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Adaptive Workplace with Indoor Health and Comfort Approach Toward Sustainable City

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Adaptive Workplace with Indoor Health and Comfort Approach Toward Sustainable City

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Abstract

The Covid-19 pandemic has an impact on public health, including workplace occupant. The spread of the coronavirus occurs a lot in the workplace. Indoor health and comfort play an important role in providing a healthy and comfortable workplace. Work patterns during the Covid-19 pandemic have changed with the work from home and physical distancing policies. The arrangement of the workplace interior accompanied by indoor health comfort can affect the work experience of occupant. This study aims to produce an adaptive workplace layout design with an indoor health and comfort approach based on occupant perception toward sustainable city. This study uses mix methods with observation and-questionnaire survey techniques. The object of research is ten offices in the Medan city, Indonesia. Observations were made to analyze the layout of the workplace, then questionnaires were distributed to employees to analyze their perceptions of comfort and the application of health protection in the workplace. The variables are lighting, ventilation, temperature and humidity, distance of workbench, and health protection. The results showed that the workplace must provide good air quality with the exchange of air through ventilation. Workbench spacing and the use of barriers are most recommended. A workplace with cubical layouts can be arranged parallel to the desk divider as a screen between desks. Whereas in a workplace with non-cubical layouts, work desks can use zig-zag or non-parallel seating arrangements and dividers between tables. Office buildings should prepare a workplace that concerned with space efficiency and comfortable indoor space.

Keywords: adaptive, indoor health and comfort, sustainable city, workplace design.

Introduction

Adaptive architecture is the capacity of buildings and humans to adapt that supports dynamic interactions between buildings and their users. The adaptive architecture design strategy has 6 strategies, namely available, flexible, refutable, scalable, movable, and reusable (Schimdt, 2009). Adaptive architecture ideally responds to the needs of sustainable architecture because it arises from the use of various spatial components. Each time the space is moved, it creates new spatial interaction between the interior and the exterior. Adaptive architecture answers the need for spatial savings which refers to the use of built forms, resulting in environmental diversity, including the complexity and variability of exterior components (Demers et al., 2014).

Adaptive architecture focuses on buildings or their components that are specifically designed to be able to adapt both to the surrounding environment, its occupants, and the objects in it (Schnädelbach, 2010). This adaptation mechanism can be done automatically or with human intervention. An exploratory space also has space flexibility which is realized by the use of built-in furniture that can be arranged according to the type of item. In designing an adaptive and exploratory space,

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designers need to pay attention to the influence of lighting, space area, flexibility, furniture, and spatial quality on the performance they want to present in a space (Sharfina and Purwanita, 2015). Adaptability allows to enhance the user's wellbeing and safety by achieving comfort, health, security, indoor environmental quality, life quality as well as a good interactivity with the building and other users (Naqib, 2009).

Several studies have linked the concept of indoor health and comfort with the concept of adaptive space (Naqib, 2009) and green workplaces (Wardhani et al., 2020). Workplace before the pandemic, using an open concept to support the flexibility of residents. The co-working space concept supports performance efficiency and is more flexible (Nediari et al., 2021). Corridors in the workplace should avoid two-way traffic. Corridors for two people to walk should have a minimum width of 1.2 - 1.5 meters. Some activities can be done in one room only. During the Covid-19 pandemic, work patterns changed and some employees worked from home (Kaushik and Guleria, 2020).

The quality of the indoor environment is related to occupants satisfaction in the workplace. Besides affecting health, it also affects employees productivity (Esfandiari, et al., 2017). Workplace depends on the condition of the building and its urban context. Workplace interior arrangement considering the main building with better attributes and performance levels in terms of location, design, construction and management, which makes retrofitting workplace interiors more effective and environmental impact and improvement of employee work experience (Gou, 2016). Energy Efficiency is one of the indicators for realizing sustainable city. There are several benefits of energy efficiency, one of which is to create a healthy indoor living environment with healthy air temperatures, humidity levels, noise levels and improved quality (Sodiq et al., 2019). The indoor environment quality can affect the health, comfort and productivity of employees. The use of materials with low emissions can reduce indoor pollutants (Gou, 2016).

