Telp. (0361) 223858; Fax. (0361) 225073  
Web: [www.warmadewa.ac.id](http://www.warmadewa.ac.id)  
E-mail: [univ-warmadewa@yahoo.co.id](mailto:univ-warmadewa@yahoo.co.id)

## Committee

### The 1<sup>st</sup> Warmadewa University International Conference on Architecture and Civil Engineering SUSTAINABILITY, DESIGN AND CULTURE

#### Board of Committee:

Dr. Drs. A. A. Gede Wisnumurti, M.Si.  
Prof. dr. Dewa Putu Widjana, DAP&E.Sp.Park.

#### Person in Charge:

Prof. Dr. Ir. I Wayan Runa, M.T.

#### Chairman:

Putu Aryastana, S.T., M.Eng., M.Si.

#### Members of Committee:

I Wayan Widanan, S.T., M.P.M.  
Ni Komang Armaeni, S.T., M.T.  
I Gede Surya Darmawan, S.T., M.T.  
I Kadek Merta Wijaya, S.T., M.Sc.  
Ir. I Nyoman Surayasa, M.Si.  
A. A. Gede Raka Gunawarman, S.T., M.T.  
Putu Ika Wahyuni, S.T., M.Si., M.T.  
Ir. I Wayan Jawat, M.T.

## TABLE OF CONTENTS

<b>Introduction</b>	iii
<b>Welcoming Speech by Rector of Warmadewa University</b>	iv
<b>Chairman Report</b>	v – vi
<b>Table of Contents</b>	vii – ix
<b>A. Keynote Speaker</b>	
1. Indonesian Sea Observed By Satellites <i>Prof. Yasuko Yanaka, Ph.D.</i>	1 – 2
2. Hope To The Future: Indicators For Sustainable Transportation Management In Indonesia <i>Prof. Dr. Ir. Agus Taufik Mulyono, M.T., ATU, IPU.</i>	3 – 13
3. Sustainability Viz -A-Viz Architecture & Culture: Case Of Diverse India <i>Anoop Kumar Sharma</i>	14 – 15
<b>B. Theme I : Sustainability</b>	
1. A Sustainable Agriculture Development in Kedungu Resort Project, Tabanan Bali <i>Ngelwan Ketut Arwin Drajendra, I Wayan Fogih Adnyana Putra</i>	16 – 21
2. Arrangement Model of Saba River Estuary Area Based on Tourism Environment for Water Conservation in Buleleng Regency <i>I Gusti Agung Putu Eryani</i>	22 – 29
3. Identification of Physical Changes of Pre- and Post-Reclamation Land in Serangan Island <i>I Gede Surya Darmawan, I Wayan Wirya Sastrawan</i>	30 – 36
4. Impact Resistance of High Strength Self Compacting Concrete With Steel Fiber <i>Gabriella Agnes Lenora S., M. Fauzie Sirwanto, Ashar Saputra</i>	37 – 44
5. Mix Design of High Strength SCC with Polypropylene Fiber based on Flow Mortar Mix <i>Kristyan Hari Subangkit, Imam Sahyarno, Andrear Triviyono</i>	45 – 52
6. Modelling as an Approach to Understand Resilience of Urban Kampung <i>Imelda Irmawati Damatik, Bakri Setiawan, Sasi Roycharyak, Sanjoto Usman</i>	53 – 61
7. Performance Based Contract Risk Relationship Analysis in Bojonegoro-Padangan Road Project <i>Eko Prihartanto, M.Djaya Balri</i>	62 – 68
8. Priority of ICT Implementation at The Largest Bus Terminal in Bandung, Indonesia <i>A. Caroline Susandi, Widyia Santosa, F. Frans Wisanto</i>	69 – 79
9. Sustainable Tourism and Fire Safety of Accommodation Facilities in Tourism Villages <i>I Dewa Gede Agung Dianana Putra, Anak Agung Gde Agung Yasa, Ngelwan Ketut Arwin Drajendra</i>	80 – 84
10. Thermal Performance of Wide Span Middle-Rise Building in Surabaya (Case Study: Gedung G-ITATS) <i>Dian P. E. Laksmiyanti, Poppy F. Nilasari</i>	85 – 90

