A CRITICAL ANALYSIS OF THE IMPACT OF CLIMATE CHANGE ON BUILDINGS AND CONSTRUCTION WORK

ARC. AKWAOWO, Dianabasi Reuben
Department of Architecture
Akwa Ibom State Polytechnic
Ikot Osura;

UMOH, Ekerete Udo
Department of Architecture
Akwa Ibom State Polytechnic

AND

OBAMOH, Hannah Yetunde
Department of Architectural Technology
Federal Polytechnic Ukana

ABSTRACT

Climate change is an imminent, multi-faceted concern that encompasses a large array of industries and will continue to evolve as the extent of this force is continuously explored and researched. In its current capacity, climate change has already had a direct impact on the construction industry. Climate change has impacted all aspects of construction projects, from the type and sources of building materials to the equipment and methods used in the physical construction, to the planning and designing of future projects with the intent of minimising climate change effects. So in the paper, we looked at the concept of building, which is a type of construction made from solid materials and used to accommodate people and objects, i.e., housing, and also for various activities such as trade, finance, art, and the practise of religion, among others. Since the beginning of mankind, man has been occupied and worried about the advancements in techniques and materials used for construction, even up to the point of bringing beauty to buildings through the decoration of some of their parts. The paper also looked into the concept of construction work, effect of climate on buildings and construction work is not exempted, and most of all the remedies for the negative impact of the climatic change effect on buildings and construction are studied. However, one of the recommendation made in this paper was that climate change should be diligently studied so as to help engineers know the type of construction project to be carried out in the area at the right time and the appropriate materials to use.

KEYWORDS: Climate change, Buildings, Construction work, Effect and Remedies

Introduction

Climate change is a global phenomenon that disturbs all aspects of human life. These range from rising temperatures, higher sea levels, and more frequent extreme weather events. The result of these changes is felt throughout all aspects of the environment. Climate change has a tangible impact on the physical environment, which in turn puts the construction sites and the individuals working there at elevated risk for mishaps and incidents. Within the construction

industry, climate change has had a direct effect on the increases in overall ambient temperature of jobsites around the country, the duration and intensity of the seasons, and the predictability and ferocity of storms (Pourmokhtarian, Bakhshi, Bannon, & Everett, 2022). As many construction professionals spend large portions of their shift in either a combination of indoor and outdoor space or entirely outdoors, a rise in ambient air temperature illustrates a significant risk for these workers, who often perform activities with a heavy level of exertion. Natural disasters can have devastating effects on jobsites and the personnel who are there. Financial losses from natural disasters in the United States have risen from $528 billion from the years of 1981-1990 to an astounding $1,230 billion between 2001 and 2010 (Schulte, Bhattacharya, Butler, Chun, et al., 2016). From period of 1992–2006, there were 62 floods, 72 hurricanes, and 80 wildfires that resulted in fatalities. While these fatalities were among multiple industries and not solely related to the construction industry, construction did make up a significant number of these fatalities, with restoration activities related to post-hurricane reconstruction accounting for 72 deaths alone (Schulte et al., 2016). Climate change brings with it dangerous and destructive forces that continue to elevate the danger level on jobsites and for the employees working there.

Inclement weather and even rare, disastrous storms are not uniquely new to the construction industry, as every project is subject to the climate and geographical risk of the site's location. Where once there was insurance to stave off significant losses due to weather-related setbacks, climate change is also altering the very fabric of certain financial institutions that used to insulate the construction industry from these losses (Pourmokhtarian, et al., 2022). Insurance companies have always faced a guessing game, but they have thrived on the ability to predict when and where disaster would strike. Climate change also alters the game as the frequency and severity of these storms are on the rise. Accordingly, Saha and Viney (2020) noted that climate change is on a trajectory to cause a collapse across multiple buildings, which will in turn change the way in which insurers are able to calculate the risks associated with these projects. If insurers are no longer willing to take on the risks associated with climate change, then there will be deep financial consequences as all industries absorb this immense cost.