One of the challenges during the post-Civod-19 pandemic is to provide a comfortable and safe workplace from coronavirus transmission. Workplace design adaptation is needed as a facility for employees. In addition, indoor health and comfort which is part of the green building principle are considered in providing a healthy workplace. This study aims to produce an adaptive workplace layout design with an indoor health and comfort approach based on occupant perception toward sustainable city.

Workplace

Workplace in the office is divided into private space as much as 70-80% and shared space as much as 20-30%. In facilitating activities in the workplace, space efficiency is needed that adapts to technology that leads to transformation (Nediari et al., 2021). In the workplace, a good quality indoor environment can increase worker productivity (VGBC, 2019).

Office buildings are occupied by many tenants so efforts are needed to make workplaces with green interiors which are the result of green buildings (Gou, 2016). According to Nediari et al. (2021), the arrangement of office interiors after the pandemic must pay attention to distance, furniture layout, and air conditioning systems. A safe workplace arrangement has an individual distance in the workplace of 2 meters or 6 feet and the furniture layout is back to back. The size of the office desk has been reduced from 1.8 m to 1.4 m. Use of panels between employees is required.

The Covid-19 pandemic has resulted in changes in work patterns and the provision of workplaces. Working from home is one way to reduce the number of employees working in one workplace at the same time. Things that need to be considered in the WFH (working from home) concept and working in an office during a pandemic include human connectivity, maintaining normality, social distancing, infrastructure, collaboration, security, policy frameworks, and emotional well-being (Kaushik and Guleria, 2020).

Indoor Health and Comfort

Indoor health and comfort is one of the principles in green building (GBCI, 2018). Efforts to apply the green concept to buildings must be supported by green behavior by users (Fachrudin, H. T. et al., 2021). Some recommendations for workplace design to obtain a usable indoor environmental quality according to ASHRAE (2020) consist of dilute, exhaust, control, and cleaning. Dilute requires increased ventilation to enter outside air, for example by disabling Demand-control Ventilation (DCF), increasing the setpoint of the outside air damper or minimum airflow, operating the air handling unit with 100 percent outside air if possible, maintaining the system ventilation operates for a long time and applies a sequence of air cleaning before and after occupancy. Exhaust is concerned with keeping the exhaust air in the restroom operating continuously. There are several recommendations for humidity control in the room, namely installing a humidity sensor to maintain a relative humidity of 40-60%, deactivating resetting the air release temperature during humid weather, and ensuring the hot water heating system is activated to control humidity. Air purification recommends upgrading the filter to MERV-13, adding a portable room air purifier with a HEPA or high-MERV filter, installing ultraviolet lamps in workplace or air-handling equipment, and retrofitting the air-handling equipment with a suitable air-purifying device.

Recommendations for maintaining indoor quality in the workplace during a pandemic (Guo et al., 2021) are: ventilation with adequate outside air and effective airflow patterns are the most important strategies to reduce the risk of SARS-CoV-2 transmission; supply as much outdoor air as possible; HVAC related devices open 2 hours before and after occupancy; using a portable room air purifier; maintain filters regularly; on AC devices (eg. AHU) should disable sector recirculation; it is also recommended to maintain negative pressure in the toilet and regularly check the water seal; control the temperature between 17 and 28°C and control the relative humidity between 40% and 70%; maintain physical distance; hand hygiene; respiratory etiquette; and proper use of face masks.

Contribution to the comfort and well-being of building occupants can be made by setting minimum standards for indoor air quality (IAQ), consisting of mechanically ventilated rooms and naturally ventilated rooms (USGBC, 2019). Minimum indoor air quality performance contributes to occupant comfort and well-being (GBI Index, 2011). Workplace should provide sufficient fresh air supply for at least 90% of the clean area of the occupied building and conduct indoor air quality testing (VGBC, 2019). Air quality can affect occupants and improve their well-being. Building sick syndrome is characterized by cases of respiratory disease in building occupants. This should be addressed with a good indoor environmental quality.

