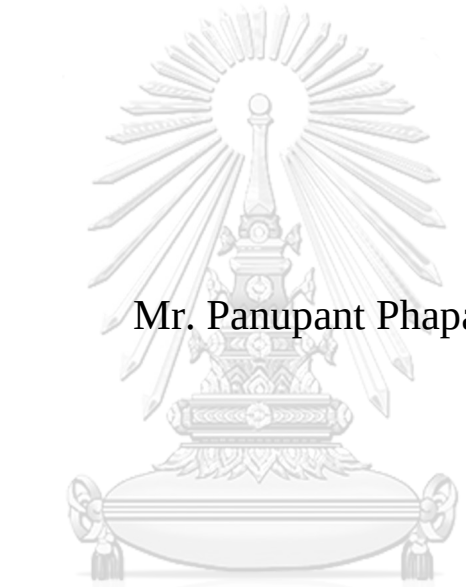
PREVENTING OCCUPATIONAL RESPIRATORY DISEASE FROM EXPOSURES IN OFFICE BUILDING : CASE STUDY COVID-19

Mr. Panupant Phapant



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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต
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บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
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By	Mr. Panupant Phapant
Field of Study	Environment, Development and Sustainability
Thesis Advisor	Professor Dr. ORATHAI CHAVALPARIT

Accepted by the GRADUATE SCHOOL, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

..... Dean of the GRADUATE SCHOOL
(Associate Professor YOOTTHANA CHUPPUNNARAT, Ph.D.)

DISSERTATION COMMITTEE

..... Chairman
(Assistant Professor Pensri Watchalayann, Ph.D.)
..... Thesis Advisor
(Professor Dr. ORATHAI CHAVALPARIT)
..... Examiner
(Assistant Professor SUTHIRAT KITTIPONGVISES, Ph.D.)
..... Examiner
(Associate Professor NUTTA TANEEPANICHSKUL, Ph.D.)
..... External Examiner
(Associate Professor Maneerat Aongwandee, Ph.D.)

ภาณุพันธ์ ผาพันธุ์ : การป้องกันโรคทางเดินหายใจจากการทำงานในอาคารสำนักงาน : กรณีศึกษา COVID-19. (PREVENTING OCCUPATIONAL RESPIRATORY DISEASE FROM EXPOSURES IN OFFICE BUILDING : CASE STUDY COVID-19) อ.ที่ปรึกษาหลัก : ศ. ดร.อรทัย ชวาลภาฤทธิ์

การระบาดของโรคติดเชื้อไวรัส *โคโรนา* 2019 (Coronavirus disease 2019 หรือ *COVID-19*) ส่งผลกระทบต่อการใช้ชีวิตของมนุษย์ในปัจจุบันเป็นอย่างมาก รวมไปถึงอาคารสำนักงาน โดยเฉพาะอย่างยิ่งการเตรียมพื้นที่เพื่อเตรียมรับการเปลี่ยนแปลงจาก Work from Home เป็น Work from Office งานวิจัยนี้ทำการศึกษา มาตรการการป้องกัน ทั้งในระดับสากล ระดับประเทศ และงานวิจัยต่างๆ เพื่อพัฒนาแนวทางในการรับมือเพื่อป้องกันการระบาด อย่างยั่งยืน จากการศึกษาพบว่า การปรับเปลี่ยนสภาพแวดล้อมและการปรับกฎเกณฑ์ต่างๆ สำหรับอาคารสำนักงานมีผลสำคัญในการลดความเสี่ยงในการติดเชื้อ ทั้งกฎระเบียบในระดับประเทศและองค์กรต่างๆ

งานวิจัยนี้ยังศึกษาเกี่ยวกับการปฏิบัติตามมาตรการการป้องกัน COVID-19 ในอาคารสำนักงาน พื้นที่จังหวัดกรุงเทพมหานครประเทศไทย โดยทำการเปรียบเทียบระหว่างอาคารที่ได้การรับรองมาตรฐานอาคารเพื่อความยั่งยืนตามมาตรฐานสากล ได้แก่ LEED, TREES, และ WELL จำนวน 4 อาคาร และอาคารที่ไม่ได้การรับรองมาตรฐานดังกล่าวจำนวน 4 อาคาร จากการศึกษาพบว่า อาคารที่ได้การรับรองมาตรฐานมีการปฏิบัติตามมาตรการป้องกัน COVID-19 ครบทุกมาตรการ ในขณะที่อาคารที่ไม่ได้การรับรอง 2 อาคาร ปฏิบัติตามมาตรการการป้องกันเกือบครบทุกมาตรการ (> 90%) และมีอีก 2 อาคารที่ปฏิบัติเพียงบางส่วน (< 90%) ซึ่งมาตรการทางวิศวกรรมที่นำไปปฏิบัติน้อยที่สุด ได้แก่ การจัดเตรียมห้องความดันลบ การติดตั้งระบบกรองอากาศ และการปรับเปลี่ยนอุปกรณ์สำนักงานเป็นระบบไร้สัมผัสตามลำดับ และการดูแลสุขภาพทางอารมณ์ได้รับการดูแลน้อยที่สุดสำหรับมาตรการทางบริหารจัดการ แต่อย่างไรก็ตาม ทางเลือกอื่นๆ ก็นำมาดำเนินการทดแทน ทำให้ไม่พบผู้ติดเชื้อในลักษณะแบบคลัสเตอร์ในทุกอาคารตัวอย่างในการศึกษา

นอกจากนั้นงานวิจัยนี้ยังได้ศึกษาถึงความพึงพอใจต่อปัจจัยทางด้านสุขภาพและความอยู่สบายของผู้ใช้งานอาคารสำนักงาน ทั้งในช่วงก่อนและระหว่างการเกิด COVID-19 โดยทำการสัมภาษณ์เชิงลึกและใช้ Rating Scale กับผู้ใช้งานอาคารทั้ง 3 แบบ จากการศึกษาพบว่า ความพึงพอใจในคุณภาพของอาคาร เพิ่มขึ้นระหว่างการเกิด COVID-19 โดยก่อนเกิด COVID-19 ผู้ใช้อาคารในอาคารที่ได้การรับรองมีระดับความพึงพอใจสูงสุด และผู้ใช้อาคารในอาคารที่ไม่ได้การรับรองแต่ปฏิบัติตามคำแนะนำการป้องกัน COVID เกือบครบทุกมาตรการ มีความพึงพอใจสูงสุดระหว่างการเกิด COVID-19 เนื่องจากอาคารมีการเปลี่ยนแปลงค่อนข้างมาก นอกจากนี้ยังได้ทำการศึกษาปัจจัยด้านสุขภาพและความอยู่สบายในอาคาร ประกอบไปด้วย ปัจจัยด้านอุณหภูมิและความชื้น คุณภาพอากาศ การรักษาระยะห่าง การมองเห็น และปัจจัยด้านเสียง เปรียบเทียบระหว่างก่อนและระหว่าง COVID-19 พบว่าปัจจัยด้านแสงสว่างและการมองเห็นคือปัจจัยที่ผู้ใช้อาคารพึงพอใจมากที่สุดก่อนการเกิด COVID-19 ในขณะที่การรักษาระยะห่าง คือปัจจัยที่ผู้ใช้อาคารมีความพึงพอใจสูงสุด และเพิ่มขึ้นมากที่สุด ระหว่างการเกิด COVID-19 ในทุกประเภทของอาคาร

การวิเคราะห์แบบ Actor-network นำมาใช้ในการวิเคราะห์ปัญหาและอุปสรรคระหว่างการดำเนินการเพื่อการแก้ไขและเพื่อป้องกันปัญหาอื่นๆ ที่อาจจะเกิดขึ้นในอนาคต ทั้งจากโรคไข้หวัด ไข้หวัดใหญ่ และโรคติดต่อทางเดินหายใจอื่นๆ จากการศึกษา พบว่า ปัญหาการบังคับใช้กฎหมายให้อาคารมีการออกแบบให้เป็นอาคารที่มีสุขภาวะที่ดี (Healthy Building) การขาดแคลนการให้การสนับสนุนด้านการเงิน การขาดการควบคุมการเผยแพร่ข่าวสาร และ การขาดความรอบรู้ทางสุขภาพ เป็นอุปสรรคที่ทำให้การป้องกันการติดเชื้อ และการพัฒนาปรับปรุงอาคารทำได้ช้าลง ดังนั้นมาตรการที่ควรเพิ่มเติมในการประเมินอาคารเพื่อรองรับการอยู่อาศัยแบบใหม่ คือ การปรับปรุงมาตรฐานการออกแบบอาคารเพื่อการมีสุขภาวะที่ดี การเพิ่มมาตรการทางวิศวกรรม การมีมาตรการสนับสนุนในการดำเนินการ และการพัฒนาองค์ความรู้ จะทำให้สามารถแก้ปัญหาอย่างยั่งยืนได้

สาขาวิชา	สิ่งแวดล้อม การพัฒนา และความยั่งยืน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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Panupant Phapant : PREVENTING OCCUPATIONAL RESPIRATORY DISEASE FROM EXPOSURES IN OFFICE BUILDING : CASE STUDY COVID-19. Advisor: Prof. Dr. ORATHAI CHAVALPARIT

The COVID-19 pandemic has affected human life in every possible way, and, alongside this, the need has been felt that office buildings and workplaces must have protective and preventive layers against COVID-19 transmission so that a smooth transition from ‘work from home’ to work from office’ is possible. The present study reviews international agency regulations, country regulations, updated journal articles, etc., to critically understand lessons learned from COVID-19 and evaluate the expected changes in sustainability requirements of office buildings and workplaces. The built environment, control environment, and regulatory environment around office buildings and workplaces have been put under test on safety grounds during the pandemic. Country regulation, agency regulations, and operational guidelines need to bring behavioral changes required to protect workers from the COVID-19 pandemic.

This study also investigates the ability of COVID-19’s measures by comparing certified (LEED, TREES, and WELL) and non-certified office buildings in Bangkok, Thailand. Certified building in this study mainly implemented COVID-19 prevention measures. For non-certified buildings, two buildings mostly implemented COVID-19 strategies (>90%), and others are less implemented (< 90%). Providing negative pressure, installing infiltration, using touchless technology, and implementing mental health policy are the most difficult to apply. However, alternative strategies were implemented until no clusters were found in all case studies.

Additionally, an in-depth interview and the Rating scale have been used to explore building satisfaction. The study shows that building satisfaction in all building types increased during this period. The certified building is the most satisfied before COVID-19, while the non-certified building with the good measure is the most pleased during this time because many strategies have been implemented. Moreover, health and comfort criteria have been examined for building occupants, including temperature & humidity, indoor air quality, spatial, visual, and acoustic. Visual is the most satisfying characteristic before COVID-19 while distancing during this period, and it is the most significant aspect that has increased significantly.

The gaps and barriers of the execution are used to explore the challenge and propose additional solutions for fighting the crisis and other respiratory diseases such as flu and influenza. By actor-network analysis, lack of law and regulation for healthy building, lack of expenditure, and lack of knowledge are the significant barriers. So, additional building assessments have been proposed, including healthy building concept design, engineering measures, and supporting and educational strategies have to be implemented to develop sustainable and better-living conditions.

Field of Study:	Environment, Development and Sustainability	Student's Signature .....
Academic Year:	2021	Advisor's Signature .....

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This endeavor would not have been possible without my parents for their love, prayers, care, and sacrifices for education, culminating in three years of learning. Also, I express my thanks to my sister, brother-in-law, and my lovely niece and nephew for their support and valuable encouragement.

Finally, please accept my condolences to the millions of people; the families, relatives, and friends of those who have passed away and been affected by the pandemic of the Coronavirus including those with secondary effects such as illness, separation, unemployment, and economic downturn. Nonetheless, during this time, it is possible to witness humanity's cooperation in protecting and preventing an outbreak, as well as exploring alternative ways to live with new conditions.

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Chapter 1
Introduction

People are spending more time inside the building. Data from the United States Environmental Protection Agency (EPA) reveals that people spend approximately 90% of their time indoors [1]. Additionally, the concentration of some indoor pollutants is often two to five times higher than outdoor levels [2]. So the quality of the indoor environment is determinant to health, well-being, and productivity. Building assessment standard is one measure to improve indoor quality, for example, LEED, WELL, fitwel standard from The United States of America, DGNB from Germany, CASBEE from Japan, Green Mark from Singapore, and TREES from Thailand. Each standard focuses on different points, such as LEED concentrates on sustainability indicators, while WELL focuses on people's well-being.

One of the most significant global pandemics in human history is the COVID-19 outbreak. Pandemics have occurred several times in history, affecting the global health population and causing economic downturns. For example, the Black Death in 1350 killed one-third of the world's population, and the Spanish flu killed fifty million people worldwide [3]. Coronavirus Disease 2019 (COVID-19) is one of the significant global pandemics found in human history. As the World Health Organization (WHO) recently announced, the COVID-19 pandemic is slowly becoming an inescapable part of human life and work [4, 5]. According to WHO data, as of September 2021, more than two hundred and thirty million people had been infected with COVID-19, and nearly five million had died as a result of the virus [6].

This pandemic has created significant challenges in public health and other various areas, including politics, economics, education, and social behavior. Even as humans are looking to minimize COVID-19′s impact on daily life through specific vaccine availabilities, different evolving virus variants have held the human world in the doldrums. The outbreak has resulted in a global economic decline, and economic growth in every global region was forecasted to decrease significantly. For instance, the World Bank predicted the economic growth of Asia and the Pacific to be a mere 0.5%, and South Asia’s economy to contract by 2.7%, Europe and Central Asia’s by

4.7%, and Latin America's by 7.2% compared to the onset of the pandemic [7]. Even after a year of coping with COVID-19 and vaccine introductions, the International Monetary Fund's outlook for the global economy in 2021 indicates very high uncertainty and uneven economic recovery [8].

The modes of transmission for the SARS-CoV-2, the virus that causes COVID-19 are similar to those of the flu, SARS-CoV-1, MERS, and influenza viruses, which include droplet, airborne, contact, fomite, blood borne, fecal-oral, mother-to-child, and animal-to-human transmission [9]. Pamidimukkala et al. [10] concluded that the virus spreads from person to person and causes symptoms that include dry cough, fever, shortness of breath and fatigue. COVID-19 infects the respiratory tract of infected people, causing breathing difficulties, fevers, and coughs. This virus infection primarily causes respiratory illness, which can range from no symptoms to mild to severe symptoms, and even death. According to current SARS-CoV-2 knowledge, transmission occurs primarily through close contact with an infected person or through coughing and sneezing. The amount of viable virus shed and expelled by an infected person, the types of contact an infected person has with others, the settings where exposure occurs, and the preventative measures in place all influence viral transmission rates [11].

COVID-19 is becoming a very difficult disease to control due to its highly infectious nature, long incubation period, difficulty in detection, and ambiguity in transmission modes [12]. As a result of the pandemic, social distancing policies have been implemented. It has had a significant impact on many workforces and workplaces because governments around the world have implemented various social restrictions to reduce infection rates, such as closing schools and requiring people to work from home [13]. Many businesses have been forced to close, affecting the economies of many countries, while employees who have kept their jobs have expressed concerns about their mental and physical well-being. People around the world are panicking about the virus's rapid spread and are isolating themselves from office buildings, with a significant portion of each country's population spending all of their time indoors.

During COVID-19, office and workplace are one of the settings that have special recommend measures to fight against and to protect building's occupants from COVID-19, comprising; agency regulation from international organizations such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), country regulations, and operational guideline. Work from home is one of the significant measures that have been implemented, however, some offices cannot be temporarily closed, for example, food providing station, security office, government service unit, and COVID-19 station services. Nevertheless, after months of strict quarantine, a reopening of society is inevitable. Many countries are planning exit strategies to progressively lift lockdown measures without leading to an increase in the number of COVID-19 cases [14].

Additionally, since an effective treatment has yet been discovered, various guidelines have been provided to alleviate this pandemic including strategies for the built environment. The living condition has to be transformed into a better living condition with COVID-19 responsive and preventive strategies. Additionally, to prevent the next or future pandemic, gaps, and barriers from the current situation must be examined and proposed to be an alternative to building guidelines for standard living in the future.

Although health and comfort criteria are already concerning in sustainable building certification assessment, when an occupational respiratory disease has occurred, the office building has to allow the occupant to work from home to protect them from the pandemic. Since lack of health and comfort condition for occupational respiratory protection and infection factor in the office building**.** This research is going to study the lesson learn from the effective responsive and protective measures for the office building. Furthermore, comparing certified buildings with normal to collect the effect from responsive and preventive strategies that improve health & comfort condition. Additionally, this research explores the gap, barrier, and impact of implementing health and comfort measures to propose additional building assessments for preventing the occupational respiratory disease from exposure in the office building.

1.1 Research Objectives

This research aims to develop a building guideline for better living conditions when facing a pandemic. There are four sub-research objectives, as follows:

1. To identify the existing measures for preventing occupational respiratory infection from exposures in an office building during the COVID-19 pandemic.
2. To study the impacts and building satisfaction of health and comfort criteria in building standards to COVID-19 pandemic protection in office building compared between certified and normal buildings.
3. To identify gaps and barriers of implementing measures for improvement of health and comfort criteria in building in order to protect occupation from occupational respiratory disease.
4. To introduce office building guidelines when facing an infection disease to improve occupant's health and comfort.

1.2 Research Questions

When facing a pandemic, what are the additional building guidelines for better living conditions?

1. When facing COVID -19 pandemic, what effective measures to prevent the employee from disease exposure in an office building?
2. Does the green building standard has higher efficiency in protecting occupational respiratory infection from exposures than non-certified building?
3. What are the gaps and barriers to implementing building guidelines on health and comfort improvement to prevent occupational respiratory infection?
4. What are the additional requirements of health and comfort measures for building assessment when facing the pandemic?

1.3 Scope of the Study

This study has been carried out in the following scope:

1. Sustainable Building Standard in this research using
    - ISO 21929-1, Sustainability in building construction–Sustainability Indicators–Part 1: Framework for developing indicators and a core set of indicators for buildings, (ISO 21929-1, 2011)
    - EN 15643, Sustainability of construction works – Framework for assessment of buildings and civil engineering works (EN 15643-3, 2019),
    - EN 16309 - Sustainability of construction works - Assessment buildings' social performance - Calculation Methodology. (EN 16309:2014+A1, 2014)
2. Sustainable Building Certification Assessment in this study includes:
    - Leadership in Energy and Environmental Design standard for Building Design and Construction (LEED BD+C) Version 4.1
    - Leadership in Energy and Environmental Design standard for Building Operations and Maintenance (LEED EBOM) Version 4.1
    - Thai's Rating of Energy and Environmental Sustainability for New Construction and Major Renovation and Core and Shell Building (TREES NC/CS) Version 1.1
    - Thai's Rating of Energy and Environmental Sustainability for Existing Building: Operation and Maintenance (TREES EB) Version 1.0
    - WELL Building Standard version 2
3. Primary data was collected from an in-depth interview and Rating scale with building owner, facility management manager, and building occupant from both certified and non-certified single-tenant office buildings that have been located in Bangkok, Thailand.

4. Four single-tenant certified buildings from various standards, including Leadership in Energy and Environmental Design (LEED), Thai's Rating of Energy and Environmental Sustainability (TREES) certified building, and WELL Building Standard.
5. Four single-tenant non-certified buildings
6. Actor-Network Analysis is used to identify gaps and barriers of COVID-19 implementing measures from policy, economic, and societal networks.

1.4 Significance of the Study

This study examined the effect of the pandemic, especially health and comfort criteria, in building assessment. Additionally, gaps and barriers from this pandemic have been explored to introduce health and comfort criteria in building standards to mitigate disease exposure in office buildings. Thus, the policymaker, building owner, developer, and designer could identify and provide solutions for better living in the following living condition with the sustainability strategy.

The following chapter introduced to the health and comfort criteria of sustainable building assessment, as well as sustainable building standards and certification assessment. In comparison to COVID-19, responsive and preventive measures from the agency, country, and operational regulations. Furthermore, the vulnerabilities during this time have investigated, and research methodology have developed in the following chapter to address this situation.

Chapter 2
Literature Reviews

2.1 Sustainable Building Assessment

2.1.1 Sustainable Buildings Standard

Sustainable Building Standard has been published to raise building construction standards, provide the necessary performance and functionality for minimizing environmental impact, and improve human well-being while encouraging economic and social aspects.

1). The International Organization for Standardization (ISO) established an internationally recognized standard for building and other construction work sustainability. Sustainability in buildings and civil engineering works - General principles, ISO 15392. Sustainability in buildings and civil engineering works – A review of terminology, ISO/TR 21932: 2013. Sustainability in building construction–Sustainability Indicators–Part 1: Framework for developing indicators and a core set of indicators for buildings, ISO 21929-1 [15]. Sustainability in building construction-environmental declaration of building products, ISO 21930. Sustainability in building construction-Framework for methods of assessing the environmental performance of construction works-Part 1: Buildings (ISO 21931-1). Figure 1 depicts the relationship of international standards.

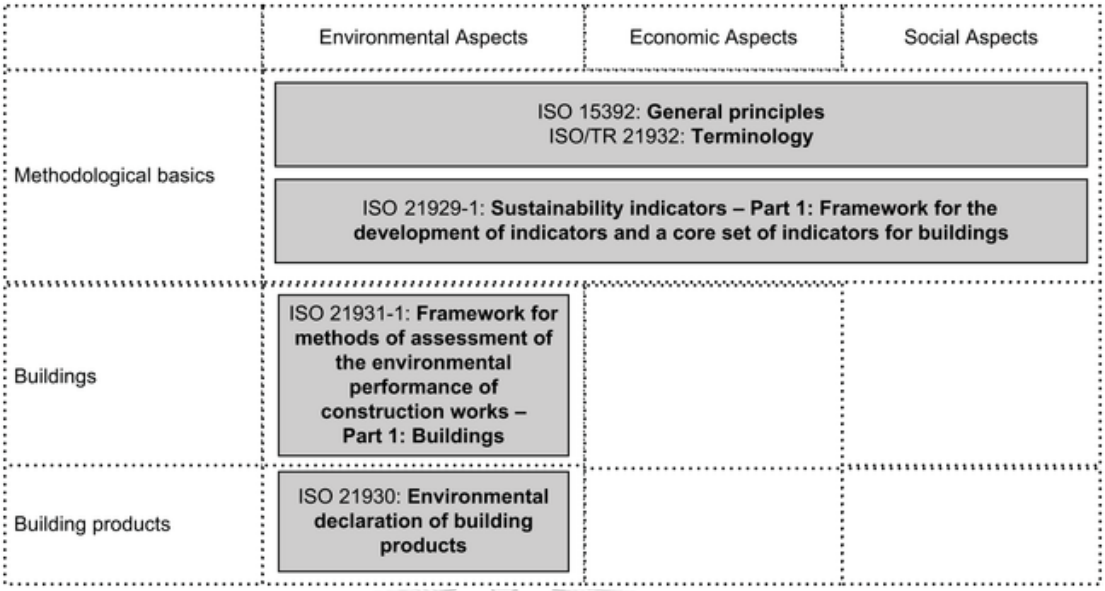


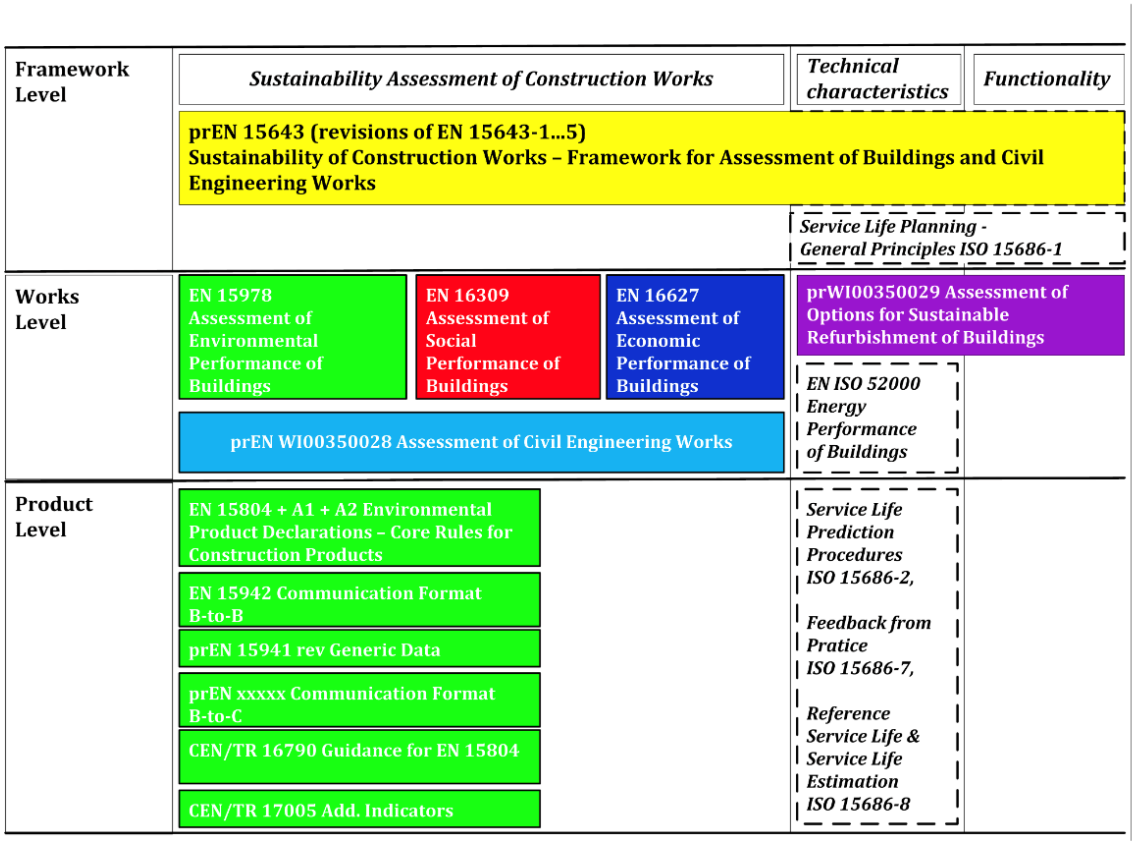
Figure 1: A collection of related International Standards for building and civil engineering sustainability. (ISO 21929-1:2011)

ISO 21929-1 is concerned with the core system of building sustainability indicators. In the context of ecosystem, natural resources, health and well-being, social equity, cultural heritage, economic prosperity, and economic capital. Indoor conditions and air quality, as well as safety, are important aspects of the building's core area of health and well-being. Indoor thermal conditions, indoor visual conditions, indoor acoustic conditions, and indoor air quality are the focus of indoor conditions and air quality.

Sub-aspects of thermal condition comprising air temperature, mean radiant temperature, vapor pressure, humidity, and air movement (velocity). Illumination level, glare, visibility, reflection, daylight factor, and satisfaction in artificial and natural illumination are all considered in visual conditions. Acoustic conditions include noise level and speech intelligibility. And indoor air quality includes odor, chemical and biological pollutants (such as carbon dioxide and carbon monoxide)

While safety aspect in this standard concerning in structural stability during earthquake, explosion, and exceptional weather condition. Second is fire safety, and the third is safety in use focusing in types of accidents.

2). CEN the Technical Committee of the European Union has established European standards. CEN/TC 350 created a framework for sustainability assessment by concentrating on environmental, social, and economic performance of buildings and civil engineering works and mentioned in EN 15643 – Sustainability of construction works – Framework for assessment of buildings and civil engineering work [16]. Figure 2 shows the work program for sustainability building assessment of CEN/TC 350.



NOTE The coloured boxes represent the current work programme of CEN/TC 350.

Figure 2: Work program for sustainability building assessment (EN 15643, 2019)

The social assessment framework in BS EN 15643 is focused on inaccessibility, adaptability, health and comfort, privacy, loadings on the neighborhood, noise and vibration, safety/security, sourcing of materials and services, stakeholder involvement, employment, spatial planning, and protection of cultural

heritage. When safety and security criteria including resilience against accidental actions (fire, explosion), climate change and natural occurrences such as earthquake and flooding, etc). When focusing in health and comfort aspect it comprises acoustic, indoor air quality, visual, water quality, electromagnetic, spatial, and thermal characteristics.

Providing calculation methodology for assessment rules in the social performance of the building in work level using BS EN 16309:2014. The building and occupant characteristics are investigated for each social assessment. Thermal, indoor air quality, spatial, visual, and acoustic characteristics are among the health and comfort criteria in this standard. The detail of each criterion have been shown in Figures 3

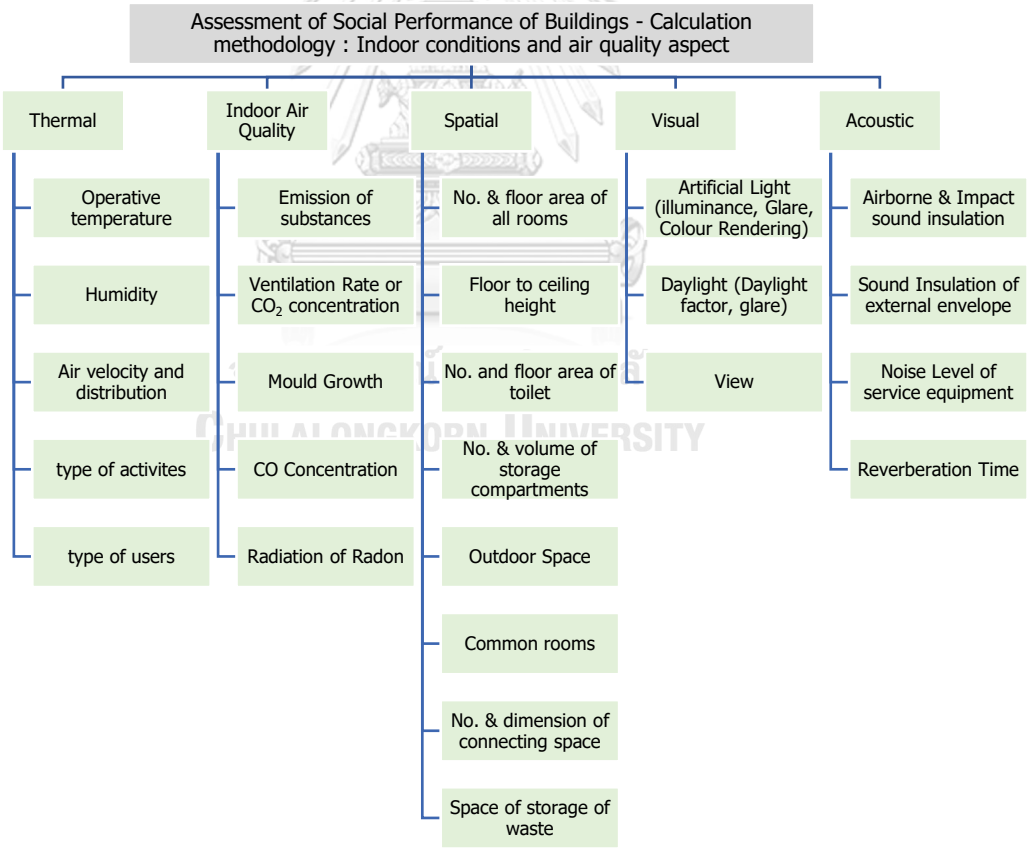


Figure 3: Health and Comfort Criteria from EN 16309, 2014

The operative temperature, humidity, air velocity and distribution, type of activities, and type of users are all thermal parameters of a building. The building-related indoor air characteristics include calculating and assessing the emission of substances, carbon dioxide, and carbon monoxide concentrations, ventilation rate, mold growth, and radon radiation. Spatial characteristics include the number and floor area of toilets, the number and floor area of bathrooms/showers, the number and volume of storage compartments, outdoor space, common rooms, the number and dimensions of connecting space, and waste storage space. Building-related visual comfort includes artificial light (illuminance, unified glare rating (UGR), and color rendering index) as well as daylight contribution (daylight factor and glare) and view. The aspect of acoustic characteristics is determined by the airborne and impact sound insulation of any partition, the sound insulation of the external envelope, the noise level, which includes service equipment, and the reverberation time.

While in BS EN 16309, safety and security are addressed in terms of resistance to climate change, accidental action, personal safety and security against intruders and vandalism, and security against utility supply interruptions.

Climate change resistance Focus on rain resistance in terms of water tightness, load-bearing capacity/water removal capacity, wind resistance based on projected peak wind loads, snow resistance based on snow loading, water tightness, and driving snow, flood resistance based on projected flood intensity and frequency, and solar radiation resistance based on protection against the harmful effects of UV and infrared radiation. Accidental actions such as earthquakes, explosions, fires, and traffic resistance. Personal security and protection against intruders and vandalism by resisting forced entry and deliberate damage, such as a high-security system, expert design analysis, and arson protection, users can feel safe and secure. Back-up equipment for heating and electricity protects against utility supply interruptions. Safety assessment from EN 16309 has been shown in Figure 4

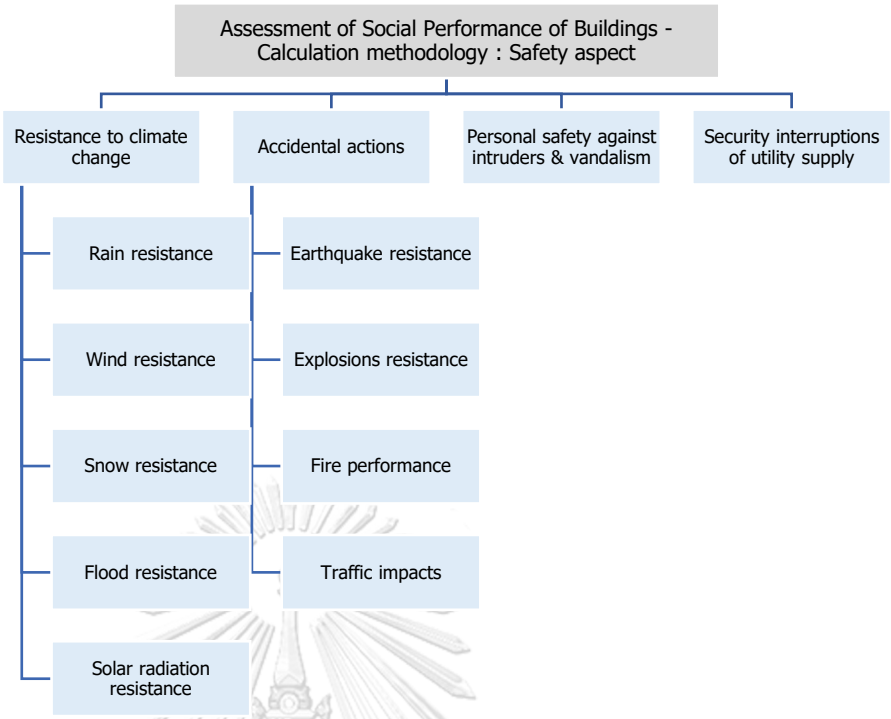


Figure 4: Safety Criteria from EN 16309, 2014

When considering health and comfort criteria from ISO 12929, EN 15643, and EN 16309, five significant characteristics have been categorized: thermal, indoor air quality, spatial, visual, and acoustic.

2.1.2 Sustainable Building Certification Assessment

Building certification is one way to improve the impact on the environment and human well-being. Currently, sustainable building assessments have become more favorable. The most famous assessment is LEED (Leadership in Energy & Environmental Design) from The United States of America, while other standards include BREEM from The United Kingdom, DGNB from Germany, CASBEE from Japan, Green Mark from Singapore, and TREES standard from Thailand. Besides sustainability building assessments, some assessments are only focusing on the health of people in the building, such as WELL from the International Well Building Institute (IWBI) and fitwel from the Center of Disease Control and Prevention (CDC). In Thailand, a sustainable building assessment is also becoming attractive to the developer. Until now (may 2021), more than 300 buildings have been certified by sustainability and well-being building certification.

1). The US Green Building Council (USGBC) created LEED (Leadership in Energy and Environmental Design) in 1993. Building Design and Construction (BD+C), Building Operations and Maintenance (O+M), Interior Design and Construction (ID+C), Residential, and Cities and Communities are all LEED rating systems. The most recent version of LEED for Building Design and Construction (BD+C) is 4.1 [17], which covers nine topics: Integrative Process (with a weighting score of 0.90%), Location and Transportation (14.55%), Sustainable Sites (9.09%), Water Efficiency (10.00%), Energy and Atmosphere (30.00%), Materials and Resources (11.82%), Indoor Environmental Quality (14.55%) and Innovation and Regional Priority (9.09%). While the most recent version of LEED for Building Operations and Maintenance is also 4.1 [18], it has seven categories, including location and transportation (14%), sustainable sites (4%), water efficiency (15%), energy and atmosphere (35%), materials and resources (9%), indoor environmental quality (22%) and innovation (1%).

2). DGNB (Deutsche Gesellschaft fűr Nachhaltiges Bauen). The abbreviation (in German) for Europe's most widespread network for sustainable construction, which was formed in 2007, is the German Sustainable Building Council. The DGNB evaluation is founded on the notion of holistic sustainability, which places equal emphasis on the environment, people, and economic viability. A range of building types, including office, education, residential, hotel, consumer market, retail center, department store, logistics, and production, are eligible for DGNB certification. The most recent version in new construction is DGNB systems version 2020 international [19], which has six criteria: environmental quality (22.5%), economic quality (22.5%), sociocultural and functional quality (22.5%), technical quality (15%), process quality (12.5%), and site quality (5%). When addressing sociocultural and functional quality, this standard focuses on thermal comfort, indoor air quality, acoustic comfort, visual comfort, user control, quality of indoor and outdoor spaces, safety and security, and design for all. In terms of building in use standards, Version 2020 is the most recent, with three primary categories: environmental (40 %), economic (30 %), and sociocultural and functional quality (30 %). Indoor comfort,

user pleasure, and mobility are all considered criteria in talks about socio-cultural and functional quality.

3). Green Mark, The Building and Construction Authority in Singapore launched the Green Mark certification scheme in January 2005, which can be applied in new buildings (non-residential, residential, data centers, and landed housing), existing buildings (non-residential, residential, data centers, and schools), user-centric (office interior, retail, supermarket, restaurant, and laboratories), and beyond building (districts, parks, and infrastructure). For new non-residential buildings, the 2015 version with revision R3 is the most recent for this certification, which focuses on five categories: climate responsive design (21.43 %), building energy performance (21.43 %), resource stewardship (21.43 %), smart & healthy building (21.43 %), and advance green effort (14.28 %) [20]. Green mark for existing non-residential building in 2017 version with main five sections including sustainable management (21.21 %), building energy performance (24.24 %), resource stewardship (18.18 %), smart and healthy building (24.24 %), and advance green effort (12.12 %) [21].

4). WELL (The WELL Building Standard) was introduced by the International WELL Building Institute in October 2014. (IWBI). WELL version 2 is currently the most recent [22], with the majority of the criteria focusing on the health and comfort of the building occupants, including air (10.31%), water (6.19%), nourishment (12.37%), light (7.22%), movement (9.28%), thermal comfort (8.25%), sound (8.25%), materials (9.28%), mind (9.28%), community (14.43%), and innovation (5.15%). WELL, projects are classified into two types based on ownership: owner-occupied (the project owner occupies the majority of the space) and WELL Core (the project owner occupies only a small portion of the space and the rest is rented or leased).

5). The Centers for Disease Control and Prevention (CDC) and the General Services Administration (GSA) developed FITWEL [23]**.** The licensed operator was chosen as the Center for Active Design. Several types of buildings can be certified, including community, commercial site, senior housing, multi-tenant base building, the multi-tenant whole building, single-tenant building, commercial interior space, retail, and multifamily residential building. Reduces morbidity and absenteeism, supports

social equity for vulnerable populations, instills feelings of well-being, improves access to healthy foods, promotes occupant safety, and increases physical activity through seven health impact categories for office building criteria.

6). Thailand also established a local building standard in 2015 called Thai's Rating of Energy and Environmental Sustainability (TREES) from the Thai Green Building Institute (TGBI) for both new and existing buildings. Version 1.1 is the official latest version for New Construction and Major Renovation And Core and Shell Building [24], and it includes eight significant criteria, including building management (3%), site and landscape (18%), water conservation (6%), energy and atmosphere (31%), materials and resources (13%), indoor environmental quality (18%), and environmental protection (5%), and green innovation (6%). While version 1.0 is the most recent version for existing buildings [25], it is divided into eight major categories: building management (6%), site and landscape (17%), water conservation (8%), energy & atmosphere (27%), materials & resources (17%), indoor environmental quality (14%), environmental protection (5%), and green innovation (6 %).

Santos, P., (2017) [26] studied standard EN 15643-3:2012 within the evaluation of social criteria and EN 16309:2014 about general guidelines. Based on qualitative & checklist approach to perform social life cycle assessment of school buildings for higher education focusing on health & comfort and by survey school building users with Analytical Hierarchy Process (AHP) and three case studies of Portugal for weighting scheme to rate social performance. McArthur (2020) [27] presents a systematic review of the requirements in the global wellness system (WELL, FITWEL, Living Building Challenge) and green building ratings (BEAM Plus, BREEAM, DGNB, Green Globes, Green Mark, Green Star, HQE, and LEED) aligns with eight critical topics related to health & productivity & academic literature: indoor air quality, thermal comfort, visual comfort, acoustic comfort, ergonomics & movement, diet & clean water, social well-being, and psychological to situate the system approaches and address gaps in existing system from health & wellness perspective. Cheung, T (2021) [28] studied occupant satisfaction in sustainable

commercial buildings with the indoor environment by a survey for building development to develop IEQ benchmarks for the commercial building.

Each sustainable building certification assessment includes health and comfort criteria for building occupants. The following data are summarized each criterion from the famous's Thailand sustainable building certification assessment.

1). Thermal Characteristic

Thermal characteristics in sustainable building certification assessment are based on ASHRAE 55: Thermal Environmental Conditions for Human Occupancy [29] except Thai's standard that can also comply with Thailand Engineering standard. Table 1 shows the thermal characteristic of each sustainable building certification assessment. All main six factors for acceptance thermal comfort must be addressed, including the characteristics of occupants, metabolic rate and clothing insulation, and building or environmental characteristic that comprise air temperature, radiant temperature, air speed, and humidity.

Table 1 : Comparison of Thermal Characteristics in building with various sustainable building assessment

Thermal Characteristic	
Building Certification	Criteria
LEED BD+C	1.Meets ASHRAE 55-2017 2.Provide individual thermal comfort at least 50% of individual occupant
LEED EBOM	Have a facility maintenance and renovation policy for indoor air quality by 1. Adhere to the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings Under Construction (Focusing on protecting stored on-site and ASHRAE 55-2017 recommendations. 2. Create a procedure for replacing all filtration media prior to occupancy

	3. Create a plan to determine whether flushing or air quality testing is necessary
TREES NC/CS & TREES EB	Mechanical Ventilation 1. Provide thermal comfort for the occupant following ASHRAE 55-2004 2. Design temperature and relative humidity to comply with Thailand Engineering Standard-3003, such as 24 degrees Celcius and 55% of relative humidity for the office building Natural ventilation Follow ASHRAE 55-2004 section 5.3
WELL	Thermal Performance: 1. Provide and monitor the acceptable thermal environment 2. Verified Thermal comfort by survey 3. Thermal zoning by providing thermostat for occupied space and individual control 4. Implement radiant heating and cooling 5. Humidity control (maintain humidity between 30%-60%) 6. Enhanced operable window by design and operation 7. Outdoor thermal comfort by managing outdoor heat, avoiding excessive wind & supporting outdoor nature access Moisture Management: 1. Develop envelope for moisture protection 2. Design Interiors for moisture management (condensation & water leak control) Implement mold & moisture management plan

2). Indoor Air Quality Characteristic

Emission to a substrate, ventilation, carbon monoxide concentration, risk of mold growth, and radon radiation is involved in these characteristics.

2.1) Emission to Substrate

Volatile Organic Compounds (VOC) content and emission, furniture, and formaldehyde content are the significant aspects in the substrate's emission. Table 2 represent the characteristic of the emission in building assessment

Table 2 : Comparison of Indoor Air Quality Characteristic – Emission of Substrate in building with various sustainable building assessment

Indoor Air Quality Characteristic - Emission of Substrate	
Building Certification	Criteria
LEED BD+C	1. VOC Content for - Adhesive and Sealant followed SCAQMD 1168 - Paint & Coating followed SCAQMD 1113 & CARB 2007 2. VOC Emission comply with CDPH V1.2-2017 for adhesive and sealant, paint & coating, flooring, wall panels, ceiling, and insulation 3. Furniture Emission: low volatile organic compound comply with ANSI/BIFMA Standard Method M7.1-2011 (R2016) and complies with ANSI/BIFMA e3-2014e or e3-2019e Furniture Sustainability Standard, section 7.6.1 or 7.6.2 or 7.6.3 4. Formaldehyde Emission: Low formaldehyde for composite wood meet California Air Resources Board (CARB) for ultra-low-emitting formaldehyde (ULEF) or no-added formaldehyde
LEED EBOM	1. VOC Content for wet-applied products: meet SCAQMD 1113 / SCAQMD 1168 / ASTM D2369-10/ISO 11890, PART 1 / ASTM D 6886-03 OR ISO 11890-2 2. VOC Emission comply with CDPH V1.2-2017 for adhesive and sealant, paint & coating, flooring, wall panels, ceiling, and insulation 3. Furniture Emission: low volatile organic compound comply with ANSI/BIFMA Standard Method M7.1-2011

	4. Formaldehyde Emission: Low formaldehyde for composite wood meet California Air Resources Board (CARB) for ultra-low-emitting formaldehyde (ULEF) or no-added formaldehyde
TREES NC/CS	1. VOC Content for wet-applied products: meet SCAQMD 1168 for adhesive & sealant and SCAQMD 1113 for wood varnish 2. Formaldehyde Emission: non-urea formaldehyde in both materials and adhesive for composite wood 3. Thai Green Label Certification 4. Green Seal Standard for wall, ceiling, anti-corrosion and anti-rust paint 5. Green label plus for carpet
TREES EB	-
WELL	1. VOC Content for wet-applied products comply with CARB 2007, SCAQMD 1113 / SCAQMD 1168 2. VOC Emission comply with CDPH 1.1-2010 or later for adhesive and sealant, paint & coating, flooring, and insulation 3. Furniture Emission: ANSI/BIFMA e3-2011/CDPH 1.1-2010 or later

4.2) Ventilation

Ventilation design and indoor air quality assessment are the significant criteria to improve indoor air quality inside the building. Table 3. Represent indoor air quality characteristics in various sustainable building assessments.

The minimum ventilation rate in mechanical and natural ventilation is specified in ASHRAE 62.1-2016: Ventilation for Acceptable Indoor Air Quality. The ventilation rate for mechanical ventilation is determined by the occupancy category, the outdoor airflow rate required per person, the outdoor airflow rate required per unit area, the number of people in the ventilation zone or occupant density, and the net occupiable floor area or floor area. For example, in an office space, the required outdoor air rate is 5 cfm/person with an occupied density at 5 person/100 m^2. For

Thailand, the ventilation rate ranges from 2 to 10 $m^3/hr/m^2$ depending on location. And under the Building Control Act 1979, Ministerial Regulation No.39 (B.E. 2537) specifies ventilation rates for mechanical systems in cubic meters/hours/square meters, such as 2 $m^3/hr/m^2$ for office buildings. The ventilation rate for natural ventilation is determined by the floor area with ceiling height and operable wall opening, as well as the location and size of the opening.