### C. Theme II : Design

1.	Behavior of Nailed-Slab System on Peat Soil Under Loading <i>Anakki Warsana, Hary Christady Hardiyatna, Ahmad Rifa'i</i>	91 – 97
2.	Changes of Geotechnical Properties of Waste Embankment for Stability Analysis at Piyungan Disposal Site <i>I Wayan Ariyana Banaka, Ahmad Rifa'i, Fikri Faris</i>	98 – 105
3.	Coastline Change Analysis in Buleleng Regency by Using Satellite Data <i>Pati Aryastana, I Made Ardantha, Adriano Eko Nugroho, Edek Winady Candrayana</i>	106 – 113
4.	Comparative Analysis of Effectiveness of "Yellow Box Junction" in The City of Jakarta and Denpasar <i>Cokerda Putra Wiranutama, Ijokorda Itri Pragasningrum</i>	114 – 119
5.	Comparison of Single Bored Pile Bearing Capacity Based on CPT and SPT <i>I Gusti Ngurah Pati Dharmayasa</i>	120 – 126
6.	Development Taman Prestasi Surabaya as Thematic Park Reviewed from The User Behavior and The Nature of Space <i>Sigit Hadi Lakana, Felicia Trua Nurfitriani</i>	127 – 131
7.	Durability of Asphalt Concrete Mixture Using Lompoto's Tras as Fine Aggregate <i>Frice L. Desai, Ayuddin</i>	132 – 138
8.	Geotechnical Characteristics of Pumice for Reduce Liquefaction Potential <i>Muhajirah, Ahmad Rifa'i, Agus Darmawan Adi</i>	139 – 146
9.	Geotechnical Properties and Characteristics of Metamorphic Rock Mass on Poboya Gold Mine <i>Sriyani Ramadhani, Ahmad Rifa'i, Kabal Banak Suryolelono, Wahyu Wilepo</i>	147 – 154
10.	Influence of Volcanic Ash and Lime on Resilient Modulus for Subgrade <i>Devi Oktaviana Latif, Ahmad Rifa'i, Latif Budi Suparna</i>	155 – 159
11.	Landslide Hazards Due to Rainfall Intensity in The Caldera of Mount Batur, Bali <i>I Nengah Sivaria, Ahmad Rifa'i, Teska Faizal Fathani, Wahyu Wilepo</i>	160 – 167
12.	Optimization of Thermal Comfort in I Gusti Ngurah Made Agung City Park Design in Denpasar <i>I Wayan Wirya Santawan, I Gede Surya Darmawan</i>	168 – 175
13.	Spatial Distribution of Mercury Concentration in Traditional Gold Mining of Buladu <i>Marika Mahmud, Eby Santeng, Frice Desai, Fitriyana Lihawa, Yani Saleh</i>	176 – 182
14.	Steel Brace Damper with Progressive Failure Mechanism <i>I. P. Elita Saraswati, H.L. Hsu</i>	183 – 187
15.	Strength and Stiffness Behavior of Concrete Modular House <i>Tonafar Aji Prasata, Anang Kristianto, Kumbara Kamajaya Cahya Hermawan, Acha Rynandita</i>	188 – 192
16.	The Behavior of Steel Structure Exposed to Fire : A Review <i>Ni Komang Ayu Agustini, Andreas Triviyono, Djoko Suliryo, Suyitno</i>	193 – 197
17.	The Effect of Water Content Change in Pluto-Volcanic Subsurface Slope Stability Based on Limit Equilibrium and Finite Element Method <i>Indriati Martha Patai, Ahmad Rifa'i, Kabal Banak Suryolelono, Suprpto Sirmawikarto</i>	198 – 205
18.	The Influence of Capital Composition to Real Estate Investment Risk in Gianyar by Using @Risk Program <i>Ni Komang Armasni, Ni Wayan Meidayani Mastika, Anak Agung Sagung Devi Rahadiani</i>	206 – 214

- |     |  |           |
|-----|--|-----------|
| 19. | The Key Success of Commercial Building Construction : A Case Study on Charcara Restaurant Bali<br><i>I Wayan Widanar</i>   | 215 – 220 |
| 20. | Risk Variables in Collaboration of Private Government (PPP) for Toll Road Contracts<br><i>Petrus Ika Wahyuni, Wastono Oetomo, Sarwono HardjonoWijodi, Ekaepidi</i>   | 221 – 228 |
| 21. | Triplet Confinement Induced High Efficiency in Single Layer Doping of Phosphorescent Organic Light-Emitting Diode<br><i>Agus Pate Abijana, I Wayan Sukadana, I Wayan Swama, I Wayan Sagrayana, Yogo Divayana</i> | 229 – 235 |

