SKRIPSI 51

EFFECT OF THE GEOMETRIC PROPORTION OF A SEMI-ENCLOSED ATRIUM ON DAYLIGHT PERFORMANCE IN ADJACENT SPACES

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BANDUNG
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Bandung, 06 January 2022

Devina T. Adisesha

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Devina T. Adisesha

Abstract

The importance of natural light in architecture relates to the anthropological benefits it presents, be it psychological and physiological well-being of the users. Furthermore, in the interest of overcoming climate change, daylighting also reduces and/or eliminate the need for artificial lighting during the day time which in turn reduces the overall energy consumption of the building. However, the desired positive outcomes from designing a space with daylight is often times hindered by lack of comprehensive planning backed by quantitative data to achieve the optimal daylight performance in the aforementioned space.

This research assesses daylight performance quantitatively in terms of the daylight index – daylight factor and its derivatives: average daylight factor (aDF) and uniformity ratio (UR), to comprehensively map and gauge the overall visual comfort in fulfilment of the Building Research Establishment Environmental Assessment Method (BREEAM) certification set by the British Research Establishment (BRE). The atrium at the Hilton Hotel Bandung is an asymmetric semi-enclosed atrium oriented to the East with translucent glass as the space-forming elements, as roofing as well as the eastern façade of the atrium.

This study is conducted in two phases; firstly, the research to assess the daylight performance of the existing case study which will then be the baseline for the modification of variables (elements and configurations) in a causal comparative research to reach the optimum daylight performance, followed by parametric correlational research to find the optimal atrium proportion that optimises daylight performance in the adjoining spaces of an asymmetric semi-enclosed atrium such that of the case study.

The on-site data collection utilizes light meter to measure the illuminance of the area as well as digital laser measure for the dimension of the atrium, while the daylight simulation of this research is conducted through the computer simulation software LightStanza. The model used in this simulation is created in SketchUp which has a direct extension into LightStanza.

It is found that the existing atrium provides a sufficient amount of daylight to the drop-off area as well as the first and third floor bridge coded S1, W1, and W3 respectively as shown with the fulfilment of all aDF, DFT, and UR standards. The problematic areas are the identified as that of the reception area, the ballroom and meeting room foyer coded N1, N3, and S3 respectively.

The parametric study shows positive relations between the width of an asymmetric semi-enclosed atrium to the average Daylight Factor (aDF) performance as well as the Daylight Factor (DF) threshold of the adjacent spaces of the atrium itself. While Uniformity Ratio (UR) remains insignificantly affected by the geometrical changes. This reaffirms the notion that the geometry of an atrium is more significant in influencing the daylight performance compared to the reflectance of the elements within the atrium.

Key Words: Atrium, daylight performance, geometric proportion, aDF, DF threshold, UR

Abstrak

Pentingnya pencahaya alami dalam arsitektur berkaitan dengan manfaat antropologis, baik itu kesejahteraan psikologis maupun fisiologis penggunanya. Selain itu, mengingat fenomena perubahan iklim, pencahayaan alami juga mengurangi dan/atau menghilangkan kebutuhan akan pencahayaan buatan pada siang hari yang dapat mengurangi konsumsi energi bangunan secara keseluruhan. Namun, hasil positif yang diharapkan dari merancang ruang dengan pencahayaan alami sering kali terhalang oleh kurangnya perencanaan komprehensif yang didukung oleh data kuantitatif untuk mencapai kinerja pencahayaan alami yang optimal di ruang tersebut.

Penelitian ini menilai kinerja pencahayaan alami secara kuantitatif melalui indeks pencahayaan alami – Daylight Factor (DF) *dan turunannya:* average Daylight Factor (aDF) dan Uniformity Ratio (UR), *untuk secara komprehensif memetakan dan mengukur kenyamanan visual secara keseluruhan dalam pemenuhan standar* Building Research Establishment Environmental Assessment Method (BREEAM) *yang ditetapkan oleh* British Research Establishment (BRE). *Atrium di Hotel Hilton Bandung merupakan atrium semi-tertutup asimetris yang berorientasi ke Timur dengan elemen pembentuk ruang kaca tembus pandang pada atap dan fasad atrium timur.*

Penelitian ini dilakukan dalam dua tahap; pertama, penelitian untuk menilai kinerja pencahayaan alami dari studi kasus yang ada yang kemudian akan menjadi dasar untuk modifikasi variabel (elemen dan konfigurasi) dalam penelitian komparatif kausal untuk mencapai kinerja pencahayaan alami yang optimal, diikuti oleh penelitian korelasi parametrik untuk menemukan proporsi atrium optimal yang mengoptimalkan kinerja pencahayaan alami di ruang sekitar atrium semi-tertutup asimetris seperti pada studi kasus.