Table 3: Comparison of Indoor Air Quality Characteristic - Ventilation in Building with Various Sustainable Building Assessment

Indoor Air Quality Characteristic - Ventilation		
Building Certification	Air Ventilation	IAQ Assessment
LEED BD+C	Mechanical Space 1. Meet ASHRAE 62.1-2016, section 4,5,6.2,6.5 and 7 2. When outdoor air intake is more than 1000 cfm, provide monitoring system and set alarm when varies by 15% Natural Space 1. Meet ASHRAE 62.1-2016 2. Provide direct exhaust airflow measurement 3. Provide automatic indication devices on opening system 4. Monitor carbon dioxide level Filter and recirculated air MERV 13 or higher accordance ASHRAE 55.2-2017, or ePM1 50% or higher as defined ISO	IAQ Testing 1. Flush-out before or during occupancy 2. Air-testing [Particulate Matter. Carbon Monoxide, Ozone, VOC]

	16890-2016 Negative Pressure Create negative pressure for hazardous gases or chemicals contaminate the room	
LEED EBOM	Mechanical Space 1. Ventilation Rate meets ASHRAE 62.1-2016, section 6.2 2. Outdoor air quantity delivery within 10% of the requirement and plan Natural Space Requires location of opening and size of opening adopted from ASHRAE 62.1-2016 section 6.4.1	IAQ Testing 1. Inorganic Contaminants 2. VOCs
TREES NC/CS & TREES EBOM	Mechanical Ventilation 1. Ventilation rate comply with ASHRAE 62.1-2007 section 6.2 (Ventilation rate depends on required outdoor air per person or area and number of people) 2. Ventilation rate comply with local standard named Ministerial Regulation No.39 (B.E. 2537) issued under the Building Control Act 1979 and maintain indoor air quality that meets Thailand Engineering standard – 3010 (Ventilation rate depends on required	For TREES EBOM: 1. Indoor Air Quality Testing: (CO_2, TVOC, Formaldehyde, PM 10) 2. Air Commissioning -Outdoor & return air do not exceed 10% of the design

	outdoor air per person or area and number of people) 3. Air intake position, at least 10 meters away from pollution and heat source with at least 3 meters height from ground. 4. For Air Handling Unit (AHU) that have 1000 liter/second have to install MERV 7 (meet ASHRAE 52.2) or 25-30% for outdoor air intake and return air position Natural Ventilation 1. Ventilation rate comply with ASHRAE 62.1-2007 section 5.1: (open space at least 4% of area within 7.6 meters) 2. Ventilation rate comply with local standard named Ministerial Regulation No.39 (B.E. 2537) issued under the Building Control Act 1979 and maintain indoor air quality that meets Thailand Engineering standard – 3010: (Ventilation rate depends on required outdoor air per person or area and number of people) 3. Air intake position, at least 10 meters away from pollution and heat source with at least 3 meters height from ground	

	Negative Pressure In chemical storage, printer, and photocopy room, air circulation is prohibited. Proper ventilation rate is 2.5 litres / second / sq.m. Pressure dropped at least 5 Pa when compared to the surrounding area and at least 1 Pa when the door was opened.	
WELL	For mechanically spaces 1. Ventilation Design meet one of following: ASHRAE 62.1-2010 / ASHRAE 62.2-2016 / EN 16798-1 / AS 1668.2-2012 / CIBSE Guide 2. Control CO_2 level < 900 ppm 3. Improve ventilation by ASHRAE RP-949, ASHRAE 62.1 & REHVA Guidebook) or outdoor air is supplied with airspeed no greater than 0.25 m/s at the occupant's head. And return air diffusers are located more than 2.8 m above the floor For Natural Ventilation 1. Ventilation design comply with one of the following: ASHRAE 62.1-2010 / CIBSE AM10 / AS 1668.4-2012 2. Vents and windows are permanently open (Openable window area at least 4%)	Air Quality 1. Meet Thresholds for Particulate Matter (PM 2.5 / PM 10) 2. Meet Thresholds for Organic Gases (Testing & VOC Monitoring)) 3. Meet Thresholds for Inorganic Gases (CO/Ozone) 4. Meet Thresholds for Radon

	Air filtration 1. 100% outdoor air (supply air has not recirculated from within the building) 2. Partially recirculated air has been treated by activated carbon filtration or media filter PM 2.5 (MERV 12 or above) / UVGI / Upper-room UVGI Negative Pressure - In cleaning & chemical storage have to separate from adjacent spaces with self-closing doors and negative pressure. Microbe & Mold Control - Implement Ultraviolet Air Treatment at all central air handling units, cooling coils, and drain pans	

4.3) Risk of mold growth

Mold growth has been considered in the sustainable building certification system by following ASHRAE 62.1 standard and protecting it during construction. Table 4 show concerning mold growth in building assessment

Table 4: Comparison of Indoor Air Quality Characteristic – Risk of mold growth in building with various sustainable building assessment

Indoor Air Quality Characteristic – Risk of mold growth	
Building Certification	Criteria
LEED BD+C	Testing resistance to mold growth of material surface followed ASHRAE 62.1 and prevent mold growth during construction
LEED EBOM	Prevent mold growth during construction by protect stored on-site and install absorptive materials from moisture damage.
TREES NC/CS & TREES EB	Testing resistance to mold growth of material surface followed ASHRAE 62.1
WELL	Require to utilize UVGI system at air handling units and cooling coils and/or inspect of cooling tower and have a moisture management plan for both exterior and interior

4.4). Radiation from Radon

LEED and WELL standards have some credit for radiation from radon, especially from building materials and secondary smoke. Table 5: Radiation from Radon from several sustainable building assessments

Table 5: Comparison of Indoor Air Quality Characteristic – Radiation from Radon in building with various sustainable building assessment

Indoor Air Quality Characteristic – Radiation from Radon	
Building Certification	Criteria
LEED BD+C	LEED for residential concerning in Radon-resistant construction
LEED EBOM	-
TREES NC/CS & TREES EB	-
WELL	Consider radon poisoning after a second cigarette.

3). Spatial Characteristic

The nine topics covered in the assessment of sustainable building certification assessment are: number and floor area, floor to ceiling height, number and floor area of the toilet, number and floor area of the bathroom, number and volume of the storage compartment, outdoor space, common rooms, number and dimension of connecting space, and waste storage space. According to ASHRAE 62.1-2016, Ministerial Regulation No.39 (B.E. 2537) published under the Building Control Act 1979, and Thailand Engineering standard – 3010, ventilation rate depends on all criteria that provide spatial characteristics.

4). Visual Characteristic

Artificial, natural daylight, and view are visual characteristics of sustainable certification building assessment are considered. Table 6 shows the visual characteristic of each sustainable building certification assessment.

Table 6: Comparison of Visual characteristics in building with various sustainable building certification assessment

Visual Characteristic	
Building Certification	Criteria
LEED BD+C	Artificial Lighting 1.Glare Control : Using light fixtures with a luminance of less than 7,000 candela/m^2 or achieving unified glare rating (UGR) < 19 2. Color Rendering : Use a light source that has a color rendering index (CRI) of at least 90 : Use light sources that have color fidelity index $\geq$ 78 and gamut index 97-110 3. Surface Reflectivity - Use ceiling that have surface reflectivity > 80% and > 55% for walls - Furniture finish surface reflectance > 45% for work surfaces

	and 50% for movable partitions 4. Lighting control : Provide dimmable or multilevel lighting for 90% of occupants Daylight : At least 55% of regularly occupied floor area access to daylight by spatial daylight autonomy & annual sunlight by simulation, calculation or measurement View : 75% of occupant space with outdoor natural or urban environment view
LEED EBOM	-
TREES NC/CS	Artificial Lighting 1. Lux level comply with the standard such as 300 lux for the office building 2. Lighting Control: one control panel for 250 sq.m. or 90% of building occupants are controllable their lighting Daylight : Daylighting simulation to calculate the area that has daylight factor (DF) more than 2% at 75 cm height
TREES EB	Artificial Lighting : One control panel for 250 sq.m. or 90% of building occupants Daylight : Daylighting simulation to calculate area that have daylight factor (DF) more than 1% at 75 cm height
WELL	Artificial Lighting 1. Envelope glazing area is no less than 7% of regularly occupied floor area 2. Circadian lighting design – at least four hours at noon project achieve at least 120 EML (Equivalent Melanopic Lux) 3. All indoor and outdoor space comply with one of the following (IES Lighting Handbook 10th edition, EN 12464, ISO 8995, GB50034, CIBSE SLL Code for Lighting)

	4. 90% of project area meet illuminance thresholds such as office and classroom have a minimum 320 lux 5. Manage glare from electric lighting by using light fixtures with a luminance of less than 6,000 candela/m^2 or achieve a unified glare rating (UGR) $\leq$ 16 6. Lighting Control At least one control per 60 m or per 10 occupants, lighting system has at least one of following: color, color temperature, distribution Daylight 1. Daylight simulation: more than 30% of regularly occupied floor area meet 200 lux of target lighting 2. 70% of all workstations have a visible light transmittance (VLT) greater than 40% 3. Average sDA300, 50% is achieved for >55% of regularly occupied floor area Manual shading is controllable at all times or automated to prevent glare

5). Acoustic Characteristic

HVAC background noise, reverberation time, sound transmission between rooms & building envelopes, and reverberation time are among the main types of acoustic characteristics. Table 7 shows the acoustic characteristic in building assessment

Table 7: Comparison of Acoustic Characteristics in building with various sustainable building assessment

Acoustic Characteristic	
Building Certification	Criteria
LEED BD+C	1. HVAC background noise Comply with HVAC systems per 2015 ASHRAE Handbook

	2. Sound Transmission Meet sound transmission class (STC) or noise isolation class (NIC) 3. Reverberation time
LEED EBOM	-
TREES NC/CS & TREES EB	-
WELL	1. HVAC Background Noise - Limit background noise levels 2. Sound Transmission - Sound barrier at walls and doors - Implement sound-reducing surfaces 3. Achieve reverberation time 4. Sound mapping by label acoustic zone and providing acoustic design plan 5. Provide enhanced speech intelligibility such as audio devices and hearing health conservation

2.1.3 Existing Guidelines and Standards to protect health and comfort to office building occupants

Different international organizations such as the National Institute for Occupational Safety and Health (NIOSH), World Health Organization (WHO), and private organizations such as ASHRAE and countries are establishing exposure guidelines and standards. For Example

1. The National Institute for Occupational Safety and Health (NIOSH)

   NIOSH is part of the U.S. Centers for Disease Control and Prevention, in the U.S. Department of Health and Human Services as a research agency that established from the occupational safety and health act of 1970 to study of worker safety and health and empowering employers and workers to create safe and healthy workplaces. For health and comfort in building occupant, NIOSH published

1.1 Dampness and mold assessment tool for schools and general building [30]

1.2 Ventilation and exhaust rate followed ASHRAE 62.1 – 2016 by controlling indoor carbon dioxide concentration no greater than 700 ppm above outdoor, five cubic feet per minute of outdoor air per person (cfm/person)

1.3 Temperature and humidity as ASHRAE 55-2017 by controlling temperature between 20 °C – 24 °C (68.5 – 75 °F) in winter, and 24 °C – 27 °C (75-80.5 °F) in summer and < 65% of relative humidity.

2. Occupational Safety and Health Administration : (OSHA), U.S. Department of Labor

OSHA recommended the indoor air quality in commercial and institutional buildings in 2011 about control methods [31] . There are three basic control methods for lowering concentrations of indoor air pollutants:

2.1 Source management: includes removal, substitution, and enclosure of sources. It is the most effective control method when it can be applied practically.

2.2 Engineering controls:

2.2.1 Local exhaust such as a canopy hood, is very effective in removing point sources of pollutants before they can be dispersed into the building's indoor air.

2.2.2 General dilution ventilation, A well-designed and functioning HVAC system controls temperature and relative humidity levels to provide thermal comfort, distributes adequate amounts of outdoor air to meet the ventilation needs of building occupants, and also dilutes and removes odors and other contaminants.

2.2.3 Air cleaning, Air cleaning primarily involves the removal of particles from the air as the air passes through the HVAC equipment

2.3 Administrative controls

2.3.1 Work Schedule Through scheduling, managers can significantly reduce the amount of pollutant exposure in their buildings. For instance, Eliminate or reduce the amount of time a worker is exposed to a pollutant, Reduce the amount of chemicals being used by or near workers, Control the location of chemical use (i.e., perform maintenance work on moveable equipment in a maintenance shop as opposed to the general area, or locate the equipment (e.g., printers, copiers) in a separate room

2.3.2 Education of building occupants regarding IAQ is important.

2.3.3 Housekeeping practices should include preventing dirt from entering the environment.

3. Singapore Standard SS 554: 2016 [32] recommended indoor air quality parameter for building that have been shown in Table 8

Table 8: Recommendation of Indoor Air Quality Parameter from Singapore Standard

Parameter	Maximum Allowance (8 Hr)
1. Indoor Air Quality Parameter	
1.1 Thermal Comfort Parameters	
Operative Temperature	23-35 °C
Relative Humidity	< 65% for new building < 70% for existing building
Air Movement	0.10-0.30 m/s
Ventilation (Depend on building type)	2-10 ($m^3/h/m^2$)
1.2 Chemical Parameters	
Carbon dioxide	700 ppm above outdoor
Carbon Monoxide (ppm)	9 ppm
Formaldehyde	100 µg/m^3 or 0.08 ppm

Total volatile organic compounds, TVOC	1,000 ppb
Respirable suspended particles (Particles sampled with a median cut-point of 4 µm)	50 µg/m^3
PM 2.5	37.5 µg/m^3
1.3 Biological Parameters	
Total viable bacterial count	1000 cfu/m^3
Total viable mould count	Up to 500 is acceptable, if the species present are primarily Cladosporium
2. Air Contaminants	
Nitrogen Dioxide	40 µg/m^3
Ozone	0.05 ppm
Radon	100 Bq/m^3
Asbestos	0.01fibre/cc
Nicotine	< 0.01 µg/m^3
Volatile Organic Compound & Semi-volatile organic compound	Permissible exposure limit (PEL) of toxic substances

In Thailand, various recommendations to protect health and comfort for office building have been provided for example

1. Indoor air Quality assessment handbook for staff, Department of Health, Ministry of Public Health 2016 [33] recommended parameter for an office area assessment. Table 9 recommend of indoor air quality parameter

Table 9: Recommendation of Indoor Air Quality Parameter

Parameter	Maximum Allowance (8 Hr)
1. Indoor Air Quality Parameter	
1.1 Thermal Comfort Parameters	
Operative Temperature	24-26 °C
Relative Humidity	< 65% for new building < 70% for existing building

Air Movement	0.10-0.30 m/s
Ventilation (Depend on building type)	2-10 ($m^3/h/m^2$)
1.2 Chemical Parameters	
Carbon dioxide	700 ppm above outdoor
Carbon Monoxide (ppm)	9 ppm
Formaldehyde	120 µg/m^3 or 0.1 ppm
Total volatile organic compounds, TVOC	3,000 ppb
Respirable suspended particles (Particles sampled with a median cut-point of 4 µm)	50 µg/m^3
1.3 Biological Parameters	
Total viable bacterial count	500 cfu/m^3
Total viable mould count	Up to 500 is acceptable, if the species present are primarily Cladosporium
2. Air Contaminants	
Dust Particle less than 2.5 µm ($PM_{2.5}$)	35 µg/m^3
Ultra-fine particle, PM_1	Not Applicable
Nitrogen Dioxide	100 µg/m^3
Ozone	0.1 ppm
Radon	150 Bq/m^3
Asbestos	0.02fibre/cc
Nicotine	Not detected
Pathogenic Bacteria	Presence of specific species
Pathogenic Mould	Presence of specific species
Volatile Organic Compound & Semi-volatile organic compound	Permissible exposure limit (PEL) of toxic substances

Moreover, this handout also recommends improving indoor air quality by follow HVAC standard system and Using highly efficient of air filtration, using UAGI in air dust system and HEPA filter, have a HVAC maintenance plan, cleaning the cooling coil & carpet, have a good ventilation in printer room, using low volatile organic compound furniture, and using air filtration (if necessary).

2. Ministerial Regulation No.39 (B.E. 2537) followed the Building Control Act B.E. 2522 (1979) from the Office of the Council of State [34]

   This regulation mentioned the ventilation and lighting condition in various places. For the office area, the ventilation rate should not be less than 7 air change rate per hour (ACH), and fresh air quantity should be at least 2 $m^3/hr/m^2$ when 100 lux is the minimum for the illuminance.

3. The Commandment of Bangkok in the subject: Building Control B.E. 2544 from the Bangkok Metropolitans Administration. [35]

   This regulation also mentioned the ventilation rate. Fresh air quantity and luminance level same as the former one.

4. Ministerial Regulation on the prescribing of standard for administration and management of occupational, safety, health and environment in relation to heat, light and noise B.E. 2549 (Version 7 October 2016) [36]

In this standard, Working condition have been divided into three categories depend on using calories per hours: Light work is using calories < 200 kcal/hr, Medium work when using calories 200 - 350 kcal/hr and Hard work for working condition who using calories > 350 kcal/hr.

1. For heat aspect: using the average Wet Bulb Globe Temperature (WBGT)
   - For light work, Average Wet Bulb Globe Temperature (WBGT) < 34 degree Celsius
   - For medium work, Average Wet Bulb Globe Temperature (WBGT) < 32 degree Celsius
   - For hard work, Average Wet Bulb Globe Temperature (WBGT) < 30 degree Celsius
2. For lighting aspect Follow the announcement from the Department of Labor Protection and Welfare about Lux Output Level 2018 for office area 300 lux is required, while toilet and emergency exit is 100 and 10 lux respectively.

3. For acoustic aspect considerate into two sub-aspect including
    1. peak sound pressure level of impact or impulse noise not exceed 140 dB or continuous steady noise not exceed 115 dBA
    2. Follow the announcement from the Department of Labor Protection and Welfare, Table 10 shown the time limitation is announced by the following

Table 10: Time Weighted Average and Duration Time for continue receiving sound

Time Weighted Average (TWA) (Not exceed, dBA)	Duration Time for continue receiving sound (Hour:Minute)
82	16:00
83	12:42
84	10:5
85	8:00
86	6:21
87	5:20
88	4:00
89	3:11
90	2:31
91	2:00
92	1:35
93	1:16
94	1:00

2.2 COVID-19 situation, responsive and preventive strategy for COVID-19

Before COVID-19, many researchers studied the effective way to solve the respiratory pandemic for example, Belfiglio, V. J. (2017) [37] examined when the Roman empire faced typhoid. Isolation and sanitation systems were implemented. Bramanti, B. et al. (2016) [38] studied the measures when faced with the Black Death.

Quarantine & restriction on movement were adopted. Ott, M. et al. (2007) [39] reviewed the Spanish flu responsive. Social distancing, closure of various public spaces, and wearing a mask were applied. Baldwin A.N. (2006) [40] investigated SARS in Hong Kong and proposed to improve ventilation and drainage system

Since the becoming of COVID-19, some researchers have conducted studies on the effect of this global pandemic. Megahed (2020) [41] studied imagining what an antivirus-built environment looks like based on lessons learned and the importance of design. This study also pointed out post-pandemic office space with more space for individuals, better ventilation, and healthy design options. Ral et., al (2020) [42] studied four major parameters comprising population density, climate severity, space volume, and air-conditioning usage, which affect infection spread and mortality in India with different climate conditions. The result showed that this virus is very active in a cold and dry environment. Additionally, some research investigated gaps and opportunities when facing COVID-19, such as Djalante (2020) [43] investigated COVID-19 response in ASEAN countries during the period from January to August 2020 by identifying gaps and opportunities in government responses and providing recommendations for the future. Furthermore, the author investigates the effect of COVID-19 on the built environment in Indonesia (Djalante,2020). Some papers focused on the impact on built environments, such as Ahsan (2020) [44] , studied policy against this pandemic by secondary-based research. The research showed that centralized decision-making, active participation, and local level implementation are critical for fighting the pandemic. Shi, K-W (2021) [45] & Megahed (2020) [41] studied the effect of indoor air quality. Kwok (2021) [46] examined the impact of spatial to COVID-19. Tleuken (2021) [47] et al. Studied the readiness of the Green Building Certification System (GBCS) during pandemics based on a literature review. The result showed that have no standard ready for pandemic

COVID-19 has affected human life in every possible way; as a result, human patterns that are changing because of COVID-19 may lead to insights that are useful in the fight against COVID-19 [48]. Since the discovery of COVID-19, people have begun to deliberately alter building infrastructures, house interiors, and lifestyles in order to provide some protective layers against the virus [49]. Fear of COVID-19 has

redirected customers' preferences from hypermarkets to decentralized commercial places for quicker shopping. Since COVID-19, decentralization, redistribution, and restructuring have emerged as critical design concerns. Even city dwellers' perceptions of cities' futures have shifted, with six-lane cycling corridors replacing six-lane highways as their preferred mode of transportation to and from offices and schools [50]. Honey-Roses et al. (2020) [51] concluded that the lengthy battle with COVID-19 forced the world to reconsider the design of urban public spaces in order to serve people's best interests. Sepe (2021) [52] went one step further and pointed out that the COVID-19 pandemic has called into question the validity of the principles and practices outlined in the 'Charter of Public Space,' which several countries use when designing public spaces. Dogan et al. (2020) [53] indicated a positive correlation between meteorological variables, and ambient air quality (PM2.5, PM10) with COVID-19 cases, while Shahzad et al. (2021) [54] showed that COVID-19 death cases were positively correlated with air quality and temperature. Emmanuel et al. (2020) [55] reemphasized the importance of introducing fresh air into crowded and poorly ventilated buildings.

Because workers may come into close contact with colleagues and visitors from various locations with varying levels of COVID-19 pandemic infectivity, virus exposure can occur at any time in the workplace [56]. As a result, regulatory guidelines and directives are critical in combating the COVID-19 pandemic in the workplace. Policies aimed at protecting workers also prevent the virus from spreading in the community and protect national economies by ensuring open and safe workplaces[11].

Countries must implement pandemic control regulations and directives that reflect their specific needs and legislative backgrounds, in addition to international health regulations. Sector-specific guidelines can provide additional clarity to business operators while also benefiting various sectors of the economy. Governments and industry associations must both actively support the development of industry-specific risk and safety guidelines for workers to follow. Tokazhanov et al. (2020) [57] noted that as a result of the current pandemic, existing building sustainability ratings based on "environmental impact" and "energy performance" needed to be

completely overhauled. Jiang et al. (2021) [58]. pointed out that to control the spread of the epidemic in the community, drastic changes in the spatial distribution of living spaces were required. The Architectural Society of China (2020) [59] emphasized the importance of improving the health performance of buildings because buildings are inextricably linked to their communities in epidemic prevention and control measures. Awada et al. (2021) [60] confirmed that building layouts cannot effectively withstand the spread of COVID-19 and must be changed. Valizadeh et al. (2021) [61] further suggested that because most infections occur indoors, the indoor environment must be altered.

Because of the COVID-19 pandemic, businesses have been forced to allow officials to stay at home while remaining active for official engagements through an online presence. Experts are concerned that working from home is less productive because employees are separated from their coworkers and managers [62]. Furthermore, studies have shown that when working from home, employees are unable to disengage from official work on time, resulting in increased worker stress and decreased productivity [63]. In fact, both managers and employees are dissatisfied with the continuation of working from home. Many countries are currently in the midst of their second or third pandemic waves, but both government and private establishments are already planning for the eventual reopening of offices to employees. As a result of the coronavirus pandemic's persistence, existing office buildings and official workplaces have been reconsidered; both office buildings and official workplaces must become more resilient against COVID-19 disease spread in order for workers to return. Companies are making extensive safety arrangements to prevent COVID-19 transmission as employees return to their offices. At this point, it is critical to consider how office buildings and workplaces can establish protective and preventive layers against COVID-19 transmission among employees and workers. To protect their wellbeing during this pandemic emergency, managers and employees needed foolproof, tailor-made COVID-19 protocols that only take the regulations and guidelines produced at the international and national levels as basic considerations.

2.3 Effect of COVID-19 to health and comfort to building occupant

Various research studied the effect of COVID-19 to building occupant health and comfort. For example, thermal comfort and indoor air quality by examining the location of the droplet, Ding, J., et al. [64] evaluated the relationship between the relative humidity and the infection rate by using simulations of computational fluid dynamics. The study discovered that with low humidity, droplets would lose water through mass transfer, shrink in size, and move farther under the ventilation system's circular airflow. It is advised that keeping indoor relative humidity between 50 and 60 percent, lower the likelihood of the transmission of airborne infectious diseases has been occurred. Cheng,P., et al. [65] conducted research on the wind-pressure coefficients for the COVID-19 epidemic in the quarantine hotel. According to the study, cross-corridor infections could be reduced in a hallway by maintaining positive pressure and having adequate ventilation and a simultaneous questionnaire and sensor monitoring campaign were performed during the reopening of the educational buildings by de la Hoz-Torres et.,al [66] to look at the effects of post-epidemic procedures on the internal environment in university buildings in one Portuguese and one Spanish institution. Even though the carbon dioxide level is still low, the results showed that there were unsatisfactory conditions, thus the indoor environment and distance from sources of carbon dioxide should be adjusted. When comparing the effects of centralized and split air conditioning systems, Fachruding,H et al. [67] looked at ventilation, air quality, thermal comfort, health protection, and passive design. The outcome demonstrated that split-type systems maximize ventilation and have management of indoor air quality. In comparison to another, occupants can manage their thermal comfort and implement health protection.

For the distancing aspect: using computer-vision cameras to analyze occupancy patterns, physical distances between occupants, group formations, and occupancy length, K. Jens and Gregg, J.S. [68] analyzed real-time occupancy trends in open learning space during COVID-19. The architectural design of shared building areas has an impact on the occupation style. M. Qian, & Jiang, J.[69] researched the COVID-19 protection with the confirmed case by a review of the literature and documents. According to this study, social isolation is now the most successful

strategy. A mixing-based Wells-Riley model was used by C. Sun, & Zhai, Z. [70] to investigate the ideal distance for COVID-19 protection when estimating the likelihood of contracting the virus by airborne contact. According to the study, the safe social distance can be up to 8.2 m (26 ft) if all droplets are taken into consideration in a calm air environment. This distance is based on the aerosol transmission of inhaled large droplets from talking and is between 1.6 and 3.0 m (5.2–9.8 ft). D.K.Chu, et.,al. [71] investigated the ideal separation to prevent COVID-19 transmission using a comprehensive study and meta-analysis. The findings indicated that a physical distance of 1 m or more reduced the risk of virus transmission compared to a distance of less than 1 m. When compared to disposable surgical masks or something similar, the usage of face masks could significantly reduce the risk of infection. These relationships are higher with N95 or similar respirators. Additionally, less illness was linked to eye protection.

Some articles focused in visual aspect for example A Batool et.,al. [72] explored the effect to view during COVID-19 by global online survey. The result shown the increasing of important of window design because of more importance given to windows as a way to provide an external view and a visual and social connection with other people for post COVID-19 era. When a home office is needed for COVID-19, C. McKee, & Hedge, A.[73] reviewed the literature on lighting conditions, including the effects of electronic light from screens, daylight, and task lighting on health and well-being. According to the study, people alter their lighting environment to suit their comfort and preferences. It is also vital for organizations to think about how to match individual lighting experiences when workers are called back into offices after the pandemic.

Additionally for acoustic topic, Andargie, M. S., Touchie, M., & O'Brien, W. [74] and A. Şentop Dümen, & Şaher, K. [75] studied the effect from teleworking in multi-unit resident building in Canada and Turkey respectively by occupant survey. Annoyed from the same suites such as family and roommate is the most significant issue, outdoor noise from neighboring suite, traffic and construction activities are the second that affected work ability. Moreover, this research pointed out that permanent teleworking is not suitable. H. P. Lee, & Kumar, S. [76] studied impact when increase

natural ventilation to mitigate the transmission of CORONA virus from the reduction of human and industrial activities. The result shown that, there are positive effect for both human health and animal during the shutdown. However, acoustic material in post COVID-19 era have to concentrate on antimicrobial and frequent disinfection properties. Additionally, acoustic design have to pay particular attention to keep distancing purpose during working hours. While, M. Caniatoet,.al [77] Examined how personal protective equipment affect speech transmission in classroom. By measuring speech transmission and sound pressure level at different position. It can be concluded that in classrooms surgical masks should be adopted as they protect from mouth spray and do not significantly reduce speech intelligibility and indoor sound field, both without and with a transparent window for lip reading. And C. Bartalucci et.,al. [78] studied unprecedented effect of the pandemic in soundscape in Italy. By comparing between outside house, from home, and neighbourhood by online survey and regression model. The result shown that noise produced by neighbourhood is significantly affect to the respondents and traffic noise is observed in people who age over 35 years.

2.4 Regulation/Measure to contain the spread of the COVID-19 disease in offices

2.4.1 Agency Regulations

International organizations/agencies, such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and International Labor Organization (ILO), have issued a number of health regulations to combat the spread of COVID-19 disease in workplaces. Maintaining good hygiene, cleaning work surfaces, promoting good respiratory hygiene, regular hand washing and developing well-defined meeting protocols in workplaces [79]. The WHO [11],[79-83] have also provided practical guidance to national and local governments, employers, workers and their representatives, and occupational health services on preventing COVID-19 outbreaks at work by reducing worker exposure to and transmission of SARS-CoV-2. In response to the COVID-19 pandemic, the Centers for Disease Control and Prevention (CDC) [84-87] issued updated employer regulations to ensure safe and healthy workplaces. The CDC mandated that employers assess workplace hazards on a regular basis and implement an effective hazards control system. The USA

Occupational Safety and Health Administration (OSHA) [88, 89] also published regulations related to infection prevention and industrial hygiene practices for the workplace. OSHA regulations emphasize employers' responsibility to provide employees with a safe working environment free of recognized hazards that can result in death or serious physical harm [89]. Similarly, the European Centre for Disease Prevention and Control (ECDC) [90-93] recommended various strategies and the installation of heating, ventilation, and air conditioning systems (HVAC) for minimizing airborne transmission of COVID-19 in workplaces and measures which reduce the risk of airborne SARS-CoV-2 transmission [94]. International Labor Organization (ILO) suggested a safe return to work practice and an action checklist for COVID-19 mitigation [95-97] . Additionally, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) introduced various strategies to fight against COVID-19 in workplaces, especially ventilation improvement [98-103].

2.4.2 Country Regulations

In addition to workplace guidelines from various international organizations, various countries have presented their own regulations and measures to limit the spread of the COVID-19 disease in offices and workplaces. Although a country's success in containing the pandemic is not solely due to effective workplace regulations, it is nearly impossible to contain the pandemic without the latter. The Bloomberg COVID-19 Resilience Ranking provides a useful snapshot of 53 countries' COVID-19 prevention successes. The countries listed in the ranking with effective regulations and success in containing COVID-19 were New Zealand, Singapore, Australia, Israel, South Korea, Finland, Norway, Denmark, Mainland China, and Hong Kong Special Administrative Region of the People's Republic of China [104]. The following are some examples of various country regulations:

Singapore [105, 106]: During the COVID-19 pandemic, work-from-home became the default mode of employment in this country; penalties were imposed for anyone who violated this policy. Employers were instructed to take care of their employees and workplaces, particularly those who became ill on the job. Employers were instructed to implement safety management measures such as monitoring plans

and safe management officers to meet this requirement. Personal hygiene, safe separation, and mental health measures were also critical in this country's success in containing the pandemic.

South Korea [107]: The Republic of Korea's government launched the "All about Korea's Response to COVID-19" initiative to assist employers and employees in maintaining good hygiene and social distancing in the workplace. Avoiding crowded work environments and implementing work-from-home and flexible work schedules were among the strategies employed.

Finland, Norway, and Denmark: received high marks for best COVID-19 management by implementing advisories for employers and employees [108-111], recommending remote work [112], and re-opening offices [113].

China: The State Council for the People's Republic of China issued guidelines for both employers and employees on how to stay safe from COVID-19 in the workplace. Strategies included [114] guidelines for the commute to work, arriving at work by stairs (rather than elevators), guidelines in the office, and guidelines for after work. Holiday customs were also discussed [115].

Hong Kong Special Administrative Region of the People's Republic of China: The Centre for Health Protection, Department of Health, advised for the prevention of COVID-19 in the workplace and businesses (Interim) [116] by maintaining good personal and environmental hygiene in workplaces, maintaining toilet hygiene, and maintaining the hygiene of overnight rooms

2.4.3 Operational Guidelines

The risk of infection spreading among employees in a workplace is also determined by the working environment's characteristics and workplace operational guidelines. For example, Dyal et al. (2020) [117] reported the ordeal of many meat processing workers when group infections occurred in this sector's closed factory environments, which frequently lack adequate ventilation. Agostinho (2020) [118] pointed out that COVID-19 spread quickly in the meat processing sector due to an inherent processing requirement that prevented coworkers from maintaining a six-foot safe working distance between one another. Furthermore, Van Den Berg et al. (2021) [119] emphasized the importance of maintaining a physical distance of 3 versus 6 feet in public schools where face marks are required. Lower distancing can be used in a

school setting, according to the data. As a result, Ijaz et al. (2021) [120] emphasized the importance of developing policies and working protocols specifically for meat production and supply chain to limit disease spread.

Furthermore, due to the inherent work patterns of the health sector, health sector workers were the most vulnerable to COVID-19 during the pandemic's peak periods in some respective countries [121]. Iavicoli et al. (2021) [122] presented a framework for general workplace risk assessment based on three intrinsic requirements: exposure, proximity, and aggregation. According to this assessment, health and social workers had a higher risk of infectivity than workers in education, arts, entertainment, and recreation. This fact supports the notion that a single safety guideline or protocol cannot effectively protect workers from the COVID-19 pandemic [123]. Understanding sector-specific risk factors and workplace characteristics, on the other hand, must be a prerequisite for developing effective, tailor-made safety guidelines and protocols for a specific workplace. Finally, workers must be informed about updated guidelines and protocols on a timely basis so that strategies are correctly implemented and problematic misperceptions between managers and workers are avoided [124].

2.5 Effects of COVID-19 Pandemic on Office and Workplace Sustainability

When comparing existing standards to protect building occupant health and comfort and COVID-19 measures. Some regulations and recommendations can be used to prevent and protect COVID-19, such as in The National Institute for Occupational Safety and Health (NIOSH), which mentioned ventilation and exhaust control rates by following ASHRAE 62.1. Ventilation control from the Occupational Safety and Health Administration, which was concerned with dilution ventilation, air cleaning, and recommended an administrative control by eliminating or reducing the amount of chemical. Including Thailand's regulation for ventilation rate and fresh air quantity, as mentioned in Ministerial Regulation No.39 (B.E. 2537) from the Office of the Council of State and from the Bangkok Metropolitans Administration's Commandment in the subject: Building Control B.E. 2544.

COVID-19 measures, on the other hand, have an additional aspect that is not mentioned in both existing building standards and sustainable building certification, which is to increase ventilation by

- As indoor and outdoor conditions permit, turn off demand-controlled ventilation and fully open outdoor air dampers.
- Maintain the system for longer periods of time (24/7 if possible).
- Before or after occupancy, flush with fresh air. Construction work should be completed at least 2 hours before and after use.
- Except in the case of air filtration or disease-killing machines, avoids air recirculation.

Since the outbreak of the COVID-19 pandemic, the pandemic has provided a variety of office working experiences that have given a better understanding of workplace vulnerabilities to disease transmission. COVID-19 has had an impact on professionals' working styles, regardless of whether they worked from home or in commercial office spaces. Business owners and facility managers had to make arrangements and implement engineering and administrative measures to ensure the safety of on-site work in some industrial operations where working from home was not possible. Workplace layouts were changed to provide some separation between adjacent workstations, and ventilation systems were improved. Employees were given administrative instructions to keep their distance from other colleagues while at work. All of these measures worked together as protective layers against the spread of COVID-19, restoring coherence to office buildings and workplaces.

Building owners and policymakers must work with the office manager to implement infection protection and prevention strategies that adhere to agency regulations and national standards. Furthermore, they must implement COVID-19 control measures, which may include (a) implementing engineering controls (such as ventilation) to prevent airborne virus transmission and (b) implementing

administrative controls and COVID-19 protocols that apply to everyone present in the workplace.

2.5.1 Engineering Control Environment in Workplaces

During the COVID-19 pandemic, many workers converted their homes into makeshift offices. Working from home allows employees to be more flexible in their official duties while also protecting them from virus infection. As managers and employees gained more experience dealing with their own safety during the pandemic, their desire to return to regular office-working arrangements grew. However, because the virus's dangers remain, office workplaces must be modified to provide workers with a sense of security so that normal productivity can resume [125-127]. The dangers of COVID-19 should compel office managers to construct protective layers around offices to prevent infection spread among workers. Living with COVID-19 has provided many practical insights in this context.

Workplaces are vulnerable areas where COVID-19 cases can rapidly multiply or infection cluster. Although allowing employees to work from home can reduce workplace hazards, most workforces include a large number of employees who cannot work from home due to the criticality of their industries. Furthermore, whether employees work in a factory or a plush office, their exposure to infection hazards puts their family members and coworkers at risk [128]. Given how quickly infected workers can spread pandemic viruses to their urban residential areas, the workplace must have protective layers in place to keep workers safe from virus transmission [129].

Günther (2020) [130] reported evidence of how a lack of infection control efforts from management in a German food processing factory resulted in workers being continuously exposed to recirculated infected air, resulting in a rapid increase in new COVID-19 cases. Elsewhere, Herstein et al. (2021) [131] described a similar super-spreading event of COVID-19 in a meat processing factory in Nebraska, USA, due to a lack of infection controls. Investigations into these cases of rapid virus transmission in factories revealed the absence of three critical infection control measures: a lack of fresh air circulation in a closed space, a lack of physical

separation between coworkers during working situations, and a lack of administrative controls. To protect workers from the COVID-19 disease, management must develop well-thought-out infection control plans, especially in environments where the risk propensity is inherently high, such as open office space environments [132]. The advanced preparedness of management to prevent COVID-19 and other pandemic diseases has been critical to the safety of their workers. Infection prevention should be the top priority in any manager's COVID-19 response plan. Successful infection prevention is dependent on accurately assessing the various degrees of risk associated with various industrial and office settings and managing these risks with effective control strategies [133]. Managers are tasked with identifying infection-spreading gateways in their respective controlled areas and then implementing the appropriate tools and techniques to close these gateways. Workers at the previously mentioned meat factories reported that managers allowed for closed spaces with limited fresh air circulation, resulting in the rapid spread of infection [134]. Workers also noted that the virus's ability to survive longer in a low-temperature closed room was not taken into account before allowing workers to be present [130]. Employees want to return to offices that are more adaptable to COVID-19. Flexible desk arrangements, improved touch-free technologies, less crowding made possible by employee roster presence plans, frequent sanitization, and the ability to switch to remote working arrangements as needed are examples of adaptive office facilities [135].

1). Ventilation

COVID-19 literature supports airborne transmission of the SARS-CoV-2 virus, primarily via respiratory droplets smaller than 5 microns. Larger respiratory droplets (more than 10 microns) cannot be suspended in the air for long periods of time, but they can still cause disease transmission when they accumulate on and contaminate surfaces. There is some disagreement about how long aerosol viruses can remain active while afloat, how fresh air dilution affects viral loads, and how far viruses can travel while airborne. However, some existing case studies unequivocally confirm the risk of COVID-19 transmission by air. Aerosol SARS-CoV-2 viruses are a legitimate concern for office workers. Aerosol viruses can remain active in the air

for some time and make a direct airborne journey into workers' respiratory tracts, according to evidence [136].

During the first COVID-19 waves, research from various countries highlighted the potential respiratory spread of the novel coronavirus under low temperature and low relative humidity (RH) conditions [137, 138]. Low RH and temperature environments aided in the rapid spread of the novel coronavirus throughout the population [139]. Engineering controls that prevent the spread of COVID-19 in workplaces have been implemented as part of management's responsibility, whether by installing or maintaining adequate air replenishment systems or climate control systems. When engineered measures are insufficient or impractical to implement, managers must consider alternative methods of preventing disease transmission in their workplaces.

2). Distancing and Building Layout

The built environment surrounding offices must be reshaped and adapted in light of the COVID-19 pandemic [140]. The pandemic has demonstrated that traditional office design concepts were overly focused on productivity and economic efficiency. Although high-rise commercial buildings can house large populations of workers, they also expose more people to a higher risk of contamination through human contact. Interior office spaces that chose less square footage per worker to save money have become the least desirable option under COVID-19 [141, 142]. State-of-the-art high-speed elevators in sophisticated multistory office buildings have unexpectedly become hotspots for infection spread; employees now perceive offices with sprawling staircases as safer and more beneficial to their health [143].

When office managers had to reduce virus propagation among office workers during COVID-19, their attitude toward open office plans shifted quickly [125]. When infected coworkers cough and expel coronavirus droplets, open office layouts can crowd and confine many employees into a shared space, facilitating aerial viral transmission. The SARS-CoV-2 virus can survive in aerosols for up to three hours, during which time humans can become infected [144, 145]. As society gains a better understanding of the possible modes of transmission for the SARS-CoV-2 viruses, an increasing number of employees find existing open-plan offices unacceptable [146].

COVID-19 literature also supports single-occupancy office rooms and even suggests leaving rooms empty for a period of time, depending on airflow rate and room size, before welcoming new employees [147].

3). Facilities and Equipment

Of course, touch-free devices can completely eliminate physical contact by workers. The desire to make day-to-day office operations touch-free has grown [148]. Employees had to touch many facilities before the COVID-19 pandemic to operate them. Touching devices such as biometric fingerprint scanners, computers, printers, tea and coffee vending machines, and many others were used on a daily basis in the office. Employees have become more hesitant to operate office facilities via touch as a result of the coronavirus situation. There will be a demand for offices where employees rarely need to touch items with their hands after COVID-19. At the same time, personal smartphones can control lifts and coffee vending machines [149]. As employees return to the workplace, offices must be equipped with touch-free technologies [150]. To allay workers' fears of infection, management must plan to use affordable, available, and workable technologies to drastically reduce office touchpoints. Otherwise, employees may become hesitant to visit offices that overly rely on touch-based operations.

Individuals can become infected with COVID-19 by touching virus-infected surfaces in the office. Van Doremalen et al. (2020) [151] indicated that the active period of SARS-CoV-2 viruses varies depending on the type of surface they are present on. SARS-CoV-2 remains active for a longer period of time (2 to 3 days in laboratory conditions) on plastic and stainless-steel surfaces but for a much shorter period of time (1 day) on cardboard surfaces. Despite being metal, copper surfaces provide the shortest possible life for viruses. Experiments in the lab have also revealed that a single contaminated door handle can cause a rapid multiplication of infected people in an office within hours [152]. Surfaces that can retain viruses for a longer period of time should be used less frequently. Workers must be aware of the risk profile of their immediate office environment and become more strategic in order to keep infection risks to a minimum [153].

4). Water and Sanitary System Safety

During the temporary building closures caused by COVID-19, the buildings' water tanks are likely to contain microbiological contaminants [154], which may take a long time to recover to normal levels. Furthermore, an increase in legionella [155] can endanger the health of the building's occupants.

2.5.2 Administrative and Organizational Control Environment in Workplaces

It is especially important for office workers to be aware of COVID-19 safety precautions such as mask use. It has been discovered that doffing COVID-19 protective equipment is common in workplaces, posing infection risks to everyone present [156]. Furthermore, workplace visitors must be carefully managed to prevent external virus sources from penetrating the disease-prevention layers.

To effectively combat COVID-19, every employee in a typical workplace must work together to adhere to disease-prevention protocols. Failures or suppression of disease symptoms by a single worker can expose entire workplace populations to infection, which, depending on local statutory guidelines, may result in the closure of the entire office [157]. As a result, office administrators must communicate basic COVID-19 prevention guidelines to all employees on a regular and effective basis. More importantly, they must face the challenge of keeping employees motivated to follow enforced guidelines and systems [158].

2.5.3 Vulnerabilities of Office Buildings and Workplaces

Different pandemic-resilient requirements must be ingrained into the collective system of building architectures, layouts, safety measures, and many more for workers to return to their respective workplaces. If these critical protective layers are successfully implemented in office and factory settings, they can ensure workplace sustainability during the pandemic. Table 11 identifies and summarizes the key vulnerabilities in the implementation of preventive COVID-19 regulations, engineering control, and administrative control. Each vulnerability must be addressed in order to reduce disease transmission risks among employees and to construct antivirus protective layers.

Table 11: Vulnerabilities of office buildings and workplaces based on experiences with COVID-19.

Category	Subcategory	Vulnerabilities	References
Regulatory environment	International agency regulations	• Virus exposure can occur at any time in an unregulated workplace. • Various international health regulations that must be followed in workplace are unknown. • A simple translation of international, national, and sectoral requirements to office-specific guidelines and protocols may not be sufficient.	[56, 159, 160]
	Country regulations	• National level COVID-19 guidelines may differ from international guidelines. • Country regulations may reflect COVID-19 resiliency at the national level, but are not office-specific. • Country regulations are only general representations of COVID-19 threats.	[104, 160]
	Operational guidelines	• Guidelines are constantly changing and evolving, which can cause confusion. • Workers may not receive timely updates to COVID-19 operating procedures and guidelines.	[122-124, 161]
Engineering Controls Environment	Ventilations	• Some offices and workplaces do not have filtered or fresh air supplies. • Lack of infection controls through engineering means in office spaces. • Management may be unaware of proper indoor temperature and humidity control	[131, 136, 137, 139]

		protocols that reduce the infectiousness of the COVID-19 disease.	
	Distancing and Building Layout	• Indoor offices are rigid and inflexible structures that prevent employees from keeping a safe distance from one another. • Existing open-plan office interior designs were deemed unsuitable due to a high COVID-19 transmission propensity. • High-rise commercial buildings have more risk of contamination.	[41, 125, 141-143, 145]
	Facilities and equipment	• Touching various gadgets and surfaces on a daily basis increases the risk of virus transmission. • Hands-free cultures are uncommon and difficult to implement in traditional workplaces. • There are no automated office environments with less physically operated systems. • Prevailing work cultures are not resistant to the spread of infectious diseases such as COVID-19 • Office equipment and facilities were not historically designed to prevent infectious diseases • SARS-CoV-2 was found on surfaces in the isolation area where suspected patients were kept.	[153, 162-164]
	Water and Sanitary System Safety	• Stagnant water can cause poor water quality, particularly microbiology and legionella, which can be harmful to building occupants.	[154, 155]

Administrative and Organizational Controls Environment	Workplace Safety Measures	• Employees who remove their COVID-19 protective gear in the workplace put their coworkers at risk.	[156]
	Cleaning and Disinfection	• Standard office cleaning policies and procedures are ineffective at preventing infection risks.	[133]
	Emergency Plan Development	• During the COVID-19 pandemic, office surveillance systems based on staff attendance are nearly useless and require upgrades. • Employees suppressing disease symptoms create risk for entire offices.	[131, 157]
	Business Continuity Guideline	• Management is not adequately assessing the carrying degrees of risk relevant to different industrial and office setups.	[133]
	Education and Communication	• Less motivated employees may avoid being trained on COVID-19 protocols or following the protocols.	[158]

A variety of strategies have been implemented in the office building to protect the occupants and combat the disease. There have been few articles and studies on the impact of COVID-19 infection, prevention, and control measures on office building owners and occupants. As a result, the consequences of this disease have been researched in order to improve building efficiency and prepare for future respiratory diseases.

2.6 Actor-network analysis

Actor-network analysis was first invented in Paris in the early 1980s by Byuno Latour et al. (Latour, Bruno 1999) [165] . It attempts to understand processes of technological innovation and scientific knowledge creation. Actor-Network sets out to describe humans' complex society and, importantly, non-humans as equal actors tied together into networks. Assuming that actors can be human or non-human and all actors are similar, an actor will not have more significant power over the other.

Mol (1996) [166] developed a methodology to analyze the changing interactions within the institutional environment for major industrial transformations. This so-called “triad-network” studies policy networks, economic networks, and societal networks. (Chavalparit, 2006), [167] comprising

- Policy network: focuses on policy and action plan of central and local government response.
- Economic network: consists of interacting organizations with financial goals and rationality as their principal motive for interactions. Economic actors are businesses, competing firms, utility, and equipment supplier
- Societal network: is dealing with industry-civil society interactions such as NGOs, communities, labor organizations, and also their connection

Chapter 3
Research Methodology

3.1 Assessment of sustainable buildings and COVID-19 infection, prevention, and control measures

1). The scope and definitions of health and comfort in sustainable building standards from the international organization for standardization (ISO) and European committee (EN) have been investigated to identify the scope and definitions of health and comfort in building assessment.