Maintaining workplace air quality is done by optimizing air circulation and sunlight entering the workplace; air conditioning filter cleaning; conducting engineering to prevent transmission such as installing barriers or glass screens for workers serving customers, arranging seating to be one meter apart at the desk/work area, during meetings, in the canteen, during breaks, and others (Kemenkes RI, 2020). Indoor health and comfort can be achieved by providing adequate ventilation of the room with outside air and introducing a network of indoor air quality sensors (REHVA, 2020). Air quality in the workplace must be improved and is a concern for architects and interior designers because it affects the health and productivity of occupants (Esfandiari et al., 2017). A good interior layout arrangements and ventilation systems are needed in the workplace.

Indoor health and comfort can be measured from the introduction of outdoor air, CO2 monitoring, Environmental Tobacco Smoke Control, Chemical Pollutants, Exterior views, Visual comfort, Thermal comfort, and acoustic comfort (GBCI, 2016) and (GBCI, 2018). Use of natural or mechanical ventilation; upgrading filters where appropriate and monitoring HVAC can provide indoor health and comfort (ECDC, 2020).

Methods

This research uses qualitative and quantitative methods. The data collection technique was by conducting observations in ten office building in Medan City, Indonesia. The workplaces that are the object of research are five workplaces using cubical concept layout, and five non-cubical workplaces. Observations were made to analyze the layout of the workplace and its suitability for indoor health and comfort. Observations were made on the location of windows and ventilation as a source of natural lighting and airing, artificial lighting used, ventilation systems used including the direction of the wind from the air conditioner in the room, the layout of the furniture and health protection applied to the workplace. Then, survey with questionnaire was conducted to occupants of the office buildings to get employee' perceptions of the indoor and health comfort in the workplace. There are 123 occupants became respondents in this research. The variables of the indoor health and comfort are lighting, ventilation, thermal and humidity, work furniture-distance and health protection in the workplace. Questionnaire forms were given to employees using a Likert scale of 1-5. Lighting consists of the use of natural lighting in the workplace, the presence of open glass on each side of the room, the comfort of indoor light, natural lighting, and artificial lighting. Ventilation consists of the availability of ventilation, the availability of clean air in the room, and efforts to enter clean air into the room. Thermal and humidity consist of the temperature in the room and the use of air conditioning. Distance regarding workplace layouts focuses on the distance between work desks, limiting work desks and limiting the number of people in closed spaces. Health protection consists of implementing work from home and providing equipment for health protection. The analysis used is descriptive analysis. The analysis results are input in preparing an adaptive workplace design layout in the post-Pandemic Covid 19 with an indoor health and comfort approach.

Results and Discussion

Lighting

Lighting is an important part of the workplace. Some rooms use natural lighting and some rely on artificial lighting. Some workplaces have good lighting, but there is workplace that place work desks away from light sources. So they added a lamp on the desk. Lighting helps occupants in carrying out their activities. Workplace with glass windows can take advantage of sunlight for natural lighting into the room (Fachrudin et al., 2022).

