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# The empirical analysis model on identifying sick building syndrome in hot humid tropical buildings

Kartikawati N.<sup>a</sup>, Setyowati E.<sup>b</sup>, Indrosaptono D.<sup>b</sup>

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# Abstract

A tropical hot humid climate provides high humidity that influences the occupant's comfort. This study highlights a comparison of physical measurements and perceptions related to thermal comfort, indoor air quality, and sick building syndrome (SBS) in tropical humid climate buildings. The research method used ASHRAE 2017 and analysis using SPSS 24 by two analytical models, i.e., Model 1 and Model 2. The Model 1 included measurement data of independent variables T, RH, V, and CO<sub>2</sub>, and SBS dependent variable, while the Model 2 used perception data of independent variables T, RH, V, and QA, and SBS

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Volume 9 2	021				
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Vol.8 No.1	Vol.8 No.2	Vol.8 No.3	Vol.8 No.4	Vol.8 No.5	Vol.8 No.6
Volume 7 2	019				
Vol.7 No.1	Vol.7 No.2	Vol.7 No.3A	Vol.7 No.3	Vol.7 No.4	Vol.7 No.5
Vol.7 No.6	Vol.7 No.6A				
Volume 6 2	018				
Vol.6 No.1	Vol.6 No.2	Vol.6 No.3	Vol.6 No.4	Vol.6 No.5	Vol.6 No.6
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Vol.5 No.1	Vol.5 No.2	Vol.5 No.3	Vol.5 No.4	Vol.5 No.5	Vol.5 No.6
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Vol.3 No.1	Vol.3 No.2	Vol.3 No.3	Vol.3 No.4	Vol.3 No.5	Vol.3 No.6
Volume 2 2	014				
Vol.2 No.1	Vol.2 No.2	Vol.2 No.3	Vol.2 No.4	Vol.2 No.5	Vol.2 No.6
Vol.2 No.7	Vol.2 No.8	Vol.2 No.9			
Volume 1 2	013				
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# Vol 9(Jan, 2021) No 1

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Filipus Priyo Suprobo, Ririn Dina Mutfianti [Abstract] [Full Text] [Full Article - PDF] pp. 1 - 8 DOI: 10.13189/cea.2021.090101



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Comparative Study on Restaurants' Furniture: Ginkgo and Niazi's Restaurants in
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Performance Characteristics of Road-base Containing Mixed Steel Slag and Cathode
Ray Tube Glass Ahmad Yusri Mohamad, Maslina Jamil, Nur Izzi Md. Yusoff, Mohd Raihan Taha [Abstract] [Full Text] [Full Article - PDF] pp. 42 - 51 DOI: 10.13189/cea.2021.090104
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Tropical Buildings Nurrahmi Kartikawati, Erni Setyowati, Djoko Indrosaptono [Abstract] [Full Text] [Full Article - PDF] pp. 52 - 73 DOI: 10.13189/cea.2021.090105
Energy Equivalent of Rainwater Harvesting for High-Rise Building in the Philippines
Jibsam F. Andres, Michael E. Loretero [Abstract] [Full Text] [Full Article - PDF] pp. 74 - 84 DOI: 10.13189/cea.2021.090106
Geotechnical Hazards and Environmental Changes Threatening the Sphinx Avenue and the Project of Luxor: Open Museum Ibrahim A. Alnaser, M. M. Abuzeid, A. F. Gelany, Ahmed H. Backar, Mohammed Y. Abdellah [Abstract] [Full Text] [Full Article - PDF] pp. 85 - 90 DOI: 10.13189/cea.2021.090107
Investigation of the Influencing Soil Parameters on the Air Entry Values in Soil-Water
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Integration of Solar Panels as the Shading Devices to Lower the Indoor Air
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Cyprus Yaman Sokienah [Abstract] [Full Text] [Full Article - PDF] pp. 124 - 129 DOI: 10.13189/cea.2021.090110
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Preserving the Object of Cultural Heritage Marina V. Knyazeva, Sergey V. Mokhovikov, Lidiya V. Alekseenko, Natalia S. Bryazgunova, Genadiy B. Baranov [Abstract] [Full Text] [Full Article - PDF] pp. 130 - 138 DOI: 10.13189/cea.2021.090111
The Acoustical Performance of Water Hyacinth Based Porous-Ceramic Compared to the Biomass Fiber Composites for Architecture Application