2). Health and comfort criteria from international standards are gathered in the assessment of sustainable building certification assessment, including

1. Leadership in Energy and Environmental Design standard for Building Design and Construction (LEED BD+C) Version 4.1

2. Leadership in Energy and Environmental Design standard for Building Operations and Maintenance (LEED EBOM) Version 4.1

3. Thai's Rating of Energy and Environmental Sustainability for New Construction and Major Renovation and Core and Shell Building (TREES NC/CS) Version 1.1

4. Thai's Rating of Energy and Environmental Sustainability for Existing Building: Operation and Maintenance (TREES EB) Version 1.0

5. WELL Building Standard version 2

3). The infection prevention and control measures strategies to COVID-19 workplace conditions from various sources have demonstrated to find out the auxiliary health and comfort criteria when confronted with a pandemic comprising

1. World Health Organization (WHO)

2. Center for Disease Control and Prevention (CDC), U.S. Department of Health & Human Services

3. Occupational Safety and Health Administration (OSHA), U.S. Department of Labor.

4. European Centre for Disease Prevention and Control (ECDC)

5. International Labor Organization (ILO)

6. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

7. Thailand ‘s COVID-19 infection, prevention, and control measures

8. Previous research and articles

4). Comparison of sustainable building assessment and infection prevention and control strategies in each health and comfort criterion

5). Additional building certification assessments in each of the health and comfort criteria have been proposed.

3.2 Comparing certified and non-certified buildings in health and comfort performance experience before and during COVID-19

3.2.1 Research Approach and method

A questionnaire and in-depth interview of the building's stakeholders has been adopted in this study to explore the efficiency in health and comfort criteria of sustainable and well-being building certification compared to the non-certified building. According to Miles & Huberman (1994, p.28) [168], the combination of mixed qualitative sampling between criterion and purposeful random sampling has been selected for the building's occupant. The criteria for determining the respondents are shown in Table 12 criterion and questions to building’s stakeholder. At the same time, the purposeful random sample has been implemented because everyone in the population has the same probability of being selected. The questions are based on the objective that focuses on studying the occupant's impact on health and well-being.

Table 12: Criteria and questions to building's stakeholder

No.	Type of Respondent	Qualification of Respondent	Question
1	Building Owner, Developer, and Facility Management Manager	1. Working in an existing building since January 2019 – present 2. Have experience in Building management more than ten years	Appendix 1 & Appendix 6
2	Building Occupants	1. Working in an existing building since January 2019 – present 2. Already know whether or not their building has been certified?	Appendix 2 & Appendix 8

Before COVID-19 period represents before December 2019 (The first COVID-19 case), while during COVID-19 starting from January 2020 up to the present. Require working experiences for building owner and facility management manager at the same building since January 2019 to control all respondents who have experience before and during COVID-19 in the same building. Moreover, the requirement of at least ten years of experience in building management to collect building owner and facility management managers to have a management crisis experience during flooding in Bangkok in 2010.

3.2.2 Data Collection

Data collection was held from April to September 2021. All respondents have worked in the same building before and during COVID-19 and have experience both working in office buildings and from home.

Building owners, developers, facility management managers, and occupants from single-tenant offices in certified and non-certified buildings represent the building's stakeholders in this study. Eight single-tenant office buildings were in the Bangkok Metropolitan area, Thailand, with a significant renovation or certification

within ten years. Four buildings LEED, TREES, and WELL certified, have been chosen to represent certified buildings. Additionally, two non-certified buildings that mainly implement COVID-19 measures and two buildings that seldom follow the recommendation have been selected. Table 13 shows the detail of each building, and Figure 5 depicts the location of each building.

Table 13: Characteristics of Building Case Study

Building	Certified body	Building type	Spatial characteristic in workstation area
A	LEED – BD&C	Private Office Building	16 stories with 17,000 m^2
B	WELL	Mixed-use Office Building	1 story with 900 m^2
C	TREES-NC	Private Office Building	2 stories with 1,600 m^2
D	LEED-BD&C	Mixed-use Office Building	5 stories with 3,100 m^2
E	Non-certified	Mixed-use Office Building	2 stories with 1,700 m^2
F	Non-certified	Private Office Building	3 stories with 2,400 m^2
G	Non-certified	Mixed-use Office Building	8 stories with 4,500 m^2
H	Non-certified	Private Office Building	3 stories with 2,000 m^2

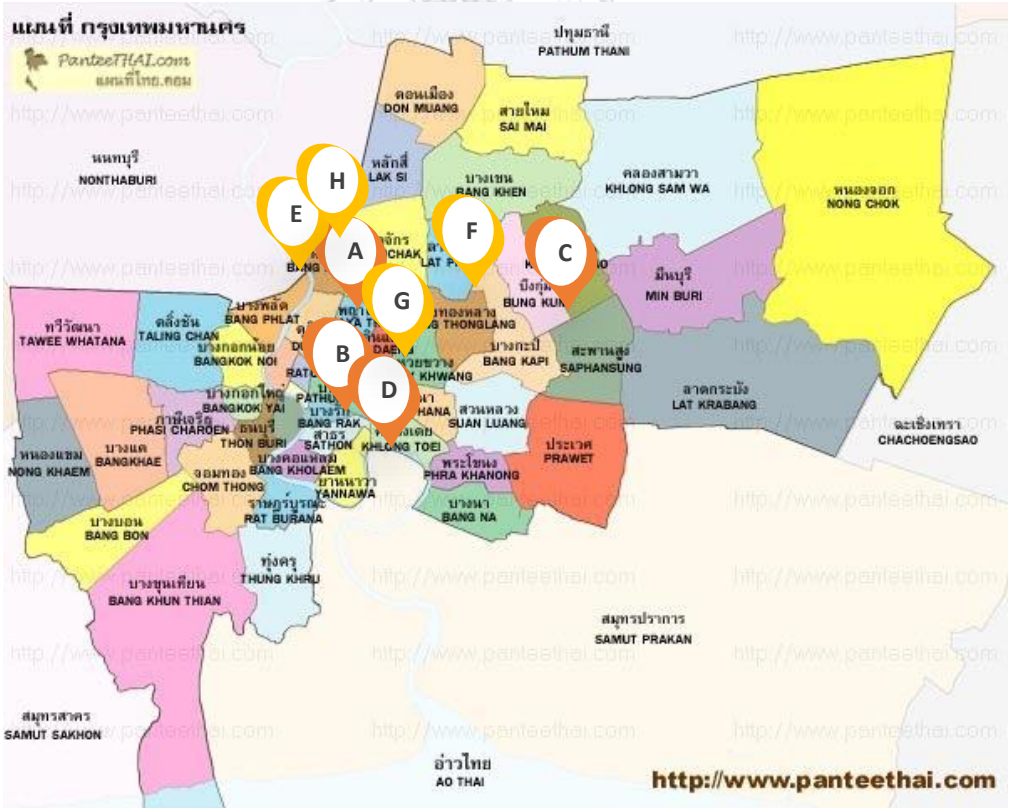


Figure 5: location of each building in Bangkok, Thailand

The number of the interviewee is shown in Table 14

Table 14: Number of the interviewee from building's stakeholders to explore the efficiency of each health and comfort criteria in an office building

Building	No. of Building Owner or Facility Manager	No. of Occupant (approx.)	No. of Respondents (Building's occupant)
A	1	2500	25
B	1	100	5
C	1	250	5
D	1	500	5
E	1	350	5
F	1	500	5
G	1	450	5
H	1	550	5
Total Respondents	8	5,200	60
Total Respondents from the building's owner, facility manager, and occupant			68

Additionally, the rating scale is used to measure the importance of building to protect health and comfort and building's satisfaction in each of health and comfort from the building's occupants on a scale of 1 to 5.

1 score is Mostly unimportant or Mostly Unsatisfied,

2 score is Unimportant or Unsatisfied,

3 score is Moderate,

4 score is Important or Satisfied, and

5 score is Mostly important or Mostly Satisfied.

3.2.3 Data Analysis

Summarize data about the impact on health and well-being of the building's occupant between certified and non-certified buildings against COVID-19.

3.3 Gaps and Barriers of implementing health and comfort improvement measure in building

3.3.1 Research Approach and Method

In-depth interviews from the actor-network analysis have been implemented to investigate gaps and barriers when facing a pandemic and introduce the strategy to fight against COVID-19 to improve the building's performance for the next normal living.

3.3.2 Data Collection

Using actor-network analysis and in-depth interviews explored gaps and barriers when implementing health and comfort measures in an office building. The question for in-depth interview questions are shown in Appendix 3-8

Actor-network analysis including

Policy network: This study focused on both the national and provincial levels. Department of Health and Department of Disease Control from the Ministry of Public Health are national-level representatives. At the same time, the Public Health and Health Department from Bangkok Metropolitan Administration stands as the local government. Additionally, laws and regulations for workplace and office building levels have been examined.

Economic network: This research concentrated on health-related and engineering specialists from Academic Institute, Ventilation, Building Technology developer, Building Owner & developer, and Building Facility Management. The waste management company is included in the economic network.

Societal network: This article involved the Engineering Institute of Thailand, Thai Green Building Institute, Thailand Facility & Management Association, Thai Health Promotion Foundation, and Building Occupants.

Actor-network analysis and list of questions are shown in Table 15

Table 15: Actor-network member and list of questions

Policy Network	Question
Health-related of Preventive & Prevention Measure	Appendix 3
Economic network	
Academic Institution Expert	Appendix 4
Innovative Product Manufacture	Appendix 5
Building Owner and Facility Manager	Appendix 6
Societal Network	
Non-Government Organizations	Appendix 7
Mass Media	Appendix 7
Building Occupants.	Appendix 8

Additionally, the infected waste management policy has been examined, followed by question appendix 9, and the financial assistance unit has been studied by the question appendix 10.

3.3.3 Data Analysis

Actor-network analysis have been used to analyze gaps and barriers when facing pandemics. Then the guidelines of health and comfort indicators for sustainable building assessment has been developed.

3.4 Introduce office building guidelines

3.4.1 Research Approach and Method

The literature, in-depth interview, and gap and barrier analysis have been collected to propose office building guideline

Research methodology is summarized by following this diagram

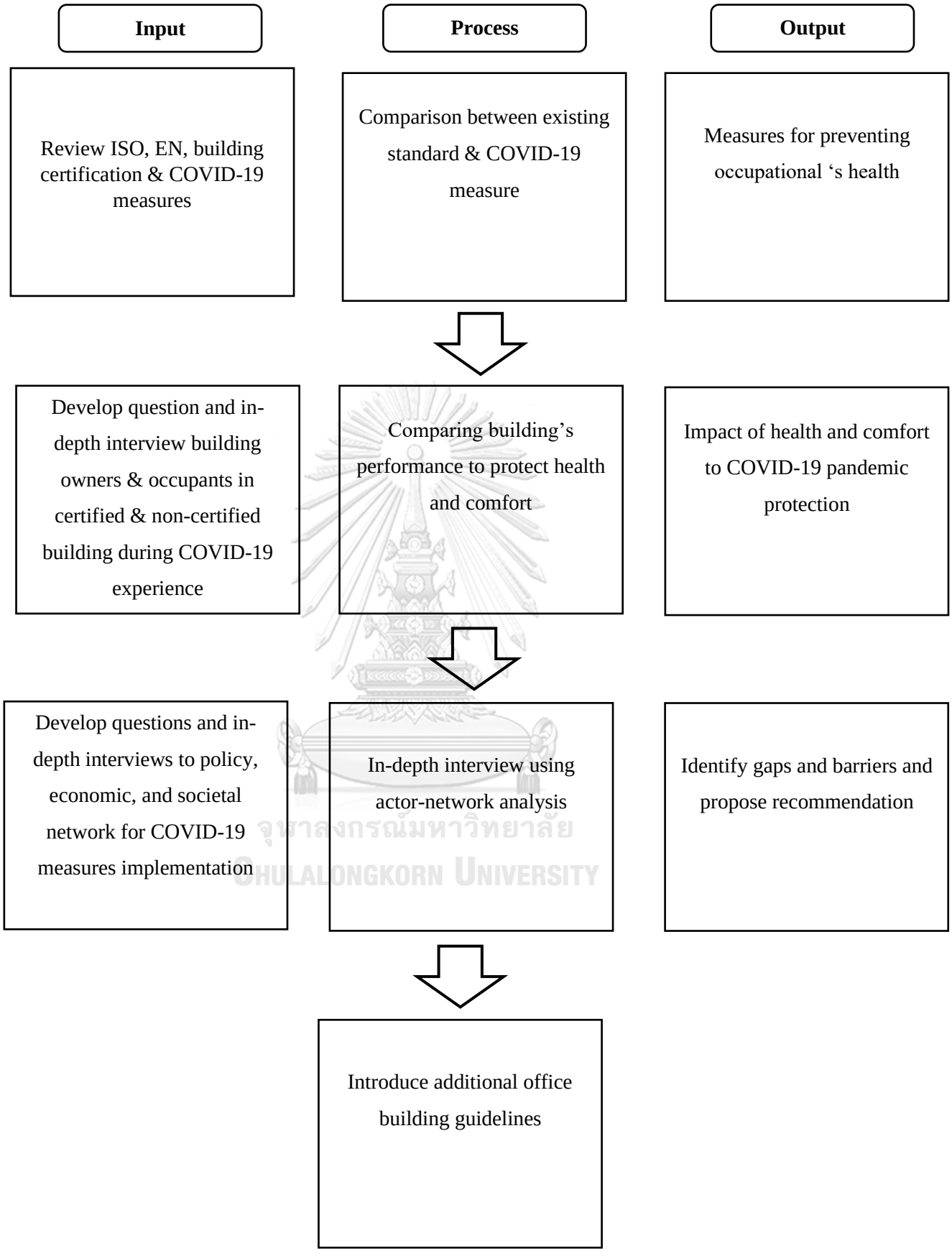


Figure 6: Research methodology diagram

Chapter 4
Infection, prevention, and control measure against COVID-19

Because of COVID-19, people must follow instructions to protect themselves from infection as a result of the pandemic's emergence. As a result, the quality of the building to preserve and prevent heath and comfort of the occupants becomes critical, particularly in office buildings where everyone with different protective measures must come to work together. As a result, various infection prevention and control strategies for the workplace or office have been recommended and published.

The specialized and international organization must develop COVID-19 prevention and protection recommendations. This study adheres to the risk management hierarchy of controls, which consists of five groups (ordered from most effective to least effective), including elimination, substitution, engineering control, administrative and organizational control, and personal protective equipment (PPE).

Hierarchy of control has been used to determine how to implement feasible and effective control solutions typically. Figure 7 is one representation of the hierarchy of control. [169]

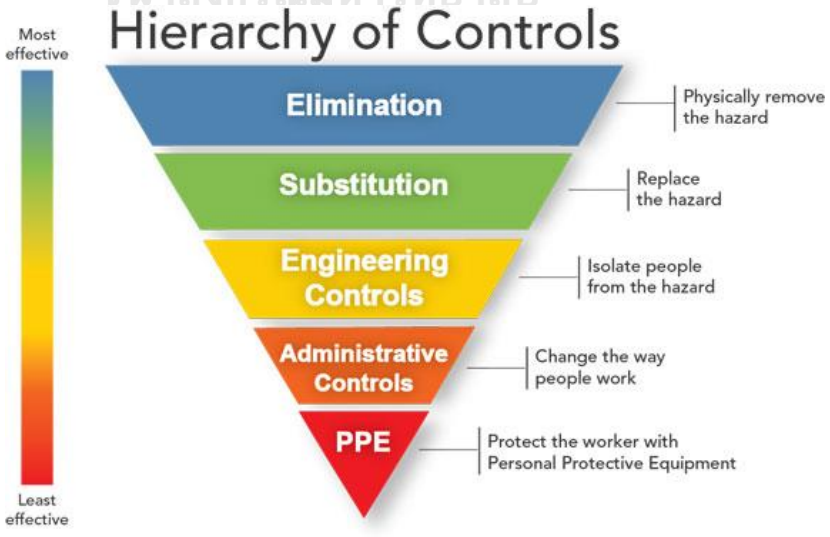


Figure 7: Hierarchy of Controls

Elimination is the most effective strategy to control and limit the number of infections by physically removing the hazard. For the COVID-19 case, eliminating or reducing the number of people in an area by staying home and working remotely is also the government's announcement to eliminate COVID-19 disease in an office building. Furthermore, do not allow employees who have symptoms or are suspected of having COVID-19 to enter the building, as this can reduce the likelihood of COVID-19 entering the workplace.

Substitution is the process to replace the hazard with non-hazardous object, device or substance. However, it is not possible to remove or replace hazards in the building inside the building, so a other measures are required.

Engineering controls are the details used to improve building facilities and equipment by reducing exposure to hazards without relying on worker behavior or working conditions. For example, ensure that air ventilation and moisture systems are clean and functioning properly, air quality is good, workspaces are changed to maintain social distance, and a physical barrier is installed.

Administrative and organizational Control is the procedure to adjust policy or business management. By changing policies & procedures to ensure work activities are conducted safely such as work from home measure, develop an emergency communication plan, clean & disinfection measure implementation, regularly monitor and update strategies by providing resources, materials, and safe environments in the workplace.

Personal Protective Equipment (PPE) All types of PPE must be worn by the worker in order to prevent unavoidable exposure. Choose based on the risk to the worker, such as wearing a face mask, using alcohol gel, and covering their coughs and sneezes.

4.1 International Organization Concerned COVID-19 measure

The specialized and international organization must develop COVID-19 infection prevention and control measures. The World Health Organization (WHO), the Center for Disease Control and Prevention (CDC) from the U.S. Department of Health and Human Services, the Occupational Safety and Health Administration

(OSHA) from the U.S. Department of Labor, the European Centre for Disease Prevention and Control (ECDC), the International Labor Organization (ILO), and the American Society of Heating, Refrigerating, and Air Conditioning Engineers all participated in this study. The following are the specifics of each advisory:

1. **The World Health Organization (WHO)** is a United Nations agency that was founded in 1948. WHO recommends the workplace advisory for personal protection and workplace strategies in general, as well as for specific purposes such as disinfection and ventilation. Table 16 shows infection, prevention and control measure from the World Health Organization [11, 79-83]

Table 16: COVID-19 infection, prevention and control measure from WHO

World Health Organization (WHO)	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Add or modify window and door to enable cross ventilation - Using a pedestrian fan, - Open HVAC systems to allow maximum outside airflow before and after occupied time - Disable demand-control ventilation for mechanical ventilation
Using stand-alone air cleaner	- MERV 14 / ISO ePM1 70-80% filter - Consider portable HEPA / Ultraviolet Germicidal Irradiation (UVGI)
Negative Pressure ventilation	-
Inspected, maintained & cleaned HVAC system	- Regularly inspect, maintain, clean HVAC system and filter
1.2 Distancing & Building Layout	
Maintain distancing	- Keep distancing at least 1 meter - Queue management

	- Install and frequently clean plexiglass barriers
Strict control over external accesses	-
1.3 Facilities and equipment	
Employ touchless technology and proper surface materials	- Encourage the use of sensors, a foot pump, and a large handle that is controlled by the lower arm or elbow.
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	- Safety drinking water, feces, and sewage
2. Administrative and Organizational Control	
2.1 Safety Workplace Measure	
Enhance Hand Hygiene	- Encourage regular handwashing with soap and water, or at least 60% of alcohol-based sanitizing hand rub dispensers that are easily accessible to all. - Use 0.5-2 liters of clean water per person. - Drying hands after washing is critical, and single-use towels are recommended.
Promote Respiratory Etiquette	- Create a face-covering policy and make sure face masks or paper tissues are available, as well as a closed bin.
Routine Screening	- Thermal screening at workplace
Proper Waste Management	- Clean bins and waste should be placed in strong bags that are completely closed.
2.2 Cleaning and Disinfection	
Cleaning Measure	- Regular disinfectant cleaning and hygiene, especially on high-touched surfaces (e.g., desks and tables) and objects (e.g., telephones, keyboard) with effective disinfectants
Cleaning Detergent	- It is recommended to clean on a regular basis with soap or a neutral detergent, water, mechanical action, and 0.1 percent sodium hypochlorite (1000 ppm) or 5 percent sodium hypochlorite to 50 parts waters.
Non-proper cleaning measure	- Spraying people with disinfectants (such as in a tunnel, cabinet, or chamber) is not recommended under any circumstances

2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Standard operating procedures should be developed, as well as a plan for when someone is ill and needs to be isolated without stigma or discrimination.
Suspected or Confirmed case measure	- Restrict the number of people who make contact with a sick person. - Make contact with your local health authorities.
2.4 Business continuity Guideline	
Transition to remote work	- Adopt a teleworking and work-from-home strategy to reduce the need for in-person meetings. - Enforce travel policies by reducing and managing work-related travel.
Shift working	- Staggering working hours, implement shift or split-team arrangements
Encourage employees for self-monitoring	- Workers' health should be observed and monitored.
Implement supporting policy	- Working risk assessment - Concerning mental health
A particular concern for vulnerable employee	- Pay special attention to the vulnerable and marginalized populations.
2.5 Education and Communication	
Establish Communicate Policy	-
Hygienic Measure Communication	- Promote handwashing with effective media - Promote good respiratory hygiene - Encourage employees to stay at home if they are experiencing symptoms
COVID-19 Information Communication	- Provide regular information about the risk of COVID-19 by using official sources
Employee Training	-
Feedback Response	- Engage worker in providing feedbacks
3. Personal Protective Equipment (PPE)	
- Hand washing and proper facing mask using	

2. The Centers for Disease Control and Prevention (CDC) is a vital component of the Department of Health and Human Services in the United States of America to protect the health, safety, and security threats while also assisting communities and citizens to do the same. Table 17 shows an infection, prevention, and control measures from the Centers for Disease Control and Prevention [84-87, 170]

Table 17: COVID-19 infection, prevention and control measure from CDC

Centers for Disease Control and Prevention (CDC)	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Open windows and doors, and use a fan if necessary. - Recirculation should be avoided. - Disable demand-controlled ventilation (DCV) and keep the machine running for longer periods of time. - Before the occupied time, run the HVAC system with the most outside airflow possible. - Reduce occupancy
Using stand-alone air cleaner	- Increase air filtration to MERV 13 or higher - Consider a portable high-efficiency particulate air (HEPA) filtration system - Use ultraviolet germicidal irradiation (UVGI) to help inactivate SARS-CoV-2 - Create clean-to-less-clean air movement
Negative Pressure ventilation	-
Inspected, maintained & cleaned HVAC system	- Inspect & maintain local exhaust ventilation
1.2 Distancing & Building Layout	
Maintain distancing	- Minimum of 6 feet by partitional control with face covering - Close or limit the use of common areas - Remove and rearrange furniture
Strict control over external accesses	-

1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	- Use touchless hand sanitizer dispensers - Use technology to promote social distancing
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	- Ensure the safety of the water and sanitary system after a prolonged shutdown because mold, legionella, lead, and copper can all be hazards in stagnant or standing water. - To protect mold, keep indoor humidity below 50% and assess dampers according to the National Institute for Occupational Safety and Health (NIOSH) and flush them out before operation. - To prevent legionella, keep the water heater temperature around 60 degrees Celsius (140 degrees Fahrenheit) and keep it clean and well-maintained. - To protect lead and copper in drinking water systems, test the amount of lead in the water, use water aerators, and use filters properly.
2. Administrative and Organizational Control	
2.1 Safety Workplace Measure	
Enhance Hand Hygiene	- Promote hand washing by soap and water or alcohol-based hand sanitizing rub dispensers
Promote Respiratory Etiquette	- Practice good respiratory such as covering their coughs and sneezes - Recommend at least two layers without exhalation valves or vents for face mask
Self-hygiene measure	- Encourage the employee to bring their water from home and monitor their health daily
Routine Screening	- Conducting daily in-person (Temperature screening and symptom) and consider testing for SAR-CoV-2 into the workplace
Proper Waste Management	-Provide no-touch trash can

2.2 Cleaning and Disinfection	
Cleaning Measure	- Increase the number of frequently touched surfaces - Proper PPE and good ventilation will be used during the cleaning process
Cleaning Detergent	- Regular cleaning and disinfection with a product approved by the United States Environmental Protection Agency (EPA) (List N: Disinfectants) If list N is not available, bleach solution, ultrasonic waves, high-intensity ultraviolet radiation, and LED blue light can be used - Proper PPE and good ventilation will be used during the cleaning process.
Non-proper cleaning measure	- Tunnel, fogging, fumigation, and broad-area or electrostatic spraying are not advised.
2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Identify workplace coordinator
Suspected or Confirmed case measure	- Separate sick employees to stay home - Determine where and how workers may be exposed to individual contaminants - Performing enhanced cleaning after the presence of suspected or confirmed COVID-19 in the facility - Reporting and recording the number of infections and deaths
2.4 Business continuity Guideline	
Transition to remote work	- Feasibility of accomplishing work by telework
Shift working	- Stagger employee shifts
Encourage employees for self-monitoring	- Encourage sick people to stay home
Implement supporting policy	- Put in place policies and practices that allow for flexible sick leave. - Monitor or close the public use area - Consider assisting employees who use public transportation, such as changing their trip or cleaning their hands.

	- Failure to distinguish between workers who have been vaccinated and those who have not been vaccinated.
A particular concern for vulnerable employee	- Protect workers at higher risk (older adults or disabilities) through
2.5 Education and Communication	
Establish Communicate Policy	- Disseminate policies that are beneficial. - Communicate with partners, suppliers, and other contractors by making verbal announcements and posting signage in multiple languages.
Hygienic Measure Communication	- Encourage employees to practice good hand hygiene and educate them on how to protect themselves.
COVID-19 Information Communication	- Consider the level of COVID-19 and monitor state and local public health communication
Employee Training	- Training to employee
Employee Feedback Response	- Implement retaliation protection and establish an anonymous process for workers to express concerns.
Other additional strategies	-
3. Personal Protective Equipment (PPE)	
- Workplace hazard assessment to determine what PPE is needed - Select and provide appropriate PPE to the worker for free	

3. Occupational Safety and Health (OSHA), U.S. Department of Labor, The United States of America advised Guidance on Preparing Workplace for COVID-19 recommends steps for all employers to reduce worker's risk of SARS-CoV-2. Table 18 shows an infection, prevention, and control measures from the Occupational Safety and Health (OSHA) [88, 89]

Table 18: COVID-19 infection, prevention and control measure from OSHA

Occupational Safety and Health (OSHA)	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Opening windows and doors - Avoid air-recirculation - Maintain the setpoints for heating, cooling, and humidification
Using stand-alone air cleaner	- Use portable air purifiers with a HEPA filter or a comparable filter - Replace your air filters with high-efficiency models.
Negative Pressure ventilation	- Promote negative Pressure ventilation
Inspected, maintained & cleaned HVAC system	-
1.2 Distancing & Building Layout	
Maintain distancing	- Install physical barriers such as clear plastic sneeze guards
Strict control over external accesses	- Install drive-through window for customer service
1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	- Use touchless hand sanitizer dispensers
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	-
2. Administrative and Organizational Control	
2.1 Workplace Safety Measures	
Enhance Hand Hygiene	- Promote personal hygiene for handwashing by providing proper resources
Promote Respiratory	- Encourage respiratory etiquette

Etiquette	- Provide customers and the public with tissue and trash receptacles
Self-hygiene measure	- Encourage employees not to use other's accessory
Routine Screening	- Follow state or local guidelines for screening
Proper Waste Management	- Provide no-touch trash can
2.2 Cleaning and Disinfection	
Cleaning Measure	- Follow existing OSHA standards, such as the OHSA's PPE standard, and maintain regular housekeeping practices that are EPA-approved.
Cleaning Detergent	- Regular cleaning and disinfection with a product approved by the United States Environmental Protection Agency (EPA) (List N: Disinfectants) - Proper PPE and good ventilation will be used during the cleaning process.
Non-proper cleaning measure	- Tunnel, fogging, fumigation, and broad-area or electrostatic spraying are not advised.
2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Create policies and procedures for identifying, isolating, and reporting sick employees.
Suspected or Confirmed case measure	-
2.4 Business continuity Guideline	
Transition to remote work	- Minimize contact among workers and other clients
Shift working	- Reduce the number of employees at a given time by establishing alternating days or extra shift
Encourage employees for self-monitoring	- Encourage employees to self-monitor and stay home when sick
Implement supporting policy	- Implement policies and practices such as worksites and flexible work schedules. - Create a COVID-19 information preparedness and response plan.
A particular concern for vulnerable employee	-
2.5 Education and Communication	

Establish Communicate Policy	- Creating an emergency communication strategy - Create, implement, and communicate workplace flexibilities and safeguards.
Hygienic Measure Communication	- Post signs in restrooms encouraging people to wash their hands.
COVID-19 Information Communication	- Providing up-to-date COVID-19 education and training
Employee Training	- Instruction in protective clothing and equipment, as well as appropriate language
Employee Feedback Response	-
Other additional strategies	- Recognize an employee's desire to provide for their family.
3. Personal Protective Equipment (PPE)	
- Choose PPE based on the hazard worker that is properly fitted, consistently worn, regularly maintained, and adequately removed.	

4. The European Centre for Disease Prevention and Control (ECDC) is a European Union agency tasked with fortifying Europe's defenses against infectious diseases. Table 19 shows an infection, prevention, and control measures from the European Centre for Disease Prevention and Control (ECDC) [90-94]

Table 19: COVID-19 infection, prevention and control measure from ECDC

The European Centre for Disease Prevention and Control (ECDC)	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Opening windows and doors for natural ventilation - Direct airflow should be diverted away from mechanical ventilation - Avoid air recirculation
Using stand-alone air cleaner	- Install self-contained air-cleaning systems with HEPA or comparable filters.
Negative Pressure ventilation	- Encourage the use of negative pressure in the specialized room.

Inspected, maintained & cleaned HVAC system	- Keep heating, cooling, and humidification setpoints
1.2 Distancing & Building Layout	
Maintain distancing	- Physical separation of 1-2 meters, as well as barrier installation
Strict control over external accesses	-
1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	- Use appropriate devices such as no-touch waste bins
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	-
2. Administrative and Organizational Control	
2.1 Workplace Safety Measures	
Enhance Hand Hygiene	- Encourage hand hygiene by using soap and water for 20-40 seconds and 70-80% alcohol-based products.
Promote Respiratory Etiquette	- Respiratory hygiene and etiquette, such as covering one's mouth and nose when coughing or sneezing - Wearing a face mask both indoors and in a crowded outdoor setting
Self-hygiene measure	-
Routine Screening	- Implement screening at points of entry
Proper Waste Management	- Provide no-touch trash bins
2.2 Cleaning and Disinfection	
Cleaning Measure	- Cleaning and disinfection should be done on a regular basis.
Cleaning Detergent	- Disinfectants are considered biocidal products and are governed by the Biocidal Product Regulation (BPR)
Non-proper cleaning measure	- Other techniques, such as spraying or UV light radiation, are not advised.

2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Create an emergency risk communication plan.
Suspected or Confirmed case measure	- Self-isolation for sick people - If a suspected and confirmed case is found, ventilate with fresh air for at least 1 hour and clean with neutral detergent.
2.4 Business continuity Guideline	
Transition to remote work	- Limit close physical interaction such as teleworking and flexible working - Implement travel-related measures
Shift working	- Implement flexible working schedules or shifts for employees
Encourage employees for self-monitoring	- Self-monitor symptoms
Implement supporting policy	- Risk assessment for various protective measures
A particular concern for vulnerable employee	- Assure protection of vulnerable groups
2.5 Education and Communication	
Establish Communicate Policy	- Communicate risk of COVID-19
Hygienic Measure Communication	-
COVID-19 Information Communication	-
Employee Training	-
Employee Feedback Response	-
3. Personal Protective Equipment (PPE)	
- Recommendation for face masks and gloves wearing	

5. The International Labor Organization (ILO) is a United Nations agency that establishes labor standards, develops policies, and implements various programs to ensure that everyone has a decent place to work. Table 20 shows an infection, prevention, and control measures from the International Labor Organization [171-173]

Table 20: COVID-19 infection, prevention and control measure from ILO

The International Labor Organization	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Opening windows and doors for natural ventilation (In case of work shift, repeat natural ventilation between shifts) - Maintain recirculation with outdoor air for mechanical ventilation.
Using stand-alone air cleaner	- Installing a high-efficiency air filter
Negative Pressure ventilation	- Specialized Negative pressure ventilation in a specific area
Inspected, maintained & cleaned HVAC system	- Proper maintenance & installation of HVAC system
1.2 Distancing & Building Layout	
Maintain distancing	- Two meters set up physical barriers - Workplaces' maximum capacity - Limit common area capacity to allow for minimum separation of 2 meters.
Strict control over external accesses	- Install drive-through window for customer service - Organize a one-way system
1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	-

1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	-
2. Administrative and Organizational Control	
2.1 Workplace Safety Measures	
Enhance Hand Hygiene	- Encourage frequent and thorough handwashing - Use soap and water for at least 40 seconds or 60 percent alcohol gel for at least 20 seconds. - Make paper towels a top priority over fabric towels or electric air jet drying devices.
Promote Respiratory Etiquette	- Inform workers about the importance of avoiding contact with greetings and promote respiratory etiquette.
Self-hygiene measure	- Inform employees to refrain from sharing items such as office supplies and tableware. - Limit or reduce the use of cash
Routine Screening	-
Proper Waste Management	-
2.2 Cleaning and Disinfection	
Cleaning Measure	- Increase cleaning and disinfection efforts, particularly on heavily touched surfaces. - Implement routine housekeeping, cleaning, and disinfection of surfaces, equipment, and other elements.
Cleaning Detergent	-
Non-proper cleaning measure	-
2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Develop policies on health monitoring and response measures for sick or potentially infected workers. - Create protocols for cases of suspected and confirmed contagion, as well as protocols for staying at home when an ill person has been found.
Suspected or Confirmed case measure	-

2.4 Business continuity Guideline	
Transition to remote work	-
Shift working	- Implementing staggered and extra shifts, or having employees present on alternate days, to reduce the number of people in the available time.
Encourage employees for self-monitoring	-
Implement supporting policy	- Plan and organize a return to work - Risk assessment in order to identify preventive and control measures - Form a joint team to plan and organize a return to work - If necessary, provide psychological counseling - In the case of company mobility, a minimum separation of 2 meters between people is required.
A particular concern for vulnerable employee	-
2.5 Education and Communication	
Establish Communicate Policy	- Effectively communicate to all workers
Hygienic Measure Communication	- Provide information about ergonomic risk during remote work
COVID-19 Information Communication	- Place signage or other graphic material in a visible location as a precautionary measure. - Monitor the situation on a regular basis as it evolves - Communicate confirmed COVID-19 cases
Employee Training	- Instruction in protective clothing and equipment, as well as appropriate language
Employee Feedback Response	-
Other additional strategies	- Inform workers about their responsibilities and rights in any situation, including 1. Their right to interrupt work if there is an imminent and serious threat to life or health, without suffering unjustified consequences.

	2. They have the right to adequate information and training. 3. The right to be informed (and consulted) about all aspects of work. 4. The obligation to cooperate with the employer for instruction and procedures, PPE use, and hazardous work situations.
3. Personal Protective Equipment (PPE)	
- Determine the type of personal protective equipment (PPE) to use based on the risk of infection while working. - Wearing properly fitted clothing, wearing it consistently, maintaining it on a regular basis, and removing it properly.	

6. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) is a professional organization that focuses on building systems, energy efficiency, indoor air quality, refrigeration, and sustainability**.** Table 21 shows an infection, prevention, and control measures from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) [98-103]

Table 21: COVID-19 infection, prevention and control measure from ASHRAE

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	- Disable demand-controlled ventilation and fully open outdoor air dampers as indoor and outdoor conditions allow. - Keep system running for longer periods of time (24/7 if possible). - Keep the temperature and humidity stable (most unfavorable survival for microorganisms when relative humidity is between 40 % -60 %) - Flushing with outdoor air before or after occupancy

Using stand-alone air cleaner	- Increase central air and other HVAC filtration to MERV-13 or the highest achievable level. - In high-density spaces, connect duct- or air-handling-unit-mounted (achieve three air changes of equivalent clean air supply), upper room, and/or portable UVGI devices to in-room fans.
Negative Pressure ventilation	- Promoting room pressure differential in a specific area
Inspected, maintained & cleaned HVAC system	- Maintain the HVAC system's operation properly. - System commissioning entails ensuring that HVAC systems are operating as intended. - During evaluation and inspection, ASHRAE guideline 36-2018, High-Performance Sequences of Operation for HVAC Systems, was used to optimize control. .
1.2 Distancing & Building Layout	
Maintain distancing	Keep social distancing
Strict control over external accesses	-
1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	-
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	Refer to EPA guidance and ASHRAE 188-2018, Legionellosis: Risk Management for Building Water Systems before reopening the building water system.
2. Administrative and Organizational Control	
2.1 Workplace Safety Measure	
Enhance Hand Hygiene	- Promote hygiene and sanitation
Promote Respiratory Etiquette	- Encourage Wearing a mask
Self-hygiene measure	-

Routine Screening	-
Proper Waste Management	-
Using Touchless technology	-
2.2 Cleaning and Disinfection	
Cleaning Measure	-
Cleaning Detergent	-
Non-proper cleaning measure	-
2.3 Emergency Plan Development	
Emergency Plan Preparedness	-
Suspected or Confirmed case measure	-
2.4 Business continuity Guideline	
Transition to remote work	-
Shift working	-
Encourage employees for self-monitoring	-
Implement supporting policy	- Implement strategies to reduce the number of occupants
A particular concern for vulnerable employee	-
2.5 Education and Communication	
Establish Communicate Policy	-
Hygienic Measure Communication	-
COVID-19 Information Communication	-
Employee Training	-
Employee Feedback Response	-
Other additional strategies	-

3. Personal Protective Equipment (PPE)
Implement PPE strategies

4.2 Comparison of various international agencies ‘s measure

Each international agency's infection and preventive control measures in relation to COVID-19 are compared in Table 22:

Table 22: Infection, Prevention and Control Measures against COVID-19 from international agencies

	WHO	CDC	OSHA	ECDC	ILO	ASHRAE
1. Engineering Control						
1.1 Ventilation						
Increase ventilation rate / outdoor air ventilation	Add or modify windows and doors to enable cross ventilation Open HVAC systems with maximum outside airflow before and after occupied times	Open windows and doors Eliminate Recirculation run HVAC system with maximum outside airflow before occupied times	Increase ventilation rate Avoid air-recirculation	Open windows And doors Avoid air Recirculation, keep heating, cooling, and humidification setpoints	Open windows and doors Maintain recirculation with outdoor air Properly maintain HVAC systems	Requirements for outdoor air ventilation Eliminate Recirculation Properly maintain HVAC systems
Using stand-alone air cleaner	MERV 14 / ISO ePM1 70-80% filter Consider portable HEPA/ Ultraviolet	MERV 13 or higher	Install high-efficiency air filters	Use stand-alone air-Cleaning devices equipped with a HEPA or comparable filter	Install a high-efficiency air filter	Improve central air and other HVAC filtration to MERV-13 or highest level achievable

	Germicidal Irradiation (UVGI)					
Negative pressure ventilation	-	-	Apply negative Pressure ventilation	Apply negative pressure in specialized rooms	Apply specialized negative pressure ventilation in specific areas	Apply negative pressure in specific areas
Inspected, maintained & cleaned HVAC system	Regular inspect, maintain, clean HVAC system and filter	Inspect & maintain local exhaust ventilation	-	Keep heating, cooling, and humidification setpoints	Proper maintenance & installation of HVAC system	Maintain HVAC system's operation properly System commissioning entails ensuring HVAC system operate as intended ASHRAE guideline 36-2018 was used to optimize control.

1.2 Distancing & Building Layout						
Maintain distancing	At least 1 meter Queue management Install and frequently clean plexiglass barriers	at least 6 feet by partitional control using face covering Close / limit the use of shared spaces	Install physical barriers such as clear plastic sneeze guards	Physical distancing 1-2 meters and barrier installation	Keep 2 meters distancing Install physical barriers Limit the capacity of workplaces / common areas	Keep social distancing
Strict control over external accesses	-	-	Install drive-through windows for customer service	-	Install drive-through windows for Customer service Organize a one-way system	-

1.3 Facilities and equipment						
Employ touchless technology and proper surface materials	Use sensors, foot pumps, and large handles that are controlled with the lower arm	Use touchless hand sanitizer dispensers	Use touchless hand sanitizer dispensers	Use appropriate devices such as touchless bins	-	-
1.4 Water and sanitary system safety						
Water quality in sanitation and plumbing systems	Safety drinking water, feces, and sewage	Eliminate stagnant or standing waters Control indoor humidity to not exceed 50% Prevent mold by control indoor temperature	-	-	-	Building water systems should be flushed before reopening: Refer to ASHRAE 188-2018

2. Administrative and Organizational Controls						
2.1 Workplace Safety Measures						
Enhance hand hygiene / self-hygiene measures	Promote hand washing by soap and water or alcohol-based Hand sanitizing rub dispensers	Maintain proper hygiene by hand washing Encourage employees to bring drinking water from home Monitor employee health daily	Promote hand washing resources Encourage employees to not use other's accessories	Promote hand hygiene by washing hands with soap and water for 20-40 seconds or with 60-85% alcohol- based hand sanitizers	Promote frequent hand washing with soap and water or alcohol Promote use of paper towels Avoid sharing items in office Reduce use of Cash	Promote hygiene and sanitation
Promote respiratory etiquette	Develop face-covering policy	Cover coughs and Sneezes Recommend at least two layers of face masks	Encourage respiratory etiquette Provide customers and	Cover mouth and nose when coughing and Sneezing Wear face masks in indoors and	Instruct workers to avoid contact when greeting and encourage respiratory etiquette	Encourage mask-wearing

		without exhalation valves or vents	the public with tissue and trash receptacles	crowded outdoor settings		
Routine screening	Thermal screening at workplace	Conduct daily in-person screening Consider testing for SAR-CoV-2	Follow state or local guidelines for screening	Implement screening at points of entry	-	-
Proper waste management	Clean bins and waste should be placed in strong bags that are completely closed	Provide no-touch trash cans	Provide no-touch trash cans	Provide no-touch trash bins	-	-
2.2 Cleaning and Disinfection						
Cleaning Measures	Regular cleanings with disinfectants (0.1% / 1000 ppm	Routine cleaning and disinfection with EPA-approved	Maintain regular housekeeping practices by	Regular cleaning and disinfection with biocidal	Increase cleaning of frequently touched surfaces	-

	sodium hypochlorite, or 5% sodium hypo-chlorite to 50 parts water), especially of high touch surfaces	products (List N: Disinfectants) or bleach solution, ultrasonic waves, high intensity ultraviolet radiation, or LED blue light	EPA-approved Methods and follow existing OSHA standards Follow CDC guideline	products regulated by the Biocidal Product Regulation (BPR)		
2.3 Emergency Plan Development						
Emergency plan prepared-ness	Prepare standard operating procedures and plans for isolating someone who falls ill without stigmatization or discrimination	Identify workplace coordinator	Develop policies and procedures to identify, isolate and report employee sicknesses	Develop emergency risk communication	Establish health monitoring policies and response measures for sick or potentially infected workers	-

Suspected or confirmed case measures	Limit the number of people who come in contact with sick person Contact local health authorities	Separate sick employees Clean facility after suspected or confirmed COVID-19 case Report number of infections and deaths	-	Separate sick employees Ventilate buildings with fresh air for 1 hour and clean with detergent	-	-
2.4 Business Continuity Guideline						
Transition to remote work	Implement work from home strategy Implement travel policy	Evaluate feasibility of Accomplishing work by telework	Minimize contact among workers and clients	Implement teleworking and flexible working arrangement Implement travel-related measures	-	-

Shift working	Stagger working hours Implement shifts or split-team arrangements	Stagger employee shifts	Reduce number of employees at a given time by establishing alternating days or extra shifts	Implement flexible working schedules or shifts for employees	Implement staggered and extra shifts or have workers present on alternate days	-
Encourage employees of self-monitoring	Observe and monitor employees' health	Encourage sick employees to stay home	Encourage self-monitoring and staying at home when sick	Encourage self-monitoring of symptoms	-	-
Implementing support policy / Concern for vulnerable employees	Perform work risk assessment Be cognizant of employees' mental health, focusing particular attention on vulnerable and marginalized groups	Implement flexible sick leave policies and practices Protect workers with higher risk (elderly or disabled)	Establish flexible worksite policies Develop COVID-19 preparedness and response plan	Risk assessment for various protective method Assure protection of vulnerable groups	Risk assessment to determine preventive and control measures Plan and organize return to work	Implement strategies to reduce the number of occupants

2.5 Education and Communication						
Establish communication policy	-	-	Implement emergency communication plan	Communicate risk of COVID-19	-	-
Hygienic measures communication	Promote handwashing with effective media	Educate employees to self-protect	Encourage hand washing by posting signs in restrooms	-	Provide information about ergonomic risks during remote work	-
COVID-19 information communication	Provide regular information about the risks of COVID-19 by using official sources	Consider the level of COVID-19 risk and monitor state and local public health communications	Provide up to date education and training on COVID-19	-	Arrange signage with preventive measures Communicate confirmed cases of COVID-19	-

Employee training/ Feedback response	Engage workers in providing feedback	Provide training to employees Implement safe methods for workers to voice concerns	Provide training in protective clothing and equipment	-	-	-
3. Personal Protective Equipment (PPE)						
PPE	Use face masks	Identify necessary PPE Provide appropriate PPE to workers	Provide select PPE to workers exposed to hazards	Recommend the wearing of face masks and gloves	Select PPE based on employees' risk of infection while working	Implement the wearing of PPE

4.3 Office Building Management for COVID-19 Pandemic in Thailand

4.3.1 Management of COVID-19 Pandemic in Thailand

The COVID-19 pandemic has primarily impacted Thailand's population wellbeing, health systems, economic status, and environment. Very few studies exist at the moment which looks at the impacts of this pandemic on Thailand. In response to the pandemic, Thailand implemented the "D-M-H-T-T-A" measures against COVID-19 – D: Distancing, M: Mask wearing, H: Hand washing, T: Temperature, T: Testing, and A: Application. Additionally, various Thai government departments (Department of Disease Control, Department of Health, Ministry of Public Health) have published a series of infection, prevention and control measures.

The first COVID-19 workplace guideline in Thailand was published by the Department of Disease Control, Ministry of Public Health (January 29, 2020) [174]. In it, set of recommendations deliberated on employee self-protection which included observing symptoms, wearing face masks, and washing hands with soap for 15 seconds or alcohol gels for 15 – 25 seconds (if soap is inconvenient). On (January 30, 2020) [175], the second recommendations were released which focused on controlling the environment of working spaces both organization owners and staff by implementing administrative measures such as providing sufficient hygiene materials, proper cleaning of high-touch surfaces, education and communication, waste collection, and self-protection. Third is a recommendation for businesses and workplaces (March 25,2020) [176] in the case of Finding COVID-19 Patients by suggest prevention, surveillance and patient isolation and cleaning measure. Fourth, the guideline for workplace to COVID-19 (April 11,2020) [177], recommend engineering, administrative and personal protective equipment based on The Occupational Safety and Health Administration (OSHA) and International Labor Organization (ILO). (January 4, 2021) [178]. In it, workplace re-building that allows for physical distancing and separation by space-marking or plastic barriers was recommended. Environmental control with increased building ventilation was also suggested. Administrative controls such as providing hygiene materials, cleaning, disinfection systems,

entrance screening, establishing communication plans, app-based tracking systems, separate waste collection, and PPE were advised.

The publication released in April 2020 [177] also presented a hierarchy of controls. At the top of it was the use of engineering controls such as increasing ventilation, using high efficiency of air filtration, and re-designing office layouts to maintain distancing; next were administrative measures such as updated working policies created by the collaboration of employers and employees, and measures to reduce infection risks such as providing hygiene materials, work from home policy, education, and self-protection. Building ventilation recommendations included discussions on both natural and mechanical ventilation systems as recommended by the Indoor Air Quality Association. Moreover, this advisory divided infection risks into four-levels by job type: low, moderate, high, and very high; each risk level was provided with different preventive strategies. For example, the PPE recommendation in low-risk areas involved wearing a proper facing mask, whereas in very high-risk areas the recommendation included wearing gloves, ground suits, face shields, and goggle masks.

The Department of Health, Ministry of Public Health has continually published advisories to combat COVID-19; these were released on March 11, 2020 [179] , March 19, 2020 [180], January 6, 2021 [181] ,January 7, 2021) [182] and June 1, 2021 [183] and also the recommendation for cleaning measure [184]. The first of these publications discussed the use of environment controls and administrative measures; the second publication discussed administrative controls; the third was a set of layout adjustments, engineering controls, organizational strategies, and operational guidelines for workplaces or factories; the fourth was once again ventilation system recommendations to and protect workplaces from COVID-19. Figure 8 shows timeline for recommendation from government sector.