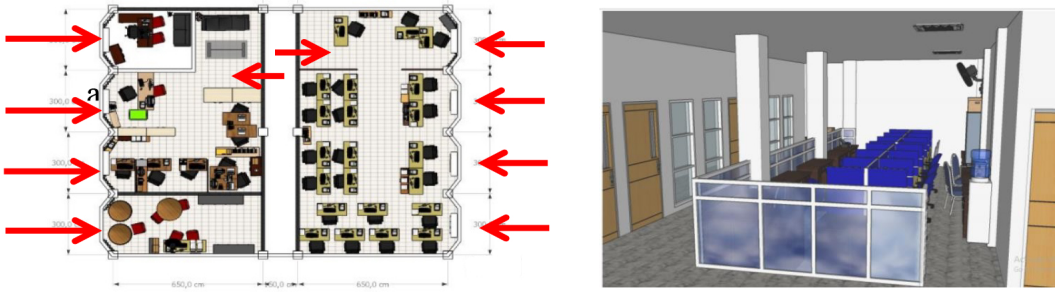
Fig. 1
Natural Lighting in Workplace

Ventilation

Efforts to clean the air by entering fresh air from outside are following the recommendations of GBCI (2018). It is important to clean indoor air to get good air quality (REHVA, 2020). Mechanical ventilation and natural ventilation can be used to maintain indoor air quality (USGBC, 2019).

Ventilation in the workplace is used to enter sunlight and fresh air from outside. In a workplace with a cubical layout, the building envelope uses glass but is not used to enter sunlight and fresh air from outside. Meanwhile, in workplaces with non-cubical layouts, ventilation is used to enter fresh air from outside by opening the windows twice a day. Opening windows during peak hours are recommended by ASHRAE (2020) and REHVA (2020) and optimizing sunlight is recommended by Kemenkes RI (2020).

Fig. 2
Ventilation in Workplace



Thermal dan Humidity

In a closed workplace with a centralized air system, it is better to use a CO2 detector and air filter so that indoor air quality is maintained (ASHRAE, 2020; REHVA, 2020; ECDC, 2020 and Kemenkes RI, 2020). Based on observation, AC used in all workplaces is set at a temperature of 22-25°C. In a workplace that uses a centralized air conditioning system, employees cannot control the temperature in the room. Whereas in a workplace with split AC, employees can can determine the temperature of the AC themselves.Temperature and humidity settings in all workplaces have complied with ASHRAE (2020) regulations.

Fig. 3
Temperature Control in workplace with split AC System

Distance

Workplaces with cubical layouts have a workbench distance of 1 until 1.2 m and a divider between tables. Setting the distance of the workbench is adjusted to the needs of space for work and circulation in the space. While the workplace with a non-cubical layout has a distance between tables of 1 m and without borders. Virus transmission will become easier. Based on information from the office manager, employee who infected the coronavirus is who sit under or in front of an AC source. During the Covid 19 pandemic, in a workplace with a non-cubical concept, several residents were found to be positive for Covid 19. Then the manager took a work from home policy to reduce the number of occupants in one room every day and use barriers between tables. The use of a barrier between work desks is recommended by Kemenkes RI (2020) to prevent the transmission of the Covid 19 virus in the workplace.

Health Protection

Health protection is carried out by all of workplaces. Before entering the workplace, residents must wash their hands, check body temperature and wear masks. While in the room, residents must wear masks and use hand sanitizer after handling objects. Workplaces are sprayed with disinfectant at least once a week to prevent the spread of coronavirus. All health protection in the workplace has been carried out in accordance with recommendations from the Indonesian Ministry of Health (2020).

Indoor and Health Comfort

Analysis of indoor and health comfort based on employee perceptions from a questionnaire survey. There are five variables asked to respondents. The results of the analysis show that lighting has a mean value of 3.19; ventilation has a mean value of 3.20; thermal and humidity have a mean value of 2.99; distance has a mean value of 3.75 and health protection has a mean value of 4.23 (Table 1). This shows that health protection and distance of workbench are prioritized in the workplace to support workplace comfort.

Table 1
Mean value

	Lighting	Ventilation	Thermal	Distance	Health Protection
Mean	3.19	3.20	2.99	3.75	4.23

Source: Analysis

In the indoor health and comfort workplace there are five variables, namely lighting, ventilation, thermal and humidity, distance of workbench and health protection (Table 2).