Concept of Climate Change

According to Riedy (2016), "climate" is the average of the weather conditions at a particular point on the Earth. Typically, climate is expressed in terms of expected temperature, rainfall, and wind conditions based on historical observations. On the other hand, "climate change" is a change in either the average climate or climate variability that persists over an extended period. The Earth's climate has always changed. Changes in the Earth's orbit, the energy output of the sun, volcanic activity, the geographic distribution of the Earth's land masses, and other internal or external processes can influence the climate. Scientists refer to this type of long-term climate change as "natural climate change" (Giddens, 2011). As a result of natural climate change, the Earth has experienced regular cold periods (or ice ages) when glaciers covered large parts of the Earth's surface. The Earth has also experienced warmer periods when sea levels were much higher than they are now. In the Earth's long-term history, the current period is characterised by a relatively warm, stable climate that has lasted since the end of the last ice age about 11,700 years ago (Riedy, 2016). This period is known to geologists as the Holocene and is the period during which human civilisation has flourished.

The impacts of climate change differ between different regions. In hot climates, the main challenges for the built environment are drought and overheating. In coastal cold climates, overheating is not likely to present a problem for buildings, but a milder climate brings challenges as well. If this were the only type of climate change, then the interest among sociologists would be minimal. However, scientific observations and models indicate that the Earth's climate changes due to human activity. This is termed "anthropogenic climate change" (Riedy, 2016). The processes involved are complex but can be summarised as follows. Human activities, such as burning fossil fuels (coal, oil, and natural gas) to make electricity and power vehicles, clearing forests for farms and cities, and cultivating livestock, release "greenhouse gases" into the atmosphere. The main greenhouse gases are carbon dioxide, methane, halocarbons, and nitrous oxide (Giddens, 2011).

However, climate change is more of interest to sociologists because the activities that are responsible for anthropogenic climate change are embedded in human social life (Hanssen-Bauer et al., 2015). Everyday social practises like eating, working, moving about, and heating and cooling our homes result in emissions of greenhouse gases that contribute to climate change. Further, the causes and impacts of climate change are unevenly distributed, raising questions of social justice. In general, wealthier countries produce more greenhouse gas emissions per person than poorer countries, which tends to make them more vulnerable to the impacts of climate change (Lisø, Kvande, and Time, 2017).

Concept of Building

The word "building" is both a noun and a verb, describing both the structure itself and the act of making it. A building, or edifice, is a structure with a roof and walls standing more or less permanently in one place. A building, derived from the Latin "aedificum", is a fixed structure that serves as a human dwelling or allows for various activities. The etymology of the term is associated with "make fire," as the first human constructions were aimed at fire protection (to prevent it being turned off by the wind or rain) (Wiki Didactic, 2013). Buildings come in a variety of sizes, shapes, and functions and have been adapted throughout history for a wide number of factors, from building materials available to weather conditions, land prices, ground conditions, specific uses, and aesthetic reasons (Egenhofer, 2012). Through the course of time, styles, materials, and techniques for building have been changing and adapting to the needs of each era. However, the materials and techniques used for the construction of buildings are changing with the advance of history. Referred to as "architecture to science," it is dedicated to the art of building construction. Buildings in general usually work with joint architects, engineers, and other workers or laborers. More likely, buildings are types of constructions made from solid materials and used to accommodate people and objects, i.e., like housing, and also for various activities such as trade, finance, art, and the practise of religion, among others (Wiki Didactic, 2013).

However, Wendt and Cerf (2009) noted that buildings serve several societal needs—primarily as shelter from the weather, security, living space, privacy, a place to store belongings, and a place to comfortably live and work. A building as a shelter represents a physical division between the human habitat (a place of comfort and safety) and the outside world (a place that at times may be harsh and harmful). As a public building (owned by the state) or a private building (whose owner is a physical or legal person) (Wiki Didactic, 2013). In terms of use, government buildings (which house the government delegations), industrial buildings (which host productive

activities), commercial buildings (composed of one or more stores), and military buildings (such as the barracks), among others (Designing Buildings, 2020).