#### D. Theme III : Culture

- |     |  |           |
|-----|--|-----------|
| 1.  | Architecture Knowledge in Manuscript of Lontar Asta Kosala Kosali (In the Perspective of Architecture is a Construction Process)<br><i>I Nyoman Nuri Arthana, Josef Prijotomo, Murni Rachmanenti, I Made Suwarya</i>   | 236 – 241 |
| 2.  | Cultural Landscape and Conservation of Balinese Cemetery, Meaning and Threatening<br><i>NI Made Fudantini</i>  | 242 – 246 |
| 3.  | Cultural Practice of Traditional Security Officers ( <i>Pecalang</i> ), Tourism and The Meaning of the Local Wisdom Value in Bali<br><i>I Wayan Wana Astara</i>  | 247 – 251 |
| 4.  | Form and Meaning of Aesthetic Elements on Architecture of Traditional House (Case Study of Traditional House in Bayung Gede, Bangli)<br><i>Silak Pate Naska Primadewi, I Gede Ngorak Sanatha, NI Pate Sada Nurjani</i> | 252 – 259 |
| 5.  | Local Wisdom in Environmental Management in Tenganan Pegriungsingan, Karangasem, Bali<br><i>I Gusti Bagas Suryawan, NI Made Jaya Senanti</i>   | 260 – 267 |
| 6.  | Proportion Identification of Candi Tebing Gunung Kawi in Tampaksiring, Gianyar - Bali<br><i>A.A. Gede Raka Gunawarman, I Edeh Merta Wijaya</i>   | 268 – 274 |
| 7.  | Soundscape Mapping in Heritage Area (Case study : 'Legi' Market, Kotagede, Yogyakarta, Indonesia)<br><i>Patricia P. Novianti</i>   | 275– 282  |
| 8.  | The Influence of Cultural Life on Spatial System in Tenganan Pegriungsingan, Karangasem - Bali.<br><i>I Wayan Rana, I Nyoman Warnata</i>   | 283 – 293 |
| 9.  | The Execution of Bali Architecture in Public Buildings as A Cultural Tourism Potential of The City of Denpasar in The Era of Globalization<br><i>Made Novia Indriani, Cornelia Hildegardis</i>                         | 294 – 303 |
| 10. | The Roles of Market Orientation and Knowledge Competency on The Relationship Between Innovation and Business Performance<br><i>NI Made Wahyuni, I Made Wardana, Gusti Ayu Ketut Gianteri</i>                           | 304 – 308 |
| 11. | Traditional Concept of Space and Building in Puri Agung Karangasem, Bali<br><i>Agus Karniawan, I Wayan Dikta</i>   | 309 – 316 |
| 12. | Typology of <i>Angkul-Angkul</i> Forms at Balinese Ethnic Houses in Denpasar<br><i>I Edeh Merta Wijaya</i>   | 317 – 324 |

# THERMAL PERFORMANCE OF WIDE SPAN MIDDLE-RISE BUILDING IN SURABAYA (CASE STUDY: GEDUNG G ITATS)

Dian P.E. Laksmiyanti<sup>1</sup>, Poppy F Nilasari<sup>2</sup>

<sup>1</sup>Department of Architecture, Institut Teknologi Adhi Tama Surabaya, Jl. Arief Rachman Hakim 100, Surabaya, Indonesia

<sup>2</sup>Department of Interior, Petra Christian University, Jl. Siwalankerto 121-131, Surabaya, Indonesia

dianpramita@itats.ac.id<sup>1</sup>

## ABSTRACT

Global warming and increase of energy consumption issues has encourage architect to design energy efficient building. The most crucial aspect in designing building in warm humid climate is solar irradiance and wind flow. High level of irradiance increase heat gain of the building and it also cause a higher cooling load and cooling energy. More compact the building form, the cooling energy consumption will be less. Compact or bulky building usually consume less cooling energy than the slim one because it has lower s/v ratio. Thus the bulky form, middle rise wide span building usually use atrium to help distribute daylight in to every room of the building. Unfortunately the daylight from the atrium brings considerable heat because the solar radiation that hit the horizontal plane is very high and it's very difficult to minimize solar gain in the roof. This research aims to evaluate the energy performance of middle rise wide span building in Surabaya. Case study of this research is Gedung G Institut Teknologi Adhi Tama Surabaya

This research use simulation method with ecotect 2011. Sample of middle-rise office buildings in Surabaya were taken randomly. Simulation was conducted to predict energy performance for cooling at a year. Energy performance of the buildings were found to bear some relations to composition of fenestration and opaque roof in atrium.