Pengambilan data di lapangan menggunakan light meter untuk mengukur iluminasi area serta pengukuran laser digital untuk dimensi atrium, sedangkan simulasi pencahayaan alami penelitian ini dilakukan melalui perangkat lunak simulasi komputer LightStanza. Model yang digunakan dalam simulasi ini dibuat di SketchUp yang memiliki ekstensi langsung ke LightStanza.

Ditemukan bahwa atrium yang ada memberikan cahaya matahari yang cukup ke area drop-off serta jembatan lantai pertama dan ketiga masing-masing berkode S1, W1, dan W3 seperti yang ditunjukkan dengan pemenuhan semua standar aDF, DFT, dan UR. Area yang teridentifikasi bermasalah adalah area resepsionis, ballroom *dan* foyer *ruang pertemuan masing-masing berkode N1, N3, dan S3.*

Studi parametrik menunjukkan hubungan positif antara lebar atrium semi-tertutup asimetris dengan kinerja average Daylight Factor (aDF) *dan* Daylight Factor Threshold (DFT) *dari ruang sekitar atrium itu sendiri. Sedangkan Uniformity Ratio (UR) tetap tidak dipengaruhi signifikan oleh perubahan geometri. Ini menegaskan kembali gagasan bahwa geometri atrium lebih signifikan dalam mempengaruhi kinerja pencahayaan alami dibandingkan dengan pemantulan elemen di dalam atrium.*

Kata Kunci: *Atrium, performa pencahayaan alami, proporsi geometris, DF, UR*

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Last but not least, other than to earn a Bachelor's Degree in Architecture from the Department of Architecture, Faculty of Engineering, Parahyangan Catholic University, the author also hopes that this undergraduate thesis to be beneficial for academic research purposes as well as practical uses in the field of built environment.

For *"a really great man is known by three signs – generosity in the design, humanity in the execution, and moderation in success."* (Otto Von Bismarck).

Bandung, January 06th, 2022

Devina T. Adisesha

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PREFACE

1.1 Background

The importance of natural light in architecture relates to the anthropological benefits it presents, both psychological and physiological well-being of the users. Natural light has been linked to the improvement of health of the body, increase in productivity, decrease stress levels, and a general increase in the overall well-being of building occupants (Edwards & Torcellini, 2002). Furthermore, in the interest of overcoming climate change, daylighting also reduces and/or eliminates the need for artificial lighting during the day time which in turn reduces the overall energy consumption of the building. However, the desired positive outcomes from designing a space with daylight is oftentimes hindered by lack of comprehensive planning backed by quantitative data to achieve the optimal daylight performance in the aforementioned space.

This research assesses daylight performance quantitatively in terms of the daylight index – daylight factor and its derivatives: average daylight factor (aDF) and uniformity ratio (UR), to comprehensively map and gauge the overall visual comfort in fulfilment of the Building Research Establishment Environmental Assessment Method (BREEAM) certification set by the British Research Establishment (BRE).

Atrium (plural: atria) is one of the common typologies found in the architecture of public buildings. Atrium is oftentimes used as a node within the circulatory path of a building with specific functions situated in the adjoining spaces as is in the case study being discussed. This research studies the daylight performance in the adjoining spaces of the atrium of the Hilton Hotel in Bandung, West Java, Indonesia.

Figure 1.1 Exterior of the Hilton Hotel Bandung
Figure 1.2 Interior atrium space of the Hilton Hotel Bandung

(Source; www.archdaily.com)

The atrium at the Hilton Hotel Bandung is an asymmetric semi-enclosed atrium oriented to the East with translucent glass as the space-forming elements, as roofing as well as the eastern façade of the atrium. This allows the desirable morning sunlight to enter the atrium while preventing the harsh afternoon rays from causing thermal discomfort. The atrium is angled at 15 degrees on the North side which is made up of light-coloured sandstone which acts as an architectural aspect as well as a reflective surface to help with the dissipation of daylight to the adjacent spaces opposite the slope. However, this resulted in an uneven daylight performance in the overall adjacent spaces of the atrium.

