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REVIEW ON IMPACT OF CLIMATE CHANGE ON THE LIFE CYCLE OF CONSTRUCTION PROJECTS IN INDIA

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Abstract - *Climate change is a scientifically proven phenomenon and affects many major industries all over the world. Due to climate change the weather in India becomes difficult to predict. Now climate change is considered to possess a major challenge to the construction industry. Climate change has a strong impact on different phases of project life cycle like design, construction, and performance of buildings, equipment, machinery and workers. Hence, there is a need to investigate methods that will allow the construction to progress with minimum damage during bad weather conditions. This research is aimed at providing knowledge about the relationship between climate change and the construction industry, the potential climatic factors that cause damage to construction project's life cycle, to identify the most affected phase and make suitable suggestions to reduce its impact on construction projects life. Questionnaire Survey as the main method of research.*

Key words: Climate change, Construction, Weather, Project Lifecycle, India.

1. INTRODUCTION

Climate is the basis for human survival provides the necessary condition for living. Climate plays an important role in people's lives and is the base for plans and designs. Climate is changing over time and is a scientifically proven and an interesting phenomenon that has become a major problem worldwide. It is one of the major threats faced by the construction industry.

Buildings are vulnerable to climate change. The construction industry is affected by climate change such as the physical impact of weather like rain, heat and cold, the need for new materials and building techniques that protect structures and roads from severe weather and the cost of insuring climate change. Scientists say that construction deadline goals will be prolonged by a more unpredictable and intense climate.

Though the buildings are designed considering the standards, the weather changes at a faster rate leading to quick deterioration of buildings and a decrease in project life. Climate change affects worker's efficiency and induces health problems like cancer and heatstroke in them. It leads to an unsafe working environment.

Climate change affects the process of concrete mixing, casting and curing which is the major source of construction. The performance and application of paints are affected by climate change. Raw materials like timber get easily damaged to unstable weather conditions which leads to delay and extra expenses. Machinery become sluggish which decreases efficiency and increases its wear and tear. Delays in the transportation of raw materials due to climate change, increase the time required to complete the project leading to delay in project completion.

More precautions and necessary steps have to be taken in order to predict the change in climate change, to identify and face the major factors causing damage to the construction project's life cycle, to decrease the damages and to increase project life. The introduction of new building practices and new materials is necessary to minimize the effects of climate change on the construction project's life cycle. So, there is a greater need to understand the effects of climate change on the construction project's life cycle to suggest better solutions for minimizing the effects of climate change on the life cycle of the construction project's in India. Hence, this project is carried out.

2. LITERATURE REVIEW

Abdullah M Alzahrani and Abdel Halim Boussabaine (2013), reviews the relationship between climate change and buildings. The risk of climate change on buildings is classified into social, economic and physical. This also deeply states the physical risk on buildings including average temperature, flooding and extreme weather events and its effects on buildings and its components.

Mohammed N Alshebania and Gayan Wedawatta. (2014), the paper focuses on investigating methods that would allow the construction activities to progress during hot summer with minimal effect on construction in the UK. The research method used was a quantitative approach through interviews and case studies.

Analysis pointed out three key points to managing construction projects in hot weather conditions which are experience, labor force and forward planning. Weather conditions magnify the management and planning issues that exist and may go unnoticed during the lifetime of a project. Experience plays a vital role in the planning and

scheduling of site activities in order to minimize labor-intensive activities in the summer.

G.H.Galbraith, J.S.Guo & R.C.McLean (2000), it involves experimental investigation on temperature dependence on moisture permeability of four commonly used building materials under three different temperatures. Test was carried using the CEN Cup test method. The influence of temperature on water vapor diffusion is negligible for the materials tested. The rate of increase in relative humidity depends on the characteristics of the material used.

Hannu Viitanen, Juha Vinha, Kati Salminen, Tuomou Ojanen, Ruut Peuhukri, Leena Paajenen, Kimmo Lahdesmaki (2010), this paper is a research on the growth of mold on different materials. The models make it possible to evaluate the risk and development of mold growth and analyze the critical conditions necessary for the start of biological growth. The model is also used to simulate the progress of mold and decay growth under different surfaces. The most critical factors for mold and microbe development are moisture, temperature conditions at the material surface, exposure period and type of material. The aging of material and accumulation of dust and other material on the surface of building material will also change the response of the material.

Kim Robert Liso, Tore Kvande, Berit Time (2017), proposed a new climate adaptation framework in compliance with the Norwegian Planning and Building Act. Future buildings need new and improved methods of vulnerability assessment for moisture resistance in relation to an extreme changing climate. Climate change renders the existing climate less useful. The suggested framework is called the Klima 2050 Framework for climate adaption. The suggested climate adaptation framework for buildings could be an important first step towards a national strategy for climate adaptation in general. The model provides a significant contribution to the development of risk mapping and adaptation measures to meet the future risks of climate change. The new framework can be used to provide verification of the existing system with reliable climate scenarios and climate indices which will reduce the risk of climate-related damages under changing climate conditions.