# The Empirical Analysis Model on Identifying Sick Building Syndrome in Hot Humid Tropical Buildings

# Nurrahmi Kartikawati<sup>1</sup>, Erni Setyowati<sup>2,\*</sup>, Djoko Indrosaptono<sup>2</sup>

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**Abstract** A tropical hot humid climate provides high humidity that influences the occupant's comfort. This study highlights a comparison of physical measurements and perceptions related to thermal comfort, indoor air quality, and sick building syndrome (SBS) in tropical humid climate buildings. The research method used ASHRAE 2017 and analysis using SPSS 24 by two analytical models, i.e., Model 1 and Model 2. The Model 1 included measurement data of independent variables T, RH, V, and CO<sub>2</sub>, and SBS dependent variable, while the Model 2 used perception data of independent variables T, RH, V, and QA, and SBS dependent variable. The study found the conditions were unsuitable with ASHRAE 2017, however, the new SBS index model for the hot-humid tropic has been established. The average temperature was 29.4-31.3°C, the perception of 'neutral' was responded by 50.6% of all respondents, 36.7% stated 'warm' and 7.6% stated 'hot'. The average relative humidity was between 77-82.4%, but about 50.6% of respondents declared 'neutral', only 8.9% declared 'slightly damp', and 2.5% stated 'damp'. The test results showed Model 2 performed the cyclical effect on SBS, in contrast, Model 1 had no significant effect on SBS because of the varied adaptation of occupants.

**Keywords** Hot Humid Tropical Buildings, Thermal Comfort, Indoor Air Quality, Sick Building Syndrome

# **1. Introduction**

One of the remarkable things in occupancy is the indoor comfort aspect and the occupant's health. The comfort and health of the residents are inseparable from thermal conditions and indoor air quality. Thermal comfort condition is determined by climatic aspects, such as in Indonesia, which has a hot humid tropical climate. As the main character of the humid tropical climate is high rainfall, high humidity, and warm to hot temperatures becomes the influential factors for indoor thermal comfort. Building with high moisture and warm temperatures can be a habitat for fungus and other microorganisms that can interfere with occupant's health [1]. On the other side, air pollutants coming from inside and outside the building affect the air quality in the building. Air quality degradation brings a notable impact on human health. Approximately 4-5 million people passed away due to air pollutions in 2017 [2]. In contrast, a good air quality takes part in effective healing for some patients that are too sensitive to air pollutants [3]. Particulate matter PM 2.5 is considered as the most remarkable factor to influence the air quality index for more than 90% [4]. The particle of PM 2.5 is associated with vehicle and traffic emission [4]. Due to the vast effect of air quality, providing a pure air policy and implementation plan is necessary, especially for areas with high air pollution [5].

During this pandemic, the environmental hygiene aspects of both outdoor and indoor become important. The

# Effect of Additional Reinforcement Length in Beams on Base-Shear Capacity in Performance-based Design of Low-Rise Buildings

Poleswara Rao Kovela<sup>1,2,\*</sup>, Balaji K. V. G. D<sup>1</sup>, Phanindranath T. S. D<sup>1,3</sup>, B. Santhosh Kumar<sup>4</sup>

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(b):Poleswara Rao Kovela, Balaji K. V. G. D, Phanindranath T. S. D, B. Santhosh Kumar(2021).Effect of Additional Reinforcement Length in Beams on Base-Shear Capacity in Performance-based Design of Low-Rise Buildings. Civil Engineering and Architecture, 9(1), 9-22. DOI: 10.13189/cea.2021.090102.