1.2 Problem Identification

Preliminary observation suggests that due to the geometric factors and material of the space forming elements, the daylight performance in the adjacent rooms around the atrium of the Hilton Hotel Bandung is insufficient and uneven which in turn might result in the less-than-optimal spatial experience by the user during certain times of the day.

The following is the section and floor plan of the atrium of the Hilton Hotel Bandung:

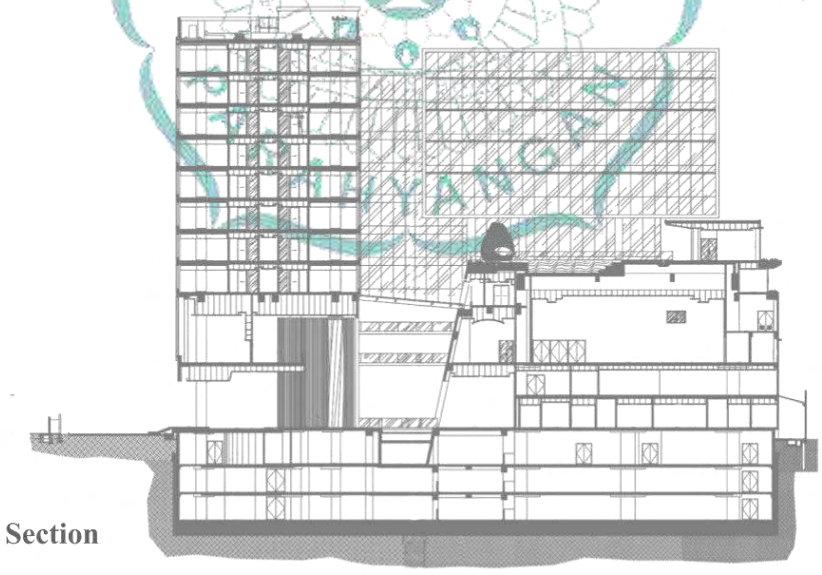
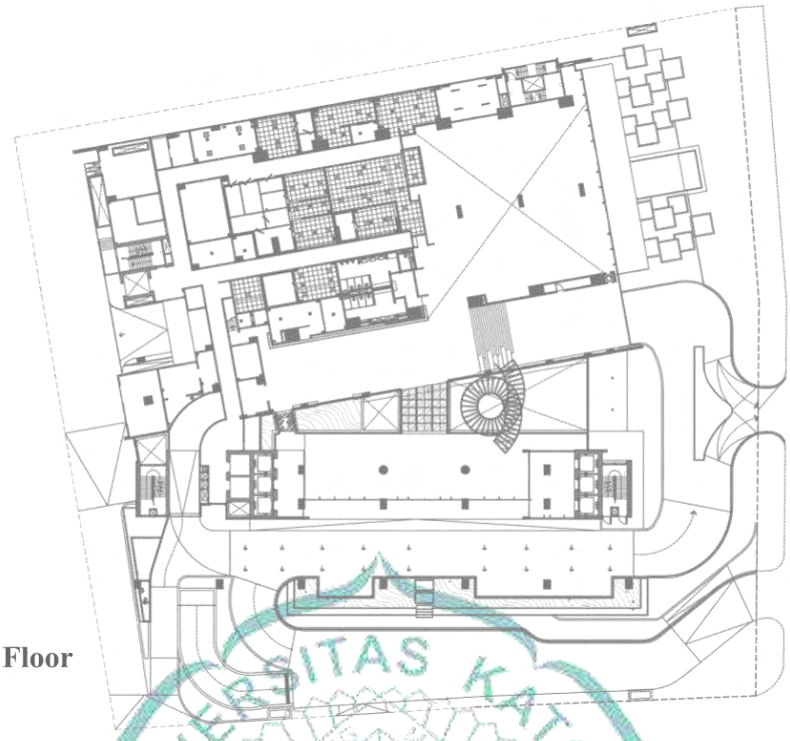


