A Comparative Study of Building Façade Material

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Abstract— Climate action will determine the future action on the construction sector because current and future change into environmental pollution due to Global warming, air pollution etc. Important part of building which can affected by the pollution is the building façade. During the construction, almost 5-10% of total cost use for the building façade. This literature review focus on the material used for façade design, their environmental effect, life cycle cost method.
Key words: Building Façade, Construction Building

I. INTRODUCTION

Buildings represent one of the main sources of energy consumption and carbon emission. This issue leads many researchers to investigate various ways to overcome the problem and identifying ways to respond to climate change and the environment. Recently, smart materials have gained attention in scientific research. Especially in Construction industry and engineering applications. Facade is an important part of building through engineering and architectural perspective. Getting benefit of building façade to reduce a pollution.

A. Building

The National Building Code (NBC) of India defines the building as;

"Any structure for whatever purpose and of whatever material constructed and every part there of whether used as human habitation or not and includes all the structural elements like foundation, plinth, walls, floors, façade, roofs etc. with all building services like W.C., bath, stairs, etc."

1) Man requires different types of building for his activities;
2) Houses, bungalows and flats for his living
3) Hospitals and health centers for his health
4) Schools, colleges and universities for his education
5) Banks, shops, offices, factories for his business
6) Railway station, bus station. Air ports for transportation
7) Clubs, theatres and cinema for recreation
8) Temples, mosques, churches, etc. for worship

B. Types of building

Following are the types of building according to usage of building:

1) Commercial buildings
2) Residential buildings
3) Industrial buildings
4) Educational buildings
5) Institutional buildings
6) Assembly buildings
7) Mercantile buildings

C. Façade

"The façade is a principal front of a building that faces on to a street or open space." It is generally one exterior side of a building, usually the front. The word comes from the French foreign loan word façade, which in turn comes from the Italian facciata, from faccia meaning face, ultimately from post classical Latin facia. In architecture, the facade of a building is often the most important aspect from a design standpoint, as it sets the tone for the rest of the building. From the engineering perspective of a building, the facade is also of great importance due to its impact on energy efficiency.

D. Façade materials

Following are the building façade materials

1) Stone
2) Brick
3) Glass fibre reinforced concrete
4) Timber
5) Metal
6) Glass
7) Vinyl
8) Plast wood

E. Aim

Aim of the study is to review various building façade material used for building construction.

F. Objectives

1) To identify the materials used for façade design.
2) To identify methods of study for the life cycle assessment of building façade material.
3) To compare various materials.

G. Need for study

The global facade market size was valued at USD 205.89 billion in 2018. It is poised to register a CAGR of 7.6% from 2019 to 2025. Rise in construction-related activities has been an important factor driving the market. In the World Health Organization's (WHO) 2014 urban air quality assessment, 13 of the top 20 most polluted cities for the worst fine particulate air pollution, are located in India. The Indian government found that in 2010, average concentrations of particulate matter (PM) in the air of 180 Indian cities were about six times higher than WHO standards. India has emerged as one of the fastest growing economies in the world leading to a growth in infrastructure development and increasing emphasis on delivering world class architecture. This has resulted in the development of new innovative façade designs. The embodied energy and greenhouse gas (GHG) emissions due to construction are a large contributor to annual global emissions. They are estimated at 5% to 10% of the entire energy consumption in developed countries and 10% to 30% in developing countries (IEA, 2016).

II. LITERATURE REVIEW

A. Life cycle assessment of ceramic façade material and its comparative analysis with three other common façade materials

Study: In this research paper author discuss about building energy consumption accounts 30 to 40% of the total energy consumption in China. Globally, this percentage is 40%. Ceramic panels as façade material are become popular in

China due to its regenerative character. In this paper they have conducted life cycle assessment of decorative ceramic faced panel products from a typical ceramic enterprise in south china. Where, both the sales aspect and material recycling were conducted. They assessed seven environmental impact of the ceramic panels, including depletion of abiotic resources, photochemical oxidant creation, global warming, acidification, eutrophication, ozone depletion and human toxicity. And also compared environmental performance of ceramic façade panel with three other traditional materials like glass, marble and aluminium plate using data from literature. The result showed that ceramic façade panels had better environmental performance than the others. But ceramic façade panel was worse than glass on depletion of abiotic resources performance and was worse than glass and aluminium on the human toxicity performance.

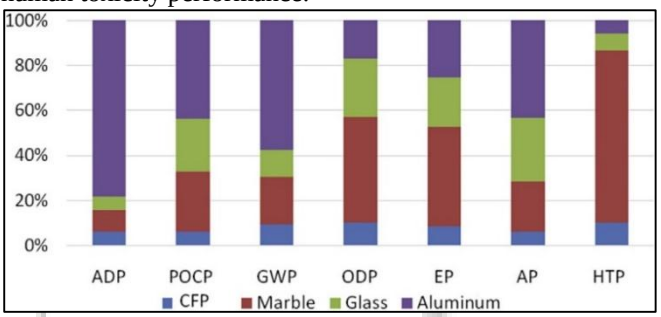

Fig. 1: The proportion among the 4 different building materials for each of the characteristic values.