**Keywords:** *Atrium, Cooling Energy, Energy Efficient, Middle-rise.*

## A. INTRODUCTION

According to Green Building Index 2010, 60% of energy use in a building allocated for cooling energy and 55% of heat transfer was heat from building envelope. Architect can save the operational energy of the building with a good design that concern the environment and climatically responsive. High solar irradiance in tropics being a challenge for architect to build a comfortable building with low energy consumption. Building façade and roof should be designed to minimize the heat gain in to the building.

Yeang (1996) and Baker (2005) said operational energy in a building can be reduced if the building has a good design. Right choice of building materials, proper form, appropriate location and site planning will reduce the heat gain of the building moreover the cooling load and cooling energy. Envelope design of tropical building

should be careful because architect better design room with daylight and good air circulation, on another hand daylight and air circulation in to the building may also cause heat flow in to the building. Gaining heat in the building mens increasing cooling load and cooling energy.

Knowles (1981) said one of factor overheating external façade caused by domination of fenestration surface on building envelope. Most of fenestration surface such as clear glass, fiber glass, polycarbonate, usually have a great U-value and the decrement factor of that materials almost 0, it means that materials receive a lot of heat from environment and transmit almost all that heat in to the building.

By previous research octagonal building consume less cooling energy consumption than other shape such as rectangle, square, L shape, H shape, etc in the same volume (Laksmiyanti 2015). Craford (2011) also says more compact the building, energy consumption will be less. Compact form has less

surface to volume ratio which is mean less heat transfer from building envelope and heat gain. Trouble in bulky building is distribution of the daylight. Natural lighting can't achieve the middle of the building even though there's a huge window in the perimeter area. Yeang (1996) suggest to put an atrium to solve this problem. Skylight on the atrium let the sun light came into the middle area of the bulky building so the daylight can be evenly distributed (Heerwagen, 2004). In warm humid area envelope design has a big contribution in thermal comfort, visual comfort, and energy consumption (Markus & Moris, 1980), so it will be necessary t think about façade and roof design.

## B. LITERATURE STUDY

### Energy Efficient

Lechner (2007) devided operational energy in to three groups: Heating, cooling, and lighting energy. That kind of the most common energy use in building. In warm humid country we don't need heating. Hilmawan (2009) said for commercial building operational energy divided in to 4 groups such as Cooling energy, Lighting energy, Transportation and energy for electrical equipment.

Cooling energy is the energy used for the air system in a building to achieve the thermal comfort of the building user (Satwiko, 2004). BPPT in Hilmawan (2009) determines the percentage sharing of energy use in office buildings as follows: 47% for air system, 25% for lighting, 22% elevators, and 6% for other equipment. Referring to the energy efficient index, the limit of electrical energy used for cooling is 47% of 200kWh / m<sup>2</sup> / year or 94kWh / m<sup>2</sup> / year.

### Climate and Building Design

According to Szokolay (1987) and Moore (1993) tropical climatic regions have the following characteristics:

1. Cloudy sky throughout the year with cloud cover 40% -80% which can cause glare / glare
2. The sun shines all year long which results in high radiation
3. Very high humidity (40% -90%)
4. The difference in temperature is relatively the same day and night, and warm mean temperature (23°C – 34°C)
5. Low wind speed 1,1m / s - 4,3m / s.
6. High rainfall (1200mm / year)

Solar radiation makes an important contribution to the heat the building receives. Predictions of the average solar insolation (in a day, month or year) are required to calculate the cooling load obtained from radiation that falls on a wall or that penetrates through a window and roof

Solar radiation will cause the temperature to increase and affect the heat that enters the building. According Szokolay (2004) to calculate the amount of heat entering in the building envelope caused by radiation on the wall material is not opaque on one side of the building used the equation:

$${}_sQ_{so} = A \times U \times \mu \times \alpha \times R_{so} \times (G_{t-\phi} - G_{av})$$

with:

${}_sQ_{so}$  = The amount of incoming heat due to radiation on the wall is opaque (Watt/m<sup>2</sup>)