Figure 1.3 Section of the atrium of the Hilton Hotel Bandung

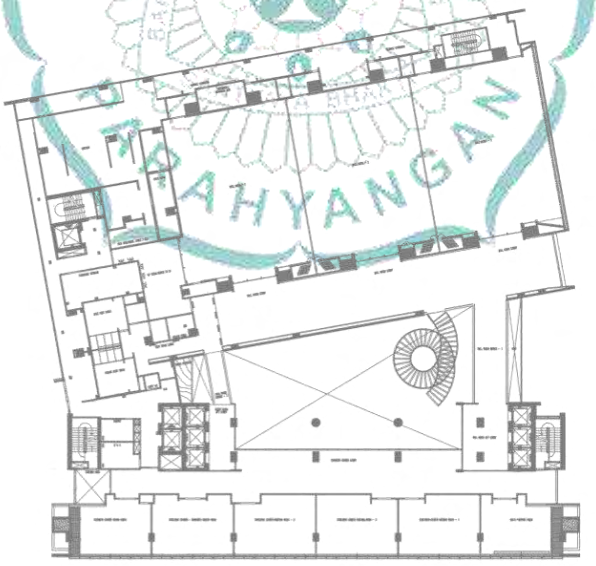
(Source: Management of the Hilton Hotel Bandung)



1st Floor

Figure 1.4 First floor plan of the Hilton Hotel Bandung (ground floor)

(Source: Management of the Hilton Hotel Bandung)



3rd Floor

Figure 1.5 Third floor plan of the Hilton Hotel

(Source: Management of the Hilton Hotel Bandung)

The result of the observation and preliminary data collection conducted on Wednesday, September 29th, 2021 at 12 00 hrs (GMT +7) [see Appendix 1] shows that the 1st floor reception area and 3rd floor meeting room and ballroom foyer does not have sufficient daylight from the atrium. The preliminary data suggests that there is room for improvements on the aspect of daylight performance in the adjacent spaces around the atrium.

1.3 Research Question

Based on the aforementioned background and problem identification, the research questions are formulated as follows:

a. How is the daylight performance of the adjacent spaces of the existing building atrium?

b. How can the architectural elements in and around the atrium can be altered to optimize the daylight performance in its adjacent spaces?

c. What is the ideal atrium proportion to meet the minimum natural lighting standards in the adjacent spaces of an asymmetric semi-enclosed atrium?

1.4 Research Purpose and Utility

1.4.1 Research Purpose

This study aims to:

a. Analyse and improve the daylight performance of the case study which is the adjacent spaces of the atrium of the Hilton Hotel Bandung,

b. Assess the effect of different geometric and elements configurations to the daylight performance in the adjacent spaces of the atrium, and

c. Produce a reference graph of the daylight performance of the adjacent spaces of an asymmetric semi-enclosed atrium of similar configuration and orientation with regards to an independent variable.

1.4.2 Utility

This research is useful for providing optimization recommendations for existing buildings by analysing the performance of natural lighting in each space,

in addition to generating reference data that can be used as a tool to better design asymmetric semi-enclosed atriums in the future.

1.5 Scope of Research

This research assesses the daylight performance of the adjacent spaces of the atrium of the Hilton Hotel Bandung. The atrium opens to the 1st/grand floor and the 3rd floor as the 2nd floor of the hotel is entirely back-of-house (BoH) area. As characteristic of a semi-enclosed atrium, the research area is limited to the direct adjacent spaces of the atrium as depicted in the figures below.