Luz S. Marína, Hester Lipscomb, Manuel Cifuentes, Laura Punnett (2019), this study examines and compares the safety of climate among the group of construction personals. The discrepancy between manager and worker perceptions was linked to injury rates. The reasons for differences in perceptions of safety climate among construction personnel might facilitate the design of comprehensive safety inventions. The lack of association between management perceptions of safety climate and injury rates has been argued to highlight the usefulness of solely measuring the perceptions of workers. safety- training programs could teach managers in specific behaviors to improve their safety leadership and commitment, managers and supervisors could be trained in hazard recognition and hazard investigation techniques that help them to develop a stronger, more committed understanding of safety issues and communication strategies could be developed to transmit effective safety messages to site supervisors and workers.

John Napier (2015), this paper elaborates double skin facades and complicated motorized shading systems which repeatedly masks the lack of basic environmental philosophy. It relates to the physics of comfort in buildings and the static strategies which can help achieve with a low energy and carbon footprint. The basis of a critical tool and a design methodology for new projects are defined by active and passive façade strategies. The facade should be able to modify the interior environments, lightning the air conditioning loads, while providing daylight, preventing solar heat gain, glare and protect privacy. To achieve this, glazing can be arranged in an appropriate way to respond to the cardinal points of the compass and the surrounding building.

Joseph L. Crissinger (2003), this paper aims to explain the effects of different types of weather like hold, cold and humid conditions and it's effects on the building materials, machinery , site and workers in construction. Hot and dry conditions affect machinery by inducing dust, leads to concrete and masonry presetting and low strength. It affects paints and sealant's performance. Climate affects workers efficiency and may lead to health problems or even death. The cold condition causes site freezing, foundation problems, restrict vehicle movements, mold growth. Heavy winds damaged doors, windows and roofs. Weather cannot be controlled but the construction practitioners can prepare for it and adjust to the changing condition. Success of a construction project will be influenced by proper planning, adjustment and reaction to the local weather.

Kiefer, Julietta Rodríguez-Guzmán, Joanna Watson, Berna van Wendel de Joode, Donna Mergler, Agnes Soares da Silva (2016), discusses the impact of climate change on the health and occupational safety of workers in America. The article discusses research needs, hazards, risk assessment, surveillance activities to better understand how OSH may be associated with climate change events. It helps the professionals to ensure worker health and safety in the event of climate change. Health professionals can access the health hazards, occupational safety and formulate training procedures to overcome climate change. They can develop risk assessments, risk management programs and include climate change in risk communications.

M.J. Camilleri (2000), this report discusses the development of a prototype Climate Change Sustainability Index (CCSI) for houses. This highlights greenhouse gas emissions, overheating, and coastal and inland flooding as

the most important potential impacts of climate change for houses. The CCSI is intended to be used to assess the severity of the impact of climate change on a house, and the impacts of a house on climate change. The greenhouse gas emissions from a house contribute directly to climate change. Any level of emissions is potentially harmful. Major sources of greenhouse gases are calculated. The framework is applicable to buildings in general.

M. J. Camilleri, R. Jaques, & N.Isaacs (2001), this paper is aimed to quantify the impacts of climate change on houses and office buildings to develop an assessment tool to rate the vulnerability of a building due to the impacts of climate change and to develop adaptation and mitigation strategies for new and existing buildings. The climate change sustainability index is used to study the buildings. It studies decreased winter space heating energy, decreased water heating energy, changes in wind speed and tropical cyclones. Climate change risks should be included in future reviews of the appropriate clauses of the New Zealand building code and associated documents.

Mohammad Tanvi, Peter Davis (2019), Using Structural Equation Modelling (SEM) the model of the Psychological contract of safety is validated. The model explains the safety obligations between workers and supervisors. Data were collected from a mega construction project in New South Wales in Australia. A reality check can be done to reveal the level of fulfillment on mutual obligations and its impacts on the worker's safety behavior, where a supervisor plays a vital role in shaping worker's behavior in a construction. Using structural equation modeling (SEM), different relationships between key safety climate factors and psychological contact of safety were examined to explain the influences they have on each other. This process revealed how a safety management system can be modified to maintain a safe workplace for the construction workers.

M. S. Jones (2002), this paper discusses the use of accelerated weathering techniques to access the durability of building materials and the effects of UV radiation on the performance and properties of polymer-based building materials. These are observed under four sites in different areas. It is observed that the tensile strength of each polymer differed at different sites. Though the climate factor has an effect on the degradation, the degradation is mainly due to the effects of UV radiation the surface.