Thailand’s Infection, Prevention and Control Measures

Figure 8: Government sector timeline for COVID-19 infective & preventive control strategies

COVID-19 advisories have also been issued from the provincial level, such as the ones from the Health Department, Bangkok Metropolitan Administration. Additional resources have also been made available by non-government associations. For example, the Air Conditioning Engineering Association of Thailand published a March 2021 edition of “Building Guides: Commercial” which references ASHRAE standards on temperature and humidity controls (ANSI/ASHRAE Standard 55-2017), ventilation systems (ASHRAE 62.1-2019), and inspection and maintenance (ASHRAE Standard 180-2018). Thailand's control-hierarchy strategies are summarized and shown in the table 23:

Table 23: Thailand’s COVID-19 infection, prevention and control measures in building segment

Thailand’s COVID-19 infection, prevention and control measures	
1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	Mechanical ventilation - Increase the amount of fresh outdoor air ventilation - It is recommended that construction work be completed at least 2 hours before and after use.

	- Air should not be forced to pass through a single person. - Avoids recirculation air except air filtration or disease killing machine - For continuous use, routine maintenance is required. - Install a mechanical fan, particularly in areas with insufficient ventilation. - Setting up a negative pressure room for specific activities such as cooking in the kitchen, using an exhaust fan in the bathroom 24 hours a day, and closing the toilet after use. - A ventilation rate of at least 10 litres per second per person (maximum 4 sq.m/person) or 10 m3/hour/sq.m is recommended. - Take care to position the exhaust fan so that it does not disturb others. Natural ventilation - utilizing cross-ventilation by having at least two sides of the room for air intake and exhaust or opening door and window with regard to outdoor weather Additionally, allow at least 15 minutes before entering the room to open the door and windows.
Using stand-alone air cleaner	- Install an air filtration system with high efficiency. - Additional equipment has been installed as needed to improve ventilation, eradicate disease, and monitor progress. a.) A high-efficiency particulate air filter with a 0.3 micrometer filter, such as the High-Efficiency Particulate Air Filter (HEPA). b.) Ultraviolet (Upper-Room Ultraviolet Germicidal Irradiation: UVGI) for disease control, particularly in the air and on the surface. However, there are numerous usage restrictions, such as distance and

	duration. Because this machine emits ozone, you must use it with caution and keep it in good working order. c.) Carbon dioxide measurement can also be adapted for ventilation measurement if the carbon dioxide content is greater than 800 ppm, fewer people are present, and increased ventilation is considered.
Negative Pressure ventilation	In an aerosol-generated room, negative pressure has been provided.
Inspected, maintained & cleaned HVAC system	-
1.2 Distancing & Building Layout	
Maintain distancing	- Maintain a physical distance of 1-2 meters in the office, canteen, meeting room, and relaxation area. Furthermore, barriers such as plastic and glass in communication or frequent person point such as reception - Installation of physical barriers such as plastic and glass barriers - A social distancing policy reduces the number of people by avoiding crowded meetings, using communication technology, working from home, and shifting working hours, breaks, and eating.
Strict control over external accesses	-
1.3 Facilities and equipment	
Employ touchless technology and proper surface materials	-
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	-
2. Administrative and Organizational Control	
2.1 Workplace Safety Measures	

Enhance Hand Hygiene	- Making soap, hand sanitizer, or alcohol gel available, particularly at the entrance, toilet, canteen, exercise room, and in front of the lift. - Hand washing in general to remove dirt, sweat, and fatty fluids washing hands for about 15 seconds with soap or liquid soap - When soap or liquid soap are not available, alcohol gel hand cleaning uses 10 ml for 15-25 seconds. - Make available resources and environmental conditions that promote good hygiene, such as paper tissues, touchless bins, liquid soap, 70% alcohol gel, cleaning detergent, and non-reusable towels. - In a public area, provide cleaning and protective equipment such as a facial mask and alcohol gel.
Promote Respiratory Etiquette	- Wearing a mask tightly - When you need to cough and sneeze, use tissue or upper sleeve when no have tissue
Self-hygiene measure	-
Routine Screening	- Perform a temperature screening and risk assessment within the last 14 days. - Establish a screening station for employees and visitors. - Create an entrance and exit route that includes a registration and screening system. If a person has 37.5 degrees or higher and has a cough, sneeze, sore throat, can't smell or taste properly, has difficulty breathing, diarrhea, or returns from a high-risk area. Stop working temporarily and seek medical attention as soon as possible.
Proper Waste Management	- Provide a separate bin with a clear label or a red bag for infected waste such as facial masks and tissues. - Exercise caution when collecting waste, such as tissue, which may be contaminated with nasal discharge or saliva.
2.2 Cleaning and Disinfection	
Cleaning Measure	- Frequent cleaning and regular cleaning - Cleaning frequently touched surfaces in the workplace and

	the restroom - Establish a regular cleaning schedule for cleaning equipment, utensils, or areas where there is a high level of regular exposure with detergent or disinfection and a 70% alcohol solution at least twice per day. - Regularly cleaning the building and its surroundings, such as the floor, walls, and doors - In the case of the canteen, proper disinfection detergents must be used. - Cleaning personnel must wear PPE.
Cleaning Detergent	- Clean building equipment with a cleaning detergent containing 70% alcohol and provide adequate ventilation. - Cleaning and disinfection of frequently touched surfaces using 0.1 percent sodium hypochlorite or 70% alcohol
Non-proper cleaning measure	-
2.3 Emergency Plan Development	
Emergency Plan Preparedness	- Workplace policies must take into account changes in working patterns, such as working from home. Teleconference, drive-thru service, cashless and online transactions - Prepare first aid points and simple treatment by first isolating the patient. - Assist an employee who has a suspected infection and is staying at home. - When a suspected symptom is discovered, stop working and seek medical attention. - When you have 37.5 degrees or higher and have a cough, sneeze, sore throat, can't smell or taste properly difficulty breathing, or diarrhea, stop working and consult a doctor. - Plan for Business Continuity including a. If you have a shuttle bus, clean it with 0.1 percent sodium hypochlorite or 70% alcohol and keep the number of people

	to a minimum to maintain distance. b. In the case of a canteen, follow the food provider's instructions. c. In the case of a dorm, follow the instructions below. d. Have an employee tracking system in place.
Suspected or Confirmed case measure	- If high-risk people have been discovered, medical attention should be sought within three hours. - Someone who was in close contact with infected people was allowed to stay at home for 14 days for home quarantine and followed the government's instructions. - Follow the instructions if you see the pandemic. If a confirmed case is discovered, contact the government sector within 3 hours, temporarily close and properly clean, waste moves properly with confidence, and spray with 0.5 percent sodium hypochlorite. - If symptoms appear, stop working and consult a doctor.
2.4 Business continuity Guideline	
Transition to remote work	
Shift working	- Stop crowed people activities
Encourage employees for self-monitoring	- If you experience symptoms within 14 days of returning from the affected area, consult your doctor. - Seek medical attention if you have a fever and respiratory symptoms such as a cough, sore throat, runny nose, or difficulty breathing.
Implement supporting policy	- Self-monitoring for the sake of others If more than five people become ill at the same time, notify the government sector. - Avoid using utensils or glasses in public. - Large organization's screening protocol should be implemented before work begins. - Reduce face-to-face contact between employees and customers by switching to telecommunication. - In the case of a food court in the workplace, adhere to a good system, particularly with regard to food preparation,

	table, chair, and hygiene measures, as well as food safety. - Business travelers must adhere to instructions. Travel should be avoided during this time. - For everyone, use Mor-chana and Thia-chana applications.
A particular concern for vulnerable employee	-
2.5 Education and Communication	
Establish Communicate Policy	- Communicate to staff - Educate and communicate for employee and visitor
Hygienic Measure Communication	- Increase worker and cleaning staff awareness of the risk of agent contamination when using, and after using, frequently cleaning and cleaning equipment. - Display signage encouraging people to wash their hands.
COVID-19 Information Communication	- In the main observation, provide knowledge, advice, or public relations media. - Provide knowledge, advice, or public relations media to restaurant employees. How to Wash Your Hands Properly and Wear a Mask
Employee Training	-
Employee Feedback Response	-
Other additional strategies	-
3. Personal Protective Equipment (PPE)	
- Personal Protective Equipment, with a mask on at all times. Employees and visitors should always wear a facial mask, and gloves and a face shield may be provided for those who need to wear them for their job. - Wash your hands frequently with soap and water, as well as alcohol gel. Touch your face, eyes, mouth, and nose as little as possible. Take a bath and change your clothes when you get home from work. - Prepare a hygiene mask and alcohol gel before going to work. If you are suspected of having the infection, consider taking a leave of absence. - Personal Protective Equipment (PPE) should be suitable for infectious with proper wearing, good maintenance, cleaning, and good management PPE for high-risk staff such as reception, avoid touching to the face, eyes, nose, and	

month Cleaning personnel are required to wear gloves. - Cleaning and waste collection personnel must wear PPE and take proper precautions. - Stay away from high-risk areas. - Always wear a mask and other personal protective equipment (PPE) depending on the type of work. - Maintain a physical distance of at least 1 meter while working and taking breaks. Avoiding talking out loud, especially in a small space, as well as inadequate ventilation. - It is not permissible to eat in the workplace. - Share no accessories or stationery with others. - PPE is required for those who must participate in cleaning measures and cleaning correctly.

Infection, prevention, and control measures for COVID-19 from the international agency and Thailand's strategies can be summarized in the table 24-26 based on the hierachy of control strategies:

Table 24: Engineering measure: Infection, prevention and control measures to COVID-19 for office building

1. Engineering Control	
1.1 Ventilation	
Increase ventilation rate /outdoor air ventilation	Mechanical ventilation - Disable demand-controlled ventilation and fully open outdoor air dampers as indoor and outdoor conditions allow. - Keep the system running for longer periods of time (24/7 if possible). - Keep the temperature and humidity stable (most unfavorable survival for microorganisms when relative humidity is between 40 percent -60 percent) - Flush with fresh air before or after occupancy. It is recommended that construction work be completed at least 2

	hours before and after use. - Air should not be forced to pass through a single person. - Except for air filtration or disease killing machines, avoids recirculation of air. - For continuous use, regular maintenance is required. - Install a mechanical fan, especially in areas with poor ventilation. - Recommend a ventilation rate of at least 10 litres per second per person (maximum 4 m^2 per person) or 10 m^3/hour/m^2. - Take care to position the exhaust fan so that it does not disturb other people. - Reduce occupancy Natural ventilation - utilizing cross-ventilation by having at least two sides of the room for air intake and exhaust or opening door and window with regard to outdoor weather - Using a pedestrian fan in suitable conditions - Allow at least 15 minutes before entering the room to open the door and windows.
Using stand-alone air cleaner	- Install a high-efficiency air filtration system MERV 13 or higher / ISO ePM1 70-80 percent filter, - Create clean-to-less-clean air movement - Additional equipment, such as stand-alone air-cleaning devices equipped with a High-Efficiency Particulate Air (HEPA) filter or Upper-Room Ultraviolet Germicidal Irradiation, has been installed as needed to increase ventilation, kill disease, and measure (UVGI). To eliminate or inactivate SARS-CoV-2 disease, particularly in the air and on the surface. However, UVGI has many limitations such as distance and duration because this machine also emits ozone, so use it with caution and good maintenance. - If the carbon dioxide content is greater than 800 ppm, fewer people, and increased ventilation have been considered, add

	duct- or air-handling-unit-mounted (achieve three air changes of equivalent clean air supply), upper room, and/or portable UVGI devices in conjunction with in-room fans in high-density spaces.
Negative Pressure ventilation	- In an aerosol-generated room, negative pressure has been provided. - Setting up a negative pressure room for specific activities such as cooking in the kitchen, running an exhaust fan in the bathroom 24 hours a day, and closing the toilet after use
Inspected, maintained & cleaned HVAC system	- System commissioning entails ensuring that HVAC systems are operating as intended. - Inspect, maintain, and clean the HVAC system and filter on a regular basis. - During evaluation and inspection, ASHRAE guideline 36-2018, High-Performance Sequences of Operation for HVAC Systems, was used to optimize control.
1.2 Distancing & Building Layout	
Maintain distancing	- Maintain a physical distance of 1-2 meters in the office, canteen, meeting room, and relaxation area. - Installation of physical barriers such as plastic and glass barriers - Adopt a social distancing policy by limiting the number of people who work from home and shifting working hours. - Queue management - Closure/restrictions on the use of shared spaces - Remove and rearrange furniture - Increase workplace and common area capacity
Strict control over external accesses	- Construct a customer service drive-through window. - Set up a one-way system
1.3 Facilities and Equipment	
Employ touchless technology and proper surface materials	- Encourage the use of sensors, a foot pump, and a large handle that is controlled by the lower arm or elbow. - Make use of technology to promote social distance. - Use a touch-free hand sanitizer.

	- Making use of appropriate materials, such as a no-touch waste bin
1.4 Water and sanitary system safety	
Water Quality in sanitation and plumbing system	- Drinking water, feces, and sewage safety - Stagnant or standing water following a prolonged shutdown can pose hazards such as mold, legionella, lead, and copper. - To protect mold, keep indoor humidity below 50% and assess dampers according to the National Institute for Occupational Safety and Health (NIOSH) and flush out before operation. - To prevent legionella, keep the water heater around 140 degrees Fahrenheit and keep it clean and well-maintained. - To protect lead and copper in drinking water systems, test the amount of lead in the water, use water aerators, and use filters properly. - Before reopening the building water system, refer to EPA guidance and ASHRAE 188-2018, Legionellosis: Risk Management for Building Water Systems.

Table 25: Administrative and Organizational Control: Infection, prevention and control measures to COVID-19 for office building

2. Administrative and Organizational Control	
2.1 Workplace Safety Measures	
Enhance Hand Hygiene	- Making soap, hand sanitizer, or alcohol gel available, particularly at the entrance, toilet, canteen, exercise room, and in front of the lift. - Encourage regular handwashing with soap and water for 20-40 seconds or at least 60% of alcohol-based sanitizing hand rub dispensers with at least 10 ml capacity for 20 seconds that are easily accessible to all. - 0.5-2 liters of clean water per person - Dry hands after washing is essential; single-use towels are recommended - Make paper towels a top priority over fabric towels or

	electric air jet drying devices. - Make available resources and environmental conditions that promote good hygiene, such as paper tissues, touchless bins, liquid soap, 70% alcohol gel, cleaning detergent, and non-reusable towels. - In a public area, provide cleaning and protective equipment such as a facial mask and alcohol gel.
Promote Respiratory Etiquette	- Promote respiratory etiquettes such as wearing a mask tightly and coughing and sneezing into a tissue or upper sleeve. - Provide tissue and trash to customers and the general public. - Create a face-covering policy and make face masks or paper tissue available, as well as closed bins. - Recommend at least two layers of facing mask without exhalation valves or vents for face mask - Wearing a face mask both indoors and in a crowded outdoor setting - Inform workers to avoid greeting and encourage respiratory etiquette
Self-hygiene measure	- Encourage employees not to use other people's equipment, such as drinking water. - Limit or reduce the use of cash
Routine Screening	- Create an entrance and exit route that includes a registration and screening system. - Conducting daily in-person (Temperature screening and symptom) assessments and considering SAR-CoV-2 testing in the workplace
Proper Waste Management	- Provide a separate bin with a clear label or a red bag for facial masks, tissues, and other infected waste. - Provide a no-touch trash can. - Be cautious when collecting waste that may be contaminated with nasal discharge or saliva.
2.2 Cleaning and Disinfection	
Cleaning Measure	- Regular disinfectant cleaning and hygiene, especially on

	high-touched surfaces (e.g., desks and tables) and objects (e.g., telephones, keyboard) - Increase the number of frequently touched surfaces. - Implement routine housekeeping, cleaning, and disinfection of surfaces, equipment, and other elements. - Establish a regular schedule for cleaning equipment, utensils, or areas where there is a high level of regular exposure with detergent or disinfection and a 70% alcohol solution at least twice per day. -Clean the building and surrounding area frequently, such as the floor, walls, and doors. -In the case of the canteen, proper disinfection detergents must be used. - Proper PPE and good ventilation will be used during the cleaning process. - Regular housekeeping practices will be followed by EPA-approved and existing OSHA standards, such as the OHSA's PPE standard.
Cleaning Detergent	- Clean building equipment with a cleaning detergent containing 70% alcohol and provide adequate ventilation. - Cleaning and disinfection of frequently touched surfaces using 0.1 percent sodium hypochlorite or 70% alcohol - It is recommended to clean on a regular basis with soap or a neutral detergent, water, mechanical action, and 0.1 percent sodium hypochlorite (1000 ppm) or 5 percent sodium hypochlorite to 50 parts water. - Routine cleaning and disinfection with a product approved by the United States Environmental Protection Agency (EPA) (List N: Disinfectants) * If list N is not available, bleach solution, ultrasonic waves, high-intensity ultraviolet radiation, and LED blue light can be used. - Proper PPE and good ventilation will be used during the cleaning process. - Disinfectants are biocidal products that are governed by

	Biocidal Product Regulation (BPR)** -Non-proper cleaning measure such as praying disinfectants on people (e.g., in a tunnel, fogging, fumigation, cabinet, chamber, or UV) is never recommended.
2.3 Emergency Plan Development	
Emergency Plan Preparedness	-Standard operating procedures should be developed, as well as a plan for when someone is ill and needs to be isolated without stigma or discrimination. - Create an emergency risk communication plan. - Choose a workplace coordinator. - Assist an employee who has a suspected infection and is staying at home. - If you have a shuttle bus, clean it with 0.1 percent sodium hypochlorite or 70% alcohol and keep the number of people to a minimum to maintain distance. - Have an employee tracking system in place.
Suspected or Confirmed case measure	- Stop working and seek medical attention if a symptom is discovered. - Prepare first aid points and simple treatment by first isolating the patient. - Contact your local health department. - If a suspected and confirmed case has been found, ventilate with fresh air for at least 1 hour and clean with neutral detergent and 0.5 percent sodium hypochlorite spray. - Someone who was in close contact with infected people was allowed to stay at home for 14 days for home quarantine and followed the government's instructions. - Report and keep track of the number of infections and deaths.
2.4 Business continuity Guideline	
Transition to remote work	- Use teleworking and work from home strategies to reduce the need for in-person meetings. - Enforce travel policies by reducing and managing work-

	related travel. - Workplace policies that consider changes in working patterns, such as working from home. Teleconference, drive-thru service, cashless and online transactions
Shift working	- Working hours should be staggered, and shift or split-team arrangements should be implemented to reduce the number of people in the available time. - Stop crowed people activities
Employee encouragement	Encourage employees to monitor and observe their health on a daily basis; encourage sick people to stay at home; and encourage employees to self-monitor and stay at home when they are ill.
Implement supporting policy	- Risk assessment in order to identify preventive and control measures - Provide psychological counseling if necessary or if there is a concern about mental health. A large organization's screening protocol should be implemented before work begins. In the case of workplace dormitories and food courts, adhere to a good system, particularly food preparation, table, chair, and hygiene measures, and cover food safety. Consider providing assistance to employees who use public transportation, such as changing their trip or cleaning their hands. - Failure to distinguish between workers who have been vaccinated and those who have not been vaccinated.
A particular concern for vulnerable employee	- Pay special attention to the vulnerable (older adults or people with disabilities) and marginalized groups.
2.5 Education and Communication	
Establish Communicate Policy	- Using verbal announcements and signage in a variety of languages, effectively communicate the risk of COVID-19, workplace flexibilities and protections, and emergency plans to all employees and visitors.

Hygienic Measure Communication	- Promote handwashing through effective media, such as signage and posting signs in restrooms - Promote good respiratory hygiene - Educate employees on how to protect themselves and encourage staff to stay home when symptoms are observed - Raise worker and cleaning staff awareness of the risk of agent contamination when using, and after using, frequently cleaning and cleaning equipment. - Disseminate information about ergonomic risks associated with remote work.
COVID-19 Information Communication	- Using official sources, provide regular information about the COVID-19 risk. - Providing knowledge, advice, or public relations media to main observation staff - Providing up-to-date education and training on COVID-19 - Confirmed COVID-19 cases should be communicated.
Employee Training	- Training in protective clothing and equipment for employees with appropriate language
Employee Feedback Response	- Involve employees in providing feedback. - Implement retaliation protection and establish an anonymous process for workers to express concerns.
Other additional strategies	- Recognize for an employee to care for their family

Table 26: Personal Protective Equipment: Infection, prevention and control measures to COVID-19 for office building

Personal Protective Equipment (PPE)
1. Select the type of PPE based on the risk of infection while working 2. Personal Protective Equipment, 100% mask wearing Employees and visitors should always wear a facial mask, and gloves and a face shield may be provided for those who need to wear them for their job. 3. Wash your hands frequently with soap and water, as well as alcohol gel. Touch your face, eyes, mouth, and nose as little as possible.

4. Personal Protective Equipment (PPE) should be appropriate for infectious environments, with proper wearing, maintenance, cleaning, and management.
5. Choose and provide appropriate PPE to the worker at no cost.
6. Choose PPE based on the hazard worker that is properly fitted, consistently worn, regularly maintained, and properly removed.
7. Wearing properly fitted clothing, wearing it consistently, maintaining it on a regular basis, and properly removing it

4.4 Protective and Preventive Layers for Office Buildings and Workplaces

Previous articles and studies on COVID-19 protection and prevention in an office building have also been investigated. The current pandemic has highlighted the need for the built environment to be hostile to viruses such as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [41]. Along with productivity and aesthetics, a building's resistance to the coronavirus has become a design consideration. To prevent COVID-19, policymakers and building owners must analyze, plan, and implement various worker safety strategies, particularly when workers return to their respective workplaces. A number of anti-COVID-19 considerations for offices and workplaces have been required for worker safety based on the lessons learned and vulnerabilities exposed during the more than a year-long pandemic. As shown in Table 27, these requirements can be divided into three categories: (1) regulatory environment, (2) engineering control environment, and (3) administrative and organizational control environment.

Table 27: Summary of office buildings and workplaces requirements to safeguard against COVID-19

Category	Subcategory	Requirements
Regulatory environment	Agency regulations	• Several international organization regulations provide practical updated workplace guidelines to protect workplaces from COVID-19 [124].
	Country regulations	• COVID-19 guidelines differ from country to country, reflecting differences in health-care facilities and strengths. • Country-specific in some cases, COVID-19 regulations may differ

		from IHF regulations [159].
	Operational guidelines	• Workplace regulatory frameworks must be constantly updated. Workplaces must be able to modify their operational policies to reflect the most recent regulatory updates at the national and international levels [123]. • Regulations should result in the behavioral changes needed required to protect workers from the COVID-19 pandemic [128]. • Specific behavior standards for each work sector should be developed and implemented based on general guidelines established by the health authority and with the participation of business chambers, trade unions, and government authorities [185]. • Organizational policies and protocols should be in place to ensure employee safety and security during COVID-19 [124, 186]
Engineering Control environment	Ventilation	• Utilize demand-controlled ventilation systems to increase fresh air supply and spent air exhaust rates in and out of workplaces [101]. • The deactivation of air recirculation systems should be strictly regulated [187]. • High-Efficiency Particulate Air (HEPA) filters must be installed to ensure that only clean air enters the building [188]. • Control inflow rates of filtered air into workplaces to prevent virus-friendly environments (control indoor humidity and temperature) [189]. • Redesign industrial hygiene (IH) and occupational and environmental health and safety (OEHS) to include considerations for virulent pathogens [133].
	Distancing and Building Layout	• Designs must take into account health and sustainability [41]. • Working should be more functional, healthier, and emotionally satisfying [190]. • People living in tall buildings may be vulnerable [143]. • Install physical barriers in made of plexiglasses, polycarbonate, and tempered glass in workplaces [117]. • Attention must be paid to avoid overcrowded interior spaces [191, 192]. • Office spaces should become more varied, with fewer desks and more options for meeting, eating, exercising, and unwinding [193]. • Opt for internal layouts with adequately open working spaces and allocate spaces for individuals [194].
	Facilities and Equipment	• Provide personal digital terminals (tablets, laptops, desktop PCs, etc.) [189]. • Automate restroom facilities (toilets, etc.) [195]. • Opt for devices with touch-free technology such as automated infrared temperature checks, facial recognition admittance devices, keycard swipers, and voice-activated elevators. [196]. Consider using surfaces (such as office desks, etc.) that have a

		shorter half-life for the SARS-CoV-2 virus [197].
	Water and Sanitary Ware System	• During COVID-19 temporary building closure, routine flushing and shock disinfection were indicated as possible microbiological and legionella risk control methods [154].
Administrative Control environment	Workplace Safety Measures	• Together, source control and pathway control play an essential role in minimizing high-risk situations [198] • Implement an efficient surveillance system that can track infection and transmission trends amongst employees and communication thereof to employees [199].
	Cleaning and Disinfection	• Cleaning detergent and disinfectants are recommended to be made available at strategic places, especially at the frequent touch surfaces [200].
	Emergency Plan Development	• Implement an efficient surveillance system that can track infection and transmission trends amongst employees and communicate to employees [199].
	Business Continuity Guideline	• Establish teams of workplace experts that can enforce effective control measures [139]. • Allow for flexible working models, such as working from home [201].
	Education and Communication	• Train workers to develop acquaintance with COVID-19 guidelines [171].

4.4.1 Workplace Regulations

The World Health Organization's International Health Regulations (2005) (IHR) are a 196-country international agreement that aims to prevent, protect against, control, and respond to the international spread of disease. This regulation went into effect on June 15, 2007. The IHR discusses how various countries can combat the spread of diseases such as COVID-19 and other public health issues. As a result, individual countries' COVID-19 health-protective guidelines must, in some ways, adhere to IHR regulations. Unfortunately, some countries were reported to have deviated from the IHR during COVID-19 [159].

Many international and national agencies, led by the WHO, have proactively issued COVID-19 workplace safety guidelines, which are constantly being updated as their understanding of the SARS-CoV-2 virus evolves. These guidelines aim to

provide national frameworks as well as organizational guidelines for the safe return of workers to the workplace. The authors of [202] , reported that during their initial outbreaks, the COVID-19 guidelines of six countries differed and explicitly reflected these nations' different healthcare strengths. The authors of [203] also highlighted the haphazard nature of national and local COVID-19 guidelines across their 20-country study.

All regulations and guidelines, be they international or national, are fundamentally meant to prevent pandemic spread [204]. However, they may overlook specific requirements for successful implementation in particular workplaces. For example, national or international guidelines may not specifically address how ventilation systems should function with assembly line workers in mind.

Countries must develop sector-specific guidelines in collaboration with business chambers, labor unions, and government officials as various sectors of the economy reopen so that benchmark standards can be implemented and followed by individual organizations [185]. Individual organizations should be prepared to ensure the safety and security of their employees during COVID-19 [124, 187]. In order to develop the necessary guidelines for their employees, office managers should actively conduct in-depth workplace analyses with expert input. Workplace policies and procedures must be updated on a regular basis in accordance with international and national standards [123]. It should be noted that regulations cannot immediately change worker behavior. Similarly, written policies or regulations alone cannot bring about the required behavioral changes [128]. Dennerlein et al., 2020 [205], as a result, multidimensional workplace regulatory frameworks covering human factors and ergonomic principles are required, because employees must ultimately be aware of their responsibility to their health.

4.4.2 Engineering Control Measure Environment

Efficient source control can help to control infectious spreads in high-risk areas [198], reducing the risk of pandemic disease infection among workers. Administrative actions that serve this purpose may include limiting office overcrowding, prohibiting PPE doffing (such as masks, shields, and so on), and barring visitors who refuse to maintain social distance [206]. Although source control can be difficult in large office spaces, surveillance systems can assist by detecting and prohibiting potential protocol violations in their early stages. Bashir et al. (2020)

[207] pointed out that even simple, low-cost end-to-end IoT architectures can aid in the surveillance of office environments in order to maintain standard operating procedures (SOP). Employers can use surveillance systems to ensure the effectiveness of source control measures and quickly communicate infection trends to employees [199].

Engineering controls such as filtration, effective air cleaning, and ventilation systems can block virus entry pathways and maintain a healthy workplace environment [158]. HVAC systems are responsible for preventing or removing micro respiratory droplets smaller than 5 microns in size from office environments. The ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) epidemic task force recommended running office HVAC systems with at least minimum outdoor airflow rates to flush airborne viruses out of office spaces. HVAC systems should be kept running until fresh air is replenished in every employee's office space. To prevent the recycling of unwanted aerosols back into the room, air cleaners and/or filters must be used in conjunction with HVACs [188]. ASHRAE also suggests using MERV (Minimum Efficiency Reporting Value) 13 or better rated air filters that can stop >95% of 0.30-1.0 micron-sized pathogens that are present in the air [101]. HVACs should also help to maintain healthy workplace temperature and relative humidity (RH) levels that are unfavorable to disease spread; research is still being conducted to determine the precise temperature and RH ranges that can best subdue the COVID-19 virus [208].

Health and sustainability should be at the core of any office building's architecture [41]. The COVID-19 pandemic demonstrated unequivocally that building designers and planners did not place enough emphasis on infectious disease control. Prior to the pandemic, office buildings were designed primarily for productivity and aesthetics, with little regard for infectious disease control features [209]. Therefore, office environments must become more versatile, infection resistant, and morally fulfilling for workers to achieve higher productivity [190]. Employees no longer look proudly upon tall and crowded office buildings outfitted with multiple fast-moving elevators due to their fear of virus infection. Instead, employees prefer lower-level office buildings with sprawling staircases [143]. Building materials with a shorter half-life for the SARS-CoV-2 virus must also be used by designers [197, 210].

Open office layouts were once lauded for their ability to boost productivity. However, their susceptibility to disease transmission was highlighted at COVID-19, particularly in Zurich, where an entire team working in an open office became infected [132]. Employees in India were hesitant to attend open-concept information technology call center offices due to virus infection fears. As a result, open floor plans must be modified to be more disease-resistant [211]. Even in the midst of a pandemic, architectural innovations were required to create open office layouts that respect personal spaces while also promoting employee morale [212]. Furthermore, physical barriers made of plexiglass, polycarbonate, or tempered glass placed in break rooms and meeting rooms can reduce the likelihood of employees coming into close contact [117].

Touch-free technologies can also help to reduce the spread of infectious diseases in the workplace. Virus-infected surfaces, such as elevator keys, doorknobs, attendance registering keyboards, and even electrical switches, are common ways for disease to spread. Network-connected devices (Internet of Things, IoT networks) can assist employees in minimizing physical contact with high-touch surfaces when passing through entry security systems, operating elevators, accessing personal cabins, or using office equipment (computers, lights, fans, etc.) [196, 213, 214].

4.4.3 Administrative and Organization Control Measure Environment

Whatever types of management-enforced risk elimination and engineering controls are implemented in the workplace, they are ineffective in keeping COVID-19 out unless they are followed up on in a timely and efficient manner. Employees who are motivated may be an organization's most valuable asset in the fight against COVID-19. Efficient administration can motivate employees to cooperate and follow COVID-19 disease control guidelines and protocols enacted by management. Individual workers who defy protocols have the potential to undermine all management efforts to contain COVID-19 if employees are not motivated [215]. As a result, the office administration's ability to involve workers in safety planning and the development of COVID-19 guidelines and protocols, such as workplace safety measures, cleaning and disinfection, emergency plan development, business continuity guidelines, and education and communication, will be enormous. Administrators must avoid exhausting employees with exhaustive COVID-19

protocol training and instead design engaging and practical training sessions to reduce workers' resistance to following the protocols.

4.5 Recommendations for Office Building Management in Thailand

Although allowing employees to work from home is an excellent way to reduce disease transmission, not all offices can be closed. In these cases, workplace safety must be prioritized. In the fight against COVID-19, numerous disease control strategies have been implemented. Employers conducted risk assessments to determine the best protective measures for their workplace and employees, and then prevention gaps were filled. The most fundamental COVID-19 protection layer that does not require large monetary investments is for everyone to practice self-protection. To protect themselves from COVID-19, everyone must be aware of their personal hygiene (e.g., using alcohol gel, covering their coughs and sneezes) and wear appropriate PPE (e.g., face masks). Occupational workplaces can provide additional protective layers to individuals in three areas, in addition to personal responsibility: built environment, control environment, and regulatory environment.

Regulatory environment

- Thailand should have COVID-19 regulations that are in accordance with international agency regulations and provide practical updated workplace guidelines to protect workplaces from COVID-19.
- To ensure employee safety and security during COVID-19, organizational policies and protocols should be in place
- Change company policies to ensure that all work activities are carried out safely. Allow employees to work from home, develop business continuity and emergency communication plans, implement cleaning and disinfection procedures, and regularly monitor and update strategies.

- Employees should be given resources and materials, as well as safe working environments, proper waste management services, and safe building water systems.

Engineering Control environment

- Install more efficient ventilation systems (both natural and mechanical) with proper temperature and humidity controls to improve air quality. Maintain good air quality in workplaces by keeping ventilation and moisture control systems in good working order.
- Change workspaces to maintain social distance by implementing various engineering measures to eliminate disease transmission threats; these may include physical barriers that can arrest floating virus particles, and design concepts must be based on health and sustainability principles.
- Using cutting-edge technologies (particularly touch-free equipment) and workplace layouts to keep people safe from one another.
- Cleaning, disinfection, and flushing of water and sanitary ware systems on a regular basis to reduce the risk of microbiological and legionella contamination.

Administrative & Organizational Control environment

- Implement various source control and workplace safety measures, such as screening before entering, providing hygienic materials, considering changing or replacing surface materials with shorter virus lifetimes, and implementing proper waste management.

- Apply an effective cleaning detergent to high-touch surfaces and provide appropriate self-protection measures to cleaning staff.
- Create an emergency response plan that allows you to track and communicate infection and transmission trends among employees.
- Create a business continuity plan that takes into account flexible working models such as working from home and the formation of a team to implement effective control measures.
- Employees should be educated and communicated with to become familiar with COVID-19 guidelines and effective measures.

Chapter 5
Comparison of Health & Comfort Criteria between certified and non-certified building

5.1 Health & Comfort Criteria of certified building

When comparing with COVID-19 infection, prevention, and control measures and sustainable building assessment. Health and comfort criteria have been categorized into two main groups.

5.1.1 Health & comfort criteria that directly mentioned in COVID-19 preventive and protection measures implementation including:

1). Thermal characteristics:

Keeping temperature and humidity during COVID-19 is the challenge. Although this characteristic is not mentioned in preventive and protective's strategies. However, other measures such as increase ventilation, keep distancing, and business continuity plan such as work from home are affected to temperature and humidity inside the building. Especially in relative humidity, which is a key for preventing transmission and promoting health. For example, aerosol particle size is decreased in lower humidity, which can suppress human immunity easier than usual. While higher humidity, the growth of fungi has been found. Additionally, temperature and relative humidity is a subjunctive issue. So, the adjustable for suitable is very crucial. Most building certification assessment recommend to maintain temperature and humidity followed by ASHRAE 55 that six categories have to concern for including occupants' characteristics in metabolic rate and clothing insulation. And the building or environmental characteristics comprising air temperature, radiant temperature, and air speed and humidity. However, for other buildings

2). Indoor air quality characteristics:

Indoor air contaminants from outdoor and indoor sources, such as fresh air intake from the outside, recirculating air performance, inhalation, combustion sources, building materials, and cleaning products, all impact human health. All of these substances have an impact on the building's occupants. So, in order to improve indoor

air quality, both outside air quality and indoor air quality substances must be considered.

2.1 Ventilation:

ASHRAE 62.1 is the majority requirement for building certification. Install infiltration and negative pressure design are also concerned in building certification and COVID-19's protection strategies. So, during COVID-19 certified building is easier than non-certified to improve building's efficiency to prevent and protect COVID-19.

2.2 Emission to substrate:

Low volatile organic compound products for surface coatings, and interior building materials are favored in building certification assessments. Furthermore, several industry regulations recommend using less hazardous cleaning detergents such as List N: Disinfectants and Biocidal Product Regulation (BPR). Additionally, surface materials have been considered for using less active disinfection.

2.3 Risk of Mold Growth:

Moisture management plan inside the building is a creditability to building certification assessment. During COVID-19, especially when after prolonged shutdown, humidity control and eliminate of stagnant water in the sanitary system is recommend.

3). Spatial or Distancing:

Distancing in certified building is mentioned in ventilation calculation especially in number and floor area topic. However, COVID-19 measures are more stringent comparing to building sustainable assessment. Number of occupants per area is used to calculate outdoor air ventilation. While, during COVID-19, building layout, point marking, plastic barrier, touchless technology in both office and public area are the recommendation to keep distancing in COVID-19 preventive and prevention measures.

5.1.2 Health & comfort criteria that does not mentioned in COVID-19 measures infection, prevention, and control measures comprising:

1). Visual characteristic

Light exposure improves mood and reduces depression symptoms in people. Human health is also impacted by exposure and reduced exposure. Integrating daylight and electric light to create lighting strategies focused on human health and traditional requirements for visual acuity and comfort can lead to healthier and more productive environments. So proper of daylight, artificial and view is so important for building occupant. In sustainable building certification, this aspect focuses on artificial lighting, daylight, view, and occupational control. Although, COVID-19 strategies does not mention these aspects. However, effect from engineering measure such as increase ventilation, keep distancing, and administrative measures such as work from home policy has been examined to improve building efficiency.

2). Acoustic characteristic

Exposure to noise sources such as traffic and neighbors affects people's health and well-being in different ways, such as a disturbance from a colleague during working hours. Furthermore, sound in enclosed spaces, such as HVAC equipment, has an impact on productivity and mental health. As a result, improving the acoustic characteristics must prioritize protection against outdoor noise, indoor sources, background noise, and reverberation time. Although, COVID-19 strategies does not mention in these aspects, the effect to building's occupant when engineering and administrative measures to prevent and protect COVID-19 in office building have been executed, effect to acoustic characteristic is challenge to improve.

Some COVID-19 infection, prevention, and control measures are already mentioned and concerned in sustainable building assessment. Specifically, in the areas of health and comfort that mentioned in COVID-19 prevention strategies (Thermal comfort, indoor air quality, and distancing). As a result, during this period, certified buildings are easier to adapt to COVID-19 response.

5.2 Data on certified and non-certified buildings during COVID-19

From an in-depth interview to building owner about the improvement of building during COVID-19both certified and non-certified building in this study has been shown in Table 28

Table 28: Improvement of building samples during COVID-19

Strategies Improvement	**Certified Building**				**Non-Certified Building**				**% Building implementation**	
	A	B	C	D	E	F	G	H	**Certified building**	**Non-certified**
1. Engineering Control										
1.1 Improve building's air quality										
- Increase air intake and exhaust fan*	√	√	√	√	√	√	√	√	100	100
- Flush air before using at least 2 hours	√	√	√	√	√	√	X	√	100	75
- Open window when outside air quality is good*	√	√	√	√	√	X	√	√	100	75
- Using an additional mechanical fan	√	√	√	√	√	√	√	√	100	100
- Install high effective air filtration system* (MERV 13, HEPA, UVGI)	√	√	√	√	√	√	X	X	100	50
- Improve ventilation for the bathroom*	√	√	√	√	√	√	√	√	100	100
- Have negative pressure room for confirmed cases	√	√	√	√	X	X	X	X	100	0
- Have an inspect, maintain & clean HVAC system plan and schedule*	√	√	√	√	√	√	√	√	100	100
1.2 Distancing & Building Layout										
- Install physical barrier	√	√	√	√	√	√	√	√	100	100
- Create a new office layout	√	√	√	√	√	√	√	X	100	75
- Change or re-route flow system	√	√	√	√	√	√	√	√	100	100
1.3 Facilities & Equipment										
- Employ touchless technology	√	√	√	√	√	√	X	X	100	50
1.4 Water and Sanitary and plumbing system										
- Have a water quality control plan in a plumbing system*	√	√	√	√	√	√	√	X	100	75
2. Administrative and Organizational Control										
2.1 Safety Workplace Measure										
- Enhanced hand hygiene measure	√	√	√	√	√	√	√	√	100	100
- Respiratory etiquette promotion	√	√	√	√	√	√	√	√	100	100
- Have other's self-hygiene measures such as using cashless and private utensil	√	√	√	√	√	√	X	X	100	50

- Implement routine screening	√	√	√	√	√	√	√	√	100	100
- Provide proper waste management*	√	√	√	√	√	√	√	X	100	75
- Have a visitor's screening policy	√	√	√	√	√	√	√	√	100	100
2.2 Cleaning and Disinfection										
- Have a proper cleaning measure by frequently increasing	√	√	√	√	√	√	√	√	100	100
- Using effective cleaning detergent including 70% alcohol, 0.1% sodium hypochlorite, and List-N disinfectant	√	√	√	√	√	√	√	√	100	100
2.3 Emergency Plan Development										
- Have a standard operation when confirmed cases have been found	√	√	√	√	√	√	√	√	100	100
2.4 Business Continuity Guideline										
- Transition to remote work	√	√	√	√	√	√	√	√	100	100
- Implement shift working	√	√	√	√	√	√	√	√	100	100
- Encourage staff to self-monitoring	√	√	√	√	√	√	√	√	100	100
- Encourage sick staff to stay home	√	√	√	√	√	√	√	√	100	100
- Implement Supporting Policy by having a risk assessment measure	√	√	√	√	√	√	√	√	100	100
- Implement Supporting Policy by improving mental health	√	√	√	√	X	√	X	X	100	25
- Implement measures in public space	√	√	√	√	√	√	√	√	100	100
- Have a particular attention program for a vulnerable person	√	√	√	√	√	√	X	√	100	75
2.5 Education and Communication										
- Establish communication policy	√	√	√	√	√	√	√	√	100	100
- Hygienic Measure Communication	√	√	√	√	√	√	√	√	100	100
- Provide update COVID-19 Information	√	√	√	√	√	√	√	√	100	100
- Confirm cased communication	√	√	√	√	√	√	√	√	100	100
- Employee Training	√	√	√	√	√	√	√	√	100	100
- Have an employee feedback program	√	√	√	√	√	√	√	√	100	100
3. Personal Protective Equipment (PPE)										
- Promote using PPE	√	√	√	√	√	√	√	√	100	100
- Provide Appropriate PPE	√	√	√	√	√	√	√	√	100	100
Number of Confirmed Cases and Cluster	0	0	0	0	0	0	0	0		

* strategies that mentioned in sustainable certified building assessment

√ symbol indicate that this strategy has been implemented in that building while, X mark is represent the non-implementation.

In this study, most of certified building (Building A,B,C,D) are implement all COVID-19 prevention strategies while non-certified building is varied. For building E

and F, 94.74% of recommend measures have been implemented. While, less than 90% of execution has been observed in building G (81.58%) and building H (78.95%).

In non-certified building, for an engineering measure, providing negative pressure is the most difficult for implementation. Installing air filtration and using hand-free technology are also the challenge. When the improvement of mental health programs is crucial for administrative and organizational control measures.

5.3 Building owner, developer & facility management manager perspective

Because the occupants spend more time indoors than outside, that building must substantially impact their health and comfort. As a result, building quality and performance will undoubtedly impact occupational health. Furthermore, occupants also benefit from the building's location close to public transportation, open space, and ergonomic design. The usage of sanitary and low volatile organic compounds is also ensured by indoor air quality. In addition, proper ventilation, carbon dioxide concentration, and mold growth have been a source of concern. Furthermore, acoustic and visual qualities also considerate for better health and comfortable living.

Some businesses pursue sustainable and well-being building certification such as LEED, TREES, and WELL to demonstrate their commitment to sustainable development as a core idea for corporate operations and serve as a role model for other companies. Moreover, the essential resource in a building is its occupant; hence this investment is for its operation. In addition, the certified building focuses on the health and comfort of the occupants, including interior air quality, temperature, lighting, acoustics, and the type of construction materials. When employees are well cared for, they perform better at work. Furthermore, improved health quality of building lead to lower medical expenses for the building occupant. In their opinion, sustainable building is worth for investment.

During COVID, most certified buildings implement infection, prevention, and control measures to fight against COVID-19. They point out that certified building is beneficial when facing COVID-19, with significantly better indoor air quality by enhancing ventilation when compared with non-certified. Additionally, high-

efficiency filter installation and adequate maintenance, using lower toxic materials such as cleaning detergent, energy and water-saving using touchless technology are also the benefits of certified buildings during this period. However, the criteria of the WELL standard focus more on the health and comfort of building occupants. Only limit recirculation air and add the negative pressure room for engineering measures. So, during this period this building have the most benefit from sustainable certification assessment.

For non-certified buildings, two types of buildings have been found. First is the building that implements most of the measures and strategies for COVID-19 prevention. Because business has to continue and have to make their customer's confidence, building owners decide to implement it. Second is the non-certified building with an obstacle or gap and barrier to implementing preventive and protective strategies, especially engineering measures. Although employees are the most important, budget and time limitations are the main reasons the implementation is limited. However, alternative strategies have been selected and implemented during this period for non-certified building. Table 29 show the alternative strategies when recommend of COVID-19 infection, prevention, and control strategies from international and national regulation cannot applied:

Table 29: Alternative for COVID-19 infection, prevention, and control strategies in non-certified building

No.	Recommend Strategies that does not implemented	Alternative strategies
1	Have a negative room for confirmed case	Separated area with natural ventilation have been provided in case of confirmed case have been found.
2	Install high effective air filtration system	Increase frequency of cleaning is selected and implemented for some building that cannot afford air filtration using.

3	Employ touchless technology	Instead, physical separation with a mark has been employed such as at the elevator area and restroom. Additionally, alcohol gel, hand-washing detergent, and promotion materials are available in public areas
4	Implement Supporting Policy by improving mental health.	The recommendation for the government support such as hotline is provided

Building owners and facility managers are more satisfied with their building's performance to protect the health and comfort of the building during COVID-19, according to an in-depth interview and rating scale. The most difficult task is improving ventilation.

Additionally, from an in-depth interview of building owners and facility managers, some suspected cases have been found in some buildings such as the excess limitation of body temperature, coughing or sneezing at work, or being tested positive during or after working time. The building owner and facility management have followed an emergency operation standard by carefully moving suspected people to a negative pressure room or open space that have been provided and monitoring their symptom. Moreover, the relevant area has been temporally closed and cleaned with effective disinfection. However, in all buildings in this case study (Both certified and non-certified buildings that have been built or renovated within ten years), no report of the infection case has been observed and no cluster outbreaks have been found. Therefore, from this study when the COVID-19 infection, prevention, and control measures and alternative strategies have been implemented, none of the COVID-19 cases has occurred in that office building.

5.4 Building Occupant perspective

This study explores buildings' importance and satisfaction in protecting their health and well-being by comparing before and during COVID-19. The data for this research was collected from April to September 2021, during the fourth pandemic outbreak in Thailand, by an in-depth interview with a Rating scale on the importance of the building and building's satisfaction in health and comfort criteria that comprising temperature & humidity, indoor air quality: ventilation, spatial, visual, and acoustic characteristic. All respondents must have working experience before and during COVID-19 in the same building.