Concept of Construction Work

All actions required for the development, construction, renovation, furnishing, equipping, and implementation of a project's plans and designs can be referred to as construction work. According to Law Insider (2018), construction work, or "works," is the provision of a set of goods and services for the development, extension, installation, repair, maintenance, renewal, removal, renovation, alteration, dismantling, or demolition of a fixed asset, such as a building or engineering infrastructure.

However, Lingard, Warmerdam and Shooshtarian (2017), viewed construction work as a variety of processes including:

- the construction of new buildings or structures
- additions and alterations to existing structures
- demolition or wrecking of existing buildings or structures
- installation, maintenance and repair of existing structures, and
- site preparation activities.

They further added that "construction work" is any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning, or dismantling of a structure. Construction is a high-risk activity that must be managed from procurement through the design process and to the end of the construction stage. Everyone involved in a construction project must appreciate their role, from client to project supervisor design process (PSDP), designer, project supervisor construction stage (PSCS), contractor, and employees (Swingland, 2011). There are many ways to classify the different types of construction: by sector, owner, occupancy, and fire resistance. All of these different categories give important information about the kind of construction work required as well as the laws that govern the construction process (Health & Safety Authority, 2020). Furthermore, Wolfe (2013) stated that the four key types of construction include residential, institutional, and commercial, specialised industrial construction, infrastructure, and heavy construction, which covers nearly every construction project. MNCS Editorial (2019) added that construction work projects can be either publicly or privately funded.

Impact of Climate Change on Construction Work

Climate change is a major concern for the construction industry due to the impact it has on the project life cycle.

Impacts on Cost and Schedule

According to Pourmokhtarian, et al. (2022), when the effects of climate change culminate in large destructive natural disasters, the construction industry is always at the forefront of institutions most directly affected. Natural disasters' effects on the construction industry are twofold, as not only do these storms have direct effects by damaging projects that are in progress, but they also cause damage to already existing roads, utilities, and other infrastructure that in turn needs to be repaired. These disasters also have an indirect effect on

the industry as they create issues with the industry's supply chain that can impact anticipated delivery dates of the project, which in turn can lead to cost overruns. In the post-natural disaster period, the combination of several contributing factors, such as disruption to basic utility services, stark increases in demand for skilled labour, and massive material price escalation, all compounded to increase the duration and cost of the project (Pamidimukkala, Kermanshachi, & Safapour, 2020).

Impact on Designs and Projects

Climate change is affecting both new construction and renovations. One aspect that is most affected is the sustainability design principles being incorporated into new designs. These sustainability features include water conservation, high-efficiency mechanical units, using environmentally sustainable products, optimizing operation and maintenance practices, choosing an appropriate building site, and enhancing the indoor air quality (GSA, 2021). New construction incorporates resiliency features in the design, which should be implemented in planned renovations as they are a crucial opportunity to upgrade the existing structures to cope with the predicted climatic conditions of the future. These resiliency additions range from planning to incorporate flood barriers to increased ventilation to deal with the predicted extended periods of high temperatures (Button, 2018). Buildings are not alone in their efforts to incorporate resiliency and sustainability features into their design; infrastructure is also an active participant in combating the effects of climate change (MassDOT, 2021).

Damages to Materials and Machinery at Construction Sites

Depending on the magnitude of the disaster, materials at construction sites, such as steel props, plywood, and other heavy objects, can be thrown about at a very high speed. However, construction projects that employ light wooden frame equipment for construction are significantly at high risk of being negatively impacted by natural disasters like climate change (Hatzikyriakou, Lin, Gong, Xian, Hu, & Kennedy, 2016). However, Hegeman (2019) added that climate change is driving significant changes in construction material composition and manufacturing. Increasingly stronger, lighter, and more durable materials are required, which drives the cost of materials up. Those costs will eventually need to be borne by the construction companies. Likely, construction companies will increasingly find themselves facing increased insurance costs due to project delays, which are related to extreme weather and (perceived and actual) labour risks as a result of climate change.