Nabil El-Sawalhi, Mahdi Mahdi (2015), studied the effects of influence of the climate on the lifecycle of construction projects at the Gaza strip to provide construction practitioners knowledge on climate change and clarify suitable procedures to face the influence of climate change within the industry. A questionnaire methodology was adopted to reach the desired goals. The results were as follows: The most important factor that temperature affects are concrete curing, concrete casting, workability, concrete hardening, choice of site location and increase minimum standards. Rainfall affects the most important factors such as concrete curing, structural damage, delays in the excavation of earthwork, project completion, handing over the project and insurance claims. The most important factor that extreme weather events influence are concrete curing, a high volume of insurance claims, delay in handing over to clients, structural damages. This gives the importance of different strategies and mechanisms to adapt to change in climate change.

Nicolas Francart, Mathias Larsson, Tove Malmqvist, Martin Erlandsson, Josefin Florell (2019), this study explores the ways, the Swedish municipality uses to reduce the impact of climate change on a construction project. It focuses on the practices that promote the use of sustainable construction materials. The first step in the study was to design a survey to quantitatively investigate the practices of Swedish municipalities in promoting building products with low climate change impact. Developers and constructors should understand what is asked of them and there are available tools adapted to their practice. Municipalities are to seek opportunities for cooperation and standardization at a regional level.

Sarieh Zareaian, Khaled Aziz Zadeh (2013), discusses the role of meteorological factors on building construction. The type of building materials used in construction depends on the temperature of a region. The quantity and quality in the construction of a building defers depending on the kind of the region, where it is being built. The type of foundation and materials to be used depends on the temperature of the soil, especially in a glacial soil it's depth is an important factor. The formation of water droplets on a physical object depends on the rate of the relative humidity present in a particular area. The more wind speed, the more powerful the building must be. In rain areas, the ceiling of buildings should be designed to scale back water erosion.

Simon Roberts (2008), this paper examines the effect of climate change on the built environment. New buildings should be designed to address the results of global climate change. Maintaining cool during high temperatures is very important. More extreme wet conditions may lead to subsidence risk. Flood risk areas may increase in the future, needing measures for resistance, initial protection and resilience for rapid recovering. Housing styles must embrace a strong wall system and a roof construction that uses surface materials that are tightly held and connected with nails in a potentially stronger pattern. Mold growing after a flood can cause allergic reactions and can be avoided through integrated design and adequate ventilation. Energy consumption by buildings can be reduced with thermal insulation, airtight structural details, high-performance windows, ventilation and, heat and cold recovery systems.

Timo G. Nijland, Olaf C.G. Adan, Rob P.J. Van Hees, Bas D. Etten (2009), This paper focuses on effects of climate change in the Netherlands on the durability of materials in the building and discusses its effect on the effect of temperature, precipitation, solar radiation, wind load, soil moisture content, freeze-thaw damage, the salinity of ground water, bio colonization. The action of individual climate parameters may strengthen each other, such as higher temperatures combined with higher precipitation may differ like the combination of higher precipitation combined with a small decrease in the number of frost-thaw cycles. Bio deterioration, salt damage, rising damp are some well-known damage process that affects the building materials. Adaption at materials may depend on new materials methods available or new techniques being developed. At a higher level of design the measures should be considered to enhance the durability of building materials.

Vanessa Bowden, Daniel Nyberg, Christopher Wright (2009), this paper investigates community responses to climate change adaptation planning at a coastal region in Lake Macquarie region, Australia. This paper shows how the community's local understandings of place informed temporalities that led to a practice of climate denial. The study makes use of 46 interviews with stakeholders and experts in the planning process such as residents in local community groups, council employees, politicians, state government employees, and business leaders. People deny climate change by referring to the past events deny the approaching dangers and opt to wait and see approach. The research observed that even in the event of climate-related disaster, the participant's responses and commitments are aimed at protecting their personal properties rather than changing practices around planning.

Xiaodong Li, Kwan Hang Chow (2016), this study aims to study the effect of high-temperature conditions on construction labor productivity and will help in creating plans to prevent heat-stress injuries and help in improving the safety and comfort conditions of construction labor working environments. Wet Bulb Globe Temperature (WBGT) is used to collect productivity data such ad direct work time, indirect work time and idle time. This study provides basic knowledge regarding the distribution of heat stress during different periods of construction workers. If WBGT increases by 1^{0} C, direct work time decreases by 0.57% and the idle time increases by 0.74. When work experience increases by 1 year, the direct work time increases by 0.33% and if age increases by 1 year the direct work time decreases by 0.72%.

3. CONCLUSION

After exploring the impacts of climate change on the construction projects life cycle, it can be concluded that the construction practitioners should be aware of the climate factors like temperature, rainfall, wind and extreme weather, should predict and adapt their works according to the local climate change. Climate change affects planning and designing like the choice of site selection, delays in construction, damage to structures and materials. Climate change leads to dangerous working conditions and affects the efficiency of the workers and machinery. Performance of paints, sealants are affected. Induces the growth of molds. Dry weather leads to the premature setting of concrete and mortars, reduced strength, poor bonds and bad finishes. Cold weather slows down curing which affects the strength, promotes spalling and ruins the finishes. This research emphasizes the need to understand climate change, develop new techniques, procedures to mitigate and overcome the effect of climate change on the project life cycle.

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