Table 2
Indoor Health and Comfort Analysis

Variables	Mean
Lighting	
Maximizes the use of natural lighting	3.32
A workplace has many glass openings in every part of the room	3.31
The light in the workplace is uncomfortable/glare in the morning making it difficult for occupant to focus on the screen	2.28
Too much natural light in the workplace	2.53
Occupant needs natural light from outside	4.12
Workplaces rely on artificial lighting (eg lamps)	3.58
Ventilation	
Workplace has window/ventilation to enter clean air into the workspace	3.48
Clean air in the workplace is not enough	2.98
The air in the workplace feels stuffy	2.41
Ventilation in the workplace is not effective	2.80
Every 4 hours or so the windows in the workplace must be opened to intake clean air	3.38
Door in workplace must be opened to intake clean air	3.33
Toilet has ventilation	3.86
Thermal and Humidity	
The air temperature in the workplace is too hot	2.26
The air temperature in the workplace is too cold	2.70
The air temperature in the workplace can be controlled	4.12
Workplace uses central air conditioning	2.88
Distance	
The work table has a minimum distance of 1 meter	4.00
Cubical work table	3.50
The work table has a divider	3.54
There is a limitation on the number of people in a closed room	3.96
Health Protection	
Work from home (WFH)	3.91
Wash hand	4.50
Checks body temperature	4.37
Masker	4.67
Hand sanitizer	4.72
Take advantage of lunch time to breathe fresh air outdoors	4.20
Disinfectan in workplace	3.25

Source: Analysis

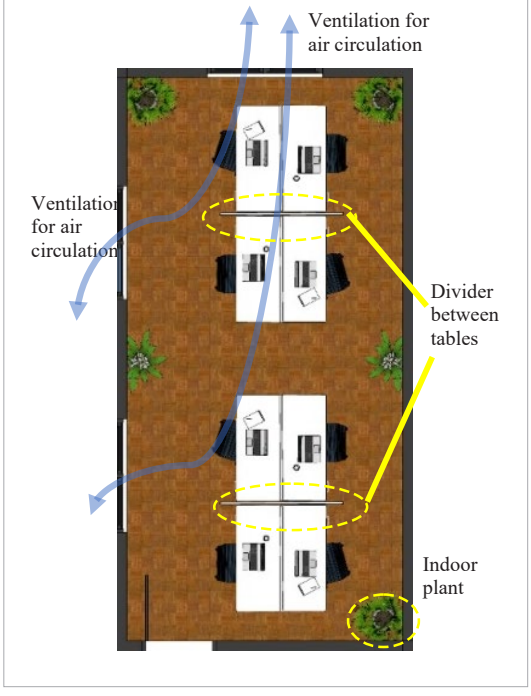
In lighting, respondents need natural light from outside in addition to using artificial lighting in the room. Sunlight can be entered through the provision of windows. However, it is necessary to consider the dimensions of the window so that the light entering the room does not cause glare in the room. The use of artificial lighting must adjust to the level of lighting or lux. According to GBCI (2018), optimization of lighting in the workplace can be adjusted to the layout of the work desk and the placement of light points. In ventilation, respondents want the ventilation to be opened to enter fresh air from outside into the workplace, including the toilet. The placement of doors and windows that can be opened can adopt a cross-ventilation system so that air can enter all parts of the workplace. Regarding thermal and humidity, respondents stated that the air temperature in the workplace should be controlled. In a workplace with a centralized AC system, the air temperature is set centrally. Standard air temperature is 24°C - 27°C with a relative humidity of 60% (GBCI). The workplace should not be too cold so that users feel comfortable and electricity consumption is not wasteful. The placement of the work table should not be directly under or facing the direction of the wind from the air conditioner.

In the distance of workbench, respondents want a cubical workbench or use a barrier with a minimum distance of 1 meter between tables. The divider between work desks can reduce physical contact and the spread of the virus between employees. Then the number of people in the workplace should be limited. Circulation paths in the workplace should be wider so that when employees pass each other they can keep their distance. Health protection efforts in the workplace must be carried out, for example by providing a place to wash hands, occupants using masks in the room, having hand sanitizers on each workbench and periodically spraying the workplace with disinfectant.