Impact on Thermal Comfort

Maintaining indoor thermal comfort during summer has become a major issue and will grow worse along with climate change. This is shown by Yildiz, (2014), who simulated the climate change impact on a typical apartment building in Istanbul. Another example, from São Paolo, Brazil, (Alves et al., 2016) came to the same conclusions. Sailor, (2014), investigates the role of global and local warming on indoor thermal comfort in representative buildings in two warm climates in the U.S. It was found through building simulations that failure of air-conditioning will have major consequences for the indoor comfort; the maximum summer indoor temperature can increase by 10–140 C. Thermal comfort and overheating risk in educational buildings in Cyprus were investigated by Heracleous and Michael, (2018).

Damage to, and Destruction of, Buildings and Infrastructure

Extreme weather events are becoming more common and severe, which has the potential to damage, destroy, or seriously impede the construction industry's operations. Buildings may be damaged or even destroyed by the effects of extreme weather events and climate change (Laurencine, 2014). As extreme temperature spells become more frequent or severe, buildings may become less comfortable. They may also degrade more quickly if changes in air pollution patterns increase their exposure to compounds that may be damaging to building materials, such as acid rain. However, construction projects that require dry conditions, such as laying roads or foundations, may be delayed indefinitely until the weather improves. This can cost contractors thousands of dollars or rupees per day if not properly planned for in advance (Laurencine, 2014).

Health and Safety

Climate change, which is creating enormous concern globally, can be extremely dangerous for construction workers. Weather conditions including heavy rain, strong wind gusts, or even extreme heat might result in damage from slipping or hyperthermia (Laurencine, 2014). These can happen in a matter of seconds, and because construction sites are open, there's a great risk of injury to workers and property. Unsecured materials at construction sites are prone to becoming debris, resulting in damage to anyone on the site when they are hurled around at high speeds (Ham, Lee & Chowdhury, 2017). Climate change may also result in flash floods and fire disasters, which are two factors to consider on a construction site, as well as the safety of the construction crew and employers. When it comes to high-rise building projects, this element should be given more consideration because personnel must be evacuated from each floor, which takes a long time (Said, Kandil & Cai, 2012).

Preventive Measures and Remedies to the Negative Impact of Climate Change on Buildings

New Technology

The usage of heavy machinery in the construction business is a symbol of the industry. The use of fossil-fueled equipment contributes to the industry's annual emissions. Electric heavy equipment is being tested as a way to reduce emissions. Caterpillar has developed an all-electric 26-ton excavator, the first of its kind in its class (Lambert, 2019). Caterpillar is not the only company pushing for electric machinery. Volvo, like other prominent manufacturers, is trying to release all-electric vehicles (Volvo, n.d., 2021). Many companies are now supplying remote-controlled equipment in addition to electric power equipment (Caterpillar, n.d., 2021). These new technologies help workers stay safe while also combating climate change. The general use of all electric equipment is lagging, prohibiting large-scale production of these machines. Technology is not just improving existing equipment; it is also on the verge of becoming a viable substitute for human labour. Robotics has progressed rapidly and continues to do so at a rapid pace. While rising temperatures have an impact on human labour, robots can continue to work unaffected (Pourmokhtarian, et al., 2022). While climate change may not be the primary driving force behind the development of these robots, it does present them with another benefit. Advance Construction Robotics, for example, makes automated tools for tying and installing rebar on horizontal planes (Advance Construction Robotics, n.d., 2021). Drones are another technology being used to boost efficiency in all phases of construction, including inspections, surveying, mapping, and progress walkthroughs, with trials underway to use drones

to accomplish chores like painting (Knight, 2020). Robotics will become more common as technology progresses. As the advantages of higher productivity, the ability to work in extreme conditions, and the cost reduction of their use become attractive, they will be implemented (Raczon, 2020).