A = Area of wall (m<sup>2</sup>)

U = U-value (W/m<sup>2</sup>K)

$\mu$  = Decrement factor

$\alpha$  = Absorbance

$R_{so}$  = Resistivity outside surface

$G_t$  = Radiation on one side at that time (Watt)

$G_{av}$  = average of Radiation on one side (Watt)

The translucent wall material usually has a time lag ( $\phi$ ), so the amount of radiation seen is several hours before the calculation. For translucent walls, the heat entering the building due to radiation is affected by the glass surface area, alternating solar gain ( $\theta_a$ ) and the current radiation and average radiation in a day (Szokolay, 2004).

$${}_sQ_{sg} = A \times \theta_a \times (G_t - G_{av})$$

With:

${}_sQ_{sg}$  = The amount of incoming heat due to radiation on the tfenestration wall (Watt/m<sup>2</sup>)

A = Area of wal (m<sup>2</sup>)

$\theta_a$  = alternating solar gain

$G_t$  = Radiation on one side at that time (Watt)

$G_{av}$  = average of Radiation on one side (Watt)

Warm Humid area tend to have high temperatures both day and night. The temperature difference

between day and night is not too far away. This temperature has much effect on heat flow by conduction on building envelope. On the wall is not translucent heat magnitude due to conduction is affected by the surface area, U-value, decrement factor, and outdoor average (Szokolay, 2004). The translucent wall has a time lag so that the temperature seen is the temperature a few hours before the calculation time.

$${}_sQ_{co} = A \times U \times \mu \times (T_{o,(t-\phi)} - T_{o,av})$$

${}_sQ_{co}$  = The amount of incoming heat in opaque wall (Watt/m<sup>2</sup>)

A = Area (m<sup>2</sup>)

U = U-value (Watt/m<sup>2</sup>K)

$\mu$  = Decrement factor

Tot- $\phi$  = Outdoor Temperature -time lag (°)

Toav = average Outdoor Temperature (°)

On the glass, the current temperature will directly affect the amount of heat coming in at this time also because the glass has no time lag. Glass also has no decrement factor so that the incoming heat is calculated by the equation :

$${}_sQ_{cg} = A \times U \times (T_{o,t} - T_{o,av})$$

${}_sQ_{cg}$  = The amount of heat entered by conduction of the fenestration wall (Watt/m<sup>2</sup>)

A = Area(m<sup>2</sup>)

U = U-value (Watt/m<sup>2</sup>K)

T<sub>O<sub>t</sub></sub> = Outdoor Temperature (°)

Toav = Average of Outdoor Temperature (°)

### C. METHODOLOGY

This research aims to find the most efficient combination of opaque roof and skylight in energy use. Before finding the perfect combination, first building with bulky form was chosen randomly as a case study. Performance of the building was tested for the base case. This paper describes the thermal performance of the case study. Generally it use simulation method.

Simulation with ecotect 2011 used to analyze thermal performance of this building. Independent variable of this research the design of the atrium's roof. Cooling energy, Heat gain and Indoor temperature are kind of dependent variable.

## D. RESULTS AND DISCUSSION

### Surabaya Climate Condition

Based on the meso climate data, According to the data of meso climate in Surabaya, temperature of Surabaya is quite high. There's no outdoor condition which is in the comfort zone (fig 4.1). Neutral temperature of Surabaya is 26.1°C so the upper and lower limit for thermal comfort in temperature in between 24.1°C – 28°C. in hottest day, almost all day the temperature in above the upper limit (fig 4.2).

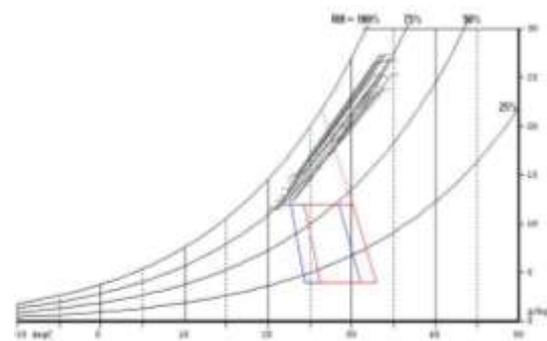


Figure 4.1 Psychrometric chart Surabaya in last 5 years (Source: Archipak)