Adaptive Workplace Layout Design

Based on the results of the analysis, an adaptive workplace that supports a sustainable city is that prioritizes indoor health and comfort. Workplace layout design should consider health and comfort in the room, work desk settings, and health protection. An open workplace must be managed by using a divider on each workbench. The distance between the work table and circulation in the room should be considered so that it meets the established physical distancing requirements.

Fig. 4
Workplace layout with cubical concept



A workplace that arranges desks in a row is a flexible space. In the workplace, work activities, team meetings, and discussions can be carried out. In cubical workplaces, work activities are carried out in each cubicle. Meetings are held in the meeting room. The meeting rooms provided are flexible because they are used for small and large capacities (Fig. 4). The provision of flexible space is following research from Konieczna (2018) which states that in adaptive architecture there is a level of flexibility, where adaptation to space is controlled directly by humans. The room can be used for various activities, enlarged or narrowed by using hinges, rails, and bearings on the room divide.

Air quality is an important thing in space. The exchange of air in the room can be done by making cross ventilation and opening windows periodically to get fresh air. Setting a temperature between 17-28°C and humid-

ity 40%-70% in the room is recommended according to ASHRAE (2020). The addition of plants in the room can help absorb CO2. The distance between the workbench should be at least 1 meter by using a barrier between the workbench. In a workplace with a cubical layout, the desk divider can be a screen between the desks (Fig. 4).

In a workplace with a non-cubical layout, the seating arrangements between work desks can be arranged in a zig-zag or unequal manner and between desks (Fig. 5). Circulation in the room should be wider than before the Covid 19 pandemic. The corridors in the workplace should have a minimum width of 1.2 - 1.5 meters and avoid two-way traffic (Nediari, et al., 2021). The application of health protection such as periodically disinfecting the workplace, washing hands before entering the workplace, measuring temperature, and using masks in the workplace, is highly recommended to become a habit at this time, according to instructions from Kemenkes RI (2020).

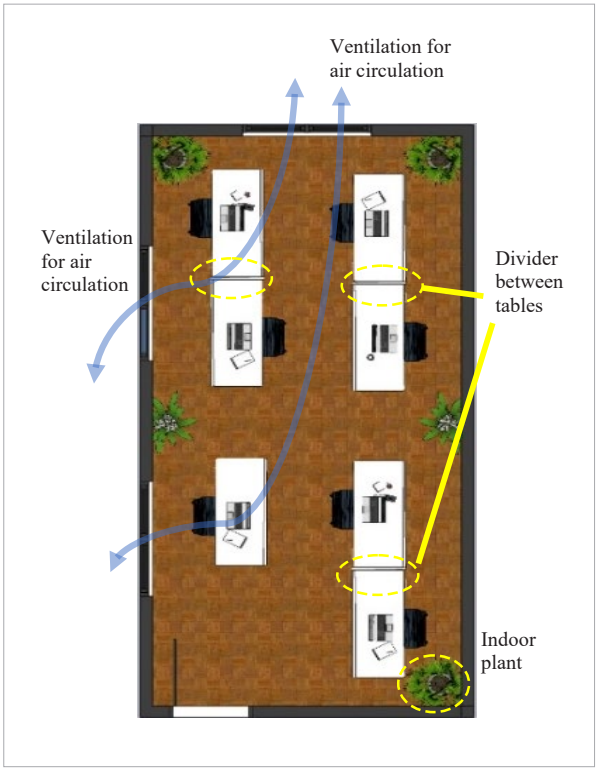


Fig. 5
Workplace layout with non-cubical concept

Design considerations with an indoor health and comfort approach can provide a sustainable and comfortable design for residents. This design can be applied to the post-pandemic Covid 19 thereby reducing the spread of the virus in the workplace (Nediari et al., 2021) and improving the performance of its occupants (VGBC, 2019).