Implementing New Designs

Not only are the current effects of climate change here to stay, but as the construction industry looks to the future, the evidence suggests that there will be future climate-related issues that will compound the current problems that will need to be identified, analysed, and accounted for in future design. Ensuring that the projects that are being constructed are at the forefront in terms of resiliency is a critical factor for both designers and developers (Pourmokhtarian, et al., 2022). As greener technologies become available and green building becomes the industry standard, the starting point for many of these projects is to adapt the project delivery method. While the traditional design-bid-build (DBB) method was used to complete projects, changing technologies and ever-changing legislation that defines green construction require all team members to communicate and be more involved. The first step in creating a resilient building is implementing an integrated construction process (ICP) and using an integrated project delivery (IPD) method. IPD ensures that all major team members in the construction process are collaborating and supporting each other to successfully integrate the necessary technologies and meet the criteria of the regulatory administrations to be considered green and resilient projects (Viana, Bonaventura, Mohammad & Kahvandi, 2020). Ensuring that all project team members are capable of delivering the desired product is essential to the project's success.

Understanding the changes that are occurring with the climate and being able to better predict the location and degree to which severe storms will affect an area is also an important aspect of the future of resiliency. Looking ahead to only the rising sea level, it is estimated that by 2070 as many as 150million people worldwide could be adversely affected by rising sea levels, and many highly populated coastal cities will be at elevated risk (Yang et al., 2020). Early warning systems that can better predict and notify individuals in the affected area of a severe impending storm would be critical to ensure adequate preparations can be made. In addition to new technologies that incorporate early warning systems, incorporating new strategic building designs can play a large factor in preventing damage to critical building systems. Designing modern buildings with electrical, HVAC, and mechanical equipment on upper floors as opposed to their traditional location in basements and other below grade areas helps protect against critical equipment failure in the event of disasters striking (USGBC, 2021).

Improving Energy Efficiency of New and Existing Buildings

In general, a building's energy efficiency is determined by the rate at which energy is lost through the building's physical structure (the building envelope) and the rate at which energy is consumed to meet the occupants' energy needs and physical comfort. These two criteria are frequently linked because the physical structure and design of a building, in combination with the local climate, have a significant impact on the energy system selected and its efficiency. As a result, it is critical to consider both aspects when developing strategies to improve building energy efficiency.

- *Building Codes*: Almost all developed countries have Building Codes which include energy efficiency standards, while many developing countries are now passing legislation

for such codes. In most cases, these codes tend to regulate new buildings, but recently many developed country governments have amended their codes to cover renovations and refurbishments of existing buildings (United Nations Environment Programme, 2009). Most building codes are performance based: that is, they set a maximum limit for level of heat transfer through the building envelope and the level of heating/cooling demand, as well as require building equipment such as heating and air conditioning systems, ventilation, water heaters and even pumps and elevators to meet certain energy performance standards.

- *Building Commissioning and Mandatory Energy Audits*: Building commissioning is the systematic testing process conducted to ensure that a building's systems have been designed, installed and made ready to perform in accordance with the design intent and the building owner's operational needs. In the same way that regular servicing extends the lifespan of an automobile, the proper commissioning of the energy systems in buildings is crucial to the efficient operation of the building later in its life cycle. According to case studies in the USA, proper building commissioning has yielded impressive results, with energy savings of up to 38% in cooling and/or 62% in heating, and an overall energy savings average higher than 30% (Levine et al, 2007). However, mandatory energy audits are an extension of Building codes and commissioning processes. In many countries, governments have made energy audits mandatory for their public buildings as well as other major energy consuming sectors, such as specific industrial and large commercial consumers (United Nations Environment Programme, 2009).