An in-depth interview evaluated a total of 60 occupants, with 40 (66.67%) working in a certified office building (CB) and 20 (33.33%) working in a non-certified office building. For non-certified buildings can be divided into two groups depending on the scale of COVID-19 infection, prevention, and control strategies. If more than 90% of the recommendation has been implemented, the building has been categorized into non-certified buildings with good measure (NGM). When less than 90% of the recommendation is executed, this building has been categorized into non-certified buildings with fair measure (NFM). The group of people that took part in this study is shown in Figure 9

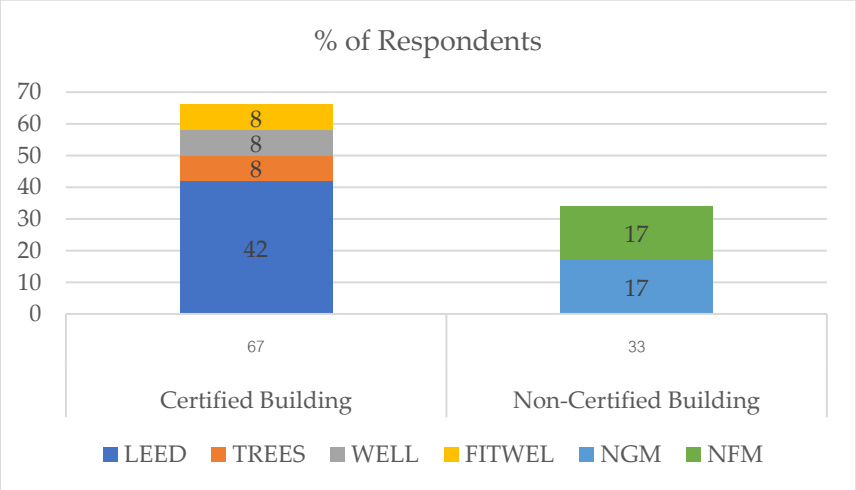


Figure 9: Proportion of the respondents

The rating scale shows that the relevance of a building to protect occupants' health and well-being during COVID-19 is more remarkable than previously thought in all types of occupants. Before COVID-19, certified building occupants had the highest score (4.03 ±0.72), Non-Certified Building: fair measure (3.80±1.17), and non-certified: good measure had the lowest relevance (3.60±0.66). While, during COVID-19, non-certified: good measure is at the top (4.40±0.49), the certified building is second (4.35±0.69), and non-certified buildings: fair measure is the last (4.10 ±0.94). Figure 10 depicts the average relevance score in protecting occupants' health and comfort.

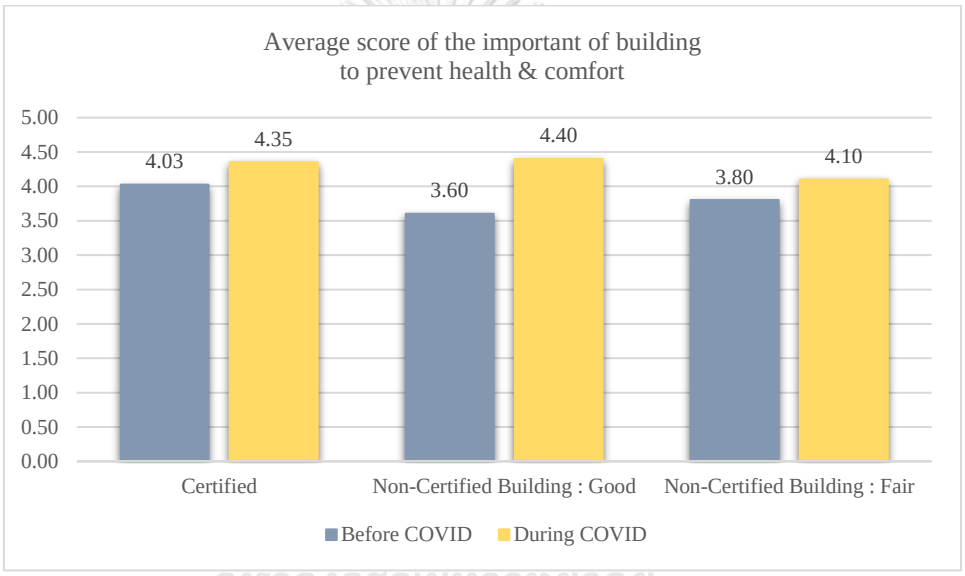


Figure 10: Average score of the awareness of the building's importance to protect occupant's health and well-being

A huge building improvement during COVID-19 is to strengthen occupants to have more awareness of the importance of building to protect and improve health and comfort to building occupant. Before COVID-19, certified buildings had the highest awareness of the building's importance. However, during COVID-19, the importance of the building is increased in all types of buildings. Especially in a non-certified building with the good measure is the best and has a huge gap between both times.

When considering the satisfaction of the building to protect health and comfort. Before COVID-19, the highest score was given to a building occupant in a certified building (3.93±0.72), followed by a non-certified building with fair measure (3.40±0.92), and the lowest score was given to a non-certified with good measure (3.30±0.64). Building satisfaction grew in all types of buildings throughout COVID-19. The highest level is non-certified building with good measure (4.30±0.49), the certified building is the second (3.95 ±0.69), and the non-certified building with fair measure is the last (3.70±0.94). The average score for building satisfaction in each occupant category is shown in Figure 11

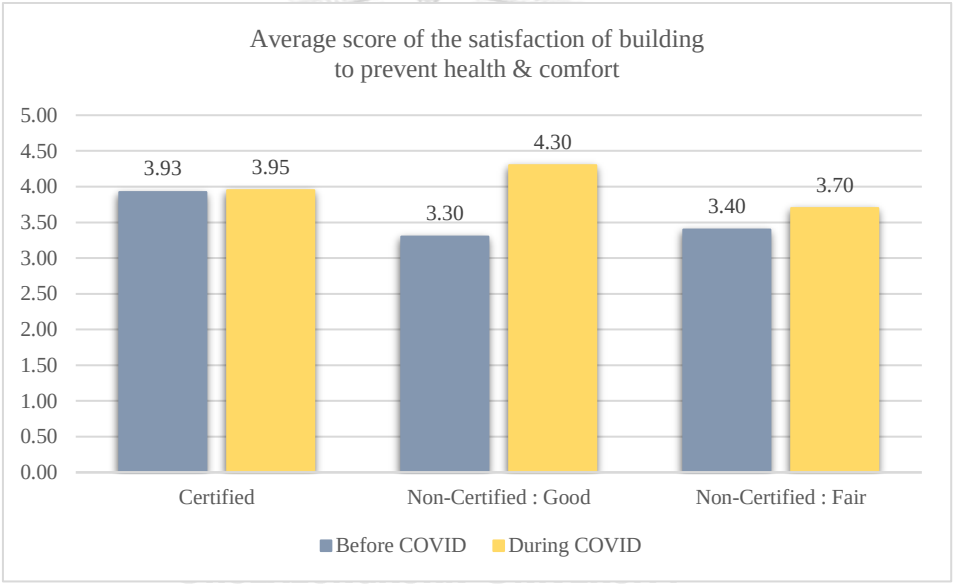
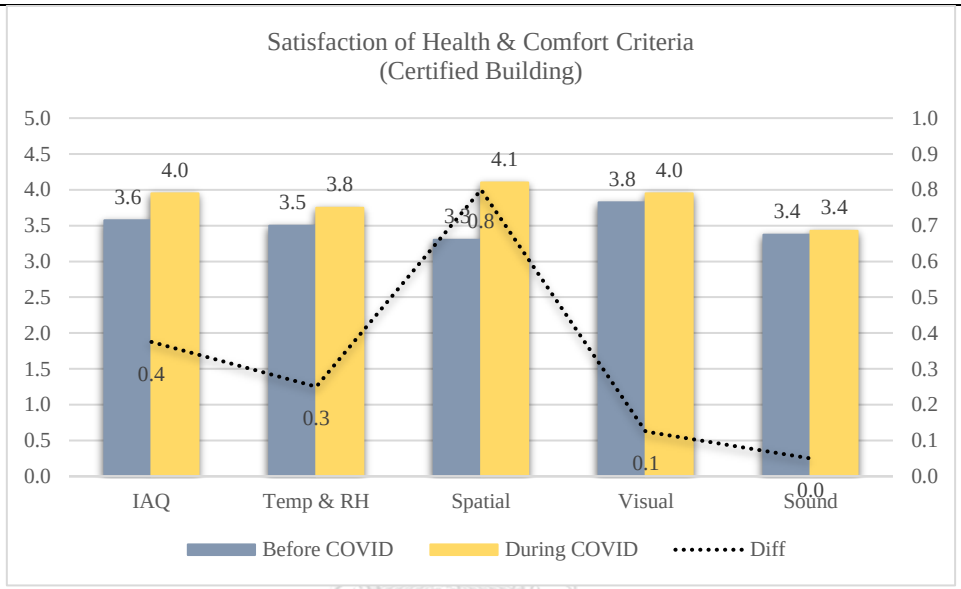


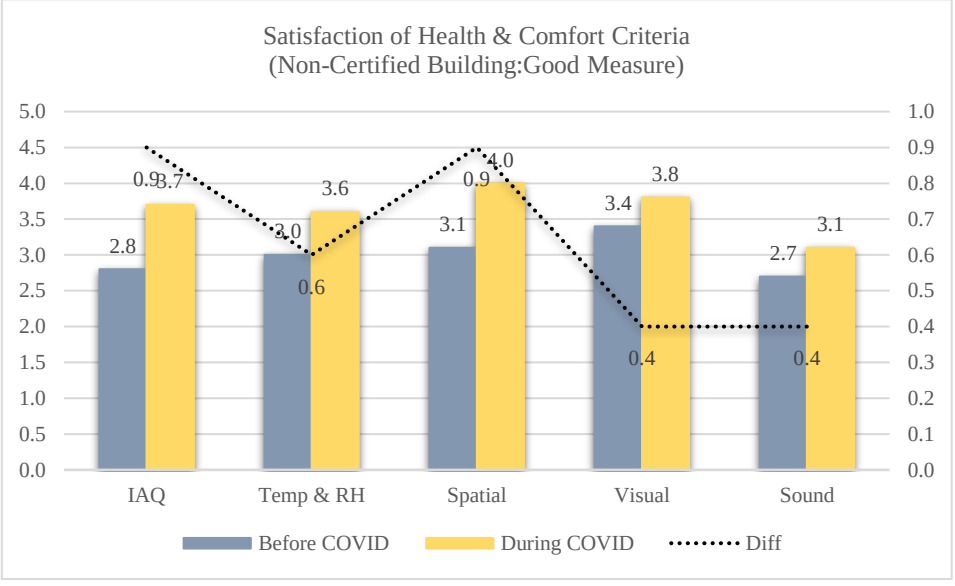
Figure 11: Average score of the satisfaction of building to protect occupant's health and comfort

Before COVID-19, the building's occupants in certified buildings had the highest level compared with others. However, during this circumstance the building's satisfaction to protect health and comfort from occupants has increased significantly in all types of occupants, especially in non-certified buildings those various strategies have been implemented (good measure). The main reason is that, because of the largest room of improvement during this period.

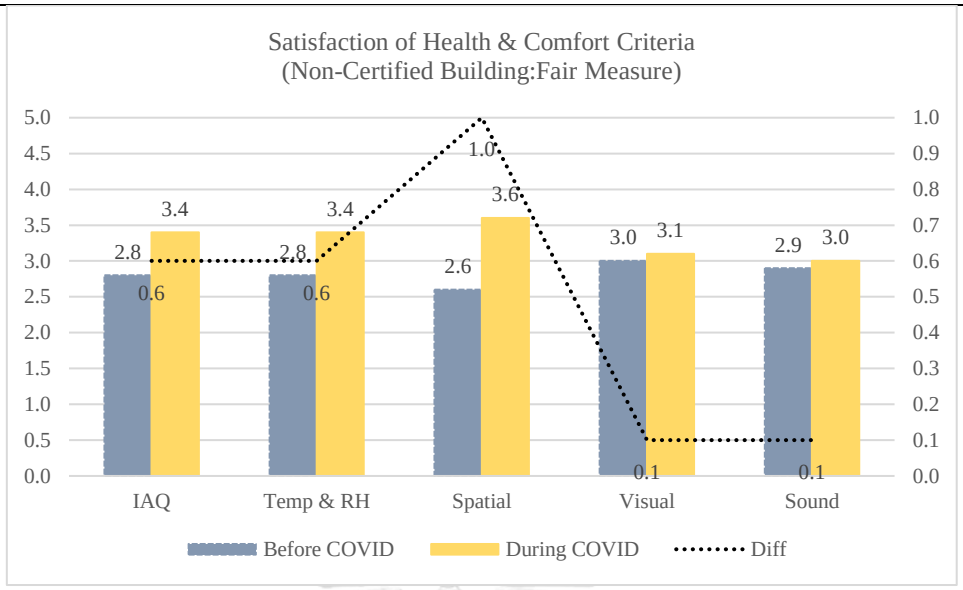
Rating scale experiment also used to measure occupant's satisfaction in each health and comfort criterion that affects from the implementation of preventive and protective COVID-19's strategies. Figure 12 indicates the building satisfaction in certified (a), non-certified buildings with good measure (b), and non-certified buildings with fair measures (c).



(a) Certified Building (CB)



(b) Non-certified building with good measure (NGM)



(c) Non-certified building with fair measure (NFM)

Figure 12: Satisfaction of each health and comfort criteria in different type of building

Before COVID-19, the level of satisfaction in health and comfort ranges between 3.3-3.8 for certified buildings which is the highest compared to other building types. While 2.8-3.4 ranges in the non-certified building with good measure and 2.6-3.0 for non-certified building with fair measure. Additionally, visual is the highest for all building type while spatial is the less for certified and non-certified building with fair measure and indoor air quality for non-certified building with good measure.

During COVID-19 period, 3.4-4.0 is the level of satisfaction in certified building, while 3.1-4.0 is the interval of satisfaction in non-certified building with good manner and 3.0-3.6 for fair measure building. During this time, most of the building's satisfaction in each health and comfort criteria is better when compared to before in all building's occupant types. Except for sound criteria in a non-certified building with fair measure that satisfaction level is equal.

Spatial or distancing is the most significant increase in all building types. The second and third are indoor air quality and temperature & relative humidity, respectively. For Certified building, 0.8 score of spatial differentiation occurs during

this situation. Second, indoor air quality (0.4) and thermal comfort (0.3) is the third one. The satisfaction of visual and acoustic criteria are not significantly changed.

Because various strategies to improve building ventilation have been implemented during this period concerning in spatial and indoor air quality. So, occupant's satisfaction both in spatial and indoor air quality are increased significantly. When considered in the non-certified building with good measure, indoor air quality and spatial are the most significant increase in satisfaction because the room of improvement is observed significantly during this period. Additionally, they point out that COVID-19 is like a catalyze for their building owner to improve air quality to protect them from building syndrome.

For a non-certified building with a fair measure for fighting with COVID-19. Although only some preventive and protective strategies are executed, it can improve the occupant's living condition. Spatial is a huge difference to them during this situation. Additionally, indoor air quality and thermal comfort satisfaction are better than before COVID-19.

5.5 Analysis of occupant's interview

When considering the level of satisfaction in each health and comfort criterion, the result shown that

5.5.1 Temperature & Humidity

Thermal comfort concerns personal factors (metabolic rate & clothing insulation) and environmental factors (air temperature, mean radiant temperature, airspeed, and relative humidity). Thermal comfort is defined as "the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation" [22] and is one of the highest contributing factors influencing overall human satisfaction in buildings. This study only focuses on air temperature and relative humidity based on the building's occupant experience. The building system or occupants usually control indoor air temperature and relative humidity to reach human comfort. However, during COVID-19, more air ventilation is required, so fresh air intake from outside have been increased. Especially in hot and humid

conditions, maintaining indoor air temperature and relative humidity, which occupant's comfort is a challenge.

Figure 13 shows the percentage of buildings' satisfaction in temperature and relative humidity criteria for each type of building, including certified buildings before COVID (CB-Before), certified buildings during COVID (CB-During), Non-certified buildings with good or more than 90% measure implementation before COVID (NGM-Before), and during COVID (NGM-During). And for non-certified buildings with less than 90% measures implementation or fair measure before COVID (NFM-Before) and during this time (NFM-During)

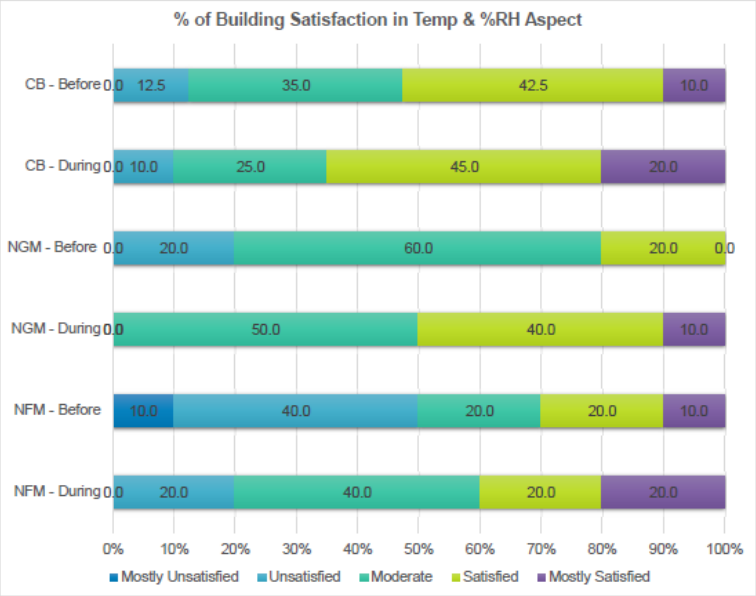


Figure 13: Occupant's Satisfaction in Temp & %RH

The satisfying level is significant for certified buildings before and during COVID-19 (42.5% and 45%, respectively). At the same time, moderate is noticeable for non-certified building with good measure. (60% and 50% for before and during COVID-19) while unsatisfied and moderate are significant levels for non-certified buildings with fair measures for before and during COVID-19 (40%). It is noticeable that 0.00 percent is mostly unsatisfied level in all building's type during COVID-19.

The level of satisfaction in a certified building does not increase during COVID-19 period because the office building has to maintain thermal comfort levels following the certification criteria. However, the level of satisfaction is increased, especially in non-certified buildings with good measure. Building has to maintain temperature and humidity levels, and a big difference between before and during COVID-19 is observed. However, some occupants point out to decrease in the level of satisfaction because of a bit of increase in temperature during this period. While, when fewer people come into the building, the temperature is too cold for some occupants.

5.5.2 Indoor Air Quality: Ventilation

Because people spend approximately 90% of their time in enclosed spaces, during this time, inhalation exposure to indoor air pollutants can lead to a variety of adverse short and long-term health and well-being outcomes that can vary in severity, include headaches, dry throat, eye irritation or runny nose to asthma attacks.

Ventilation is essential for living indoor conditions. The quantity and quality of outdoor air intake and exhaust air are fundamental to good ventilation. In building certification, ventilation is mandatory for the certificate, which international standards such as ASHRAE 62.1 concerning outdoor air intake, exhaust air, number of populations, and area. While non-certified building, ventilation is also essential without minimum standard requirement.

Because air media is one of causing of COVID-19, increasing ventilation with proper filtration has to implement against COVID-19. Furthermore, air quality has to be concerned by filtration installation. Figure 14 shows percentage of building's satisfaction in indoor air quality - ventilation criteria for each building type

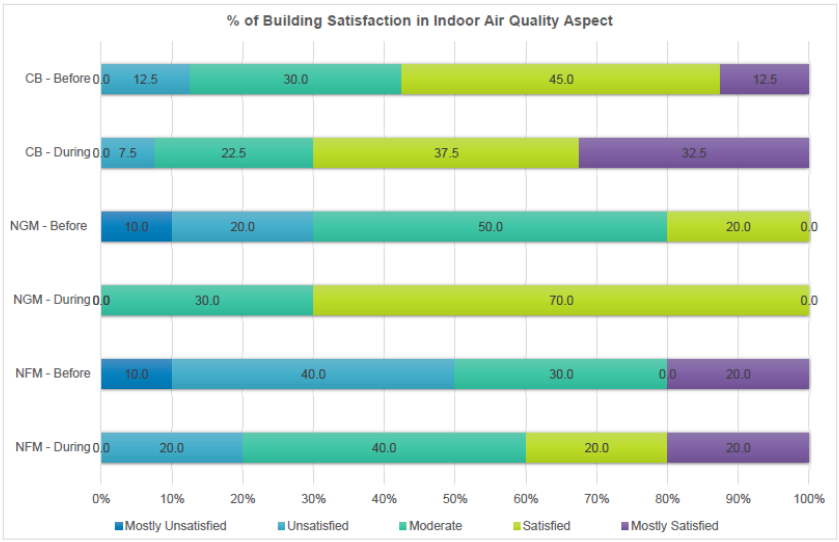


Figure 14: Occupant's Satisfaction in Indoor Air Quality – Ventilation

Before COVID-19, the satisfied indoor air quality level is significantly altered depending on the building's type. For certified building, the satisfying level is the most significant. At the same time, moderate is the peak for non-certified buildings with good measure and unsatisfied level for non-certified with fair measure. However, during COVID, the satisfied level becomes the most significant level in certified and non-certified with good measure.

For certified buildings, during COVID, the level of satisfaction in mostly satisfied is significantly increased from 12.5% to 32.5%. While non-certified buildings with good measure, the satisfaction level increases considerably from 20% to 70%. Remarkably, mostly satisfied level is not observed in this building type. For non-certified buildings with moderate measure, satisfied and fair levels are increased during COVID-19. Although limited strategies were implemented, building ventilation is better than before this time.

Some of them believe in existing measures implemented from certification awarded for certified building. So they keep the satisfaction level at a satisfying level. Moreover, the communication about the implementation measures such as install filtration, using UV filter and other measures makes them more confident about indoor air quality. Although not many strategies have been implemented in non-

certified buildings with fair measures, the level of satisfaction is a little bit increased during COVID-19.

However, the indicator to show indoor air quality is required for all building types. Additionally, for non-certified buildings with fair measures, some are worried about ventilation because proper measures are rarely implemented during working time. The air-conditional system is still open to increase disease dispersion inside the building.

5.5.3 Spatial or distancing

Spatial or distancing is the fundamental requirement for certified building by ventilation calculation together with the local law and regulation that mentioned in air quantity and number of people per area. However, distancing does not concern in other parts of building such as cafeteria, entrance way, and other public space. So, before COVID design layout in the public area are not stringent.

For non-certified building is not concerned about the distancing except to comply with the local's regulation. During COVID-19, physical distancing is fundamental to prevent and protect COVID-19 so. This strategy has to implement seriously. Figure 15 shows % of building's satisfaction in spatial criteria in all type of building.

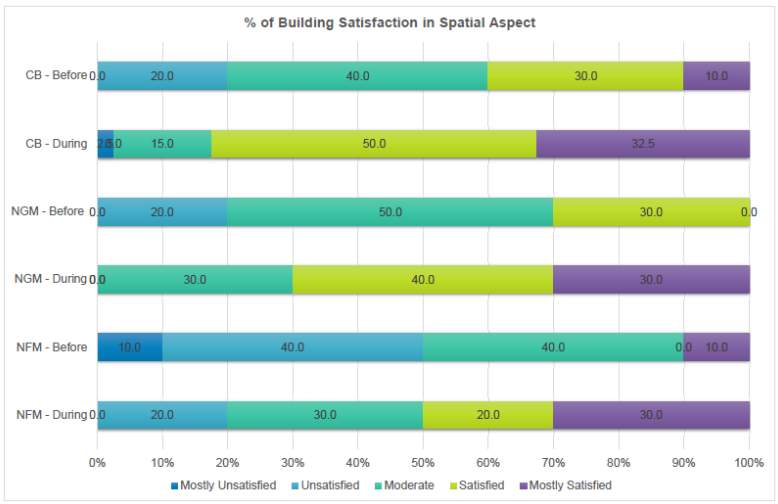


Figure 15: Occupant's Satisfaction in Spatial

Before COVID-19, the Moderate level is the most significant in all building's types, except unsatisfied level, which is the most significant in a non-certified building with fair measure. However, during COVID-19, the satisfying level in increased to significant level for certified buildings (50%) and non-certified buildings with good measure (40%). While, significant change in non-certified building with fair measure to mostly satisfied and moderate in this building type. For all building types, re-design office layout, install the physical barrier, and work from home policy are implemented during the COVID-19 period so the satisfaction level increases.

Some Certified building points out that even building has the physical barrier, mark for physical distancing, and reducing the number of people. However, when they chat to others, they have to get closer, so the risk is still high. Furthermore, because of the new lay-out design, sharing place and the equipment such as table, chair, and office equipment might increases the possibility of the infection when non-proper cleaning measure is applied.

5.5.4 Visual Characteristic

Although visual characteristic is not mentioned in COVID-19 infection, prevention, and control measure, the effect to this criterion has been examined to study the effect from the implementation.

The satisfying level is the most significant level before (37.5%) and during (45%) COVID-19 for certified building. While the level of satisfaction is increased during COVID-19 in both non-certified building with good measure (50% for before COVID-19 at moderate level to 50% for during COVID-19 at satisfied level) and moderate measure (50% for before COVID-19 at unsatisfied level to 40% for during COVID-19 at moderate level for non-certified building with fair measure). Figure 16 shows the percentage of building's satisfaction in visual criteria

The level of satisfaction during COVID-19 is increased in an office building, especially in non-certified buildings with good measure because fewer people allow them to access better views. While, designing a new layout for the office can eliminate or reduce glare and darkness spots that might be avoided during working time. So, the level of satisfaction is increased. However, some people in certified

buildings decrease their satisfaction levels. Because the partition to keep distancing disturb their vision and lighting and insufficient lighting can be observed in some area.

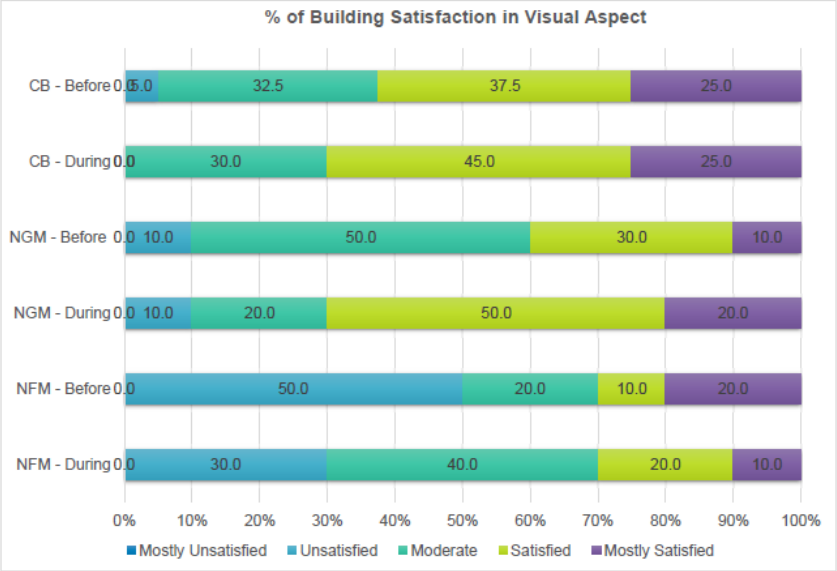


Figure 16: Occupant's Satisfaction in Visual Characteristic

5.5.5 Sound Characteristic

The level of satisfaction of sound characteristics in certified buildings is much more than non-certified buildings in both good and fair measure. For certified and non-certified buildings with good measure, the level of satisfaction in sound criteria in moderate level is the most significant before COVID-19 and in satisfying level during COVID-19. At the same time, unsatisfied and moderate are the most significant level of satisfaction for non-certified buildings with fair measure before and during COVID-19. Figure 17 shows the percentage of building's satisfaction in visual criteria.

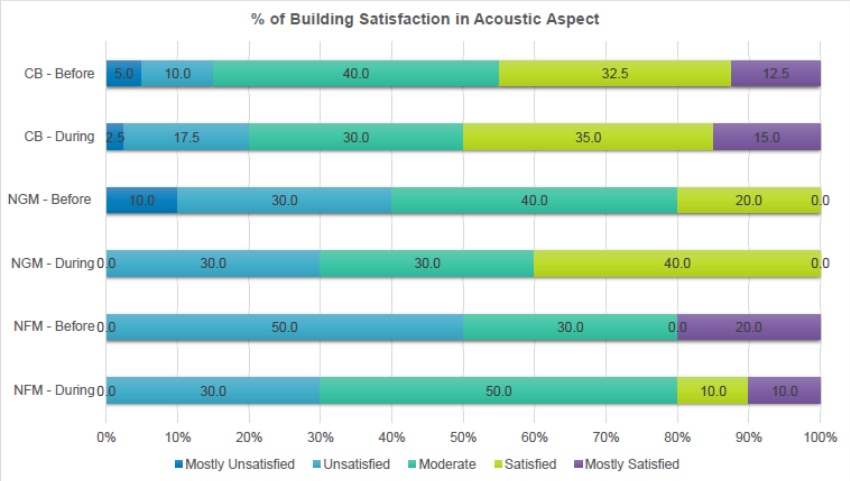


Figure 17: Occupant's Satisfaction in Sound Characteristic

Sound protection from adjacent area and outside are the main reasons while level of building satisfaction in sound criteria is higher during COVID-19. However, some people reduce the level of satisfaction because the limitation of meeting room or public place. Additionally, especially in non-certified building with good measure, HVAC background noise is more disturbing to the occupant.

Chapter 6
Gap & barrier analysis of implementing health & comfort improvement measures

Because COVID-19 is the newest disease that everyone has never experienced. Many institutes try to overcome it with the existing knowledge about SAR-CoV-2 transmission, including policy, economic, and societal networks. Especially in an office building and workplace segment with high risk and possibilities to be a new cluster because everyone with different protective measures is coming together. So, the protective and preventive strategies for COVID-19 have to execute thoughtfully. Although work-from-home is the alternative, the transition from work-from-home to work-from-office is crucial.

COVID-19's measure are concerning in the proper waste management strategies especially infected waste that have been occurred during this period. Furthermore, some COVID-19 infection, prevention, and control measures are required additional investment for both building's owner and occupant. Therefore, investigating this challenge is essential to improve and prevent it for other respiratory disease such as flu, influenza, and further respiratory disease that might occur in the future.

6.1 Policy Network

This section analyzed the current legislation and government authorities that are involved in COVID-19 infection, prevention, and control measures for an office building into three levels:

- National Level
- Provincial Level
- Workplace and Office Building Level

6.1.1 National Level

The government sector that has been involved in the infective, preventive and control measures for COVID-19 comprising:

1). The Ministry of Public Health (MOPH).

This Ministry is one of the most significant units for combating the spread of COVID-19. The principal units responding to COVID-19 are the Department of Disease Control (DDC-MOPH) and the Department of Health (DOH-MOPH).

1.1) ***Department of Disease Control (DDC-MOPH).*** During COVID-19, this department announced the recommendation for general people, healthcare professionals, and organizational settings. Additionally, this agency released the Communicable Disease Act, B.E. 2558 (A.D. 2015), which defines communicable diseases and lists Coronavirus Disease 2019 (COVID-19) as one of the categories. In response to the pandemic, this department announced the "D-M-H-T-T-A" measures to fight against COVID-19 – D: Distancing, M: Mask wearing, H: Hand washing, T: Temperature, T: Testing, and A: Application. And the measure to re-opening country (V-U-C-A: V-Vaccine, U-Universal Prevention, C-COVID Free Setting, and A-ATK (Antigen Test Kit). This department is also one of the government's formal communication units.

The Department of Disease Control published the first COVID-19 workplace guideline in Thailand, Ministry of Public Health (January 29, 2020) [174]. In it, a set of recommendations deliberated on employee self-protection included observing symptoms, wearing face masks, and washing hands with soap for 15 seconds or alcohol gels for 15 – 25 seconds. On (January 30, 2020) [175], the second recommendations were released, which focused on controlling the environment of working spaces both organization owners and staff by implementing administrative measures such as providing sufficient hygiene materials, proper cleaning of high-touch surfaces, education, and communication, waste collection, and self-protection. The third is a recommendation for businesses and workplaces (March 25, 2020) [176] in the case of Finding COVID-19 Patients by suggesting prevention, surveillance, and patient isolation and cleaning measure. Fourth, the guideline for the workplace to COVID-19 (April 11, 2020)

[177] recommend engineering, administrative, and personal protective equipment based on The Occupational Safety and Health Administration (OSHA) and International Labor Organization (ILO). (January 4, 2021) [178]. In it, workplace re-building that allows for physical distancing and separation by space-marking or plastic barriers was recommended. Environmental control with increased building ventilation was also suggested. Administrative controls were advised to provide hygiene materials, clean, disinfection systems, entrance screening, establish communication plans, app-based tracking systems, separate waste collection, and PPE. The publication released in April 2020 [177] also presented a hierarchy of controls. At the top of the hierarchy was the use of engineering controls such as increasing ventilation, using high efficiency of air filtration, and re-designing office layouts to maintain distancing; next were administrative measures such as updated working policies created by the collaboration of employers and employees, and measures to reduce infection risks such as providing hygiene materials, work from home policy, education, and self-protection. Building ventilation recommendations included discussions on both natural and mechanical ventilation systems as recommended by the Indoor Air Quality Association. Moreover, this advisory divided infection risks into four-levels by job type: low, moderate, high, and very high; each risk level was provided with different preventive strategies. For example, the PPE recommendation in low-risk areas involved wearing a proper facing mask, whereas, in very high-risk areas, the recommendation included wearing gloves, ground suits, face shields, and goggle masks.

1.2) ***Department of Health (DOH-MOPH).*** The department's mission is to protect people's health by establishing, advocating, and enforcing policies and regulations that promote health and environmental well-being. The department issued a statement urging individuals and companies to enhance their ventilation systems, cleaning procedures,

and infectious waste disposal. Additionally, this department has continually published advisories to combat COVID-19; these were released on March 11, 2020 [179] , March 19, 2020 [180], January 6, 2021 [181], January 7, 2021 [182] and June 1, 2021 [183] and also the recommendation for cleaning measure [184]. The first of these publications discussed the use of environmental controls and administrative measures; the second publication discussed administrative controls; the third was a set of layout adjustments, engineering controls, organizational strategies, and operational guidelines for workplaces or factories; the fourth was once again ventilation system recommendations to and protect workplaces from COVID-19.

Moreover, this department announced the recommend for waste and infected waste management during this period including, waste management recommendation for local government organization during COVID-19 (March 31, 2020) [216] , recommendation for infected waste during COVID-19 (April 8,2020) [217] , and environmental health operation system handbook for local government organization (May, 2020) [218].

Additionally, Bureau of Health Promotion, the Department of Health, Ministry of Public health launched Thai Stop COVID, Thai Stop COVID plus and COVID free setting measures for various places to self-assessment before re-opening with confidently for instance market, department store, public transportation, hotel, and office workplace. All programs are volunteer program that corresponds with the preventive strategies from the Center for COVID-19 Situation Administration (CCSA)

On January 18, 2022 [219], total registered project in Thai Stop COVID Plus program approximately 366,683 projects and 10,172 are the business establishment Workplace (not including factory). For

workplace, three prominent aspects have been concerned, including environment, personal and customer.

1. COVID Free Environment concerns about:

1). Health and Safety: By providing alcohol at the entrance, exit, elevator, and canteen. Identify, inspect, and frequent cleaning measures, especially in public areas and stationery, and provide proper bin for good waste management

2). Distancing: By concentrating on a measure to control densely of people such as work as a shift, keep distancing, install a physical barrier when 1-meter distancing cannot implement, and have a physical barrier between staff and visitors.

3). Ventilation. The purpose of this measure is to increase ventilation rate by the recommendation to increase ventilation, have a HVAC maintenance program, special design of ventilation for toilet and open the ventilation before and after working operation at least 2 hours.

2. COVID Free Personal

1). Using Thai Save Thai of other applications to make a self-assessment for building's occupant with three main topics including symptom, place, and behavior of risk

2). Inspect building's occupant and employer to follow DMHTT seriously

3). Full vaccinated for building's occupant, have a random check to high-risk employees, testing with Antigen Test Kit (ATK) in every seven days.

3. COVID Free Customer

1). Have a visitor risk assessment both entrance and exit by using Thai Save Thai or other programs that can record the data concerning three significant risk factors, including symptom, place, and behavior

2). Have a vaccinated or ATK testing within 72 hours

3). Visitors have to follow DMHTT seriously

Additionally, People can also help evaluate the workplace by using Thai stop covid plus by reviewing seven topics, including cleanliness, alcohol gel providing, mask-wearing for staff and visitors, keeping distancing, screening at the entrance for both staff and visitor, and ventilation. Currently, monitoring and inspection system for the workplace to follow COVID free setting system was held by people, customer, and communicable disease committee.

Besides two major responsible departments, other units from the Ministry of Public Health that have been involved in COVID-19 comprising

1.3) ***Department of Medical Sciences*** takes the main responsibility for COVID-19 testing by controlling method and laboratory testing.

1.4) ***Department of Thai Traditional and Alternative Medicine*** explore an alternative way for COVID-19 patient treatment by Thai herb especially ***Andrographis paniculate***

1.5) ***Department of Health Service Support***, during COVID-19, takes responsibility to establish field hospitals, issue the guideline for hospitel, alternative hospital, wellness quarantine, and promote quarantine instruction.

1.6) ***Department of Mental Health*** has the main responsibility to take care of mental health during COVID-19.

1.7) ***Department of Medical Services*** establishes guidelines for health workers, treatment, and isolation for patients during COVID-19.

1.8) ***Food and Drug Administration*** takes responsibility for quality control of the COVID-19 vaccine and test kit.

2). Ministry of Interior (MOI)

Thailand establishes the Center for COVID-19 Situation Administration (CCSA) under the Ministry of Interior, responsible for directing, cooperating, controlling, monitoring, and centering the communication of the COVID-19 situation by every provincial governor. Moreover, this ministry controls and enforces COVID-19 strategies by provincial unit control with the Department of Provincial Administration (DPA), Department of Local Administration (DLA), and Department of Disaster Prevention and Mitigation (DDPM).

3). The National Communicable Disease Committee (NCD Committee)

From the Communicable Diseases Act, B.E. 2558 (2015), section 11. the "National Communicable Disease Committee" shall be established to create policies, systems, guidelines on surveillance, provide an opinion, standard operation, consultation, monitor, evaluate, and investigate the prevention and control of communicable diseases. The member consisting of the Ministry of Public Health as Chairperson, the Permanent Secretary of Ministry of Defence, the Permanent Secretary of Ministry of Foreign Affairs, the Permanent Secretary of Ministry of Transport, the Permanent Secretary of Ministry of Interior, the Permanent Secretary of Ministry of Labor, the Permanent Secretary of Ministry of Education, the Permanent Secretary of Ministry of Public Health, the Secretary-General of Council of State, the Commissioner-General of Royal Thai Police, the Director-General of Department of Medical Services, the Director-General of Government Public Relations Department, the Director-General of Department of Livestock Development, the Director-General of Department of Disaster Prevention and Mitigation, the Director-General of Department of Medical Sciences, the Director-General of Department of Local Administration, the Director-General of Department of Health, the Director-General of Department of National Parks, Wildlife and Plant Conservation and the Permanent Secretary of Bangkok Metropolitan Administration as member. Additionally, the representative of the Medical Council of Thailand, Thailand Nursing and Midwifery Council, Medical Technology Council, Private

Hospital Association, and four qualified expertise members. Furthermore, the Department of Disease Control Director-General shall be a member and secretary. The Director of Bureau of General Communicable Diseases shall be a member. The first assistant secretary and the Director of the Bureau of Epidemiology shall be a second assistant secretary.

4) Emergency Operation Center (EOC)

During this situation, both national and provincial levels established an Emergency Operations Center (EOC) and Incident Command System (ICS) in response to public health emergencies in the context of coronavirus disease 2019 to support the commander for policy & decision-maker in public health emergency that is comprising in three main operating groups including

1. Incident commanders (IC) have a responsibility to command and make a decision on the policy to handle this disease
2. Information and Strategy group, including Situation Awareness Team (SAT) and strategic team (STAG)
3. Operation Team including operation, risk communication, point of entry, stockpiling & logistics, legal, finance, human resource, liaison, administration, and coordination

Additionally, EOC at the provincial level has to control, monitor and assess the COVID-19 situation, Preparing in hospitals, medicine, laboratory, and healthcare professionals. Moreover, special attention to respiratory disease patients, using the volunteer unit to communicate and inspect high-risk people and establish a hotline.

5). Ministry of Finance (MOF)

This government sector has the main responsibility for financial assistance by creating and implementing various policies However, for building owner and facility manager, non-financial assistance have been proposed. Only the soft loan with the reducing tax is provided.

6). Ministry of Labor, Social Security Office (SSO)

Social Security Office has a main priority to register the employee, get the subsidy from them, and give the return to them when disorder, death, disabled, pregnant, child, old, and vacant work. During COVID-19, various assistance

programs have been implemented, including reducing the subsidies, increasing compensation when job vacancies, cooperating with saving banks with the employer to increase working hire, and free of charge for COVID-19 treatment. Additionally, providing responsive guidance for the workplace, COVID-19 testing, and treatment by establishing a temporary hospital.

6.1.2 Provincial and local government

1). Bangkok Metropolitan Administration (BMA)

BMA has responsibilities to manage and service Bangkok's population. During COVID-19, BMA has responsibilities for vaccine management, establishing a quarantine hospital, and advising to prevent COVID-19 in the community. The Bangkok Metropolitan Administration (BMA) has some units that take care of COVID-19 in Bangkok, including

1.1) ***Department of Health (DOH-BMA)*** is responsible for promoting, supporting, preventing, and protecting public health in the community. During COVID-19, this department has obligations to provide a quarantine place and advise health workers and patients.

1.2) ***Medical Service Department*** takes care of infected people's treatment, health promotion, and prevention. During COVID-19, this unit provided quarantine, drugs, and medicine to infected people.

1.3) ***District office***. This unit is the subunit for every district to take care of each community. This unit gets the order from Bangkok metropolitan and takes action in the district unit.

1.4) ***Bangkok Communicable Disease Committee*** comprising Provincial Governor, Permanent Secretary, Public Relations, Livestock, Disaster of Prevention and Mitigation, The office of Disease Prevention and Control, hospital director, and experts who know about infectious diseases.

1.5) ***Department of Environment, Bangkok Metropolitan Administrator (DOE-BMA)*** This unit have the responsibilities

to waste quantity monitor and control waste management follow the instruction from department of health, ministry of public health. During COVID-19, additional responsibility is to indicate guidelines for COVID-19 infected waste management in Alternative Hospital Quarantine, State Quarantine, Local Quarantine, and Alternative State Quarantine, including from regular home and Home Quarantine). The data from the department of environment, Bangkok Metropolitan Administration, revealed Waste has increased throughout COVID-19, primarily upon returning to work, because everyone must follow protective guidelines. Furthermore, face masks and toilet paper could be contaminated with saliva from infected waste management. Improper waste separation caused contaminated trash to spoil the general waste, resulting in a higher-than-normal waste quantity.

2). Other provinces

2.1) ***The Provincial Public Health Office*** (PPH-MOPH) has some units responsible for responding with COVID-19 at the community level. "One tambon, one hospital" (small unit of the community) is the policy of the public health system in Thailand. So, the protective and preventive system for COVID-19 has a straightforward approach to local people. Moreover, in every village, we still have village health volunteers (Or-sor-mor: in the Thai language) that are well-trained people who a public health agent to prevent, protect, and improve health system.

2.2) ***Department of Provincial Administration (DOPA-MOI)*** This department takes orders from COVID-19 Situation Administration (CCSA) Ministry of Interior and implements them in each community.

2.3) ***Department of Local Administration (DLA-MOI).*** It's main responsibility to promote and support the work of the local administrative organizations (LOAs). During COVID-19, this unit has a responsibility to control COVID-19 infection at the local community level, such as vaccine management and isolation

2.4) ***Department of Disaster Prevention and Mitigation (DDPM-MOI)*** has been established to handle disaster management in the community. During COVID-19, this department has responsibilities to protect, prevent infection and assist infected people, followed the announcement from CCSA and the Ministry of Interior.

2.5) ***Provincial Communicable Disease Committee (PCD Committee)*** that is comprising Provincial Governor, Permanent Secretary, Public Relations, Livestock, Disaster of Prevention and Mitigation, The office of Disease Prevention and Control, Chief Executive of the Provincial Administrative Organization (PAO), Mayor, Chief Executive of the Subdistrict Administrative Organization (SAO), hospital director, and the representative from provincial and district public health.

2.6) ***Municipality.*** This unit has a responsibility to take care of general and infect waste management during COVID-19 by follow the recommendation from department of health, Ministry of Public Health

6.1.3 International agency

Various international agency recommended COVID-19 infection, prevention, and control measure such as WHO, CDC, OSHA, ECDC, ILO, and ASHRAE. Additionally, because Thailand is one of the members of WHO South-East Asia and has to corporate by focusing on national health policies with the Ministry of Public Health of the Royal Thai Government, one of the significant responsibilities is to solve untreatable diseases such as SARS, bird-influenzas including COVID-19. So, some preventive and protective COVID-19 strategies for the government, local, building,

and personal protection mostly come from the corporative of WHO Thailand and the Ministry of Public Health. At the same time, the Centers for Disease Control and Prevention (CDC) has worked with Thailand's Ministry of Public Health (MOPH) since 1980 to prevent and control various infectious diseases such as HIV/AIDS, tuberculosis, and influenza. For COVID-19, as the partnership of the Thai Government, CDC provides laboratory technical assistance, supports vaccine preparedness, and collaborates on border health.