Conclusion

Indoor health and comfort is one of the principles in green buildings. This principle aims to provide a comfortable and healthy indoor space. The workplace layout design concept is based on data collection by means of observation to obtain workplace conditions based on the location of ventilation, use of natural and artificial air, lighting, the layout of the furniture and applied health protection. In addition, employees provide their perceptions through questionnaires regarding the implementation of indoor health and comfort in the workplace. A workplace that meets the principles of indoor health and comfort can improve the performance of its occupants and reduce the spread of viruses in the space. Workplaces during the post-covid-19 pandemic require adaptation. Air quality regulation and workplace layout are important concerns to suppress the spread of the virus and improve occupant health. Setting the distance between the work desk and the seat should be at least 1.2 meter by providing a barrier on each work desk. Workplace ventilation is used to change the air in the room and enter sunlight into the space. Indoor air must flow so that indoor air conditions are maintained. Health protection is carried out before occupants enter the workplace and when in the workplace. Based on the results of user observations and perceptions, an adaptive workplace layout design can be developed that meets indoor health and comfort standards and meets the needs of employees as users.

Adaptation of the workplace layout related to the concept of sustainability. This adaptation effort aims to provide a healthy and hygienic workplace. Office buildings should prepare a workplace that is not only concerned with space efficiency but also provides a healthy and comfortable indoor

space. This has an impact on productivity and work comfort for residents. But all these efforts must be supported by the new normal behaviors of space users. The workplace layout design is expected to be a model for the workplace in office buildings.

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References

ASHRAE. (2020). Updated ASHRAE® Recommendations for COVID-19, providing insights for today's hvac system designer. Engineers Newsletter. vol. 49-2. https://www.tranehk.com/files/News/EngrNewsletter/Trane%20Engineers%20Newsletter_vol49_2.pdf. accessed 18 March 2021.

Demers, Claude, André Potvin, dan Hélène Giguère-Duval. (2014). Inhabiting Adaptive Architecture: Environmental Delight in Adaptable Spaces. Proceeding of International Conference on Adaptation and Movement in Architecture (ICAMA2013).

ECDC. (2020). Heating, ventilation and air-conditioning systems in the context of COVID-19: first update. European Centre for Disease Prevention and Control. 10 November 2020. Stockholm: ECDC, online available, https://www.ecdc.europa.eu/sites/default/files/documents/Heating-ventilation-air-conditioning-systems-in-the-context-of-COVID-19-first-update.pdf, accessed 8 March 2021.

Fachrudin H. T., Fachrudin K. A. (2021). Factors Influencing Energy Conservation Application in Green Campus Design Based on Green Behavior. International Journal of Energy Economics and Policy. Vol. 11. No. 4. pp.511-520. https://doi.org/10.32479/ijeep.11355

Fachrudin H. T., Fachrudin K. A., Pane I. F., (2022). Workplace Design Concept Based on Indoor Environmental Quality Analysis to Prevent Coronavirus Transmission, Civil Engineering and Architecture, Vol. 10, No. 1, pp. 121 - 130, 2022. https://doi.org/10.13189/cea.2022.100111

GBCI. (2016). Greenship Existing Building Version 1.1, Divisi Rating dan Teknologi Green Building Council Indonesia. Green Building Council Indonesia. Juni 2016, www.gbcindonesia.org .

GBCI. (2018). Greenship New Building Version 1.2, Divisi Rating Dan Teknologi Green Building Council Indonesia. Green Building Council Indonesia. November 2018.

GBI Index. (2011). Green Building Index Assessment Criteria For Nreb, First Edition, Version 1.1. GREENBUILDINGINDEX SDN BHD (845666-V).. https://www.greenbuildingindex.org/Files/Resources/GBI%20Tools/GBI%20NREB%20NonResidential%20Existing%20Building%20Tool%20V1.1%20Final.pdf. accessed 12 April 2021.