Conclusion

From the study we have discovered that buildings and construction work are important infrastructures in the modern days. It serves a lot of purposes that enables human activities to be carried out easily. Climate change is a natural phenomenon that cannot be stopped. The effect of climate change has great impact on buildings and construction works. Some climate changes which could result in flood, hurricane, tornados, global warming, landslide and earthquake causes damages to construction work. The effect of global warming causing overheating in houses and buildings making them uncomfortable for dwelling and use. Looking at these negatives impacts of climate change on buildings and construction work, some remedies were outlines such as the redesign building construction, and using of more modernised machines for construction work to be able to cope with the climate change.

Recommendations

From the study, the following recommendation were outlined;

1. Climate change should be diligently studied so as to help engineers know the type of construction project to be carried out in the area at the right time and the appropriate materials to use.
2. New project designed should be implemented on buildings and construction work to adapt the climate change.
3. Policies should be implemented to guide construction works and building projects avoiding the damage from climate change.

REFERENCES

Advance Construction Robotics, n.d. (2021). *TyBot*. Retrieved from Advance Construction Robotics: https://www.constructionrobots.com/

Alves, C.A.; Duarte, D.H.S. and Gonçalves, F.L.T. (2016). Residential buildings' thermal performance and comfort for the elderly under climate changes context in the city of São Paulo, Brazil. *Energy Build.*, 114, 62–71.

Button, R. (2018). *Resilience planning in design and construction*. Retrieved from Constructable Trimble: https://constructible.trimble.com/construction-industry/ resilienceplanning-in-design-and-construction

Caterpillar, n.d. (2021). *CAT® COMMAND*. Retrieved from Caterpillar: https://www.cat.com/en_US/by-industry/construction-industryresources/technology/ command.html

Designing Buildings (2020). *Public building definition*. Retrieved from: https://www.designingbuildings.co.uk/wiki/

Egenhofer, M. J. (2012). *Geographic information science*. Second International Conference, GIScience 2012, Boulder, CO, USA, September 25–28, 2012. Proceedings. Springer Science & Business Media. p. 110.

Giddens, A. (2011). *The Politics of Climate Change*. Second Edition. Cambridge, UK and Malden, USA: Polity Press.

GSA (2021). *Sustainable design*. Retrieved from U.S. General Services Administration: https://www.gsa.gov/real-estate/design-construction/designexcellence/sustainability/ sustainable-design/

Ham, Y., Lee, S. J. and Chowdhury, A. G. (2017). Imaging-to-simulation framework for improving disaster preparedness of construction projects and neighboring communities. *Computing in Civil Engineering*, 2(7), 197 – 218.

Hatzikyriakou, A., Lin, N., Gong, J., Xian, S., Hu, X. and Kennedy, A. (2016). Component-based vulnerability analysis for residential structures subjected to storm surge impact from Hurricane Sandy. *Natural Hazards Review*, 17(1), 05015005,

Health & Safety Authority (2020). *Project Supervisor Design Process (PSDP)*. Health & Safety Authority: https://www.hsa.ie/

Hegeman, K. (2019). *How changing climate is changing the construction industry*. AC Business Media, LLC: https://www.forconstructionpros.com/

Knight, W. (2020). *Robots invade the construction site*. Retrieved from Wired: https://www.wired.com/story/robots-invade-construction-site/

Lambert, F. (2019). *Caterpillar unveils an all-electric 26-ton excavator with a giant 300 kWh battery pack*. Retrieved from Electrek: https://electrek.co/caterpillarelectric-excavator-giant-battery-pack/

Laurencine, G. (2014). *The construction industry and climate change*. Sustainability for Seychelles: http://www.s4seychelles.com/

Law Insider (2018). *Construction works definition*. Law Insider: https://www.lawinsider.com/dictionary/construction-work

Levine, M., Urge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., L S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., RIling, J. and Yoshino, H., (2007). *Residential and commercial buildings, Climate Change 2007*: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, U.K. & New York, NY, U.S.A.

Lingard, H., Warmerdam, A. and Shooshtarian, S. (2017). *The definition of a construction project*. RMIT University: Centre for Construction Work Health and Safety Research Publishers.