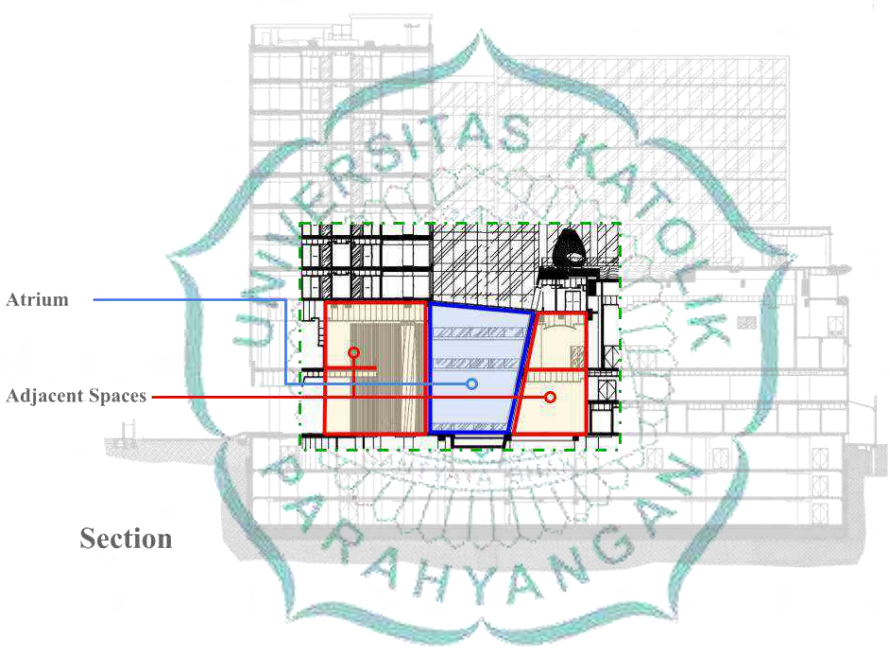


Figure 1.6 Scope of atrium and adjacent spaces in case study (section)

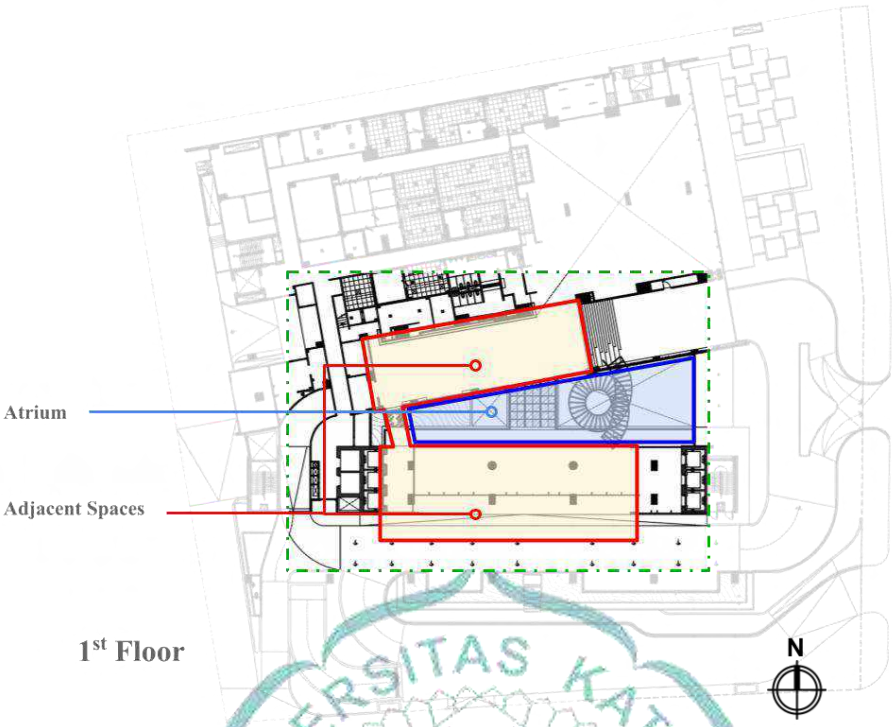


Figure 1.7 Scope of atrium and adjacent spaces in case study (1st floor plan)

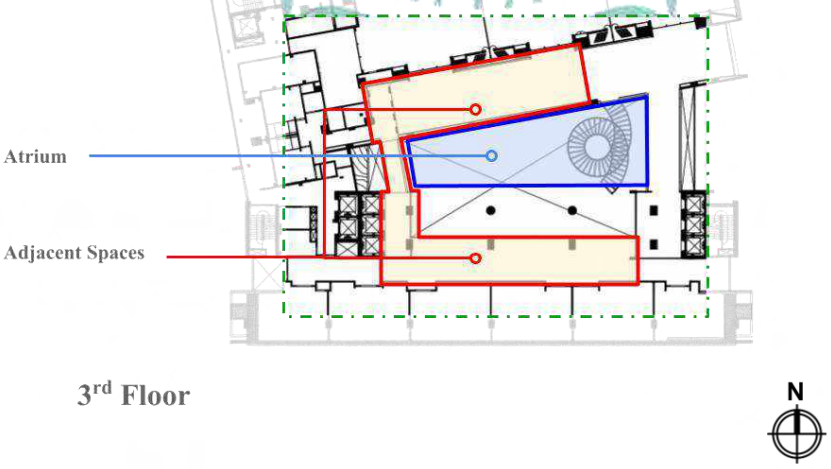


Figure 1.8 Scope of atrium and adjacent spaces in case study (3rd floor plan)