Gou Z. (2016). Green building for office interiors: challenges and opportunities. Facilities. Vol. 34. No. 11/12. pp. 614-629. Emerald Group Publishing Limited 0263-2772. https://doi.org/10.1108/F-04-2015-0022

Guo M., Xu P., Xiao T., He R., Dai M., Miller S. L. (2021). Review and comparison of HVAC operation guidelines in different countries during the COVID-19 pandemic. Building and Environment. 187. 107368. https://doi.org/10.1016/j.buildenv.2020.107368

Kaushik M., Guleria N. (2020). The Impact of Pandemic COVID -19 in Workplace. European Journal of Business and Management. Vol. 12. No.15. 2020.

Kemenkes RI. (2020). Keputusan Menteri Kesehatan Republik Indonesia Nomor Hk.01.07/Menkes/328/2020. Panduan Tentang Pencegahan Dan Pengendalian Corona Virus Disease 2019 (Covid-19) Di Tempat Kerja Perkantoran Dan Industri Dalam Mendukung Keberlangsungan Usaha Pada Situasi Pandemi. [Decree of the Minister of Health of the Republic of Indonesia Number Hk.01.07/Menkes/328/2020. Guidelines on Prevention and Control of Corona Virus Disease 2019 (Covid-19) in Office and Industrial Workplaces in Supporting Business Continuity in Pandemic Situations]. http://hukor.kemkes.go.id/uploads/produk_hukum/KMK_No__HK_01_07-MENKES-328-2020_ttg_Panduan_Pencegahan_Pengendalian_COVID-19_di_Perkantoran_dan_Industri.pdf, accessed 8 March 2021.

Nakib F. (2010). Toward an Adaptable Architecture Guidelines to integrate Adaptability in the Building. Conference: CIB 2010 World Congress Proceedings:

Building a Better World At: Salford Quays - United Kingdom.

Nediari A., Roesli C., Simanjuntak P. M. (2021). Preparing post Covid-19 pandemic office design as the new concept of sustainability design. IOP Conf. Series: Earth and Environmental Science. 729. 012095. https://doi.org/10.1088/1755-1315/729/1/012095

REHVA, (2020). How to operate HVAC and other building service systems to prevent the spread of the coronavirus (SARS-CoV-2) disease (COVID-19) in workplaces. REHVA COVID-19 guidance document, Federation of European Heating, Ventilation and Air Conditioning Associations.

Schmidt, Robert, Simon Austin, dan Dave Brown. (2009). Designing Adaptable Buildings. 11TH INTERNATIONAL DESIGN STRUCTURE MATRIX CONFERENCE, DSM'09. Greenville, South Carolina, USA.

Schnädelbach, H. (2010). Adaptive Architecture - A Conceptual Framework. MediaCity: Interaction of Architecture, Media and Social Phenomena.

Sodiq A., Baloch A. A. B., Khan S. A., Sezer N., Mahmoud S., Jama M. and Abdelaal A. (2019). Towards modern sustainable cities: Review of sustainability principles. https://doi.org/10.1016/j.jclepro.2019.04.106

And trends, Journal of Cleaner Production, Vol. 227, pp. 972-1001.

Sharfina, S. E., Purwanita. S. (2015). Penerapan Konsep Adaptif dan Eksploratif pada Ruang Pamer Museum Terbuka. [Application of Adaptive and Explorative Concepts in Open Museum Showrooms]. JURNAL SAINS DAN SENI ITS, Vol. 4. No. 2. Pp. 79-81.

USGBC. (2019). LEED v4.1 Building Design And Construction Getting started guide for beta participants. https://www.usgbc.org/sites/default/files/2021-03/LEED%20v4.1%20BD%2BC%20Guide%2004092019.pdf, accessed 19 April 2021

VGBC. (2019). LOTUS Buildings in Operation V1, Technical Manual, LOTUS BIO V1 Updated Version - Technical Manual - September 2019. https://vgbc.vn/en/lotus-bio/, accessed 16 April 2021.

Wardhani D. K., Susan, Anastasia M., Setiando M. J. (2020). Indoor health and comfort for the green workplace at university. Arteks, Jurnal Teknik Arsitektur. Vol. 5. Issue 3. December 2020. https://doi.org/10.30822/arteks.v5i3.582

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