When comparing between preventive and protective measures against COVID-19 of office Building by international agency and Thailand with actual practical by in-depth interview for building owner and facility management manager during COVID-19 period are summarized in Table 30

Table 30: Preventive and protective measures against COVID-19 from international agencies and Thailand's government with Thailand's building practices

Measure	Recommend Strategies	Implement Strategies
1. Engineering Control		
1.1 Ventilation		
Increase ventilation rate / outdoor air ventilation	For Mechanical Ventilation Space - Open HVAC systems with maximum outside airflow before and after occupied times - Eliminate recirculation - Properly maintain HVAC systems For Natural Ventilation Space - Add/Modify windows & doors to enable cross ventilation - Provide mechanical fan to increase ventilation	For Mechanical Ventilation Space - Open HVAC systems with maximum outside airflow before and after occupied times - Eliminate recirculation - Properly maintain HVAC systems and increase the frequency of cleaning, especially for some workplaces that cannot afford to improve ventilation - Increase outdoor airflow as much as possible For Natural Ventilation Space - Increase ventilation by adding cross ventilation - Provide mechanical fan to increase ventilation
Using a stand-alone	- Install MERV 14 / ISO ePM1 70-	- Install high-performance filter by using

air cleaner	80% filter - Consider using portable HEPA/ Ultraviolet Germicidal Irradiation (UVGI)	MERV 13 or above - Install HEPA filter and UVGI filter, additionally bi-ionizer to capture virus and bacteria by positive and negative ion method
Negative pressure ventilation	- Apply specialized negative pressure ventilation in specific areas	- In some offices, provide negative pressure room to isolate symptoms person.
1.2 Distancing & Building Layout		
Maintain distancing	- Physical distancing 1-2 meters, frequently clean and barrier installation - Queue management -Close/limit the use of shared spaces	- Design new office layout to keep physical distancing - Install barrier especially information counter, toilet, and canteen - Using a label to increase distancing and queue management - Limit time and number of people when using public area
Strict control over external accesses	- Install drive-through windows for customer service - Organize a one-way system	- Reduce direct contact with external by using alternative technology such as Bluetooth speakerphone - Limit number of entrances to limit number of people
1.3 Facilities and equipment		
Employ touchless technology and proper surface materials	- Use sensors, foot pumps, and large handles that are controlled with the lower arm - Use touchless hand sanitizer dispensers - Use appropriate devices such as no-touch waste bins	Using touchless technology for avoiding contact with other including - Intelligent elevator by scanning technology - Building's occupant check in by facial scanning instead of fingerprint - Changing sanitary system to touchless toilet and faucet
1.4 Water and sanitary system safety		
Water quality in sanitation and plumbing systems	- Safety drinking water, faeces, and sewage - Eliminate stagnant or standing waters	- Testing drinking and cooling water quality before reopening office - Control indoor humidity and temperature to prevent mold

	- Control indoor humidity to not exceed 50% and temperature to prevent mold - Building water systems should be flushed before reopening: Refer to ASHRAE 188-2018	growth
2. Administrative and Organizational Controls		
2.1 Workplace Safety Measures		
Enhance hand hygiene / self-hygiene measures	- Promote handwashing by soap and water for 20-40 seconds or with 60- 85% alcohol-based hand sanitizing rub dispensers - Encourage employees to not use other's accessories - Encourage employees to bring drinking water from home - Monitor employee health daily - Promote use of paper towels - Reduce use of cash	- Provide effective liquid soap and encourage handwashing measure. - Encourage to avoid using public accessory such as glass, cutlery - Encourage using cashless payment
Promote respiratory etiquette	- Encourage mask-wearing by develop face-covering policy - Wear face masks in indoors and crowded outdoor settings - Encourage respiratory etiquette by cover coughs and Sneezes - Recommend at least two layers of face masks without exhalation valves or vents - Provide customers and the public with tissue and trash receptacles - Instruct workers to avoid contact	- Wearing facial mask is a mandatory Encourage mask

	when greeting	
Routine screening	- Conduct daily in-person screening (Temperature and symptoms) at points of entry in workplace - Consider testing for SAR-CoV-2	- Install digital temperature screening before entering building - Provide COVID-19 testing at least every week or two weeks / time - have a tracking program for daily check-in and report the timeline
Proper waste management	- Clean bins and waste should be placed in strong bags that are completely closed - Provide no-touch trash cans	- Provide additional infected waste bin with no-touch trash - Increase frequent for waste collection because of the increasing of food waste packaging
2.2 Cleaning and Disinfection		
Cleaning Measure	- Regular cleanings with disinfectants (0.1% / 1000 ppm sodium hypochlorite, or 5% sodium hypochlorite to 50 parts water), especially of high touch surfaces or disinfection with EPA-approved products (List N: Disinfectants) or bleach solution, ultrasonic waves, high intensity ultraviolet radiation, or LED blue light or biocidal products regulated by the Biocidal Product Regulation (BPR)	- Using proper disinfectant followed international regulations especially EPA-approved
2.3 Emergency Plan Development		
Emergency plan preparedness	- Identify workplace coordinator - Prepare standard operating procedures and plans for isolating someone who falls ill without stigmatization or discrimination - Develop emergency risk communication	- Set up risk and crisis management committee to evaluate the situation and create strategies to handle with including standard operation when suspected symptom has found and working from home preparedness when situation is getting worse. - Develop communication team to inform building's staff when emergency case has occurred.
Suspected or	- Limit and report number of people	- Separate infected people from others

confirmed case measures	who come in contact with sick person - Contact local health authorities - Separate sick employees - Clean facility after suspected or confirmed COVID-19 case - Ventilate buildings with fresh air for 1 hour and clean with detergent	into negative pressures room - Follow emergency plan by contact health authorities - Temporary closed that area for cleaning after ventilation
2.4 Business Continuity Guideline		
Transition to remote work	- Implement work from home strategy to minimize contact among workers and clients - Evaluate feasibility of accomplishing work by telework - Implement travel-related policy	- Implement Work from Home strategies and providing proper equipment to staff such as laptop, table, chair, and internet WIFI if needed. - Implement travel policy including daily, local and international travel.
Shift working	- Reduce number of employees at a given time by establishing alternating days or extra shift	- In some unit that cannot work from home, stagger is implemented.
Encourage employees of self-monitoring	- Encourage self-monitoring and staying at home when sick	- Communicate to self-observe symptom for all occupant and inform how to proceed when have a suspicious symptom
Implementing support policy / Concern for vulnerable employees	- Perform work risk assessment - Be cognizant of employees' mental health, focusing particular attention on vulnerable and marginalized groups (such as elderly people) - Implement flexible sick leave policies and practices - Plan and organize return to work	- Provide mental health service for employee especially vulnerable people - Create the policy for preparing for the reopening workplace - Periodically site assessment to explore best solution for COVID-19's protection
2.5 Education and Communication		

Establish communication policy	- Implement communication plan	- Setup communication committee to interact with all staff with effective and trust information with various language.
Hygienic measures communication	- Promote handwashing with effective media - Educate employees to self-protect - Encourage hand washing by posting signs in restrooms - Provide information about ergonomic risks during remote work	- Encourage hygienic measure for handwashing and mask-wearing with effective wording and infographic - Provide proper work-from-home information including during working and relaxing time
COVID-19 information communication	- Provide education and training with up to date information about the risks of COVID-19 by using official sources - Consider the level of COVID-19 risk and monitor state and local public health communications - Arrange signage with preventive measures - Communicate confirmed cases of COVID-19	- Provide trusted information to all staff about COVID-19 transmission, confirmed case, current situation, preventive, and protective strategies.
3. Personal Protective Equipment (PPE)		
PPE	- Use face masks - Identify necessary PPE and provide appropriate PPE to workers - Setup some penalties when a non-using facial mask has been found.	- Personal protective equipment such as mask-wearing is mandatory when staying in the workplace

6.1.4 Law & Regulation

Law and regulation concerning preventive and protective strategies for COVID-19 in workplace and office buildings have been shown in Table 31

Table 31: Law & Regulations of preventive and protective strategies for COVID-19 in workplace and office building level

Sources	Subject	Content
Office of the Council of State	Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 1) Revised Edition 25 March 2020 [220]	Number 11. Disease Prevention Measures: There shall be disease prevention measures to be applied generally or in cases where there is relaxation or exemption of the compliance of this regulation, as follows: (1) The cleaning by wiping surfaces of relevant places before the organization of activities and the disposal of waste daily; (2) Officials, entrepreneurs, guests, participants, employees, and customers shall wear surgical masks or cloth masks; (3) Persons in (2) shall wash their hands with soap, alcohol, gel, or disinfectant; (4) Persons in (2) shall keep a distance of at least one meter apart while sitting or standing to prevent physical contact or the spread of the disease through saliva droplets; (5) The limitation of the number of participants to prevent overcrowding or the reduction of the time spent on activities as necessary based on avoidance of physical contact; Officials may introduce additional measures utilizing tracking applications via mobile telephones and may use observation measures, or a minimum 14-day quarantine measure following laws concerning communicable diseases for particular categories of people or specific individuals as necessary. Government offices, state enterprises, and other government agencies shall remain open during usual operating hours unless a notification for temporary closure or suspension has previously been issued, such as educational institutions. However, working staff shall provide facilitation, such as arranging overlapping shifts for working hours and lunch breaks and working outside the usual office. Additional facilitation shall be provided to the people, such as the holding of teleconferences, the provision of services through digital communication, the waiver of physical presence requirement, or exemption, extension, suspension, or reduction of fees as prescribed

		under the provisions of the law. Businesses, shops, and government offices that remain open shall set up measures to screen working staff and visitors or customers following the disease prevention measures specified in Clause 11.
Office of the Council of State	Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 23) Revised Edition 15 May 2021 [221]	Number 1. Follow the instruction of medical and cloth mask-wearing from the Ministry of public health when outside accommodation or public place Number 7. Considerate for working outside workplace both for public and private company. To reduce the infectious rate by reducing the number of people in the workplace such as reducing frequent of transportation, shift work implementation
Office of the Council of State	Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 24) Revised Edition 19 June 2021 [222]	Number 9. Considerate for working outside workplace both for public and private company. To reduce the infectious rate by reducing the number of people in the workplace such as reducing frequent of transportation, shift work implementation
National Communicable Disease Committee	Regulation from the National Communicable Disease Committee Subject: The penalty when not following the regulation Issued under the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) under the Coronavirus Disease 2019	Section 51. Whoever fails to comply with an order of the Communicable Disease Control Officers shall be liable to the punishment of a fine. Punishment: Penalty 1st time: not exceed 1,000 baht 2nd time: 1,000 – 10,000 baht 3rd time: More than 10,000 baht

	(COVID-19) Revised Edition 7 June 2021 [223]	
MOPH-DOH	The Announcement from Department of Health, Ministry of Public Health. Subject: The measure to prevent and protect from Coronavirus Disease 2019 (COVID-19) for government, private, and workplace 2020 (Date 11 March 2020) [224]	Number 3. Head of Department, Building Owner, shall 1. Control of a hygienic condition of the building by 1.1 Regular cleanings such as floor, wall, and door 1.2 Especially cleaning at high touch surface area such as door knot, handrail, information counter, electrical switch, elevator bottom with proper cleaning detergent 1.3 Increase ventilation with proper maintenance and cleaning 1.4 Cleaning at highly frequent and proper detergent in food preparation and food service area 1.5 Cleaning at high touch surface in toilet comprising toilet, flushing bottom, doorknob, and faucet with proper detergent 2. Prepare hygienically and clean Detergent 2.1 Provide hand washing alcohol gel in a public place such as information counter, canteen, fitness room, entrance and exit door, and elevator 2.2 Provide soap at handwashing basin and toilet 2.3 Prepare cleaning agents and accessories such as cleaning detergent and forceps 3. Protective for staff or building's occupant 3.1 Mask wearing, hand washing, and avoiding contact to eyes, face, mouth, and nose for high-risk staff such as reception or customer relations. The glove is the additional equipment for the cleaning team. 3.2 If some symptom has been observed, those staffs have to leave and observe themselves temporally 3.3 PPE is very nesseccary for waste collection staff, such as facial masks, rubber gloves, and forceps. Waste separation have to provide and washing hands

		after working 4. Education and Recommendation Building owners have to provide mass media to educate the preventive and protective measures to fight against Coronavirus Disease 2019 (COVID-19) to all staff, such as observing suspected staff and having proper management.
Ministry of Public Health	The Announcement from Department of Health, Ministry of Public Health. Subject: The measure to prevent and protect from Coronavirus Disease 2019 (COVID-19) for high health risk workplace 2021 (Date 17 September 2021) [225]	For low-risk level work such as general office, during the disease of Coronavirus 2019 (COVID-19) workplace have to 1. Provide regular cleaning measures, especially highly touched surfaces such as a doorknob, ladder, elevator bottom, table, chair, and toiler 2. Provide proper and good ventilation and good maintenance 3. Keep distancing for at least four sq.m/person except have other measures 4. Cleaning office equipment before and after operating hours 5. Provide soap or at least 70% alcohol gel, especially in a public place 6. Provide sufficient bin collector with good waste separation 7. Provide sufficient cleaning detergent 8. Provide self-protective equipment for cleaning staff such as gloves, facial mask, booth shoes, including forceps for waste collection 9. Keep and promote personal hygiene and cleaning 10. Provide temperature checking, registration, and tracking system such as Thai Chana 11. Self-screening by using an application such as Thai Save Thai 12. Workplace have to self-assessment using the application program, for example, Thai Stop COVID Plus

		13. In the case of the food preparation area, hygienic measures have been implemented, such as providing a proper handwashing tub or 70% of alcohol gel Penalty: Whoever fails to comply with an order of the Communicable Disease Control Officers shall be liable to the punishment of a fine not exceeding 50,000 Baht.
Ministry of Interior	Missive from Ministry of interior 0230/ 3451 (Date 12 June 2020) [226]	Increase the awareness and understanding of living with new normal by: 1. shall wear surgical masks or cloth masks when outside residence or accommodation 2. shall wash their hands with soap, alcohol, gel, or disinfectant 3. avoid to participate or go to overcrowding place 4. shall keep a distance of at least one metre apart 5. cleaning by wiping surfaces of relevant areas before the organization of activities and the disposal of waste daily Promoting for Using Thai Chana application when check-in before going inside
Bangkok Metropolitan Administrative (BMA)	Announcement of the BMA, Subject: Citizens in Bangkok Metropolis Area Shall Always Wear Sanitary or Fabric Face Masks outside Residence or Accommodation (Date 25 April 2021) [227]	Refer to the order of temporary closure of premises (No.25) date 25th April 2021 announced 1. Citizens in the Bangkok Metropolis area shall always correctly or properly wear sanitary or fabric face masks outside residence or accommodation. 2. Any persons who violate or fail to comply with clause one shall be guilty of an offense under section 51 of the Communicable Diseases Act B.E. 2558 (2015), which shall be liable to a fine not exceeding twenty thousand Baht.

During COVID-19, a facial mask is a mandatory measure to prevent and protect COVID-19. The building's occupant must wear a facemask, even fabric, and medical masks when returning to the office. However, most of them used mask facing

and throw it out of the office. Workplace or office buildings have to provide additional space for further management.

Because of infection, prevention, and control measures are concerning in waste management. So, laws and regulations for these issues have been examined. Infected waste management's law and regulation and have been provided in Table 32

Table 32: Law & Regulations of infected waste management practice during COVID-19

Sources	Subject	Content
Ministry of Public Health	Ministerial regulations: infected waste management 25 July 2002 [228] & Revised edition 3 February 2021 (issue 2) [229]	Number 3. Define infected waste: waste contaminated with disease that can affect or infect someone close to that waste. Moreover, for issue number 2, other debris that has been announced from the committee are also the infected waste Number 4. The local government have to provide proper infected waste management Number 7. At least one expert has been involved in the waste collector and management team Number 25. Waste management methods comprising 1. Burned in the kiln at more than 760 degrees Celsius, and more than 1,000 degrees Celsius for air treatment 2. Use Stream 3. Using heat 4. Others that recommended by MOPH The penalty for someone who cannot comply with this regulation is imprisonment for not exceeding six months and maximum 50,000 baht fine.
Ministry of Public Health	Announcement from Ministry of Public Health: Infected waste management by other methods: Date 16 September	Because infected waste has been increased significantly during COVID-19, besides the waste management method announced in number 25 from Ministerial regulations: infected waste management 2002, infected waste is also managed by heat at more than

	2021 [230]	760 degrees Celsius and more than 1,000 degrees Celsius for air treatment with air quality control.

The relationship from the policy network has been shown in figure 18

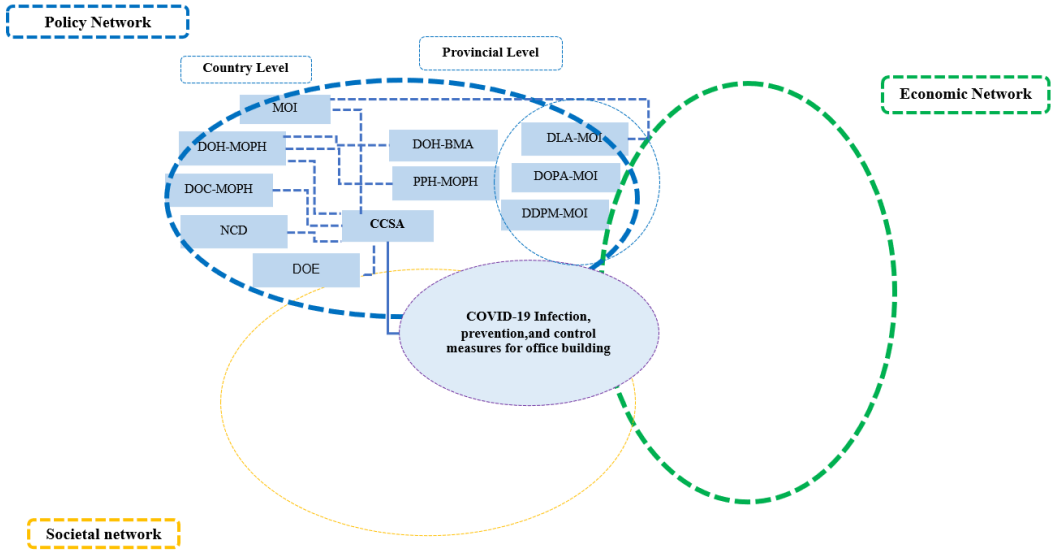


Figure 18: Policy networks relevant to preventive and protective of COVID-19's for office building

6.2 Economic Network

The collaboration from the economic network is significant to drive and implement the preventive and protective strategies to COVID-19. Building owner and facility manager, product manufacturer, and experts from academic institutions are important for execution.

6.2.1 Building Owner and facility management manager

Building owners and facility managers have to follow the recommendations and instructions, such as improving ventilation and using touchless technology for engineering measures or increasing the frequency of cleaning for administrative and organizational measures. The interview result reveals that local and private

governments follow the infection, prevention, and control recommended by the international agency and Thailand's government.

For engineering measures, increasing ventilation is challenge for implementation, especially for the extended building period. Some mechanical design does not support ventilation and air filtration system, some building have to keep temperature, and some facilities have no window or open area to increase ventilation. In this case, substitute measures have been implemented. The most significant barriers are the lack of budget to access the better mechanical system and having no time to adjust. In this case, increasing open surfaces such as windows, increasing frequent cleaning detergent spraying, and using pedestrian fans are the alternative measures that have been implemented. Other barriers such as a difficulty to change to work from home, and physical barrier implementation. In this case, installing a plastic barrier and forcing one to wear a facial mask are different ways of protection.

For Administrative measures, most building owners and facility managers implement workplace safety measures comprising hand hygiene, respiratory etiquette, and screening. Qualified detergent and increasing frequency of cleaning, developing an emergency plan and business continuity guideline such as encouraging self-monitoring and tracking system have been implemented. However, education and communication are obstacles because too much of the government's information at the beginning and much fake news distorts the data.

From this point, before the construction period is most important for the building owner and facility manager to consider or follow the building design for an emergency such as pandemic preparation. Building codes, laws, and regulations of building design should gain more attention from policy-makers and building owners.

Furthermore, office buildings increase in interest in sustainability concepts. So waste separation is become significant in this building type under the circular economy concept. For instance, using food waste for landscape purposes, collecting plastic for recycling, including hazardous waste such as chemical substances and used batteries. During COVID-19, although work from home is the primary prevention strategy, some production, security, and service departments have to go to the workplace**.** Infected waste collection bin has to provided and have a proper

management although not too much in terms of quantity. Private company who collects and manage infected-waste were contacted by building owner and facility manager with additional cost approximately 300 baht/60 kilograms /month. In building owner opinion, this is the effective way with reasonable price to them.

6.2.2 Product manufacturer

Building owners and facility managers have to corporate with building materials and health-protected product manufacturers to modify or improve the building's performance. Building Materials and health-protected products take a responsible role in examining how to improve building performance to reduce the transmission during building's occupant, following the instruction and recommendation from preventive and protective's COVID-19 strategies.

By following the engineering measure, the following product has to create an innovative product that

1). Improve ventilation performance by increasing ventilation and air filtration performance and also adjusting to negative pressure

2). Increase distancing and building layout by designing the innovative product to increase distancing

3). Modify facilities and equipment by using touchless technology

4). Water and sanitary system safety by controlling stagnant water during the temporal shutdown

By following the administrative measure following product have to create

1). Workplace safety measures by creating hand-hygiene detergent, proper mask-wearing, temperature screening, and innovative waste management

2). Effective cleaning and disinfection

Health-related products are very favored from the increasing demand during this period, such as facial masks, alcohol gel, temperature screening instruments, touchless toilet accessories, and PPE. And engineering instruments to improve health and comfort, such as increasing ventilation systems and filtration. As long as we do

not know how long it takes, it’s become more important—however, the investment of engineering measure implementation is quite high. So the subsidize from the government has been required.

Because the COVID-19 situation becomes better soon after this period, product manufacturers have continued to produce these products because human behavior has been changed to healthier to avoid and prevent COVID-19 such as increase and improve ventilation instrument have to continue to fight against with COVID-19, following disease, other air pollutants such as PM 2.5, PM 10, dust, and volatile organic compounds.

6.2.3 Academic institution both in health-related and engineering

This segment has to generate knowledge, education, performance testing for fighting with COVID-19. Research institutes and universities conduct research and development on COVID-19's preventive and prevention strategies in both health and engineering concerns.

Their significant activities have been educating, conducting research, and demonstrating. Most research determines to reduce COVID-19 transmission in buildings and workplaces by encouraging engineering and administrative measure and self-protection. Academic agencies often take initiatives by investigating the risk of COVID-19 transmission and exploring how to reduce the infection by innovative product and policy implementation.

Economic network for fighting with COVID-19 as shown in Figure 19

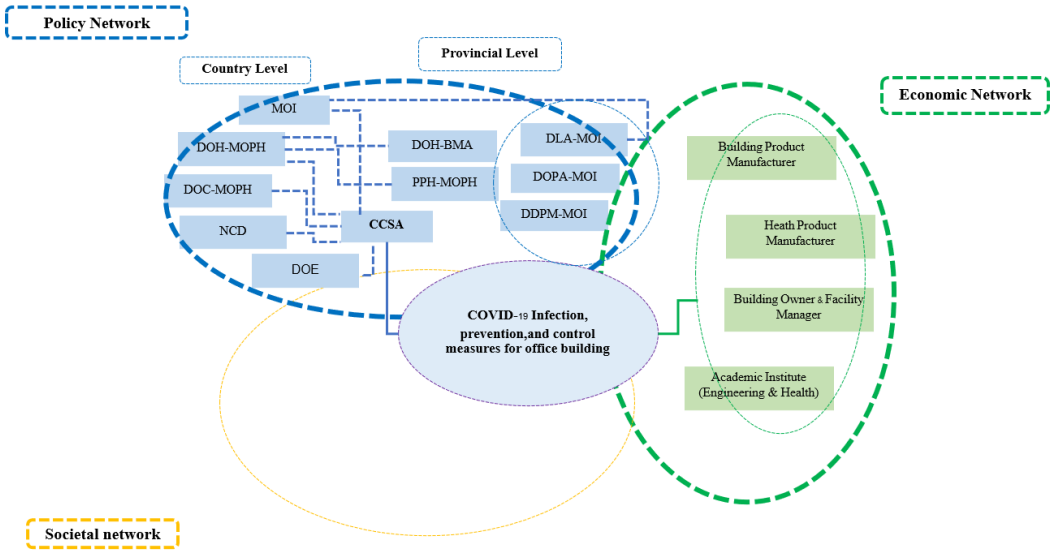


Figure 19: Policy & Economic networks relevant to preventive and protective of COVID-19 for office building

6.3 Societal Network

During COVID-19, the social network consists of associations, Non Government Organizations (NGOs), mass media, and building occupants. They have main responsibilities to provide building management recommendations and health-related commodities such as using alcohol and face masks, as well as communicating preventive and protective measures for each building type through multiple channels. Additionally, From the societal network perspective, infected waste such as facial masks is increased and waste contamination from non-proper separation process is also essential.

6.3.1 Building occupant

Building Occupant who has worked both before and during COVID-19 that have an effect from preventive and protective COVID-19 strategies. Although during COVID-19, some offices implement work from home policy for continuity business, however, when the COVID-19 situation is alleviated, they have to return to work at the office occasionally. To transform work from home to work from the office smoothly. The workplace has implemented many strategies to make the workplace is safe for everyone with different protective measures. Both employees and visitors

come to work together. Mask wearing is mandatory for everyone, employees have to register in the application for daily self-assessment, vaccinated, and COVID-19 testing has been reported. Workplace, risk behavior, traveling, contact with high-risk people have been reported in daily-self-assessment. Alcohol gel is always taken along with all the time and using it frequency to washing hand especially. Even workplace layout has been changed to increase physical distancing. Stagger shifts have been implemented. Awareness of keep distancing is increased during this period, especially using or staying in public areas such as elevators, canteen, and cafeterias. Dining behavior is also changed from having it together to separately food and beverage. Not only did behavior change during this period, but a type of transportation also changed from public to private using as much as possible. Increasing frequent cleaning is observed from well-trained maids who always wear personal protective equipment such as face shields and rubber gloves. A limited number of assessments have been observed with digital or physical temperature screening measures at the entrance. Physical plastic barriers have been installed at the information desk to keep the distance between staff and visitors. A self-assessment and registration system have been implemented. Entrance and exit times have been reported, and meeting time is online as much as possible; however, online pre-booking has been implemented if someone wants to use a public space like a meeting room.

Thailand's government launched a 50-50 co-payment scheme that subsidized by registered individuals for half of their purchases at small shops, with the government subsidizing the other half. The government paid half of food, drink, and general goods purchases up to 150 baht per day, capped at 3,000 baht per person for the scheme's duration. This scheme stimulates consumer spending to breathe life back into an economy decimated by the pandemic.

For a formal employee in the private company under section 33

1. "Section 33 We Love Each Other Project" This program has helped to alleviate the cost of living of insured persons under section 33 by giving 6,000 baht/person
2. Special assistance for section 33 insured people who work in high restrict areas (dark-red zones) with nine business groups received financial aid

including 1. construction, 2. hotel and foodservice, 3. arts, entertainment and recreation, 4. Other types of service businesses, 5. Auto retail and repair, 6. Cargo transport and depots, 7. Management and support activities, 8. Science and academic activities, 9. News and information and communication.

6.3.2 Mass Media

Communication is key to implementing the infection, preventive, and control measures. Misunderstanding information led to big chaos, dissatisfaction, and distrust until cause the protest. In-country level, the Center for COVID-19 Situation Administration (CCSA) is the center for public communication about the COVID-19 situation in Thailand. When the condition worsens, like many new clusters have been found or the number of infected and dead people has suddenly increased. The suggestion for working from home has been announced both for the public and private sector.

Moreover, this unit also announced the regulation and recommendation to everyone and all settings to protect from COVID-19 infection, especially self-assessment by Thai Stop Covid Plus (TSC+) for a workplace setting and Thai Save Thai (TST) for building's occupant. Anti-Fake News Center Thailand, Ministry of Digital Economy and Society has been established to solve online fake news problems that might cause separation misunderstanding and affect society. During COVID-19, the number of fake news has increased significantly in policy, health, and economics. For instance, in health-related topics, COVID-19 treatment, protection, and spread of COVID-19 are the top priorities of these news types, with the penalty for both who make and share fake content (going to jail not more than five years and 100,000 baht for penalty).

For the company level, most workplaces established a risk management committee to assess the situation, create a business continuity plan, set up visitor meeting procedure, and communicate to all employees about the business direction, CCSA announcement, online learning and knowledge for self-development, physical and mental health treatment, recreation activities during

this period such as volunteer for help people, and how to deal during this situation. An individual e-mail has been sent like one-way communication. Moreover, social media such as line applications have been used to communicate that require a response from the employer as a two-way communication method. Channel for the employer to feedback, inform their symptom, and register when COVID-19 has been found are also created to assist employers who are infected and for vulnerable people. Additionally, mental health healing is also communicated by various communication such as personal e-mail, encouragement by the management team, and direct contact with a psychologist.

6.3.3 NGOs

1) Thailand Association is especially engineering institute of Thailand, Thailand facility management of Thailand, and Thai Green Building Institute are the key associate to improve and recommend preventive and protective COVID-19 strategies for publication by various communication ways such as seminar and exhibition. During this period, building standard organization should rethink and review their standards and guidelines focusing more on people.
2) Thai Health Promotion. To prevent and eliminate fake or distorted news from the publication. Not only take a responsivity to be an association but also take a formal one of mass media from the government.

6.3.4 Community/ visitor

Meeting and greeting from visitors and customers have been changed to an online platform. However, in an extraordinary case, that cannot be abandoned. All visitors have to register by sending their COVID-19 testing result, vaccinated history, and health checking through the application before coming in. Moreover, temperature screening and ATK testing have been implemented in the registered area. During the meeting, physical distancing has been executed, alcohol is provided, and non-coffee or snacks have been served.

Entrance and exit times are recorded. All actor-network analysis in this study are summarized and shown the in Table 33 and Figure 20

Table 33: Actor Network Analysis Respondents

Policy Network	**Number of respondents**
Department of Disease Control, Ministry of Public Health	1
Department of Health, Ministry of Public Health	1
Department of Health, Bangkok Metropolitan Administration	1
Department of Environment, Bangkok Metropolitan Administration	1
Social Security Office, Ministry of Labor	1
Economic network	
Academic Institution Expert in Ventilation from 1. Faculty of Engineering, Chulalongkorn University 2. Faculty of Public Health, Thammasat University 3. Faculty of Engineering, King Mongkut's University of Technology Thonburi	3
Academic Institution Expert in Sick Building Syndrome and Building related illness from 1. Faculty of Medicine, Chulalongkorn University 2. Faculty of Public Health, Thammasat University	2
Fresh air intake and sir filtration Developer	2
Furniture manufacturer	1
Faucet and Toilet manufacturer	1
Paint and coating product manufacturer	1
Facial mask manufacturer	1
Building Owner and Facility Manager	8
Societal Network	
Engineering Institute of Thailand	2
Thai Green Building Institute	1
Thailand Facility & Management Association	1
Thai Health Promotion Foundation	1
Building Occupants.	60
Total	89

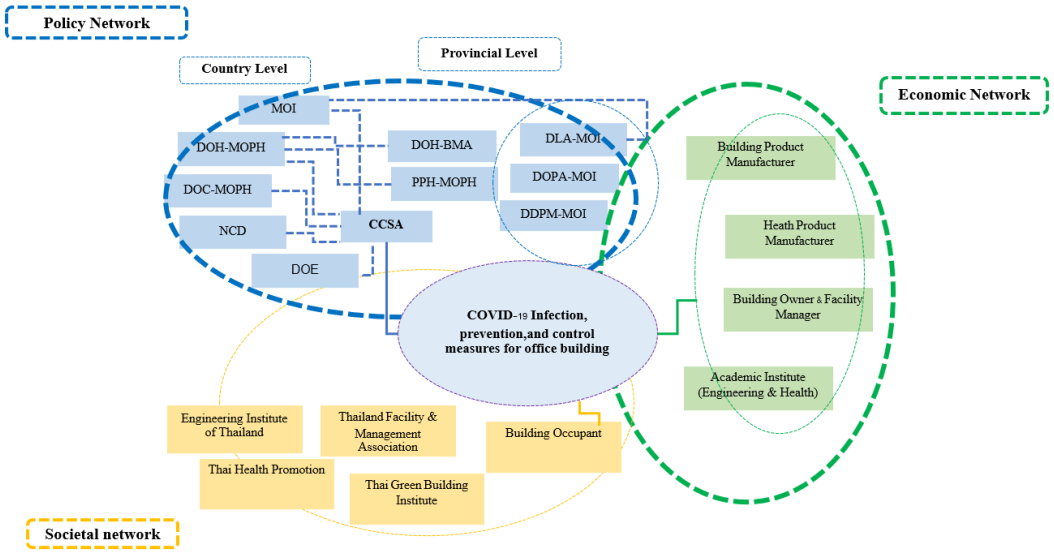


Figure 20: Actor-network analysis relevant to preventive and protective of COVID-19's for office building

6.4 Key success for COVID-19 implementation

6.4.1 Enforcement and penalty from COVID-19 infection, prevention, and control measures implementation

The penalty for building owner and building occupant who cannot comply with the announcement or the recommendation is one of the key success to implement COVID-19 infection, prevention, and control measures. The penalty are including:

1) The penalty with not exceed 50,000 baht to building owner who cannot comply with the announcement from Department of Health, Ministry of Public Health in the subject the measure to prevent and protect from coronavirus disease 2019 for high health risk workplace on 17 September 2021
2) For mask wearing, at least 1,000 baht for the penalty when someone who fail with the regulation from the National Communicable Disease Committee in the subject: The penalty when not following the regulation issued under the emergency decree on public administrative in emergency

situation B.E. 2548 (2005) under the coronavirus disease 2019 on 7 June 2021.

3) The announcement from Bangkok Metropolitan Administration (BMA) about “Citizens in Bangkok Metropolis Area shall always wear sanitary or fabric face mask outside residence or accommodation” points out the penalty for someone who violate or fail to comply with this issue to a fine not exceeding twenty thousand baht.

When considerate to waste management, the enforcement is effective by follow the Ministerial regulations and announcement from Ministry of Public health. During this time, infectious garbage has been required by public, private, and individual. Private company that involved in waste management is the key to success to solve infected waste management.

6.4.2 Effective collaboration

For the government level: Successful management occurs because of the good collaboration from the CSCA that points out national policy and top management leaders such as the Ministry of Public Health, Ministry of labor and the Ministry of industry.

For the building level: the collaboration between the owner of the building and the occupants by establishing a common aim to safeguard and prevent COVID-19 in the building with the cooperation and participation of all stakeholders. For example, always wear a face mask during working hours, maintain public awareness, and practice cough etiquette.

6.4.3 Effective of Communication

For the policy level: Chain of command, effective, strictness, and correspondent from the communication are the key success to fight against COVID-19. Although, when start knowledge of this disease is not good enough so, communication is lead to misunderstanding. However, when knowledge of this disease is better and hierarchy of communication have to control, the situation is become better.

For the building level: Most building establish risk management committee to be the center of management and communicate with proper / clearly understand and

non-bias information to the employee with various communication tools such as e-mail, line, an announcement with multi-language so everyone can access communication. Moreover, when daily check in and confirmed case has been found, hierarchy of demand are using to avoid the mis-communication. The information hierarchy with effective order is the third. Furthermore, clearly communication can control some occupants that are too nervous or too eager, causing the situation to deteriorate and become out of control.

6.4.4 The Readiness of the public health system

Thailand is one of the countries with a world-class healthcare system. Especially for epidemiology, which we have been planning for many years to deal with various epidemics like diarrhea and dengue fever as a preventative and warning system. Thailand also develops a local hospital in each district and have a village health volunteer to ensure that the guarding, screening and treatment systems are prepared to manage this circumstance.

At the building level, when a confirmed case is reported, even the workplace and accommodations are affected. Employers have an access to government health care assistance, such as telemedicine, hospital and hospital finding, and an online monitoring system. The workplace has full-time medical assistance from a doctor and nurse. The occupant received personal protective equipment, a COVID-19 testing kit, and even the vaccine. COVID-19 prevention strategies have been announced, and confirmed or suspected case instructions, such as registering the system, seeking medical assistance, and providing the supplementary drug, have been established. In addition, a mental health hotline and advisor have been provided for infected and affected residents.

6.5 Barrier for COVID-19 ‘s measure implementation

Although the government has provided many COVID-19 infections, prevention, and control measures to suggest, recommend, and enforce to the workplace for improving their place to fight against COVID-19. However, some strategies have not been implemented during this period. After an in-depth interview

to explore gaps and barriers, the result showed that various obstacles had been found, including

6.5.1 Insufficient law and enforcement

The insufficient to improve building efficiency to protect health and comfort of building occupants (Healthy Building) and promote sustainable building certification. Building that concerns health and comfort such as sustainable building certification have a higher potential to handle respiratory disease than others—however, lack of support from the government to encourage these buildings. Moreover, only the recommendation for indoor air quality inside the building. So, when an outbreak has occurred, it is difficult to control and prevent the infection. Additionally, non-proper law and enforcement for better health and comfort in an office building. The existing building that the most building is challenging to modify and requires more investment to fight against COVID-19. Moreover, Special law and regulation for vulnerable people in an office building when facing respiratory disease or health emergency crisis is also desired. Although a special design for these people groups is already implemented, special assistance for this group must be considered when a crisis occurs.

In an office building, laws and regulations are necessary to safeguard the tenants' comfort and health. Building occupants' productivity, operational effectiveness, and morale decrease when they are forced to operate in an unsuitable setting. Prior to this, only building owners and facilities managers were concerned with the building's functionality in order to safeguard health and comfort. However, during COVID-19, the office building was recognized as one of the high-risk places, raising building occupants' knowledge of building efficiency to safeguard health and comfort. The occupant then claimed the right to work in a safe workplace.

6.5.2 Lack of Expenditure and incentive program

1) Lack of investment to modify and renovate the workplace:

Because building owners must invest in any building technology that protects and prevents inhabitants from harming themselves, such as air ventilation and monitoring systems. Furthermore, they have to prepare for the next outbreak that may emerge. Indoor air quality improvement

appears to be too difficult in terms of the business advantage; thus, the most challenging component is persuading the building owner to take action. Furthermore, some strategies have to adjust to being suitable for Thailand, such as increasing open outside air intake ventilation. However, air filtration is recommended in a humid and hot climate with dust pollution like PM 2.5 in Thailand. Existing building design and function is one of the challenges to modify. Some conditions are no longer ideal for working, such as floor-air, some partitions and rooms ‘s design is limited ventilation and airflow so, building's efficiency in protecting health and comfort is reduced.

2) Lack of incentive program for workplace who follow the instruction

Until date, there has been no positive agenda for an employer who adopts COVID-19 protective, preventive, and response tactics. It would be preferable if a campaign were initiated. The cost of increasing ventilation, upgrading other building systems, and improving indoor air quality is prohibitively expensive. As a result, the preventative and protective measures have not be implemented. A subsidy scheme may be implemented when merging with other departments, such as the Ministry of Industry and the Ministry of Labor**.**

3) Lack of budget to switch working patterns to work from home

When shifting to an online working pattern, some businesses cannot accommodate complete online working because of a lack of appropriate equipment, such as a personal computer and Wi-Fi access.

4) Lack of research and development of innovative products support

Currently, the private sector is the primary driver of innovation to improve the living quality of building occupants, with only a slight tax advantage from R&D investment. Nonetheless, this substance is required to protect the building's occupants from respiratory disease and improve quality of life. On the other hand, building owners must invest in this product to protect their employees. If any subsidized initiatives to promote innovative items are available during this time, building owners used them to improve their buildings more efficiently.

5) Lack of readiness to prepare for the financial crisis.

Although effective financial assistance programs for the building's occupants have been implemented, such as Mor. 33 we love. However, some problems and obstacles have occurred, including

a) Financial discipline, especially low money-saving on a personal level, is crucial. Cost of living is increased during this period for many reasons such as personal protective equipment, increased building efficiency for protection, and some are unemployed.
b) The assistance programs are online registered programs with limit number. If someone who cannot access the internet, or who cannot be registered on time. This assistance program is not provided.
c) This program is a temporary solution, as long as this problem is still existed, other sustainable ways is required such as job employment.

6.5.3 Lack of knowledge and communication control

1). In-sufficient of knowledge

Because COVID is a new epidemic, fundamental understanding, control measures, treatment, and waste management are lacking, limiting everyone's access. Ventilation, air movement, and other knowledge are tough to grasp, particularly in the building industry. The objective is to broaden information until everyone recognizes and understands how to deal with and manage the problem. Moreover, various data sources from the government sector, universities, hospitals, NGOs, and other organizations have produced information that sometimes has the same issue but confusing in detail.

Furthermore, in the early stages of COVID-19, the number of infected cases and deaths is very low due to strict policies and measures. On the contrary, the number of infected people has increased significantly since then, but the measure is weaker. The study found that vaccination, COVID-19 mutation, and the long period of COVID-19 cause an increase in infection rates due to a failure to protect themselves. This is a high risk of misperception

caused by insufficient and inadequate education. Furthermore, insufficient knowledge of healthy building design among building owners, facility managers, and building occupants is a barrier to COVID-19 protection.

2). In proper communication control

Because online technologies may be accessed from anywhere and anytime with various online influencers or sources, controlling fake news and information epidemics (infodemic). Furthermore, because they have many influencers, online platforms facilitate the propagation of fake news that is difficult to control.

3). Lack of Health literacy

Health literacy is the capacity to which individual to obtain, process, and understand basic health. This barrier has been pointed out from academic institute and most of association that both building owner and occupant have less knowledge about the effect of building on their health. for example, they do not know about the disadvantage of poor ventilation, non-proper moisture, and distancing between the occupant. So, building design concept have not focusing on this issue. Additionally, when investigate to the building's occupant, health and comfort to protect is rarely understand. To increase health literacy to building occupant is also important. However, as COVID-19 approaches, health awareness has improved, for example mask-wearing is no longer concerned; however, it is unavoidable and must be worn whenever going outside during this period. Health literacy must begin in school and university to raise knowledge of building's quality.

6.5.4 Infected Waste Management

Effect on infected-waste management for both organization and personal level is also examined in this study because it's mentioned in COVID-19 infection, prevention, and control measures. Same as in the preventive measures' implementation, the organization's penalty is the key for success for infected-waste management even if the quantity is significantly increased during this period. However, infected waste bins have to provide in proper place such as in the toilet by

separating with other waste types to prevent contamination from non-proper waste separation. Additionally, for the personal level, waste contamination has to avoid by waste separation education. In case of infected waste bin is not provided, contamination to other containers might be occurred and become a significant environmental management issue during this period.

6.6 Recommendation

COVID-19 experience gives most people a worse attitude because many people have died or been infected. People face some troubles when living in normal life to protect and prevent infection. For example, always wearing a face mask, washing hands frequently, staying at home, restricting travel, screening temperature before entering the building, and working from home. However, COVID-19 is like a catalyst to improve personal and public hygienic measures, increase healthcare system efficiency, and enhance living conditions. Especially in the office building that must improve building efficiency by regulatory, engineering control, and administrative control measure environment to protect the health and comfort of building's occupant during COVID-19 and when turning from work from home to work from office period.

However, during the improvement period, some gaps and barriers were found during COVID-19 infection, prevention, and control implementation, including lack of Expenditure and incentive program, lack of knowledge, education and well-communication, lack of Health literacy, and the political issue.

To overcome gaps and barriers to prepare for the next normal living condition following strategies have been implemented

6.6.1 Building Standard Enforcement Strategy

Because currently only draft version for indoor air quality recommendation for an office building have been made so, both new and existing building design does not concern in healthy building. Additionally, insufficient support to promote health and comfort in building especially sustainable building certification have been observed. At the same time, building assessment certification need to be revised especially in

local standard. Moreover, building occupant have no health and comfort protection law to protect them for living in the proper condition.

Building regulation to improve and maintain proper health and comfort have to implement. Especially all criteria that have an impact on occupants' health and comfort. Improve building's law and regulation have to execute to increase building's performance by

1. Increase the penalty and enforcement for office buildings that are unable to improve their residents' health and comfort. Furthermore, provide a benefit and incentive to office buildings that can improve.
2. Promote IAQ strategies only or with other programs such as energy saving & carbon reduction and give some reward & benefit to those buildings.
3. Furthermore, promoting better health and comfort building using revised-sustainable certification tools.
4. Integrate flexible & adaptable design in building regulations an emergency purpose including for the vulnerable people.
5. Have a regulation or feedback response program from occupant.

6.6.2 Supporting Strategy

Because the budget is limited for both public and private building, and have no incentive program for health and engineering measure for innovative product manufacturer.

1. So, during emergencies, the government has to provide funding support for building owners to improve their health and comfort efficiency.
2. Additionally, to increase research and development competitiveness and to reduce improvement cost government have to support innovator to create an innovative product.
3. Beside financial assistance, other benefits to building owner who well-managed is required such as floor area ratio and specify in the government's green procurement for product manufactured is required.

6.6.3 Educational Strategy

Because of Inadequate knowledge about proper living condition for building owner and occupant and insufficient infected waste bins and non-proper waste separation during this period. To prepare for the other flu & influenza, following crisis that might occur, increasing personal and public health awareness, improving environmental consciousness in waste management, and encouraging people to save money are the topics that must be cultivated.

1. Public and private health education, both formal and informal, have to apply in all segments. For building owner, the benefit of better health and comfort building must be concerned. Additionally, when people especially building occupants, are aware of their health literacy, working in buildings in poor condition have to consider, and the building's quality must be improved.
2. Not only related-health topics, environmental issues especially waste management issues, must apply. Waste separation and reducing waste are fundamental for education with the proper position of bins and labels.
3. At the same time, financial discipline by saving money is a significant knowledge that must improve for sustainable living.

6.7 Introduction strategies & measures to improve building performance against COVID-19

To overcome this situation and avoid the following respiratory diseases in the future. Furthermore, to protect the health and comfort of building occupants by preventing related building illnesses caused by poor indoor air quality such as volatile organic compounds, mold, dust, and particulate matter. Additional sustainable office building guidelines must be proposed in order to improve building quality and living conditions. During this time period from the building owner and occupant perspective, the most significant aspect that has increased significantly is spatial or distancing and it is also the most satisfied aspect of all building types. While indoor air quality and temperature and humidity are the second and third most important factors to consider. Although visual was the most complacent prior to this period, it

must improve to meet building occupant satisfaction, and supplementary acoustic characteristics are also required.

From the actor-network analysis the three significant recommendation have been proposed comprising:

6.7.1 Healthy Building law and regulation Concept Design

1). Besides energy and environmental aspect must be mentioned in sustainable building assessment same as existing standards, for example, LEED & TREES. The healthy building concept [231] consists in nine factors including ventilation, air quality, thermal health, moisture, dust & pests, safety & security, water quality, noise, and lighting & view that influence human health, well-being, and productivity of people who live or work in those building must be concerned.

Additionally, to integrated building design together and for increase building efficiency to establish law and regulation for building. Other sustainable concept of building efficiency has been integrated for example Net zero carbon, zero energy, zero water, and zero waste have been integrated.

- Net Zero Carbon Building recognizes buildings operating with net zero carbon emissions over the course of the past year. This concerning of the balance of carbon caused from energy consumption and occupant transportation to carbon emissions avoided or offset.

- Net Zero Energy building recognizes buildings that achieve a source energy use balance of zero for the past year. Based on the quantity of source energy delivered and renewable energy that displaces non-renewable energy on the grid. Renewable energy generated and used on site reduces the amount of energy delivered

- Net Zero Water recognizes buildings that achieve a potable water use balance of zero for the past year. By concerning in total alternative water used and water returned to original source. (Water returned to its original source includes rainwater stored and infiltrated or evapotranspirated via green infrastructure, and

wastewater treated and returned to the local watershed or aquifer via decentralized wastewater treatment systems)

- Net Zero Waste recognizes buildings that achieve as much as possible of reducing, reusing, and recovering waste from landfill, incineration (waste-to-energy) and the environment for solid, non-hazardous wastes.

2). Building functions must be appropriate for building design; however, adjustable design is also a concern from future crises, such as new respiratory disease, air pollution, and disasters. Circular economy design has been concerned, particularly when respiratory diseases such as flu, influenza, and other respiratory pandemics have occurred. Because of the work-from-home policy and the limited number of people permitted inside the building. The requirement of a workplace or office building is a lesson. However, the building's quality is improving. Better living conditions, particularly for health and comfort, are required.

Sharing space has become the new norm in the workplace or office building. Because office space is limited, office layout must consider keeping occupants apart. Sharing space is a circular building design concept in which products and components of the building are designed and manufactured to be easily disassembled at the end of their use and reused in a new situation. The circular building design concept includes design and construction for long-term use, building efficiency, and developing a new materials mindset.

1. Design and build for long-term value by increasing building utilization, designing for longevity, adaptability, and disassembly.
2. Increase efficiency by avoiding unnecessary components and maximizing material efficiency.
3. Use appropriate materials by reducing the use of virgin materials, the use of carbon-intensive materials, and the design of hazardous/polluting materials.

3). The building design concept must be supplemented with universal design for all occupants, particularly vulnerable people. Buildings must provide specific rooms and places for vulnerable people to live normally, as well as special attention

for disabled people and senior staff when the following respiratory disease is present. For example, a working area for pregnant women, a lactation room for breastfeeding mothers, and visual and acoustic characteristics appropriate for senior living design. Additionally, at least in the organization level, work for home policies one of the elimination methods in hierarchy of control must be implemented to protect and prevent these group of people from other disease such as flu, influenza, and other respiratory disease. Work from home policy when suspected people who have flu symptom should start in some unit of the workplace with proper indicators such as sick leave rate and satisfaction. Additional supports from the government such as the Ministerial Regulation from Department of labor Protection and Welfare, Ministry of Labor is the further encouragement.

6.7.2 Engineering Measures

By establish or implement various strategies in order of the efficiency and sustainability to improve health and comfort of building occupant

1). Enhance Indoor Environments. Because indoor air quality is the most significant effect to building occupant health. Improve ventilation is the first priority for better health and comfort living condition by:

- Increase ventilation measures for both mechanical and natural ventilation. (For mechanical, at least follow the existing standard (ventilation rate 7 air change rate per hour and fresh air quantity at least 2 $m^3/hr/m^2$ for office building) and avoid recirculation air.
- Install a filtration system with MERV 13 or higher, or High-Efficiency Particulate Air (HEPA), or Upper-Room Ultraviolet Germicidal Irradiation (UVGI) and filtration maintenance plan
- Improve special ventilation such as negative pressure for the bathroom
- Have an inspect, maintain & clean HVAC system plan and schedule
- Implement a qualifying enhanced Indoor Air Quality (IAQ) Testing and Monitoring Protocol to monitoring the levels of air

quality metrics in real-time with the recommended limits such as CO_2 concentration, particulate matter (PM)

- Flush air before using at least 2 hours
- Open window when outside air quality is good
- Using an additional mechanical fan

2). Implement Temperature & Humidity Control Policy by

- Incorporates measures for regulating temperature and relative humidity by preventing infiltration around windows, doors, lighting fixtures, and other locations by sealing any cracks and gaps.
- Individual control or separately control in temperature and relative humidity (RH) is recommended because increased ventilation, physical distancing layout, implement shift working are affected by temperature and humidity.
- Real-time monitoring and control systems are required to show existing temperature and humidity.
- Includes microbial and mold control tactics outlined by
  - Use of mold-resistant materials
  - Support air flow
  - Implement a mold or water damage notification system
  - Frequent inspections for mold growth, water damage, and condensation, within 24 to 48 hours after discovery, establish a strategy for drying any damp areas and repairing any leaks.

3.) Managing Closures and Significant Reductions in Occupancy by

- Design building, occupant route & furniture layout to keep physical distancing.
- Increase the physical distancing, especially in public space areas such as meeting room and elevator.