MassDOT. (2021). MassDOT Statewide Climate Change Adaptation Plan Objectives. Retrieved from Mass: https://www.mass.gov/service-details/massdot-statewide-climate-changeadaptation plan-objectives

MNCS Editorial (2019) Major Types of Construction; https://www.miaminewconstructionshow.com/blog/major-types-construction/ 19 May

Pamidimukkala, A., Kermanshachi, S. and Safapour, E. (2020). Challenges in post-disaster housing reconstruction: analysis of urban vs. rural communities. *Proceedings of the Creative Construction e-Conference (2020)*, 49 – 57.

Pourmokhtarian, A., Bakhshi, P., Bannon, Z. and Everett, B. (2022). Construction and Climate Change; Challenges and Opportunities: A Case Study of the Northeast U.S. *IOP Conf. Ser.: Mater. Sci. Eng.*, 1218(01), 012046.

Raczon, F. (2020). *Current State of Electric Equipment*. Retrieved from Construction Equipment: https://www.constructionequipment.com/current

Riedy, C. (2016). Climate Change. In book: *Blackwell Encyclopedia of Sociology*. Blackwell Publishers.

Saha, S. and Viney, B. (2020). How climate change could spark the next financial crisis. *Journal of International Affairs*, 73(1), 205-216.

Said, H., Kandil, A. and Cai, H. (2012). Agent-based simulation of labour emergency evacuation in high-rise building construction sites. *Construction Research Congress*, 10(1), 111 – 123.

Sailor, D.J., (2014). Risks of summertime extreme thermal conditions in buildings as a result of climate change and exacerbation of urban heat islands. Build. Environ. 78, 81–88.

Schulte, P. A., Bhattacharya, A., Butler, C. R., Chun, H. K., Jacklitsch, B., Jacobs, T., Kiefer, M., Lincoln, J., Pendergrass, S., Shire, J., Watson, J., & Wagner, G. R. (2016). Advancing the framework for considering the effects of climate change on worker safety and health. *Journal of occupational and environmental hygiene*, 13(11), 847–865.

Swingland, I. R. (2011). Definition of Construction Work. *Journal of Civil Engineering and Management*, 25(7), 377 – 382.

United Nations Environment Programme (2009). *Buildings and climate change: Summary for decision makers*. UNEP Sustainable Buildings and Climate Initiative, France.

USGBC (2021). *LEED Zero*. Retrieved from U.S. Green Building Council: https://www.usgbc.org/programs/leed-zero

Viana, M., Bonaventura, H. W., Mohammad, M. Z. and Kahvandi, Z. (2020). Integrated Project Delivery (IPD): An Updated Review and Analysis Case Study. *Journal of Engineering Project and Production Management*, 10(1), 147 – 161.

Volvo, n.d. (2021). *Emobility*. Retrieved from Volvo Construction Equipment: https://www.volvoce.com/global/en/our-offer/emobility/

Wendt, P. F. and Cerf, A. R. (2009). *Real estate investment analysis and taxation*. McGraw-Hill, p. 210

Wiki Didactic (2013). *What is the meaning of Building? Concept and Definition of Building*. Available at: https://edukalife.blogspot.com/2013/05/building-definition-concept-meaning.html

Wolfe Jr, S. (2013). *What are the different types of construction*. Levelset Blog: https://www.levelset.com/blog/types-of-construction-projects/

Yang, s. l., Luo, X., Temmerman, S., Kirwan, M., Bouma, T., Xu, K., Zhang, S., Fan, J., Shi, B., Yang, H., Wang, Y. P., Shi, X., and Gao, S. (2020). Role of delta-front erosion in sustaining salt marshes under sea-level rise and fluvial sediment decline. *Limnol. Oceanogr.*, 65, (1), 1990 – 2009.

Yildiz, Y. (2014) Impact of Energy Efficiency Standard and Climate Change on Summer Thermal Comfort Conditions: A Case Study in Apartment Buildings. Gazi Univ. J. Sci., 27, 1005–1013.