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**Abstract** Most of the existing low rise RCC buildings with 4 to 6 floors were constructed pursuant to the code provisions without detailed Earthquake analysis. To comply with the revised code provisions, it is essential to build up the seismic resistance of the existing buildings. International building safety agencies such as NEHRP, FEMA, and ATC etc., formulated the Performance-based design methods to verify the seismic resistance of the existing buildings and also recommend the retrofit the building to achieve the targeted performance. Pushover method (nonlinear static analysis) is one of the methods. This paper describes the increase of seismic capacity of structure with the additional steel contribution from 25 % to 75% increase in the beams near the beam-column joints. Moreover, this additional steel is placed up to 02.L, 0.25L and 0.3L of the beam span. To accomplish the above parameters, 4-storey, 5-storey and 6-storey rectangular framed structures are analyzed with the pushover analysis. The seismic capacity curves in terms of base shear versus displacement are illustrated. It is found that 10 to 25% of base shear is increased when beams are provided with additional reinforcement from 25% to 75% @0.2L. In this case of increasing the additional steel length from 0.20L to 0.3L, nearly 5% increase of the base shear is observed in width direction but no augmentation is observed in the

length direction of the building.

**Keywords** Pushover Analysis, Base Shear Capacity, Seismic Demand, Hinge

# **1. Introduction**

Buildings in urban India are predominantly observed from 4 to 6 floors which were constructed long back as per the code provision applicable at that point of time. The codal provisions for the seismic design are being updated/revised based on the research done in the field of seismic engineering. About thirty earthquakes occurred in India during the last 50 years. It was estimated that more than one lakh people died and more than two lakh people injured in the last 20 years due to the damages occurred to the buildings and other structures during the earthquakes in the Indian subcontinent.

To reduce the human loss and property damage in future, it is essential to provide the adequate seismic capacity to the existing buildings. In this context, a lot of research work is being carried out in the USA and other developed countries. Guidelines were formulated in

# **Energy Equivalent of Rainwater Harvesting for High-Rise Building in the Philippines**

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Abstract The Philippines is in a tropical location where rainwater is abundant for the frequent rain in a year. Rainwater becomes waste flowing down the drains causing flood, especially in urban areas. This problem initiates local governments in some cities in the Philippines to adapt and implement Green programs that require the installation and utilization of rainwater catchment system. Though this program addresses the control of flood caused by the rain, the generation of energy by utilizing rainwater as an energy source is not yet considered. With this, the study computes the equivalent energy generation by utilizing rainwater. The rainwater energy equivalent includes the following: the increasing number of high-rise building construction as catchment facility; the rainfall precipitation of 58 stations in the Philippines; the floor area and the types of the building: and the volume of water consumption per person per day. The energy equivalent was computed using the 40% of the time the rainfall precipitation equaled or exceeded the other with the average floor area specified from the approved building permit as of 2017. The study established a mathematical equation as an equivalent energy of rainwater utilization. The equation of energy equivalent was derived using the initial building height of 5 meters and an additional succeeding height of 3 meters per floor level.

**Keywords** Rainwater, Rainfall Precipitation, Energy, High-Rise Buildings

# **1. Introduction**

Heavy rainwater precipitation, which in other contexts is welcomed because it provides and supplies the necessary water for agricultural purposes and even for domestic use. On the other hand, heavy rainwater precipitation may also cause deadly and destructive flash floods. The presence of rainfall exists in many locations and is considered an abundant source of water. Though it might have a negative impact in a few aspects, the utilization of this water resource was studied in terms of rainwater harvesting system abbreviated as RWH or RHS. Studies on rainwater harvesting were considered sustaining shortage of water supplies for irrigation, washing purposes as well as potable water. Rainwater harvesting is an indigenous resources considered as a source of renewable energy. This implies that this RWH contributes importance for sustainable development since it has zero environmental impact compared to conventional energy [1].

The study on hybrid system, solar-wind-rain eco-roof system also includes and mix Rainwater harvesting [2]. Rainwater in this study is collected in the tanks purposely for the efficient use of energy in which the collected rainwater will be used to spray the roof to maintain cooling in the building. Another tank in the design system was used for washing purposes. Rainwater harvesting technique was significantly studied as a supply of water needed mostly for non-potable water application followed by rainwater treatment for potable or drinking water purposes.