- Employ touchless and sensor technology, especially on high-touch surfaces such as elevators, door knots, and office appliance.
- Increase open and more green space to increase physical distancing area, improve outside air quality, and decrease inside air temperature.

4). Increase visual performance by:

- Provide illumination level that meets the standard depending on office space activities.
- Provide individual lightness and glare control that correspondence to building layout
- Provide quality of view to all occupant

5). Encourage acoustic characteristics by:

- Stringent level of noise, sound barrier, and reverberation time
- Increase the level of HVAC backgrounds noise design

6.7.3 Administrative & Encourage Behavioral Change

1). Enhanced Hand Hygiene and respiratory etiquette measures that are located in entryways, restrooms, and public area that include one of the following: hand sanitizer, soap, water, and hand drying method.

2). Enhanced Cleaning, Disinfecting, and Maintenance Protocol by

- Enhanced Green Purchasing Policy for the beneficial health and environmental impacts of all cleaning, hygiene product, instrument, and services.
- Install cleaning measures that concerning in
  - Effective, healthy, and environmentally friendly detergent to promote better air quality inside the building.
  - Increase the frequency of routine housekeeping, especially in shared spaces, shared kitchens, shared bathrooms, and shared office equipment

- Disinfectants listed on EPA List N are recommended
- Use the lowest disinfectant concentration possible while still killing the pathogen.

3). Encourage waste separation behavior by

- Providing proper bins including general, recyclable, infected, and hazardous waste
- Implement a zero-waste program by trying to divert all solid waste from landfills, incineration (waste-to-energy), and the environment.

4). Create & implement the communication plan by

- Establish a risk communication policy with effective hierarchy, verbal announcements, signage in various languages, and access for all.
- Consider declaring the enforcement when cannot comply with the announcement.
- Have a two-way communication plan

5). Establish a training program for staff and orientation program that is updated annually, with clear virtual materials

6). Have a special program for vulnerable people and mental health treatment when emergency crisis might be occurred.

6.7.4 Personal Protective Equipment (PPE)

Establish Personal Protective Equipment (PPE) by providing a protocol for all staff and visitors to operations, maintenance, engineering staff, and third-party contractors that:

- Require PPE to be worn while on-site, including masks, reusable gloves, and eye protection.
- If possible, provide PPE for all required staff.
- Require adequate stockpiling and inventory of relevant and effective PPE

Chapter 7
Conclusion and Recommendation

Covid-19 is an emerging infectious disease that we faced during this period, with millions of people dying and being infected. Besides giving the deteriorating health to people, the healthcare system has a very challenging to handle and treat many patients. At the same time, the environment, especially infected waste from facial masks and contaminated items. Moreover, the economic system also faced a recession handling and assisting people.

However, the COVID-19 experience is a good lesson for the others and following respiratory diseases that might be occurred and also the catalyst for following standard living patterns such as touchless technology and online communication from keep distancing measures, work from home strategies for business continuation. The building environment has been transformed from COVID-19's prevention implementation, such as a touchless society, indoor technology with health factors, increased open space, and prioritizing space over convenience.

From the study of the measures for preventing the occupational respiratory disease from exposures in an office building to COVID-19 infection based on the hierarchy of control concepts from international agencies, including the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), The USA Occupational Safety and Health Administration (OSHA), the European Centre for Disease Prevention and Control (ECDC), International Labor Organization (ILO), and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Compared with the COVID-19 effective management countries, Thailand's strategies have been established by the Ministry of Public Health from the Department of Health and Department of Disease Control and literature review. Thailand occupational workplace have to provide additional protective layer to protect building occupant from COVID-19 comprising:

7.1 Regulatory environment

- Country-specific COVID-19 regulations in line with international agency.
- Workplace policies and protocols should be ready at organization level.
- Adjust workplace policies for work from home and provide sufficient resources and materials safety working environment.

7.2 Engineering Control Environment

- Provide more efficient ventilation system with proper temperature and humidity control and maintain good air quality.
- Alter workspaces to maintain social distancing by installing various engineering measures to eliminate disease transmission threats and design concept based on health and sustainability concepts.
- Employing innovative technologies and workplace layout.
- Routine cleaning with proper disinfection and flushing in water and sanitary ware system to prevent risk of microbiological and legionella.

7.3 Administrative & Organizational Control Environment

- Implement various source control and safety measures in workplace condition and applying proper waste management.
- Apply effective cleaning detergent especially high frequent touch surface.
- Design emergency development plan that can track amongst employees and communication thereof to them.
- Develop business continuity plan by considering flexible working models.
- Educate and communicate with employee to develop acquaintance with COVID-19 guideline.

When comparing COVID-19 infection, prevention, and control measures to the sustainable building certification assessment, including Leadership in Energy and Environmental Design (LEED), Thai's Rating of Energy and Environmental Sustainability (TREES), and WELL standard in Thailand. Some COVID-19 preventive and protective strategies have mentioned in the standard. Increase ventilation and distancing are the prerequisites for building certification that comply with ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality both for mechanical and natural ventilation by concerning outdoor air intake and exhaust air, number of populations and area. Additionally, ventilation improvement in the bathroom, an inspection or maintenance plan, and a water control plan are the existing in sustainable building assessment. While provide proper waste management area is the standard practice in certified buildings. So, during the COVID-19 period, the certified building is easier to adapt to comply with COVID-19 preventive and prevention measures especially for WELL standard.

Furthermore, when studied by an in-depth interview, building owners and facility management managers for COVID-19 infection, prevention and control measures were implemented in certified and non-certified building in Bangkok area. All building is the single-tenant and have been certified and major renovate with five years. The study found that certified buildings (CB) are performing one hundred % of the COVID-19 strategies. On the other hand, non-certified buildings have been divided into two groups. One is implementing more than ninety percent of recommended' s strategies is categorized in non-certified buildings with good measures (NGM). In comparison, non-certified buildings with fair measure (NFM) represent less than ninety percent of the suggested actions. Preparing a negative pressure room for a confirmed case is the least strategy implemented in engineering measures. At the same time, mental health support is the least in administrative and organizational measures. However, alternative strategies have been implemented including provide natural ventilation area instead of providing negative pressure room for suspected and confirmed case, increase frequency of cleaning replace install high effective air filtration, install physical barrier instead of employ touchless technology, and recommend hotline number from department of mental health instead of

providing supporting mental health activities. In addition, in all buildings in this case study (Both certified and non-certified building that have been built or renovated within ten years), no report of the infection case has been observed and no cluster outbreaks have been found. Therefore, from this study when the COVID-19 infection, prevention, and control measures and alternative strategies have been implemented, none of the COVID-19 cases has occurred in that office building.

From the actor-network analysis, the recommendation for building owner and facility manager to improve health and comfort to building occupant comprising:

1. Engineering Measures

By establish or implement various strategies in order of the efficiency and sustainability to improve health and comfort of building occupant

1). Enhance Indoor Environments. Because indoor air quality is the most significant effect to building occupant health. Improve ventilation is the first priority for better health and comfort living condition by:

1.1 Increase ventilation measures for both mechanical and natural ventilation and avoid recirculation air.

1.2 Install a filtration system with MERV 13 or higher, or High-Efficiency Particulate Air (HEPA), or Upper-Room Ultraviolet Germicidal Irradiation (UVGI) and filtration maintenance plan.

1.3 Improve special ventilation such as negative pressure for the bathroom.

1.4 Have an inspect, maintain & clean HVAC system plan and schedule.

1.5 Implement a qualifying enhanced Indoor Air Quality (IAQ) Testing and Monitoring Protocol to monitoring the levels of air quality.

1.6 Flush air before using at least 2 hours or open window when outside air quality is good, or using an additional mechanical fan.

2). Implement Temperature & Humidity Control Policy by

2.1 Maintain and keep proper temperature and relative humidity by preventing infiltration by sealing any cracks and gaps.

2.2 Individual control or separately control in temperature and relative humidity (RH) is recommended.

2.3 Real-time monitoring and control systems.

2.4 Includes microbial and mold control tactics outlined by

- Use of mold-resistant materials
- Support air flow
- Implement a mold or water damage notification system
- Frequent inspections for mold growth, water damage, and condensation.

3.) Managing Closures and Significant Reductions in Occupancy by

3.1 Design building, occupant route & furniture layout.

3.2 Increase the physical distancing, especially in public space areas such as meeting room and elevator.

3.3 Employ touchless and sensor technology, especially on high-touch surfaces such as door knots, and office appliance.

3.4 Increase open and more green space.

4). Increase visual performance by:

4.1 Provide illumination level that meets the standard

4.2 Provide individual lightness and glare control that correspondence to building layout

4.3 Provide quality of view to all occupant

5). Encourage acoustic characteristics by:

5.1 Stringent level of noise, sound barrier, and reverberation time

5.2 Increase the level of HVAC backgrounds noise design

2. Administrative & Encourage Behavioral Change

1). Enhanced Hand Hygiene and respiratory etiquette measures especially in the public including hand sanitizer, soap, water, and hand drying method.

2). Enhanced Cleaning, Disinfecting, and Maintenance Protocol by

2.1 Enhanced Green Purchasing Policy for the beneficial health and environmental impacts.

2.2 Install cleaning measures that concerning in

- Effective, healthy, and environmentally friendly detergent

- Increase the frequency of routine housekeeping, especially in shared spaces

- Disinfectants listed on EPA List N are recommended

- Use the lowest disinfectant concentration possible while still killing the pathogen.

3). Encourage waste separation behavior by

3.1 Providing proper bins including general, recyclable, infected, and hazardous waste

3.2 Implement a zero-waste program by trying to divert all solid waste from landfills, incineration (waste-to-energy), and the environment.

4). Create & implement the communication plan by

4.1 Establish an effective risk communication policy

4.2 Consider declaring the enforcement when cannot comply with the announcement.

4.3 Have a two-way communication plan

5). Establish a training program with clear virtual materials

6). Have a special program especially for vulnerable people and mental health treatment.

This study examined the effect of health and comfort criteria on the building's occupant, comparing certified buildings, non-certified buildings with good measure, and non-certified buildings with fair measure. Health and comfort criteria comprising; thermal comfort, indoor air quality, distancing, visual, and acoustic (Definition from ISO 21929, EN 15643, and EN 16309). By using an in-depth interview and rating scale method, before COVID-19 period building occupants in certified buildings were more satisfied with building performance to protect health and comfort than others. However, during COVID-19, non-certified buildings with good measures have the highest building satisfaction compared with certified and non-certified buildings with fair measures because the large room of improvement have been observed.

Spatial or distancing is the superior level of satisfaction during this period and the highest level of improvement compared to before COVID-19 in all types of buildings because it's a significant change to their place during this situation. Indoor air quality is the second satisfaction in the certified and non-certified buildings with fair measure and the first for non-certified building with good measure. During COVID-19 period, too hot and too cold are occurred during limit number of people. Real-time monitoring for indoor air quality is required for more satisfaction. Visual and acoustic are not mentioned in COVID-19 preventive and protective measures. Nevertheless, the level of satisfaction is slightly higher in all types of buildings because more access for better daylight and view and level of sound protection from adjacent area and outside.

Actor-network analysis has been used to analyze gaps and barriers to COVID-19 prevention and control measure implementation from policy both country and provincial level, economic, and societal networks. From their perspective, the critical success in fighting against this situation is the enforcement and penalty for COVID-19 measures implementation. Compliance with recommended' s strategies is rarely observed without penalty, and the infection rate is significantly increased. Other key success is the effective collaboration and communication with building owner and

facility manager to building occupant, effective, and the readiness of public health system from the government and building level.

The obstacles during this period are comprising: First, lack of laws and regulations for healthy building. Second is lack of Expenditure and incentive program including investment to modify and renovate the workplace, incentive program for workplace who follow the instruction, budget to switch working patterns to work from home, research and development of innovative products support, and readiness to prepare for the financial crisis. Third is a lack of knowledge and communication control comprising insufficient of knowledge, improper communication control, and lack of health literacy.

Effect on infected-waste management for both organization and personal level is also examined. The penalty to the organization is the key for success, proper bins have to provide to prevent contamination from non-proper waste separation. Additionally, for the personal level, waste contamination has to avoid through waste separation education and training.

Furthermore, this study also proposes a sustainable building standard for following normal living to increase the building's performance and preserve the occupant's health and comfort. Firstly, implementing a building law and regulation for concept design that integrates health and comfort to the occupant with other building efficiencies such as net-zero building, adaptable building design following circular economy design concept, and universal design, especially for vulnerable people, is required. Secondly, engineering measures by providing real-time monitoring of indoor air quality and temperature, having a ventilation control for common areas and particular areas such as a bathroom, increasing distancing design by a physical barrier in both office and public areas, and use touchless technology, give an individual temperature and relative humidity control. Thirdly, encourage behavioral change, enhance hygienic measures, establish proper cleaning and equipment, proper waste management, implement effective communication, and promote personal protective equipment use.

This research mainly focused on SDG 11 in sustainable cities and communities. Moreover, it also concerned SDG 3 and SDG 8 to improve the occupant's good health and well-being and decent work. At last, infected waste management was studied during this period corresponding to SDG 12 responsible consumption.

Recommendation for Further Research

1. To propose the building guideline, the others type of buildings should be studied to explore the building satisfaction of each health and comfort.
2. The recommendation from this study should examine find the best solution for the preparedness respondent for the following respiratory disease.
3. Other aspect of building efficiency such as energy and materials consumption should investigate to study the impact to health and comfort protection.

Appendix

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 2
สังคมศาสตร์ มนุษยศาสตร์ และศิลปกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
อาคารจามจุรี 1 ชั้น 1 ห้อง 114 ถนนพญาไท แขวงวังใหม่ เขตปทุมวัน กรุงเทพมหานคร 10330
โทรศัพท์ : 0 2218 3210-11 E-mail: curec2.ch1@chula.ac.th

COA No. 113/2564

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 087/64 การป้องกันโรคทางเดินหายใจจากการทำงานในอาคารสำนักงาน : กรณีศึกษา COVID-19

ผู้วิจัยหลัก นายภาณุพันธ์ ผาพันธุ์

หน่วยงาน สาขาสิ่งแวดล้อม การพัฒนา และความยั่งยืน บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 2 สังคมศาสตร์ มนุษยศาสตร์ และศิลปกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย พิจารณาจริยธรรมการวิจัยโดยยึดหลัก ของ Declaration of Helsinki, the Belmont report, CIOMS guidelines และ The international conference on harmonization – Good clinical practice (ICH-GCP) อนุมัติให้ดำเนินการศึกษาวิจัยเรื่องดังกล่าวได้

ลงนาม.....
(ศาสตราจารย์กิตติคุณ ดร.ธีระพันธ์ เหลืองทองคำ)
ประธานคณะกรรมการ

ลงนาม.....
(ผู้ช่วยศาสตราจารย์ ดร.หนึ่งหทัย แรงผลสัมฤทธิ์)
กรรมการและเลขานุการ

รูปแบบการพิจารณาทบทวน: แบบลดขั้นตอน

วันที่รับรอง: 27 พฤษภาคม 2564 **วันหมดอายุ:** 26 พฤษภาคม 2565

เอกสารที่คณะกรรมการรับรอง

1. ข้อเสนอโครงการวิจัย
2. ประวัติและผลงานของผู้วิจัย
3. เอกสารข้อมูลสำหรับกลุ่มตัวอย่าง/ผู้มีส่วนร่วมในการวิจัย
4. หนังสือยินยอมเข้าร่วมในการวิจัย (ยกเว้น)
5. แบบสอบถาม

เงื่อนไข

1. ผู้วิจัยรับทราบว่าเป็นการผิดจริยธรรม หากดำเนินการเก็บข้อมูลการวิจัยก่อนได้รับการอนุมัติจากคณะกรรมการพิจารณาจริยธรรมการวิจัยฯ
2. หากใบรับรองโครงการวิจัยหมดอายุ การดำเนินการวิจัยต้องยุติ เมื่อต้องการต่ออายุต้องขออนุมัติใหม่ล่วงหน้าไม่ต่ำกว่า 1 เดือน พร้อมส่งรายงานความก้าวหน้าการวิจัย
3. ต้องดำเนินการวิจัยตามที่ระบุไว้ในโครงการวิจัยอย่างเคร่งครัด
*4. ใช้เอกสารข้อมูลสำหรับกลุ่มตัวอย่าง/ผู้มีส่วนร่วมในการวิจัย ใบยินยอมของกลุ่มตัวอย่างหรือผู้มีส่วนร่วมในการวิจัย และเอกสารเชิญเข้าร่วมวิจัย (ถ้ามี) **เฉพาะที่ประทับตราคณะกรรมการเท่านั้น***
5. หากเกิดเหตุการณ์ไม่พึงประสงค์ร้ายแรงในสถานที่เก็บข้อมูลที่ขออนุมัติจากคณะกรรมการ ต้องรายงานคณะกรรมการภายใน 5 วันทำการ
6. หากมีการเปลี่ยนแปลงการดำเนินการวิจัย ให้ส่งคณะกรรมการพิจารณารับรองก่อนดำเนินการ
7. โครงการวิจัยไม่เกิน 1 ปี ส่งแบบรายงานสิ้นสุดโครงการวิจัย (AF 03-13) และบทคัดย่อผลการวิจัยภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น สำหรับโครงการวิจัยที่เป็นวิทยานิพนธ์ให้ส่งบทคัดย่อผลการวิจัย ภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น ทั้งนี้เพื่อเป็นหลักฐานในการปิดโครงการ
8. โครงการวิจัยที่ได้รับการอนุมัติโครงการโดยการพิจารณาทบทวนแบบกรณียกเว้น (Exemption review) ปฏิบัติตามเงื่อนไข ข้อ 1,6 และ 7 เท่านั้น

Office of the Research Ethics Review Committee for Research Involving Human Subjects:
The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts
Chamchuri 1 Building, Room 114, Phayathai Road, Wang Mai Sub-district,
Pathum Wan District, Bangkok 10330
Telephone number 0 2218 3210-11 E-mail curec2.ch1@chula.ac.th

COA No. 113/2564

Certificate of Research Approval

Research Project Number 087/64 PREVENTING OCCUPATIONAL RESPIRATORY DISEASE FROM EXPOSURES IN OFFICE BUILDING: CASE STUDY COVID-19

Principal Researcher Mr. Panupant Phapant

Office Environment Development and Sustainability, Graduate School, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Subjects: The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts at Chulalongkorn University, based on Declaration of Helsinki, the Belmont report, CIOMS guidelines and the Principle of the international conference on harmonization – Good clinical practice (ICH-GCP) has approved the execution of the aforementioned research project.

Signature Theraphan Luangthongkum
(Emeritus Prof. Theraphan Luangthongkum, PhD.)
Chairman

Signature
(Asst. Prof. Nunghatai Rangponsumrit, PhD.)
Secretary

Research Project Review Categories: Expedited Review

Date of approval: 27 May 2021 **Expiry date:** 26 May 2022

Documents approved by the Committee

1. The research proposal
2. The researcher CV
3. The information sheets for research participants
4. The informed consent forms (exempted)
5. The questionnaires

Office of the Research Ethics Review Committee for Research Involving Human Subjects in Social Sciences, Humanities and Fine and Applied Arts The Second Allied Academic Group

Protocol No. 087/64
Date of Approval 27 MAY 2021
Approval Expiry Date 26 MAY 2022

Conditions

1. *The researcher has acknowledged that it is unethical if he/she collects information for the research before the application for an ethics review has been approved by the Research Ethics Review Committee.*
2. *If the certificate of the research project expires, the research execution must come to a halt. If the researcher wishes to reapply for approval, he/she has to submit an application for a new certificate at least one month in advance, together with a research progress report.*
3. *The researcher must conduct the research strictly in accordance with what is specified in the research project.*
4. *The researcher must only use documents that provide information for the research sampling population/participants, their letters of consent and the letters inviting them to take part in the research (if any) that have been endorsed with the seal of the Committee.*
5. *If any seriously untoward incident happens to the place where the research information, which has requested the approval of the Committee, is kept, the researcher must report this to the Committee within five working days.*
6. *If there is any change in the research procedure, the researcher must submit the change for review by the Committee before he/she can continue with his/her research.*
7. *For a research project of less than one year the researcher must submit a report of research termination (AF 03-13) and an abstract of the research outcome within thirty days of the research being completed. For a research project which is a thesis, the researcher must submit an abstract of the research outcome within thirty days of the research being completed. This is to be used as evidence of the termination of the project.*
8. *A research project which has passed the Exemption Review, must observe only the conditions in 1, 6 and 7.*

APPENDIX 1

แบบสอบถามความพึงพอใจต่อประสิทธิภาพด้านการป้องกันและส่งเสริมสุขภาพและความอยู่สบายของอาคารสำนักงาน

สำหรับเจ้าของอาคารและผู้บริหารอาคาร

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 3 ส่วน เป็นคำถามแบบเลือกตอบ จำนวนรวมทั้งหมด 22 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป – เกี่ยวกับผู้ให้สัมภาษณ์

1. อาคารสำนักงานในปัจจุบันของท่านได้การรับรองมาตรฐานใดต่อไปนี้

☐ LEED ☐ TREES ☐ WELL ☐ FITWEL

☐ ไม่ได้การรับรอง

2. ระยะเวลาทำงานในอาคารสำนักงานปัจจุบันของท่าน

☐ น้อยกว่า 10 ปี ☐ มากกว่า 10 ปี

APPENDIX 1

ส่วนที่ 2: ประสิทธิภาพของอาคารในการส่งเสริมสุขภาพและความอยู่สบายของคนในอาคาร ก่อน การเกิด COVID-19

	1 มีบทบาทน้อยที่สุด, 5 มีบทบาทมากที่สุด				
2.1 ท่านคิดว่าอาคาร มีบทบาทในการช่วยส่งเสริมสุขภาพและความอยู่สบายของคนที่อาศัยอยู่ในอาคารได้ในระดับใด	1	2	3	4	5
2.2 ความพึงพอใจในประสิทธิภาพของอาคาร ในการช่วยส่งเสริมสุขภาพและความอยู่สบาย อยู่ในระดับใด	1	2	3	4	5
2.3 ระดับความพึงพอใจของปัจจัยที่ส่งเสริมสุขภาพและความเป็นอยู่ของคนในอาคารสำนักงานอยู่ที่ระดับใด					
2.3.1 คุณภาพอากาศและการระบายอากาศ	1	2	3	4	5
2.3.2 อุณหภูมิและความชื้น	1	2	3	4	5
2.3.3 การใช้แสงธรรมชาติและการมองเห็นทิวทัศน์	1	2	3	4	5
2.3.4 การป้องกันเสียงรบกวนจากภายนอก	1	2	3	4	5
2.3.5 ระยะห่างระหว่างบุคคล และผังที่นั่ง	1	2	3	4	5
2.3.6 วัสดุก่อสร้างที่ปลอดภัยต่อสุขภาพ	1	2	3	4	5
2.3.7 คุณภาพน้ำดื่มน้ำใช้ในอาคาร	1	2	3	4	5
2.3.8 มาตรการการทำความสะอาด	1	2	3	4	5

ส่วนที่ 3: ประสิทธิภาพของอาคารในการส่งเสริมสุขภาพและความอยู่สบายของคนในอาคาร ระหว่างและหลัง การเกิด COVID-19

	1 มีบทบาทน้อยที่สุด, 5 มีบทบาทมากที่สุด				
3.1 ท่านคิดว่าอาคาร มีบทบาทในการช่วยส่งเสริมสุขภาพและความอยู่สบายของคนที่อาศัยอยู่ในอาคารได้ในระดับใด	1	2	3	4	5
3.2 ความพึงพอใจในประสิทธิภาพของอาคาร ในการช่วยส่งเสริมสุขภาพและความอยู่สบาย อยู่ในระดับใด	1	2	3	4	5
3.3 ระดับความพึงพอใจของปัจจัยที่ส่งเสริมสุขภาพและความเป็นอยู่ของคนในอาคารสำนักงานอยู่ที่ระดับใด					
3.3.1 คุณภาพอากาศและการระบายอากาศ	1	2	3	4	5
3.3.2 อุณหภูมิและความชื้น	1	2	3	4	5
3.3.3 การใช้แสงธรรมชาติและการมองเห็นทิวทัศน์	1	2	3	4	5
3.3.4 การป้องกันเสียงรบกวนจากภายนอก	1	2	3	4	5
3.3.5 ระยะห่างระหว่างบุคคล และผังที่นั่ง	1	2	3	4	5
3.3.6 วัสดุก่อสร้างที่ปลอดภัยต่อสุขภาพ	1	2	3	4	5
3.3.7 คุณภาพน้ำดื่มน้ำใช้ในอาคาร	1	2	3	4	5
3.3.8 มาตรการการทำความสะอาด	1	2	3	4	5

Appendix 2

แบบสอบถามความพึงพอใจต่อประสิทธิภาพด้านการป้องกันและส่งเสริมสุขภาพและความอยู่สบายของอาคารสำนักงาน

สำหรับผู้อยู่อาศัยในอาคาร

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 3 ส่วน เป็นคำถามแบบเลือกตอบ จำนวนรวมทั้งหมด 22 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป – เกี่ยวกับผู้ให้สัมภาษณ์

1.1 อาคารสำนักงานในปัจจุบันของท่านได้การรับรองมาตรฐานใดต่อไปนี้

☐ LEED ☐ TREES ☐ WELL

☐ ไม่ได้การรับรอง ☐ ไม่ทราบ

1.2 ระยะเวลาทำงานในอาคารสำนักงานปัจจุบันของท่าน

☐ น้อยกว่า 2 ปี ☐ มากกว่า 2 ปี

Appendix 2

ส่วนที่ 2: ประสิทธิภาพของอาคารในการส่งเสริมสุขภาพและความอยู่สบายของคนในอาคาร ก่อน การเกิด COVID-19

	1 มีบทบาทน้อยที่สุด, 5 มีบทบาทมากที่สุด				
2.1 ท่านคิดว่าอาคาร มีบทบาทในการช่วยส่งเสริมสุขภาพและความอยู่สบายของคนที่อาศัยอยู่ในอาคารได้ในระดับใด	1	2	3	4	5
2.2 ความพึงพอใจในประสิทธิภาพของอาคาร ในการช่วยส่งเสริมสุขภาพและความอยู่สบาย อยู่ในระดับใด	1	2	3	4	5
2.3 ระดับความพึงพอใจของปัจจัยที่ส่งเสริมสุขภาพและความเป็นอยู่ของคนในอาคารสำนักงานอยู่ที่ระดับใด					
2.3.1 คุณภาพอากาศและการระบายอากาศ	1	2	3	4	5
2.3.2 อุณหภูมิและความชื้น	1	2	3	4	5
2.3.3 การใช้แสงธรรมชาติและการมองเห็นทิวทัศน์	1	2	3	4	5
2.3.4 การป้องกันเสียงรบกวนจากภายนอก	1	2	3	4	5
2.3.5 ระยะห่างระหว่างบุคคล และผังที่นั่ง	1	2	3	4	5
2.3.6 วัสดุก่อสร้างที่ปลอดภัยต่อสุขภาพ	1	2	3	4	5
2.3.7 คุณภาพน้ำดื่มน้ำใช้ในอาคาร	1	2	3	4	5
2.3.8 มาตรการการทำความสะอาด	1	2	3	4	5

ส่วนที่ 3: ประสิทธิภาพของอาคารในการส่งเสริมสุขภาพและความอยู่สบายของคนในอาคาร ระหว่างและหลัง การเกิด COVID-19

	1 มีบทบาทน้อยที่สุด, 5 มีบทบาทมากที่สุด				
3.1 ท่านคิดว่าอาคาร มีบทบาทในการช่วยส่งเสริมสุขภาพและความอยู่สบายของคนที่อาศัยอยู่ในอาคารได้ในระดับใด	1	2	3	4	5
3.2 ความพึงพอใจในประสิทธิภาพของอาคาร ในการช่วยส่งเสริมสุขภาพและความอยู่สบาย อยู่ในระดับใด	1	2	3	4	5
3.3 ระดับความพึงพอใจของปัจจัยที่ส่งเสริมสุขภาพและความเป็นอยู่ของคนในอาคารสำนักงานอยู่ที่ระดับใด					
3.3.1 คุณภาพอากาศและการระบายอากาศ	1	2	3	4	5
3.3.2 อุณหภูมิและความชื้น	1	2	3	4	5
3.3.3 การใช้แสงธรรมชาติและการมองเห็นทิวทัศน์	1	2	3	4	5
3.3.4 การป้องกันเสียงรบกวนจากภายนอก	1	2	3	4	5
3.3.5 ระยะห่างระหว่างบุคคล และผังที่นั่ง	1	2	3	4	5
3.3.6 วัสดุก่อสร้างที่ปลอดภัยต่อสุขภาพ	1	2	3	4	5
3.3.7 คุณภาพน้ำดื่มน้ำใช้ในอาคาร	1	2	3	4	5
3.3.8 มาตรการการทำความสะอาด	1	2	3	4	5

APPENDIX 3

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับหน่วยงานภาครัฐที่ดูแลด้านสุขภาพ

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 3 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 11 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป เกี่ยวกับข้อมูลผู้ให้สัมภาษณ์

1.1 ประสบการณ์ในการทำงานที่เกี่ยวข้องกับนโยบาย ..... ปี

1.2 ประสบการณ์ในการทำงานที่เกี่ยวข้องกับนโยบายการจัดการและป้องกันโรคติดต่อทางเดินหายใจ ..... ปี

1.3 นโยบายที่มีประสบการณ์ในอดีตเกี่ยวกับการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ (ถ้ามี) ได้แก่

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1.4 บทบาทของผู้ตอบแบบสอบถามที่เกี่ยวข้องกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

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APPENDIX 3

ส่วนที่ 2: มาตรการและผลกระทบต่างๆ ในการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 หน่วยงานของท่านมีบทบาท หน้าที่เกี่ยวกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ กรณีศึกษา โรค COVID-19 อย่างไร **(ถ้ามี ตอบคำถามต่อในข้อ 2.2-2.5, ถ้าไม่มีข้ามไปตอบข้อ 2.4-2.5)**

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2.2 ในความคิดของท่าน การนำนโยบายที่ออกจากหน่วยงานท่านไปประยุกต์ใช้ เพื่อการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ กรณีศึกษา โรค COVID-19 กับอาคารสำนักงาน ส่งผลกระทบทั้งในด้านบวกและด้านลบต่ออาคารสำนักงานอย่างไรบ้าง

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2.3 จากมาตรการต่างๆ ที่เกี่ยวข้องกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ กรณีศึกษา โรค COVID-19 ที่ใช้ในปัจจุบันจากหน่วยงานของท่าน ทั้งในด้านของการดำเนินการและด้านงบประมาณ

2.3.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.3.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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2.4 ในความคิดของท่าน มาตรการใดที่ควรต้องมีเพิ่มเติม ในการจัดการขยะในอาคารสำนักงาน เมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19

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2.5 จากมาตรการต่างๆ ที่ควรต้องเพิ่มเติมเข้ามา ในความคิดของท่านคิดว่า

2.5.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.5.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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เลขที่โครงการ 087/64
วันที่รับรอง 27 พ.ค. 2564
วันหมดอายุ 26 พ.ค. 2565

APPENDIX 4

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับผู้เชี่ยวชาญในสถาบันการศึกษา

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 2 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 7 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป เกี่ยวกับข้อมูลผู้ให้สัมภาษณ์

1.1 บทบาทของผู้ตอบแบบสอบถามที่เกี่ยวข้องกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

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1.2 ในความคิดของท่าน อาคารมีส่วนร่วมในการส่งเสริมสุขภาพและสภาวะความอยู่สบายของผู้อยู่อาศัยในอาคารได้อย่างไร

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PANUPANT PHAPANT

เลขที่โครงการ 087/64
วันที่รับรอง 27 พ.ค. 2564
วันหมดอายุ 26 พ.ค. 2565

APPENDIX 4

ส่วนที่ 2: มาตรการและผลกระทบต่างๆ ในการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 ในฐานะผู้เชี่ยวชาญ ท่านคิดว่ามาตรการใดบ้างที่ควรจะต้องนำมาประยุกต์ใช้เพื่อให้การจัดการและการป้องกันการเกิดขึ้นของโรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน มีประสิทธิภาพ

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2.2 ปัจจัยที่ทำให้มาตรการที่ต้องนำมาประยุกต์ใช้ดังกล่าวมีความสำเร็จ เมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน ประสบความสำเร็จ คือสิ่งใด

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2.3 ปัญหาและอุปสรรคในการนำมาตรการดังกล่าวมาประยุกต์ใช้ เมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน คือสิ่งใด

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2.4 ในความคิดของท่าน การเกิดขึ้นของโรคติดต่อทางเดินหายใจ COVID-19 ส่งผลกระทบทั้งทางด้านบวกและด้านลบในด้านเศรษฐกิจ การลงทุน กับการใช้งานอาคารสำนักงานอย่างไร

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2.5 ในความคิดของท่าน การเกิดขึ้นของโรคติดต่อทางเดินหายใจ COVID-19 ส่งผลกระทบทั้งทางด้านบวกและด้านลบต่อสิ่งแวดล้อม เช่น การจัดการขยะ กับการใช้งานอาคารสำนักงานอย่างไร

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PANUPANT PHAPANT

APPENDIX 5

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับผู้ผลิตสินค้านวัตกรรม

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 2 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 6 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: ข้อมูลเกี่ยวกับผู้ให้สัมภาษณ์

1. ประสบการณ์ในการทำงานที่เกี่ยวข้องด้านนวัตกรรมสินค้าและบริการเพื่อการออกแบบและการปรับปรุงระบบต่างๆ ของอาคาร ..... ปี
2. บทบาทของผู้ตอบแบบสอบถามที่เกี่ยวข้องกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

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APPENDIX 5

ส่วนที่ 2: การจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 ในฐานะผู้เชี่ยวชาญด้านนวัตกรรมสินค้าและบริการเพื่อการออกแบบและการปรับปรุงระบบต่างๆ ของอาคาร สิ่งใดบ้าง ที่ควรจะต้องนำมาประยุกต์ใช้เพื่อการจัดการและการป้องกัน โรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน

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2.2 ปัจจัยที่ทำให้การจัดการและการป้องกัน โรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน ด้วยนวัตกรรมสินค้าและบริการ ประสบความสำเร็จ คือสิ่งใด

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2.3 ปัญหาและอุปสรรคในการจัดการและการป้องกัน โรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน ด้วยการใช้นวัตกรรมสินค้าและบริการ คือสิ่งใด

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2.4 เพื่อให้การป้องกันโรคมีประสิทธิภาพเพิ่มมากขึ้น แนวทางการพัฒนาสินค้าและบริการเพื่อการออกแบบและการปรับปรุงระบบต่างๆ ของอาคารในอนาคตมีแนวโน้มเป็นอย่างไร

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APPENDIX 6

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับเจ้าของอาคารและผู้บริหารอาคาร

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 4 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 8 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป – เกี่ยวกับอาคารสำนักงานของผู้ให้สัมภาษณ์

1.1 ปัจจัยสำคัญที่อาคารยื่นขอการรับรองมาตรฐานคืออะไร **(ตอบเฉพาะในกรณีที่อาคารได้การรับรองมาตรฐาน)**

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1.2 ในความคิดของท่าน อาคารมีส่วนร่วมในการส่งเสริมสุขภาพและสภาวะความอยู่สบายของผู้อยู่อาศัยในอาคารได้อย่างไร

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ส่วนที่ 2: มาตรการต่างๆ ในการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 อาคารของท่านมีการดำเนินการเพื่อจัดการและป้องกันการแพร่ระบาดของโรคติดต่อทางเดินหายใจ COVID-19 อย่างไรบ้าง

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2.2 ในความคิดของท่าน การได้การรับรองมาตรฐานต่างๆของอาคาร มีส่วนช่วยให้การปฏิบัติตามนโยบายหรือมาตรการต่างๆ เพื่อการจัดการและป้องกันการแพร่ระบาดของโรคติดต่อทางเดินหายใจ COVID-19 หรือไม่ เพราะเหตุใด **(ตอบเฉพาะในกรณีที่อาคารได้การรับรองมาตรฐาน)**

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APPENDIX 6

ส่วนที่ 3: ผลกระทบทางด้านเศรษฐกิจ จากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

3.1 การปฏิบัติตามมาตรการและคำแนะนำต่างๆ เพื่อการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน เช่นการจัดเตรียมเครื่องวัดอุณหภูมิ หน้ากากอนามัย เจลแอลกอฮอล์ ส่งผลกระทบต่อค่าใช้จ่ายในการดำเนินการของอาคารของท่าน อย่างไรบ้าง

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3.2 ในความคิดของท่าน ควรมีมาตรการการช่วยเหลือจากภาครัฐต่อเจ้าของอาคารและผู้บริหารจัดการอาคารสำนักงานอย่างไรบ้าง

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ส่วนที่ 4: ผลกระทบทางด้านสิ่งแวดล้อม จากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

4.1 ประเภทและปริมาณขยะที่เกิดขึ้นระหว่างการเกิด COVID-19 เช่น หน้ากากอนามัยใช้แล้ว หรือ ขยะจากการขนส่งอาหาร มีการ เปลี่ยนแปลงอย่างไรเมื่อเทียบกับก่อนการเกิด COVID-19 และอาคารมีแนวทางการจัดการอย่างไร

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4.2 ปัญหาและข้อเสนอแนะ เพื่อการปรับปรุงประสิทธิภาพการจัดการขยะระหว่างการเกิด COVID-19

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APPENDIX 7

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับสถาบันและองค์กรอิสระ

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 2 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 9 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป เกี่ยวกับข้อมูลผู้ให้สัมภาษณ์

1.1 ประสบการณ์ในการทำงานที่เกี่ยวข้องกับการพัฒนาและปรับปรุงอาคาร ..... ปี

1.2 บทบาทของผู้ตอบชุดคำถามที่เกี่ยวข้องกับการจัดการและการป้องกันการระบาดของโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

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APPENDIX 7

ส่วนที่ 2: การจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 หน่วยงานของท่าน มีส่วนร่วมในการจัดการและการป้องกัน โรคติดต่อทางเดินหายใจ กรณีศึกษา โรค COVID-19 อย่างไรบ้าง

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2.2 ในความคิดของท่าน การนำมาตรการและข้อเสนอแนะ ที่ออกจากหน่วยงานท่านไปประยุกต์ใช้ เพื่อการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 กับอาคารสำนักงาน ส่งผลกระทบทั้งในด้านบวกและด้านลบต่ออาคารสำนักงานอย่างไรบ้าง

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2.3 ปัจจัยที่ทำให้การจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน ประสบความสำเร็จ คือสิ่งใด

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2.4 ปัญหาและอุปสรรคในการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ในอาคารสำนักงาน คือสิ่งใด ทั้งในด้านของการดำเนินการและด้านงบประมาณ

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2.5 เพื่อให้การป้องกันโรคมีประสิทธิภาพเพิ่มมากขึ้น มาตรการต่างๆที่นำมาใช้ในการจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 มีข้อเสนอแนะ เพิ่มเติมอย่างไรบ้าง

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2.6 ในความคิดของท่าน การเกิดขึ้นของโรคติดต่อทางเดินหายใจ COVID-19 ส่งผลกระทบทั้งทางด้านบวกและด้านลบในด้านเศรษฐกิจกับการใช้งานอาคารสำนักงานอย่างไร

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2.7 ในความคิดของท่าน การเกิดขึ้นของโรคติดต่อทางเดินหายใจ COVID-19 ส่งผลกระทบทั้งทางด้านบวกและด้านลบต่อสิ่งแวดล้อม เช่น การจัดการขยะ กับการใช้งานอาคารสำนักงานอย่างไร

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เลขที่โครงการ 087/64
วันที่รับรอง 27 พ.ค. 2564
วันหมดอายุ 26 พ.ค. 2565

Appendix 8

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับผู้อยู่อาศัยในอาคาร

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 3 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 7 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: มาตรการต่างๆ ในการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

1.1 อาคารมีการดำเนินการเพื่อจัดการและป้องกันการแพร่ระบาดของโรคติดต่อทางเดินหายใจ COVID-19 อย่างไรบ้าง

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1.2 ในความคิดของท่าน มาตรการใดที่ควรต้องมีการปรับปรุงเพิ่มเติม เพื่อการป้องกันและส่งเสริมสุขภาพของคนในอาคารสำนักงาน เมื่อเกิดภาวะโรคติดต่อทางเดินหายใจ COVID-19

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ส่วนที่ 2: ผลกระทบทางด้านเศรษฐกิจ จากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 การปฏิบัติตามมาตรการและคำแนะนำต่างๆ เพื่อการจัดการและการป้องกันโรคติดต่อทางเดินหายใจของอาคารสำนักงาน - กรณีศึกษา COVID-19 เช่น การจัดเตรียมหน้ากากอนามัย เจลแอลกอฮอล์ และการใช้รถยนต์ส่วนตัวเพื่อหลีกเลี่ยงการเดินทางด้วยรถสาธารณะ ส่งผลกระทบต่อค่าใช้จ่ายในการดำรงชีวิตในด้านอื่นๆ หรือไม่ อย่างไร

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2.2 มาตรการการช่วยเหลือจากภาครัฐ เช่น โครงการคนละครึ่ง, เราชนะ, เรารักกัน และอื่นๆ ท่านคิดว่ามีประสิทธิภาพเพียงพอ เหมาะสมหรือไม่ และท่านมีข้อเสนอแนะอื่นๆ ในการดำเนินการอย่างไร

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Appendix 8

ส่วนที่ 3: ผลกระทบทางด้านสิ่งแวดล้อม จากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

3.1 ประเภทและปริมาณขยะที่เกิดขึ้นระหว่างการเกิด COVID-19 เช่น หน้ากากอนามัยใช้แล้ว หรือ ขยะจากการขนส่งอาหาร มีการเปลี่ยนแปลงอย่างไรเมื่อเทียบกับก่อนการเกิด COVID-19

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3.2 ระหว่างการเกิด COVID-19 มีปัญหาและอุปสรรคในการจัดการขยะที่เกิดขึ้นอย่างไรบ้าง

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3.3 ข้อเสนอแนะอื่นๆ เพื่อการปรับปรุงประสิทธิภาพการจัดการขยะระหว่างการเกิด COVID-19

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APPENDIX 9

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับหน่วยงานภาครัฐที่ดูแลด้านสิ่งแวดล้อม

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 2 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 10 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป เกี่ยวกับข้อมูลผู้ให้สัมภาษณ์

1.1 ประสบการณ์ในการทำงานที่เกี่ยวข้องกับนโยบายการป้องกันและการจัดการขยะ ..... ปี

1.2 บทบาทของผู้ตอบแบบสอบถามที่เกี่ยวข้องกับการป้องกันและจัดการขยะเมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19

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APPENDIX 9

ส่วนที่ 2: การจัดการและการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 ในความคิดของท่าน ชนิดและปริมาณ ขยะที่เกิดขึ้นในช่วงการเกิดโรคระบาดทางเดินหายใจ COVID-19 เมื่อเปรียบเทียบกับก่อนการเกิดโรคระบาด มีความเหมือนหรือแตกต่างกันอย่างไร

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2.2 หน่วยงานของท่านมีบทบาท หน้าที่เกี่ยวกับการป้องกันและจัดการขยะเมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19 อย่างไร **(ถ้ามี ตอบคำถามต่อในข้อ 2.3-2.5, ถ้าไม่มีข้ามไปตอบข้อ 2.4-2.5)**

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2.3 หน่วยงานของท่านมีบทบาท หน้าที่เกี่ยวข้องกับการออกนโยบายและมาตรการต่างๆ ทางการจัดการขยะ ที่เกี่ยวข้องกับอาคารสำนักงาน กรณีศึกษา COVID-19อย่างไร **(ถ้ามี ตอบคำถามต่อในข้อ 2.4-2.5 ถ้าไม่มีข้ามไปตอบข้อ 2.4 -2.5)**

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2.4 จากมาตรการต่างๆ ที่ใช้ในปัจจุบัน

2.4.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.4.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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2.5 ในความคิดของท่าน มาตรการใดที่ควรต้องมีเพิ่มเติม ในการจัดการขยะในอาคารสำนักงาน เมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19

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2.6 จากมาตรการต่างๆ ที่ควรต้องเพิ่มเติมเข้ามา ในความคิดของท่านคิดว่า

2.6.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.6.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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APPENDIX 10

ชุดคำถามสำหรับการสัมภาษณ์

เกี่ยวกับมาตรการและผลกระทบจากการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

สำหรับหน่วยงานภาครัฐที่ดูแลด้านเศรษฐกิจ

ประกอบการทำวิทยานิพนธ์ หลักสูตร สิ่งแวดล้อม การพัฒนาและความยั่งยืน จุฬาลงกรณ์มหาวิทยาลัย

คำชี้แจง:

1. คำถามมีทั้งหมด 2 ส่วน เป็นคำถามปลายเปิดจำนวนทั้งหมด 9 ข้อ
2. ผู้ตอบแบบสอบถามสามารถให้ข้อมูลโดยการสัมภาษณ์ทั้งแบบพบหน้า และแบบออนไลน์

ส่วนที่ 1: คำถามทั่วไป เกี่ยวกับข้อมูลผู้ให้สัมภาษณ์

1.1 ประสบการณ์ในการทำงานที่เกี่ยวข้องกับนโยบายทางด้านเศรษฐกิจ ..... ปี

1.2 บทบาทของผู้ตอบแบบสอบถามที่เกี่ยวข้องกับนโยบายและมาตรการต่างๆ ทางเศรษฐกิจที่เกี่ยวข้องกับกลุ่มผู้ประกอบการที่เป็นเจ้าของอาคาร กรณีศึกษา COVID-19

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APPENDIX 10

ส่วนที่ 2: มาตรการและผลกระทบต่างๆ ในการป้องกันโรคติดต่อทางเดินหายใจ COVID-19 ของอาคารสำนักงาน

2.1 หน่วยงานของท่านมีบทบาท หน้าที่เกี่ยวกับมาตรการทางเศรษฐกิจ ในกรณีเกิดโรคติดต่อทางเดินหายใจ COVID-19 อย่างไร

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2.2 หน่วยงานของท่านมีบทบาท หน้าที่เกี่ยวข้องกับการออกนโยบายและมาตรการต่างๆ ทางเศรษฐกิจที่เกี่ยวข้องกับกลุ่มผู้ประกอบการที่เป็นเจ้าของอาคารและผู้บริหารอาคาร และผู้อยู่อาศัยในอาคารสำนักงาน กรณีศึกษา COVID-19อย่างไร **(ถ้ามี ตอบคำถามต่อในข้อ 2.3-2.5 ถ้าไม่มีข้ามไปตอบข้อ 2.4 -2.5)**

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2.3 จากมาตรการต่างๆ ที่ประกาศจากหน่วยงานของท่าน

2.3.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.3.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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2.4 ในความคิดของท่าน มาตรการทางเศรษฐกิจใดที่ควรต้องมีเพิ่มเติม เมื่อเกิดโรคติดต่อทางเดินหายใจ COVID-19

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2.5 จากมาตรการต่างๆ ที่ควรต้องเพิ่มเติมเข้ามา ในความคิดของท่านคิดว่า

2.5.1 ปัจจัยที่ทำให้การดำเนินนโยบายดังกล่าวมีความสำเร็จคืออะไร

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2.5.2 ปัญหาและอุปสรรคในการดำเนินนโยบายดังกล่าวมีอะไรบ้าง

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REFERENCES

1. United States Environmental Protection Agency (EPA). *EPA's Report on the Environment*. 2008; Available from: https://cfpub.epa.gov/roe/documents/EPAROE_FINAL_2008.PDF.
2. Klepeis, N.E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M., Switzer, P., ... & Engelmann, W. H. , *The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants.* Journal of Exposure Science & Environmental Epidemiology, 2001. **11**(3): p. 231-252.
3. History.com Editors. *Pandemics That Changed History*. 2020 Jan 30, 2020 [cited 2021 January, 10]; Available from: https://www.history.com/topics/middle-ages/pandemics-timeline.
4. UNCTAD, *International production beyond the pandemic,UNCTAD world investment report 2020New York, USA*. 2020, United Nations Publications
5. Wang, Z. and K. Tang, *Combating COVID-19: health equity matters.* Nature medicine, 2020. **26**(4): p. 458-458.
6. World Health Organization. *WHO Coronavirus (COVID-19) Dashboard*. 2021 [cited 2021 1 October]; Available from: https://covid19.who.int/.
7. The World Bank. *The Global Economic Outlook During the COVID-19 Pandemic: A Changed World*. 2020 June 8, 2020 [cited 2021 31 July]; Available from: https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world.
8. IMF. *Managing Divergent Recoveries, World Economic Outlook, International Monitory Fund, .* 2021 [cited 2021 31 July]; Available from: https://www.imf.org/en/Publications/WEO/Issues/2021/03/23/world-economic-outlook-april-2021.
9. Bazaid, A.S., et al., *Knowledge and practice of personal protective measures during the COVID-19 pandemic: A cross-sectional study in Saudi Arabia.* PloS one, 2020. **15**(12): p. e0243695.
10. Pamidimukkala, A. and S. Kermanshachi, *Impact of Covid-19 on field and office workforce in construction industry.* Project Leadership and Society, 2021: p. 100018.
11. World Health Organization. *Preventing and mitigating COVID-19 at work: policy brief*. 2021 [cited 2021 25 June]; 19 May 2021 [Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-workplace-actions-policy-brief-2021-1.
12. Alenezi, M.N., F.S. Al-Anzi, and H. Alabdulrazzaq, *Building a sensible sir estimation model for covid-19 outspread in kuwait.* Alexandria Engineering Journal, 2021. **60**(3): p. 3161-3175.
13. Yifang, X., et al., *Airborne infection risks of SARS-CoV-2 in US Schools and impacts of different intervention strategies.* Sustainable Cities and Society, 2021. **74**: p. 103188.
14. D'angelo, D., et al., *Strategies to exiting the COVID-19 lockdown for workplace and school: A scoping review.* Safety science, 2020: p. 105067.
15. Standard, I., *Sustainability in Building Construction - Sustainability Indicator -*

Part 1: Framework for the development of indicators and a core set of indicators for buildings. 2011, ISO: Geneva.