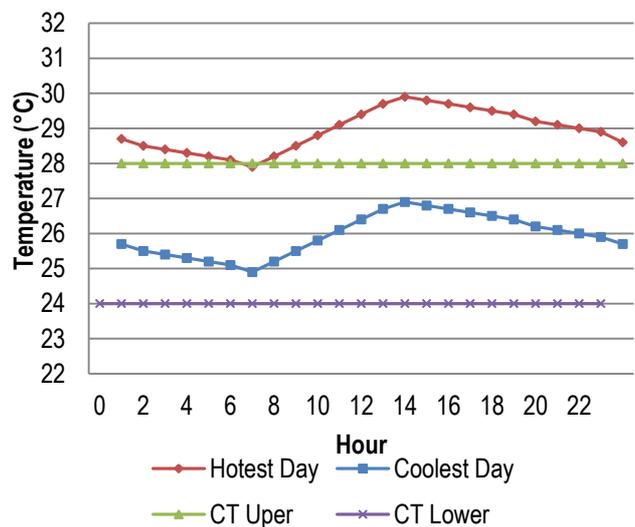
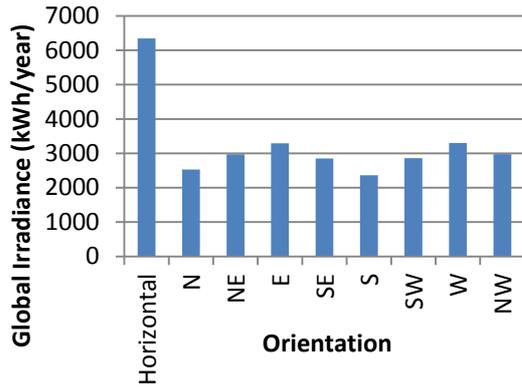


Figure 4.2 Outdoor Temperature (Source: Ecotect)

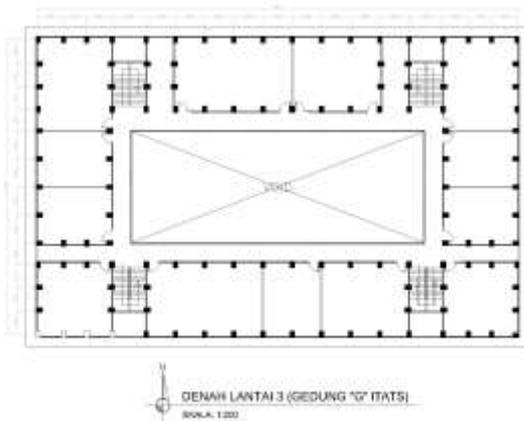


**Figure 4.3** Outdoor Temperature  
(Source: Archipak)

Thermal comfort also depended on global irradiance and humidity. Tropical climate has high amount of solar radiation. Figure 4.3 describe the amount of global solar irradiance at all orientation in Surabaya. The highest radiation comes at horizontal plane. It means building with high area of roof supposed to be aware about the roof design and material to minimize the radiation which is transmit to the building.

#### Condition of Gedung G ITATS

Gedung G ITATS is one of 4 storey building in Institut Teknologi Adhi Tama Surabaya with bulky appearance and having atrium on it. Ground floor of this building use for administrative room. 2<sup>nd</sup> up to 4<sup>th</sup> floor of this building use for classroom. Figure 4.4 show the typical floor plan of this building. Operational time of the building from 8.00 am – 10.30 pm in weekdays and off in weekend.



**Figure 4.4** Floor plan of Gedung G ITATS  
(Source: Laksmiyanti)

#### Cooling Energy and Heat Flow in Gedung G ITATS

Total cooling energy consumption in gedung G Institut Teknologi Adhi Tama Surabaya in a year is 407.4 kWh/m<sup>2</sup>/Year (Tabel 4.1), it's way too far from the standart. Energy efficient building suppose to consume total operational energy less than 200kWh/m<sup>2</sup>/Year. According to SNI in Hilmawan (2009), maximum percentage for Air conditioning system for office building is 47% or equal 98kWh/m<sup>2</sup>/Year