1.6 Research Framework

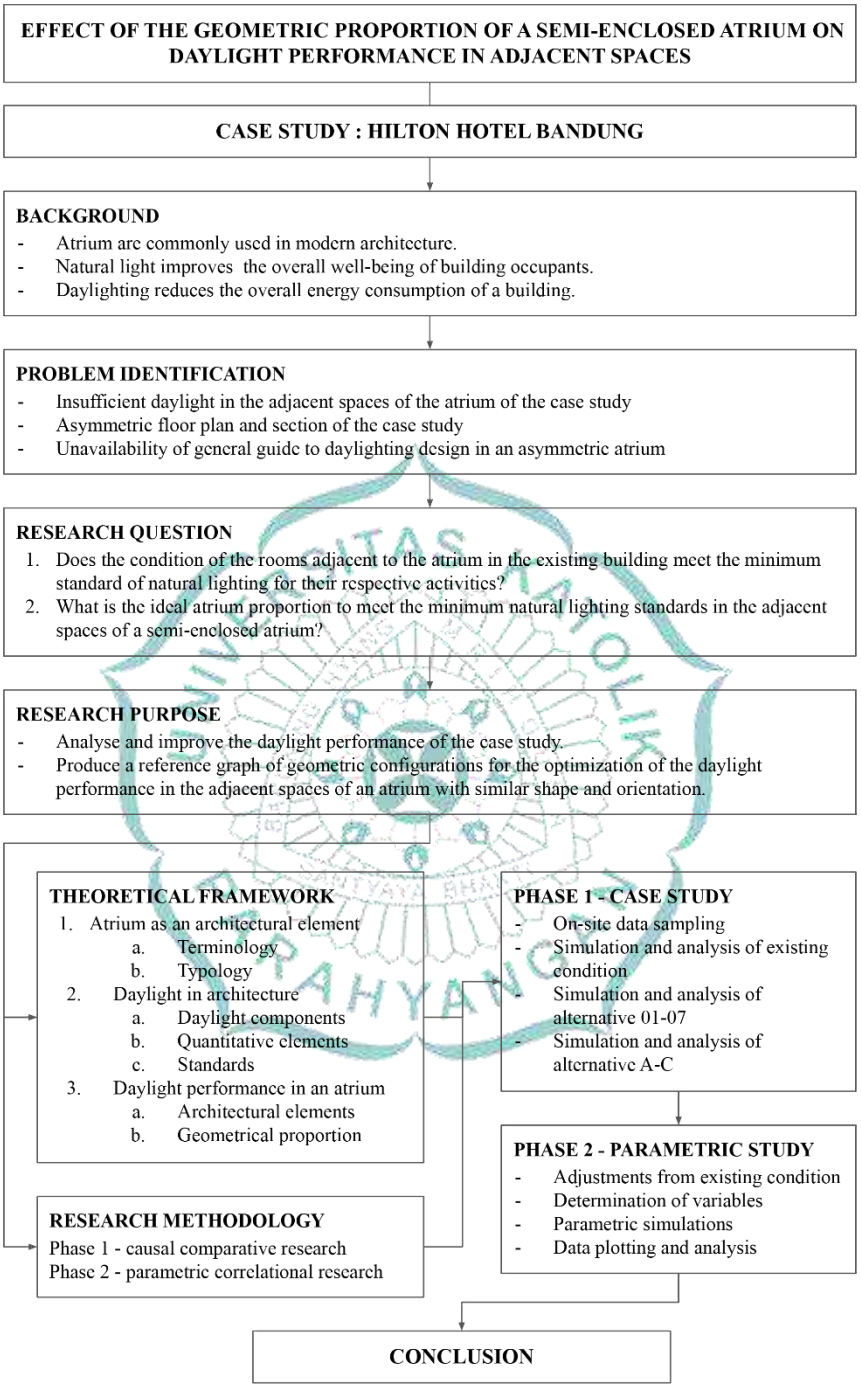


Figure 1.9 Research framework