16. European committee (EN), *EN 15643-2019, Sustainability of construction works – Framework for assessment of buildings and civil engineering works* 2019.
17. The United State of Green Building Council (USGBC), *Leadership in Energy and Environmental Design for Building Design & Construction (LEED BD+C) Version 4.1*. October 2021.
18. The United State of Green Building Council (USGBC), ***Leadership in Energy and Environmental Design for Operation and Maintenance (LEED O&M) Version 4***. 2021.
19. Council, G.S.B., *DGNB*. 2020.
20. The Building and Construction Authority, S., *Green Mark for new non-residential buildings*. 2015.
21. The Building and Construction Authority, S., *Green mark for existing non-residential building* 2017.
22. International WELL Building Institute (IWBI), *The WELL Building Standard*. 2020.
23. The Centers for Disease Control and Prevention (CDC) and the General Services Administration (GSA), *FITWEL Standard*. 2020.
24. Thai Green Building Institute (TGBI), *Thai's Rating of Energy and Environmental Sustainability (TREES) for New Construction and Major Renovation And Core and Shell Building*. 2020.
25. Thai Green Building Institute (TGBI), *Thai's Rating of Energy and Environmental Sustainability (TREES) for existing buildings version 1.0*. 2020.
26. Santos, P., Pereira, A. C., Gervásio, H., Bettencourt, A., & Mateus, D., *Assessment of health and comfort criteria in a life cycle social context: Application to buildings for higher education.* Building and Environment, 2017. **123**: p. 625-648.
27. McArthur, J.J., & Powell, C., *Health and wellness in commercial buildings: Systematic review of sustainable building rating systems and alignment with contemporary research.* Building and Environment, 2020. **171**: p. 106635.
28. Cheung, T., Schiavon, S., Graham, L. T., & Tham, K. W., *Occupant satisfaction with the indoor environment in seven commercial buildings in Singapore.* Building and Environment, 2021. **188**: p. 107443.
29. American Society of Heating, R.a.A.-C.E., *ASHRAE 55: Thermal Environmental Conditions for Human Occupancy* 2017.
30. NIOSH, C.-G.J., Martin M, Park JH, Game S. Morgantown WV, *Dampness and Mold Assessment Tool for General Buildings - Form & Instruction*. Vol. Publication No. 2019-115. 2018: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH).
31. OSHA, D.o.L., United States of America, *Indoor Air Quality in Commercial and Institutional Buildings*. 2011.
32. Singapore Standard, *Code of Practice for Indoor air quality for air-conditioned buildings*. 2016, Spring Singapore.
33. Department of Health, M.o.P.H., *Indoor Air Quality assessment handbook for staff*. 2016: Department of Health, Ministry of Public Health,

.

34. Office of The Council of State, *Ministerial Regulation No. 39*, in *Chapter 3: Ventilation & Lighting*. B.E. 2537.
35. Administration, B.M., *The Commandment of Bangkok in the subject: Building Control B.E.2544*. B.E. 2544.
36. Ministry of Labor, *Ministerial Regulation on the prescribing of standard for administration and management of occupational, safety, health and environment in relation to heat, light and noise B.E. 2549* 2016, 7 October.
37. Belfiglio, V.J., *Control of epidemics in the Roman army: 27 BC–AD 476.* Int. J. Community Med. Public Health 2017. **4**: p. 138.
38. Bramanti, B., Stenseth, N. C., Walløe, L., & Lei, X., *Plague: A disease which changed the path of human civilization. In Yersinia pestis: retrospective and perspective* 2016: p. 1-26.
39. Ott, M., Shaw, S. F., Danila, R. N., & Lynfield, R., *Lessons learned from the 1918–1919 influenza pandemic in Minneapolis and St. Paul, Minnesota.* Public health reports, 2007. **122**: p. 803-810.
40. Baldwin, A.N., *Sars and the built environment in Hong Kong.* In Proceedings of the Institution of Civil Engineers-Municipal Engineer (2006, March). **159**(1): p. 37-42.
41. Megahed, N.A. and E.M. Ghoneim, *Antivirus-built environment: Lessons learned from Covid-19 pandemic.* Sustainable cities and society, 2020. **61**: p. 102350.
42. Raj, A.A.V., Velraj, R., & Haghighat, F., *The contribution of dry indoor built environment on the spread of Coronavirus: Data from various Indian states.* Sustainable Cities and Society, 2020. **62**: p. 102371.
43. Djalante, R., Nurhidayah, L., Van Minh, H., Phuong, N. T. N., Mahendradhata, Y., Trias, A., ... & Miller, M. A., *COVID-19 and ASEAN responses: Comparative policy analysis.* Progress in Disaster Science, 2020. **8**: p. 100129.
44. Ahsan, M.M., *Strategic decisions on urban built environment to pandemics in Turkey: Lessons from COVID-19.* Journal of Urban Management 2020. **9**(3): p. 281-285.
45. Shi, K.W., Huang, Y. H., Quon, H., Ou-Yang, Z. L., Wang, C., & Jiang, S. C., *Quantifying the risk of indoor drainage system in multi-unit apartment building as a transmission route of SARS-CoV-2.* Science of the Total Environment, 2021. **762**: p. 143056.
46. Kwok, C.Y.T., Wong, M. S., Chan, K. L., Kwan, M. P., Nichol, J. E., Liu, C. H., ... & Kan, Z. , *Spatial analysis of the impact of urban geometry and socio-demographic characteristics on COVID-19, a study in Hong Kong.* Science of the Total Environment, 2021. **764**: p. 144455.
47. Tleuken, A., Tokazhanov, G., Guney, M., Turkyilmaz, A., & Karaca, F., *Readiness assessment of green building certification systems for residential buildings during pandemics.* Sustainability, 2021. **13**(2): p. 460.
48. Bereitschaft, B. and D. Scheller, *How Might the COVID-19 Pandemic Affect 21st Century Urban Design, Planning, and Development?* Urban Science, 2020. **4**(4): p. 56.
49. Dietz, L., et al., *2019 novel coronavirus (COVID-19) pandemic: built environment considerations to reduce transmission.* Msystems, 2020. **5**(2): p.

e00245-20.
50. Anderson, J., L. Rainie, and E.A. Vogels. *Experts say the 'new normal'in 2025 will be far more tech-driven, presenting more big challenges*. Retrieved from PEW: https://www.pewresearch. org/internet/2021/02/18/experts-say-the-new-normal-in-2025-will-be-far-more-tech-driven-presenting-more-big-challenges 2021 [cited 2021 01 July].
51. Honey-Rosés, J., et al., *The impact of COVID-19 on public space: an early review of the emerging questions–design, perceptions and inequities.* Cities & Health, 2020. **4**: p. 1-17.
52. Sepe, M., *Covid-19 pandemic and public spaces: improving quality and flexibility for healthier places.* URBAN DESIGN International, 2021. **26**(2): p. 159-173.
53. Doğan, B., et al., *Investigating the effects of meteorological parameters on COVID-19: case study of New Jersey, United States.* Environmental Research, 2020. **191**: p. 110148.
54. Shahzad, K., et al., *Does environmental quality and weather induce COVID-19: case study of Istanbul, Turkey.* Environmental Forensics, 2021. **22**: p. 1-12.
55. Emmanuel, U., E.D. Osondu, and K.C. Kalu, *Architectural design strategies for infection prevention and control (IPC) in health-care facilities: towards curbing the spread of Covid-19.* Journal of Environmental Health Science and Engineering, 2020: p. 1-9.
56. Asian Development Bank. *Asian Development Bank. Protecting the Safety and Well-Being of Workers and Communities from COVID-19*. 2020 [cited 2021 31 July]; Available from: https://www.adb.org/sites/default/files/publication/614811/safety-well-being-workers-communities-covid-19.pdf.
57. Tokazhanov, G., et al., *How is COVID-19 experience transforming sustainability requirements of residential buildings? A review.* Sustainability, 2020. **12**(20): p. 8732.
58. Jiang, J., M. Chen, and J. Zhang, *How does residential segregation affect the spatiotemporal behavior of residents? Evidence from Shanghai.* Sustainable Cities and Society, 2021. **69**: p. 102834.
59. Architectural Society of China, *Draft of Assessment Standard for Healthy Building*, in *T/ASC 02—2016*. 2020, China Construction Industry Press: Beijing. p. 163-166.
60. Awada, M., et al., *Ten questions concerning occupant health in buildings during normal operations and extreme events including the COVID-19 pandemic.* Building and Environment, 2021. **188**: p. 107480.
61. Valizadeh, J., et al., *Hazardous infectious waste collection and government aid distribution during COVID-19: A robust mathematical leader-follower model approach.* Sustainable cities and society, 2021. **69**: p. 102814.
62. Collins, J.H., *The benefits and limitations of telecommuting.* Defense AR Journal, 2009. **16**(1): p. 55.
63. Eddleston, K.A. and J. Mulki, *Toward understanding remote workers' management of work–family boundaries: The complexity of workplace embeddedness.* Group & Organization Management, 2017. **42**(3): p. 346-387.
64. Ding, J., Yu, C. W., & Cao, S. J.,, *HVAC systems for environmental control to*

minimize the COVID-19 infection. Indoor and Built Environment, 2020. **29**(9): p. 1195-1201.

65. Cheng, P., Chen, W., Xiao, S., Xue, F., Wang, Q., Chan, P. W., ... & Li, Y., *Probable cross-corridor transmission of SARS-CoV-2 due to cross airflows and its control.* Building and environment, 2022. **218**: p. 109137.
66. de la Hoz-Torres, M.L., Aguilar, A. J., Costa, N., Arezes, P., Ruiz, D. P., & Martínez-Aires, M. D., *Reopening higher education buildings in post-epidemic COVID-19 scenario: monitoring and assessment of indoor environmental quality after implementing ventilation protocols in Spain and Portugal.* Indoor Air, 2022. **32**(5): p. e13040.
67. Fachrudin, H.T., Fachrudin, K. A., & Pane, I. F. , *Workplace Design Concept Based on Indoor Environmental Quality Analysis to Prevent Coronavirus Transmission.* Civil Engineering and Architecture, 2022. **10**(1): p. 121-130.
68. Jens, K., & Gregg, J. S. , *The impact on human behaviour in shared building spaces as a result of COVID-19 restrictions.* Building Research & Information, 2021. **49**(8): p. 827-841.
69. Qian, M., & Jiang, J., *COVID-19 and social distancing.* Journal of Public Health: From Theory to Practice, 2020. **30**: p. 259-261.
70. Sun, C., & Zhai, Z. , *The efficacy of social distance and ventilation effectiveness in preventing COVID-19 transmission.* Sustainable cities and society, 2020. **62**: p. 102390.
71. Chu, D.K., Akl, E. A., Duda, S., Solo, K., Yaacoub, S., Schünemann, H. J., ... & Reinap, M., *Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis.* The lancet, 2020. **395**(10242): p. 1973-1987.
72. Batool, A., Rutherford, P., McGraw, P., Ledgeway, T., & Altomonte, S., *Window views: Difference of perception during the COVID-19 lockdown.* LEUKOS, 2021. **17**(4): p. 380-390.
73. McKee, C., & Hedge, A., *Ergonomic lighting considerations for the home office workplace.* Work, 2022. **71**: p. 335-343.
74. Andargie, M.S., Touchie, M., & O'Brien, W., *Case study: A survey of perceived noise in Canadian multi-unit residential buildings to study long-term implications for widespread teleworking.* Building Acoustics, 2021. **28**(4): p. 443-460.
75. Şentop Dümen, A., & Şaher, K. , *Noise annoyance during COVID-19 lockdown: A research of public opinion before and during the pandemic.* The Journal of the Acoustical Society of America, 2020. **148**(6): p. 3489-3496.
76. Lee, H.P., & Kumar, S. , *Perspectives on the Sonic Environment and Noise Mitigations during the COVID-19 Pandemic Era.* Acoustics, 2021, July. **3**(3): p. 493-506.
77. Caniato, M., Marzi, A., & Gasparella, A., *How much COVID-19 face protections influence speech intelligibility in classrooms?* Applied Acoustics, 2021. **178**: p. 108051.
78. Bartalucci, C., Bellomini, R., Luzzi, S., Pulella, P., & Torelli, G., *A survey on the soundscape perception before and during the COVID-19 pandemic in Italy.* Noise Mapping, 2021. **81**(1): p. 65-88.
79. World Health Organization. *Considerations for public health and social*

measures in the workplace in the context of COVID-19. 2020 [cited 2021 31 July]; 10 May 2020:[Available from: https://www.who.int/publications/i/item/considerations-for-public-health-and-social-measures-in-the-workplace-in-the-context-of-covid-19.

80. World Health Organization. *Getting your workplace ready for COVID-19: How COVID-19 spreads,*. 2020 [cited 2020 5 May]; March 19, 2020:[Available from: https://apps.who.int/iris/bitstream/handle/10665/331584/WHO-2019-nCov-workplace-2020.2-eng.pdf?sequence=1&isAllowed=y.
81. World Health Organization. *Water, sanitation, hygiene, and waste management for the COVID-19 virus (interim guidance)*. 2020 [cited 2020 5 July]; April 23, 2020:[Available from: https://apps.who.int/iris/handle/10665/331846.
82. World Health Organization. *Roadmap to improve and ensure good indoor ventilation in the context of COVID-19*. 2021 [cited 2021 5 July]; March 1, 2021:[Available from: https://www.who.int/publications/i/item/9789240021280.
83. World Health Organization. *Considerations for implementing and adjusting public health and social measures in the context of COVID-19. Interim guidance* 2021 [cited 2021 25 June]; 14 June 2021:[Available from: https://www.who.int/publications/i/item/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance.
84. Centers for Disease Control and Prevention. *COVID-19 Employer Information for Office Buildings* 2021 [cited 2021 31 July]; Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html.
85. Centers for Disease Control and Prevention. *Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation* 2020 [cited 2021 9 April]; September, 22 2020:[Available from: https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html.
86. Centers for Disease Control and Prevention. *Guidance for Businesses and Employers Responding to Corona*. 2021 [cited 2021 25 June]; March 8, 2021:[Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html.
87. Centers for Disease Control and Prevention. *Cleaning and Disinfecting Your Facility* 2021 [cited 2021 25 June]; June 15,2021:[Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html.
88. Occupational Safety and Health Administration United States, D.o.l. *Protecting Workers: Guidance on Mitigating and Preventing the Spread of COVID-19 in the Workplace*. . 2021 [cited 2021 9 August]; Available from: https://www.osha.gov/coronavirus/safework.
89. Occupational Safety and Health Administration, U.S., Department of labor,. *Guidance on Preparing Workplace for COVID-19*. 2020 [cited 2021 25 Jube]; 03,2020:[Available from: https://www.osha.gov/sites/default/files/publications/OSHA3990.pdf.
90. European Centre for Disease Prevention and Control. *Guidelines for the implementation of non-pharmaceutical interventions against COVID-19* 2020 [cited 2021 July 1]; 24 September 2020:[Available from: https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-guidelines-non-pharmaceutical-interventions-september-2020.pdf.

91. European Centre for Disease Prevention and Control. *Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2*. 2020 [cited 2021 1 July]; 26 March 2020:[Available from: https://www.ecdc.europa.eu/sites/default/files/documents/Environmental-persistence-of-SARS_CoV_2-virus-Options-for-cleaning2020-03-26_0.pdf.
92. European Centre for Disease Prevention and Control. *Heating, ventilation, and air-conditioning systems in the context of COVID-19: first update* 2020 [cited 2021 1 July]; 10 November 2020:[Available from: https://www.ecdc.europa.eu/sites/default/files/documents/Heating-ventilation-air-conditioning-systems-in-the-context-of-COVID-19-first-update.pdf.
93. European Centre for Disease Prevention and Control. *Guideline for the use of non-pharmaceutical measures to delay and mitigate the impact of 2019-nCoV*. 2020 [cited 2021 1 July]; 10 February 2020:[Available from: https://www.ecdc.europa.eu/sites/default/files/documents/novel-coronavirus-guidelines-non-pharmaceutical-measures_0.pdf.
94. European Centre for Disease Prevention and Control. *All resources on COVID-19*

2021 [cited 2021 25 June]; Available from: https://www.ecdc.europa.eu/en/covid-19/all-reports-covid-19.
95. International Labor Organization. *A Safe and healthy return to work during the COVID-19 pandemic*. 2020, May [cited 2021 June, 25]; Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_745541.pdf.
96. International Labor Organization. *Safe Return to Work: Ten Action Points*. 2020, May [cited 2021 June, 25]; Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_745541.pdf.
97. International Labor Organization. *Prevention and Mitigation of COVID-19 at work, Action Checklist*. 2020, April 9 [cited 2021 June 25]; Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_741813.pdf.
98. American Society of Heating, R.a.A.-C.E. *ASHRAE Position Document on Infectious Aerosols*. 2020 [cited 2021 25 June]; April 14, 2020:[Available from: https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf.
99. American Society of Heating, R.a.A.-C.E. *Pandemic COVID-19 and Airborne Transmission, Environmental Health Committee (EHC) Emerging Issue Brief:*. 2020 [cited 2021 25 June]; 17 April 2020:[Available from: https://www.ashrae.org/file%20library/technical%20resources/covid-19/eiband-airbornetransmission.pdf.
100. American Society of Heating, R.a.A.-C.E. *COVID-19: One Page Guidance Documents*. 2021 [cited 2021 25 June]; Available from: https://www.ashrae.org/technical-resources/covid-19-one-page-guidance-documents.
101. American Society of Heating, R.a.A.-C.E. *ASHRAE EPIMEDIC TASK FORCE*.

2021 [cited 2021 25 June]; January 6, 2021 [Available from: https://www.ashrae.org/file%20library/technical%20resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf.

102. American Society of Heating, R.a.A.-C.E. *Guidance for Re-Opening Buildings*. 2021 [cited 2021 25 July]; September 14, 2021:[Available from: https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-re-opening-buildings.pdf.
103. American Society of Heating, R.a.A.-C.E. *Guidance for Building Operation During the COVID-19 Pandemic* 2020 [cited 2021 25 June]; Available from: https://www.ashrae.org/file%20library/technical%20resources/ashrae%20journal/2020journaldocuments/72-74_ieq_schoen.pdf.
104. Chang R., V., K., Munoz, M., Tam, F., Makol, M.K. *The Covid Resilience Ranking. The Best and Worst Places to Be in Covid: U.S. Sinks in Ranking. Bloomberg*. 2021 [cited 2021 9 August]; 28 July, 2020:[Available from: https://www.bloomberg.com/graphics/covid-resilience-ranking/. .
105. Ministry of Manpower, S. *Requirements for Safe management Measures at the workplace*. 2020 [cited 2021 25 June]; issued on 9 May 2020 update as of 10 June 2021:[Available from: https://www.mom.gov.sg/covid-19/requirements-for-safe-management-measures.
106. Federation, E.S.a.S.B. *Guide on Business Continuity Planning for COVID-19*. 2020 [cited 2021 31 July]; Available from: https://www.enterprisesg.gov.sg/-/media/esg/files/covid-19/guide-on-business-continuity-planning-for-covid.pdf?la=en.
107. Ministry of Foreign Affairs, R.o.K. *All About Korea's Response to COVID-19,*. 2020 [cited 2021 31 July]; October 7, 2020:[Available from: https://www.mofa.go.kr/eng/brd/m_22591/view.do?seq=35&srchFr=&srchTo=&srchWord=&srchTp=&multi_itm_seq=0&itm_seq_1=0&itm_seq_2=0&company_cd=&company_nm=&page=1&titleNm=.
108. Finnish Institute of Occupational Health. *Guidelines for Workplaces to Prevent Coronavirus Infection*. 2020 update 22 april 2021

[cited 2021 25 June]; 16 March 2020:[Available from: https://hyvatyo.ttl.fi/en/koronavirus/koronaohjeita-tyopaikoille-eri-kielilla/.
109. Denmark, W. *Prevent the spread of coronavirus*. 2021 [cited 2021 25 June]; Available from: https://www.sst.dk/en/English/Corona-eng.
110. Norwegian Institute of Public Health (NIPH). *Hand hygiene, cough etiquette, cleaning and laundry – Advice and information to the genral public*. 2020 [cited 2021 25 June]; published 07.04.2020 updated 04.03.2021:[Available from: https://www.fhi.no/en/op/novel-coronavirus-facts-advice/facts-and-general-advice/hand-hygiene-cough-etiquette-face-masks-cleaning-and-laundry.
111. Norwegian Institute of Public Health (NIPH). *Cleaning for COVID-19 – advice for sectors outside the healthcare service*. 2020 [cited 2021 25 June]; published 01.04.2020 updated 22.03.2021:[Available from: https://www.fhi.no/en/op/novel-coronavirus-facts-advice/advice-and-information-to-other-sectors-and-occupational-groups/cleaning-and-disinfection/.
112. Finnish Institute of Occupational Health. *Guidelines for Remote Work*. 2020 [cited 2021 25 June]; 29 April 2020 update 05.03.2021:[Available from:

https://www.ttl.fi/en/guidelines-for-remote-work/.
113. Mia Boesen, S.P. *Guidance for Employers in Denmark*. 2021 [cited 2021 25 June]; Available from: https://www.twobirds.com/en/news/articles/2020/denmark/covid-19-guidance-for-employers-in-denmark.
114. The state council. The people's republic of china. *China How to stay safe from COVID-19 at your work*. 2020 [cited 2021 26 June]; Available from: http://covid-19.chinadaily.com.cn/a/202002/25/WS5e67679fa31012821727ded6.html.
115. The state council. The people's republic of china. *China WHO recommends 10 basic personal prevention measures against COVID-19*. 2020 [cited 2021 26 June]; 25 February 2020:[Available from: https://english.www.gov.cn/news/topnews/202002/29/content_WS5e59a8cfc6d0c201c2cbd36f.html.
116. Centre for Health Protection. *Health Advice on Prevention of Coronavirus disease (COVID-19) in Workplace (Interim)* 2021 [cited 2021 26 June]; 14 April 2021:[Available from: https://www.chp.gov.hk/files/pdf/nid_guideline_workplace_eng.pdf.
117. Dyal, J.W., *COVID-19 among workers in meat and poultry processing facilities—19 states, April 2020.* MMWR. Morbidity and mortality weekly report, 2020. **69**: p. 557-561.
118. Agostinho, S. *Coronavirus outbreak continues to infect workers at both companies despite all measures on the ground*. 2020 [cited 2021 31 July]; Available from: https://www.jornalvalorlocal.com/nuacutemero-de-casos-de-covid-jaacute-chega-aos-26-na-sonae-e-aos-129-na-avipronto.html.
119. van den Berg, P., et al., *Effectiveness of 3 versus 6 ft of physical distancing for controlling spread of coronavirus disease 2019 among primary and secondary students and staff: A retrospective, statewide cohort study.* Clinical Infectious Diseases, 2021.
120. Ijaz, M., et al., *Meat production and supply chain under COVID-19 scenario: current trends and future prospects.* Frontiers in Veterinary Science, 2021. **8**: p. 432.
121. Adams, J.G. and R.M. Walls, *Supporting the health care workforce during the COVID-19 global epidemic.* Jama, 2020. **323**(15): p. 1439-1440.
122. Iavicoli, S., et al., *Risk assessment at work and prevention strategies on COVID-19 in Italy*. Plos one, 2021. **16**(3): p. e0248874.
123. Spinazzè, A., A. Cattaneo, and D.M. Cavallo, *COVID-19 outbreak in Italy: protecting worker health and the response of the Italian Industrial Hygienists Association.* Annals of work exposures and health, 2020. **64**(6): p. 559-564.
124. Ho, K.F.W., Ho,K.F.,Wong,S.Y.,Cheung,A.W.,&Yeoh,E., *Workplace safety and coronavirus disease (COVID-19) pandemic: survey of employees. [Preprint]*. 2020, Bulletin of the World Health Organization p. 1-7.
125. Molla, R. *This is the end of the office as we know it*. 2020 [cited 2021 29 July]; Available from: https://www.vox. com/recode/2020/4/14/21211789/coronavirus-office-space-work-from-home-design-architecture-real-estate.
126. Aday, S. and M.S. Aday, *Impact of COVID-19 on the food supply chain.* Food Quality and Safety, 2020. **4**(4): p. 167-180.

127. Braier, A., Garrett, M., Smith, S., Datar, A., Eggers, W.D. . *Designing adaptive workplaces, How the public sector can capitalize on lessons learned from COVID-19. Deloitte insights*. 2021 [cited 2021 5July]; 10 February 2021:[Available from: https://www2.deloitte.com/us/en/insights/industry/public-sector/designing-for-adaptive-work-in-the-public-sector.htm.
128. Semple, S. and J.W. Cherrie, *COVID-19: protecting worker health*. 2020, Oxford University Press UK.
129. Kurgat, E.K., et al., *Impact of a hygiene intervention on virus spread in an office building.* International journal of hygiene and environmental health, 2019. **222**(3): p. 479-485.
130. Günther, T., et al., *SARS-CoV-2 outbreak investigation in a German meat processing plant.* EMBO molecular medicine, 2020. **12**(12): p. e13296.
131. Herstein, J.J., et al., *Characteristics of SARS-CoV-2 transmission among meat processing workers in Nebraska, USA, and effectiveness of risk mitigation measures.* Emerging infectious diseases, 2021. **27**(4): p. 1032.
132. Weissberg, D., et al., *Does respiratory co-infection facilitate dispersal of SARS-CoV-2? investigation of a super-spreading event in an open-space office.* Antimicrobial Resistance & Infection Control, 2020. **9**(1): p. 1-8.
133. Zisook, R.E., et al., *Assessing and managing the risks of COVID-19 in the workplace: Applying industrial hygiene (IH)/occupational and environmental health and safety (OEHS) frameworks.* Toxicology and Industrial Health, 2020. **36**(9): p. 607-618.
134. Bromage, E. *The Risks - Know Them - Avoid Them*. 2020 [cited 2021 9 Aug]; Available from: https://www.erinbromage.com/post/the-risks-know-them-avoid-them.
135. Consulting, D. *Office layouts for the post COVID-19 workplace*. 2020 [cited 2021 31 July]; Available from: www.condecosoftware.com/blog/office-design-post-covid-19-workplace/.(
136. Judson, S.D. and V.J. Munster, *Nosocomial transmission of emerging viruses via aerosol-generating medical procedures.* Viruses, 2019. **11**(10): p. 940.
137. Falagas, M.E., et al., *Effect of meteorological variables on the incidence of respiratory tract infections.* Respiratory medicine, 2008. **102**(5): p. 733-737.
138. Mäkinen, T.M., et al., *Cold temperature and low humidity are associated with increased occurrence of respiratory tract infections.* Respiratory medicine, 2009. **103**(3): p. 456-462.
139. Moriyama, M., W.J. Hugentobler, and A. Iwasaki, *Seasonality of respiratory viral infections.* Annual review of virology, 2020. **7**: p. 83-101.
140. Priday, C. *Architecture after coronavirus*. 2020 [cited 2021 31 July]; Available from: https://exepose.com/2020/ 05/05/architecture-after-coronavirus.
141. Volini, E. *Returning to work in the future of work.* 2020 [cited 2021 July 29]; May 15, 2020.:[Available from: https://www2.deloitte.com/us/en/insights/focus/human-capital-trends/2020/covid-19-and-the-future-of-work.html. .
142. Muggah R., E.T. *Opinion: Re-designing the COVID-19 city.* . 2020 [cited 2021 July 29]; Available from: https://www.npr.org/2020/04/20/839418905/opinion-redesigning-the-covid-19-city
143. Gormley, M. *Coronavirus: People in tall buildings may be more at risk*. 2020

[cited 2021 July 29]; September 20:[Available from: https://www.fastcompany.com/90488321/live-in-a-tall-building-you-may-be-more-at-risk-of-contracting-coronavirus.
144. Klompas, M., M.A. Baker, and C. Rhee, *Airborne transmission of SARS-CoV-2: theoretical considerations and available evidence.* Jama, 2020. **324**: p. 441-442.
145. Franklin, N. *Offices in the post lockdown era will focus on what they are good at*. 2020 [cited 2021 July 29]; June 16, 2020:[Available from: https://workplaceinsight.net/offices-in-the-post-lockdown-era-will-focus-on-what-they-are-good-at/. .
146. Zhang Jensen, *Integrating IAQ control strategies to reduce the risk of asymptomatic SARS CoV-2 infections in classrooms and open plan offices.* Science and Technology for the Built Environment, 2020. **26**(8): p. 1013-1018.
147. Augenbraun, B.L., et al., *Assessment and mitigation of aerosol airborne SARS-CoV-2 transmission in laboratory and office environments.* Journal of Occupational and Environmental Hygiene, 2020. **17**(10): p. 447-456.
148. Diebner, R., Silliman, E., Ungerman, Kelly., Vancauwenberghe, M. . *Adapting customer experience in the time of coronavirus*. 2020 [cited 2021 31 July]; Available from: https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/adapting-customer-experience-in-the-time-of-coronavirus.
149. Kretchmer, H. *COVID-19: Is this what the office of the future will look like* 2020 [cited 2021 31 July]; Available from: https://www.weforum.org/agenda/2020/04/covid19-coronavirus-change-office-work-homeworking-remote-design/. .
150. Billington, L. *Understanding the Touchless Workplace*. 2020 [cited 2021 31 July]; April 15, 2020:[Available from: https://www.gensler.com/blog/understanding-the-touchless-workplace.
151. Van Doremalen, N., et al., *Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1*. New England journal of medicine, 2020. **382**(16): p. 1564-1567.
152. Reynolds, K.A., et al., *The healthy workplace project: reduced viral exposure in an office setting.* Archives of environmental & occupational health, 2016. **71**(3): p. 157-162.
153. Capolongo, S., et al., *COVID-19 and cities: From urban health strategies to the pandemic challenge. A decalogue of public health opportunities.* Acta Bio. Medica: Atenei Parmensis, 2020. **91**(2): p. 13.
154. Ye, C., et al., *Recovery of microbiological quality of long-term stagnant tap water in university buildings during the COVID-19 pandemic*. Science of The Total Environment, 2021: p. 150616.
155. Liang, J., et al., *Impact of Building Closures during the COVID-19 Pandemic on Legionella Infection Risks.* American Journal of Infection Control, 2021.
156. Baloh, J., et al., *Healthcare workers' strategies for doffing personal protective equipment.* Clinical Infectious Diseases, 2019. **69**(Supplement_3): p. S192-S198.
157. McMillan, L.L.P. *Terminations of Employees Breaching COVID-19 Protocols | Canada* 2020 [cited 2021 9 August]; Available from: https://iclg.com/briefing/15267-canada-terminations-of-employees-breaching-covid-19-protocols.
158. Dehghani, F., et al., *The hierarchy of preventive measures to protect workers*

against the COVID-19 pandemic: A review. Work, 2020(Preprint): p. 771-777.
159. Habibi, R., et al., *Do not violate the International Health Regulations during the COVID-19 outbreak.* The Lancet, 2020. **395**(10225): p. 664-666.
160. Sinha, R., Bhati, D. *Ivermectin for COVID-19: Mismatch between global and Indian policies, 19 May 2021*. *Down to earth.* . 2021 [cited 2021 30 July]; Available from: https://www.downtoearth.org.in/news/health/ivermectin-for-covid-19-mismatch-between-global-and-indian-policies-76984. .
161. Chikermane, G., Agrawal, R. . *Regulatory Changes in India in the Time of COVID-19: Lessons and Recommendations,ORF Special Report No. 110*. 2020 [cited 2021 30 July]; June 2020:[Available from: https://www.orfonline.org/research/regulatory-changes-in-india-in-the-time-of-covid19-67604/.
162. Boland, B., Smet, AD., Palter, R., Sanghvi, A. . *Reimagining the office and work life after COVID-19*. 2020 [cited 2021 July 29]; June 8, 2020:[Available from: www.mckinsey.com/business-functions/organization/our-insights/reimagining-the-office-and-work-life-after-covid-19.
163. Alter, L. *Architecture after the coronavirus*. 2020 [cited 2021 30 July]; Available from: https://www.treehugger.com/green-architecture/architecture-after- coronavirus.html
164. Guo, Z.-D., et al., *Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020.* Emerging infectious diseases, 2020. **26**(7): p. 1586.
165. Latour, B., *On recalling ANT' in Actor Network Theory and after*. Vol. John Law and John Hassard (eds). 1999: Oxford: Blackwell.
166. Mol, A.P., *[BOOK REVIEW] The refinement of production, ecological modernisation theory and the chemical industry.* Vol. 5. 1996: Environmental Politics. 569-570.
167. Chavalparit, O., *Clean technology for the crude palm oil industry in Thailand.* 2006: Wageningen University and Research.
168. Matthew B. Miles, A.M.H., *Qualitative Data Analysis: An Expanded Sourcebook*. 1994: Sage Publications, Inc.
169. The National Institute for Occupational Safety and Health (NIOSH). *Hierarchy of Controls*. 2021, [cited 2021 25 June]; Available from: https://www.cdc.gov/niosh/topics/hierarchy/default.html.
170. Centers for Disease Control and Prevention. *Ventilation in Buildings*

2021 [cited 2021 25 June]; June 2, 2021:[Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html.
171. International Labor Organization. *A Safe and healthy return to work during the COVID-19 pandemic*. 2020 [cited 2021 25 June]; May 2020:[Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_745541.pdf.
172. International Labor Organization. *Safe Return to Work: Ten Action Points*. 2020 [cited 2021 25 June]; May 2020:[Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_745541.pdf.
173. International Labor Organization. *Prevention and Mitigation of COVID-19 at*

work, Action Checklist. 2020 [cited 2021 25 June]; 9 April 2020:[Available from: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_741813.pdf.

174. Department of Disease Control, M.o.P.H. *Recommendations for self-protection*. 2020 [cited 2021 22 June]; January 29,2020:[Available from: https://ddc.moph.go.th/viralpneumonia/eng/file/recommendation/01self_protection.pdf.
175. Department of Disease Control, M.o.P.H. *Recommendations for Working Spaces and Organizations* 2020 [cited 2021 22 June]; January 30, 2020:[Available from: https://ddc.moph.go.th/viralpneumonia/eng/file/recommendation/012working_space.pdf.
176. Department of Disease Control, M.o.P.H. *Recommendations for businesses and workplaces in the Case of Finding COVID-19 Patients*. 2020 [cited 2021 22 June]; March 25, 2020:[Available from: https://ddc.moph.go.th/viralpneumonia/eng/file/introduction/22_workplace_owner.pdf.
177. Department of Disease Control, M.o.P.H. *Guideline for workplace to COVID-19*. 2020 [cited 2021 22 June]; April 11, 2020:[Available from: https://ddc.moph.go.th/viralpneumonia/file/int_operator/int_operator01_110463.pdf.
178. Department of Disease Control, M.o.P.H. *Preventive and Protective COVID-19's measures for workplace* 2021 [cited 2021 22 June]; January 4, 2021:[Available from: https://ddc.moph.go.th/viralpneumonia/file/int_operator/int_operator23_050164.pdf.
179. Department of Health, M.o.P.H. *Regulation, method and protective strategies to reduce the infection risk of COVID-19 for public and private workplace* 2020 [cited 2021 22 June]; March 11, 2020:[Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/34113/file_download/2ec9a1bb1574adf39d3f0515d74b0335.pdf.
180. Department of Health, M.o.P.H. *Recommendation to the public workplace during the pandemic of Corona Virus 2019 (COVID-19)*. 2020 [cited 2021 22 June]; March 19, 2020:[Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/34118/file_download/433d8f0d40a0063792472c87855ee8a8.pdf.
181. Department of Health, M.o.P.H. *Recommendation to protect and prevent the pandemic of Corona Virus 2019 (COVID-19) for workplace or factory* 2021 [cited 2021 22 June]; January 6, 2021:[Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/35211/file_download/1e58c8a4e887b4346ea7721a94f86e08.pdf.
182. Department of Health, M.o.P.H. *Guidance to control and protect the pandemic of Corona Virus 2019 (COVID-19) The first edition* 2021 [cited 2021 22 June]; January 9, 2021:[Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/35215/file_d

ownload/835ac85353ecec9753e6ba53f7bd3526.pdf.
183. Department of Health, M.o.P.H. *Recommendation for ventilation to prevent and protect the pandemic of Corona Virus 2019 (COVID-19)* 2021 [cited 2021 12 August]; Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/35238/file_download/aab124b5252413c76048e5323c538208.pdf.
184. Department of Health, M.o.P.H. *Cleaning and disinfection measure during COVID-19*. 2021 [cited 2021 12 August]; Available from: https://covid19.anamai.moph.go.th/web-upload/2xdccaaf3d7f6ae30ba6ae1459eaf3dd66/m_document/6736/35237/file_download/7d257a9842f8c584c842a0ba3d049c2b.pdf.
185. ECLAC. *Economic Commission for Latin America and the Caribbean COVID-19 Special Report No.4: Sectors and businesses. Facing COVID-19: Emergency and Reactivation. 2021*. 2021 [cited 2021 31 July]; Available from: https://repositorio.cepal.org/bitstream/handle/11362/45736/5/S2000437_en.pdf. .
186. Tran, B.X., et al., *The operational readiness capacities of the grassroots health system in responses to epidemics: Implications for COVID-19 control in Vietnam*. Journal of global health, 2020. **10**(1).
187. Persily, A., et al., *Building retrofits for increased protection against airborne chemical and biological releases*. National Institute of Standards and Technology, Gaithersburg, MD, 2007.
188. Christopherson, D.A., et al., *High-efficiency particulate air filters in the era of COVID-19: function and efficacy*. Otolaryngology–Head and Neck Surgery, 2020. **163**(6): p. 1153-1155.
189. Cortiços, N.D. and C.C. Duarte, *COVID-19: The impact in US high-rise office buildings energy efficiency*. Energy and Buildings, 2021. **249**: p. 111180.
190. Alraouf, A.A., *The new normal or the forgotten normal: contesting COVID-19 impact on contemporary architecture and urbanism*. Archnet-IJAR: International Journal of Architectural Research, 2021.
191. Mudditt, J. *Pandemic-proofing offices could involve short-term fixes, new working patterns and long-term design upgrades that put hygiene at the heart of workplace planning.2020*. 2020 [cited 2021 9 August]; Available from: https://www.bbc.com/worklife/article/20200514-how-the-post-pandemic-office-will-change.
192. Budds, D. *Design in the age of pandemics, throughout history, how we design and inhabit physical space has been a primary defense against epidemics, Curbed*. 2020 [cited 2021 31 July]; Available from: https://www.curbed.com/2020/3/17/21178962/design-pandemics-coronavirus-quarantine. .
193. Buxton, P. *Rethink: Working miracles, the office design revolution*. 2020 [cited 2021 9 August]; 22 May, 2020:[Available from: https://www.ribaj.com/intelligence/post-pandemic-design-offices-bco-alexi-marmot-cushman-and-wakefield-hassell.
194. Wilson, M. *Our offices will never be the same after COVID-19. Here's what they could look like*. 2020 [cited 2021 9 August]; Available from: https://www.fastcompany.com/90488060/our-offices-will-never-be-the-same-after-covid-19-heres-what-they-could-look-like.

195. Pocock, L. and R. Shams, *The post Covid world: architecture, internal spaces, public spaces and streetscapes.* Middle East Journal of Business, 2020. **15**(3).
196. Carino, M.M. *Offices prepare for post-virus return to work*. 2020 [cited 2021 9 August]; Available from: https://www.marketplace.org/2020/04/22/how-will-office-spaces-change-after-covid19/. .
197. Cirrincione, L., et al., *COVID-19 pandemic: Prevention and protection measures to be adopted at the workplace.* Sustainability, 2020. **12**(9): p. 3603.
198. Brosseau, L.M., J. Rosen, and R. Harrison, *Selecting controls for minimizing SARS-CoV-2 aerosol transmission in workplaces and conserving respiratory protective equipment supplies.* Annals of work exposures and health, 2021. **65**(1): p. 53-62.
199. Plantes, P.J., et al., *Model for mitigation of workplace transmission of COVID-19 through population-based testing and surveillance.* Population Health Management, 2021. **24**(S1): p. S-16-S-25.
200. Pan, L., et al., *Prevention and control of coronavirus disease 2019 (COVID-19) in public places.* Environmental Pollution, 2021: p. 118273.
201. Helmold, M., *New Work, Transformational and Virtual Leadership.* Management for Professionals, 2021.
202. Yoo, J.Y., et al., *Comparative analysis of COVID-19 guidelines from six countries: a qualitative study on the US, China, South Korea, the UK, Brazil, and Haiti.* BMC public health, 2020. **20**(1): p. 1-16.
203. Lavizzari, A., et al., *International comparison of guidelines for managing neonates at the early phase of the SARS-CoV-2 pandemic.* Pediatric research, 2021. **89**(4): p. 940-951.
204. Johansen, T.B., et al., *Infection prevention guidelines and considerations for paediatric risk groups when reopening primary schools during COVID-19 pandemic, Norway, April 2020.* Eurosurveillance, 2020. **25**(22): p. 2000921.
205. Dennerlein, J.T., et al., *An integrative total worker health framework for keeping workers safe and healthy during the COVID-19 pandemic.* Human factors, 2020. **62**(5): p. 689-696.
206. Brooks, J.T. and J.C. Butler, *Effectiveness of mask wearing to control community spread of SARS-CoV-2.* Jama, 2021. **325**(10): p. 998-999.
207. Bashir, A., U. Izhar, and C. Jones. *IoT-based COVID-19 SOP compliance and monitoring system for businesses and public offices*. in *Engineering Proceedings*. 2020. Multidisciplinary Digital Publishing Institute, Basel, Switzerland.
208. Dutta, A. and W. Jinsart, *Air Quality, Atmospheric Variables and Spread of COVID-19 in Delhi (India): An Analysis.* Aerosol and Air Quality Research, 2021. **20**.
209. Forsyth, A. *What role do planning and design play in a pandemic?* 2020 [cited 2021 31 July]; 19 March 2020:[Available from: https://www.gsd.harvard.edu/2020/03/what-role-do-planning-and-design-play-in-a-pandemic-ann-forsyth-reflects-on-covid-19s-impact-on-the-future-of-urban-life/
210. Spolidoro, B. *Healthy Buildings: How Architecture Can Defend Us from COVID-19.* 2020 [cited 2021 31 July]; Available from: https://www.workdesign.com/2020/05/healthy-buildings-how-architecture-can-

defend-us-fromcovid-19/.(

211. Bahadursingh, N. *Ways COVID-19 Will Change Architecture*. 2020 [cited 2021 31 July]; Available from: https://architizer.com/blog/inspiration/industry/covid19-city-design/. .
212. Alhusban, A.A., S.A. Alhusban, and M.A. Alhusban, *How the COVID 19 pandemic would change the future of architectural design.* Journal of Engineering, Design and Technology, 2021.
213. O., W. *Smart lifts, lonely workers, no towers or tourists: architecture after coronavirus.* . 2020 [cited 2021 9 August]; Available from: https://www.theguardian.com/artanddesign/2020/apr/13/smart-lifts-lonely-workers-no-towers-architecture-after-covid-19-coronavirus.
214. Nichols, M. *An IoT-Enabled Office Is a Must, Post-COVID*. 2020 [cited 2021 31 July]; Available from: https://connectedremag.com/smart-buildings/iot/an-iot-enabled-office-is-a-must-post-covid/.
215. Michaels, D. and G.R. Wagner, *Occupational Safety and Health Administration (OSHA) and worker safety during the COVID-19 pandemic.* Jama, 2020. **324**(14): p. 1389-1390.
216. Health, M.o.P., *Waste Management During Corona Virus 2019 (COVID-19)*, D.o. Health, Editor. March 31, 2020.
217. Health, M.o.P., *Infected waste management recommendation for waste collector during Corona Virus 2019 (COVID-19)*, D.o. Health, Editor. April 8, 2020.
218. Ministry of Public Heaalth. *Environmental health operation system handbook for local government organization* May, 2020.
219. Department of Health, M.o.P.H. *Number of workplace that have been registered in Thai Stop COVID program*. 2022 [cited 2022 January, 18]; Available from: https://stopcovid.anamai.moph.go.th/dashboard_top10/.
220. State, O.o.t.C.o., *Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 1)*. March, 25 2020.
221. State, O.o.t.C.o., *Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 23)*. May 15, 2021.
222. State, O.o.t.C.o., *Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) (No. 24)* June 19, 2021.
223. Committee, N.C.D., *Regulation from the National Communicable Disease Committee Subject: The penalty when not following the regulation Issued under the Emergency Decree on Public Administration in Emergency Situations B.E. 2548 (2005) under the Coronavirus Disease 2019 (COVID-19)* June 7, 2021.
224. Health, M.o.P., *The Announcement from Department of Health, Ministry of Public Health. Subject: The measure to prevent and protect from Coronavirus Disease 2019 (COVID-19) for government, private, and workplace 2020*, D.o. Health, Editor. March 11, 2020.
225. Health, M.o.P., *The Announcement from Department of Health, Ministry of Public Health. Subject: The measure to prevent and protect from Coronavirus Disease 2019 (COVID-19) for high health risk workplace 2021* September 17,

2021.

226. Interior, M.o., *Missive from Ministry of interior 0230/ 3451* June 12, 2020.
227. Bangkok Metropolitan Administrative (BMA). *Announcement of the BMA, Subject: Citizens in Bangkok Metropolis Area Shall Always Wear Sanitary or Fabric Face Masks outside Residence or Accommodation*. April 25, 2021 [cited 2022 January, 6].
228. Health, M.o.P., *Ministerial regulations: infected waste management 2002* D.o. Health, Editor. July 25, 2002.
229. Health, M.o.P., *Ministerial regulations: infected waste management 2021 (Issue2)*, D.o. Health, Editor. February 3, 2021.
230. Health, M.o.P., *Annoucemeent from Ministry of Public Health: Infected waste management by other methods: 2021*. September 16 ,2021.
231. Allen, J.G., Bernstein, A., Cao, X., Eitland, E., Flanigan, S., Gokhale, M., & Yin, J. , *The 9 foundations of a healthy building*. 2017: Harvard: School of Public Health.

VITA

NAME	Panupant Phapant
DATE OF BIRTH	7 December 1979
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Environment, Development, and Sustainability, Graduate School
HOME ADDRESS	50/19 Moo 4 Soi Phaholyothin 52 Klongtanon Saimai Bangkok
PUBLICATION	Phapant, P., Dutta, A., & Chavalparit, O. (2021). COVID-19 Experience Transforming the Protective Environment of Office Buildings and Spaces. Sustainability, 13(24), 13636.