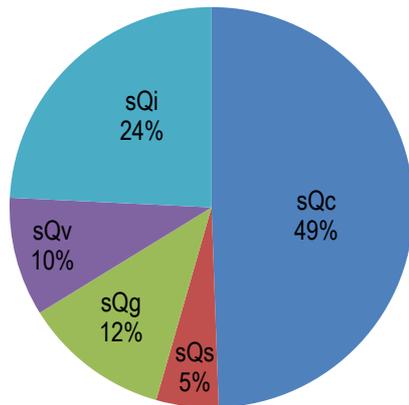
Total energy use at ground floor is lower than others because this floor has smaller room and it is an administrative room which is operate 8 hours a day during the weekdays and off in weekend. Moreover there are a lot of tree around the building which also shade the building and reduce the direct and indirect radiation heat gain in to this building. This building has no ceiling, and no insulation in the roof. The classroom covered by concrete roof and the void covered with galvalum and polycarbonate. Galvalum, polycarbonate and concrete has high conductivity so the conduction heat gain in the 3<sup>rd</sup> floor of this building is higher than others. Ceiling can use as insulation because plafond and cavity between concrete and plafond can block the heat by the convection.

**Tabel 4.1** Total cooling energy of model in a year

MONTH	COOLING ENERGY (kWh/m <sup>2</sup> )				TOTAL COOLING ENERGY (kWh/m <sup>2</sup> )
	Ground floor	1st floor	2nd floor	3rd floor	
Jan	4.2	9.0	9.2	10.3	32.8
Feb	3.6	7.4	7.5	8.7	27.2
Mar	4.2	9.9	10.1	12.4	36.6
Apr	4.1	10.6	10.9	13.0	38.5
May	4.1	10.7	11.0	12.9	38.7
Jun	3.7	8.3	8.6	9.6	30.2
Jul	3.7	7.8	8.0	8.8	28.3
Aug	3.4	5.9	6.0	6.3	21.6
Sep	3.8	7.6	7.8	9.1	28.3
Oct	4.4	11.8	12.1	15.2	43.6
Nov	4.3	10.9	11.1	13.4	39.7
Dec	4.7	11.5	11.7	13.8	41.7
Total	48.2	111.4	114.1	133.7	407.4

Great amount of cooling energy in this building caused by a great heat gain into the building. Most het gain comes from transfer by conduction (fig 4.5). sQc is conduction heat flow, it's heat flow from that building envelope which is occur 24 hours. To minimize the sQc we should design the wall and roof carefully. Too many window in the wall, too large fenestration roof in atrium, high u-

value of opaque wall and roof can caused the increase of the conduction heat gain.



**Figure 4.5** Heat Gain Breakdown of Gedung G ITATS

(Source: Laksmiyanti)

sQi is the second highest from that diagram. sQi means internal heat gain, heat which is come from electricity and activity in the building. Electricity in this building is divided in to three groups: Lighting, Air Conditioning, and electrical equipment. Thus long operational hours, internal heat gain of this building increase. Wrong design of the window also being next factor of increasing sQi. Actually, there is no window in this building, only fenestration wall. No windows means no air flow, and wide area of fenestration wall make the heat which is transmit to the building well be remain and increasing over and over again because there is no way of air flow to bring the heat out. The only way to create thermal comfort in no window building is use air conditioning system. It means increasing of power consumption and internal load.

The 3<sup>rd</sup> highest heat gain in this building is radiation heat gain. Radiation gain divided in to two:

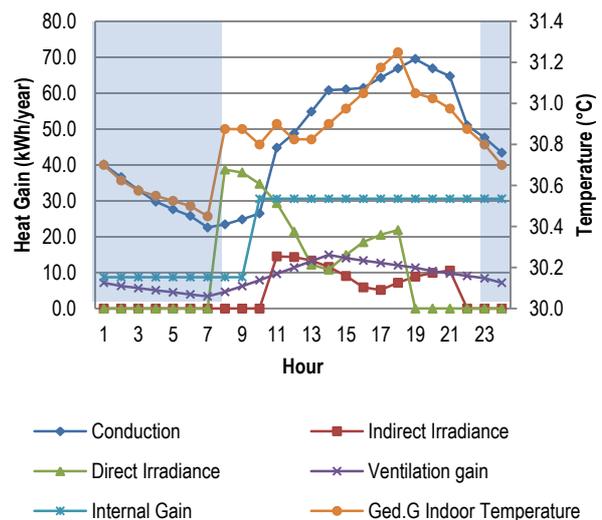
1. Direct irradiance heat gain (sQg) is the radiation which is comes and transmit directly to the building. Usually this type of heat flow occur in transparent wall and roof.
2. Indirect irradiance gain (sQs) is the radiation heat gain trough opaque surface. The solar radiation hit the opaque surface, and there some of it reflected and absorbed. The absorbed heat will be transmit to the building in a while depend on the time lag of the materials.

In this building sQg is so much higher than sQs. There are a lot of solar radiation transmit into this building from the fenestration surface. This atrium has 50% skylight, it makes high quantity of direct irradiance transmitted. To make it lower, the composition of transparent surface should be reduced.

sQv is ventilation gain. Heat gain which is enter the building through air flow of the building. This building has no window doesn't mean has no air flow at all. All room use air conditioning which is usually has 2 Air Change per Hour, so the ventilation gain of this building comes from this air flow. This building use full air conditioning, that's why the ventilation gain of the building quite low.

### Hourly Heat Flow in Gedung G ITATS

Indoor temperature in this building starts increasing in 8.00.am and decrease after sunset, after the direct irradiance being zero (fig. 4.6). According to that graphic the increasing of indoor temperature at that time caused by the increase of direct irradiance gain in the same time. Indoor temperature keep increasing till 18.00.pm because there's delay heat gain through opaque component . To reduce sQs and sQg in this building, architect can reduce the transparent surface. Designing the shape of atrium could be a good alternative to reduce the direct irradiance gain.



**Figure 4.6** Hourly Heat Gain of Gedung G ITATS

(Source: Laksmiyanti)

High conduction flow in this building caused by the huge area of material with high U-value. Tabel 4.2 and 4.3 describe the thermal properties of opaque and fenestration material inthi building. Using metal roof with no insulation is a bad idea. Change the materials with lower conductivity can cut the amount of conduction heat flow.

**Tabel 4.2** Thermal Properties of Opaque Materials

	Brick Plester	Concrete	Galvalum
U val	3.0	0.9	7.14
admittance	4.1	2.3	7.1
T lag	2.9	7.0	0
Dcr factor	0.8	0.6	1
abs	0.3	0.9	1

**Tabel 4.3** Thermal Properties of Fenestration Materials

	Clear Glass	Poly- carbonate
U val	6.00	5
admittance	6.00	5
Sgf	0.80	0.78
Asgf 1	0.64	0.38
Asgf 2	0.47	0.47
SC	0.93	1

## 1. CONCLUSION

Thermal performance of gedung G Intitut Teknologi Adhi Tama Surabaya is awful. too many fenestration surface in the wall and roof make the heat gain increase rapidly. Instead of saving energy by reduce the lighting energy, put a wide opening causing the high irradiance and conduction heat flow. Unfortunately total energy consumption for cooling is higher than lighting energy which is wanted to save.

## REFERENCES

- Baker Nick dan Koen Steemers, (2005), *Energy and Environmental in Architecture*, Taylor & Francis Group, New York
- Crawford Robert H, Czerniakowski Isabella, Fuller Robert J (2010), A comprehensive framework for assessing the life cycle energy of building construction assemblies, *Journal Science Direct*, Architectural Science Review 53 (2010) 288–296.
- Dian P.E. Laksmiyanti (2016), Kinerja Bentuk Bangunan Perkantoran Bertingkat Menengah Di Surabaya Terhadap Efisiensi Energi Pendinginan, *Jurnal IPTEK ITATS* vol:20 no 1.
- Yeang Ken (1996), *Bioclimatic Skyscraper*. London: Artemis London Limited
- Hilmawan Edi dan Said Mustafa (2009), “Energy Efficiency Standart and Labeling Policy in Indonesia”, International cooperation for Energy Efficiency Standart and Labelinmg Policy, Tokyo

Knowles, R.L. (2003), “The Solar Envelope: Its Meaning for Energy and Buildings”, *Journal of Energy and Buildings*

Lenchner Norbert (2007), *Heating, Cooling and Lighting*, PT. Raja Grafindo Persda, Jakarta

Markus T.A, Morris E.N (1980), *Buildings, Climate and Energy*, Pitman Publishing Limited, London

Satwiko Prasasto (2004), *Fisika Bangunan 2*, Andi, Yogyakarta

Szokolay, S.V. (1987), *Thermal Design of Buildings*. RAI A Education Division, Canberra, Australia.

Szokolay, S.V. (2004), *Introduction to Architectural Science: The Basis of Sustainable Design*. Oxford: Elsevier Science