B. Life Cycle Costing for Materials on Building Facade

Study: In this research paper author discuss about selection of materials for the sustainable building façade requires various issues, such as the analysis of economic performances as well as physical performances at every stage of their life cycle. In this regard, a number of researches have been done for life cycle costing (LCC) of buildings and building systems to compare economic effects of their options. This research method includes "life cycle costing" (LCC) and "value engineering" (VE) as research methodologies. During its economic life an item is subject to purchase, use, repair, maintenance, perhaps modification, and finally disposal. These processes comprise the life cycle of the item, and the costs of these processes make up the life cycle cost, or total cost of ownership, of the item.

For the LCC Cost model of façade material,

LCCFM = IC(initial cost) + PVOR(overall Replacements, year 40) + PVD(disposal)

Where LCCFM = LCC for façade material,

PV = present value

C. Effects of apartment building façade and balcony design on the reduction of exterior noise

Study: Multi-residential buildings are the most common type of dwelling in Korea, and approximately 40% of the population lives in high rise apartment buildings. In a mega city like Seoul, many buildings are exposed to severe exterior noise due to their proximity to roads and train railways. Many researchers have investigated the screening effect of balconies using either scale models or computational studies. To investigate the effect of different balcony forms on the reduction of the exterior noise field measurements, scale model tests, and computer simulations were performed. The results of the field measurements in an apartment complex indicated that sound pressure level in most floors were less than the 65 dBA Korean legal limit of exterior noise, the upper floors of the building experienced a maximum level of traffic noise; however, the difference in traffic noise between each floor was not large. A scale model test was conducted to investigate the potential noise reduction. The variation of noise reduction from sounds with incidence angles ranging from 17 - 75 ◦ Therefore, the effect of the incidence angle on the noise reduction should be considered carefully when the high-rise building greater than ten floors are built.

D. The application of smart materials in building facades

Study: Buildings represent one of the main sources of energy consumption and carbon emission. This issue leads many researchers to investigate various ways to overcome the problem and identifying ways to respond to climate change and the environment. Recently, smart materials have gained attention in scientific research, especially in industry and engineering applications and lately in the architectural field. Smart materials is classified as homogeneous in composition and the reaction with external influences, however, the latter is responsive to external stimulus in order to control temperature changes or solar radiation such as electrochromic glass with glazing material in curtain walls, windows, shading devices and more applications. The molecular compositions of smart materials control and produce a performance on the level of material form, to interact with environmental influences such as humidity, temperature, light, and carbon dioxide. Smart materials can be varied in terms of the type of installation such as wood, metals, fibers, tissues and fabric thicknesses. Researchers at Clemson University have developed deployable wet-responsive fibrous materials based on the spontaneous unfolding of tree leaves. This model demonstrates the ability of the leaves in trees fibers to absorb moisture and respond to the transformation of the self-energy to curvature.

E. Building for Environmental and Economic Sustainability (Bees): Software for Selecting Cost-Effective Green Building Products

Study: The BEES (Building for Environmental and Economic Sustainability) tool implements a rational, systematic technique for selecting cost-effective green building products. The technique is based on consensus standards and designed to be practical, flexible, and transparent. BEES measures the environmental performance of building products using the environmental life-cycle assessment approach specified in the International Standards Organization (ISO) 14040 series of standards. To combine environmental and economic performance into an overall performance measure, BEES uses the ASTM standard for Multi attribute Decision Analysis (American Society for Testing and Materials, 1995). The conclusion is environmental claims based on single impacts, such as reduced global warming alone, should be viewed with skepticism. Second, assessments must always be quantified on a functional unit basis as they are in BEES, so that the products being compared are true substitutes for one another.

One roof covering product may be environmentally superior to another on a kilogram-for-kilogram basis, but if that product requires twice the mass as the other to cover one square meter of roof, the results may reverse.

F. Façade Material Selection Criteria For Optimizing Building Maintainability

Study: This research paper focuses on Maintainability of building facilities that partially relies on the materials selection as their potential to resist defects from common deterioration, ease maintenance, and minimize maintenance cost can be improved throughout their designed life. . It is vital to know the preventive measures to be taken to improve maintainability of the buildings. This article identify ten maintainable façade material selection criteria which is durability, clean ability, material sustainability, compatibility and suitability, health and safety, material economy, material availability, functional performance, thermal performance and acoustical. The findings in this paper suggest that Durability', 'Material Economy' and 'Thermal Performance' are the significant criteria that demand attention for the successful selection of maintainable façade material for optimizing building maintainability. The failure of incorporating maintainability attributes in façade material selection in the past had led to various maintenance problem in post occupancy stage and this may cease to persist if the maintainable façade material selection criteria are considered in future building projects.

G. Assessment of the decrease of CO_2 emissions in the construction field through the selection of materials: Practical case study of three houses of low environmental impact

Study:A great quantity of CO_2 is emitted to the atmosphere through the different phases of a building life cycle, in the production of materials and products, in the construction of the building itself, in the setting on site, in the exploitation, the renovations, the later rehabilitations, up to the final demolition. The research presented here has been carried out on a case study of three terraced houses built in Spain, comparing them with a building with similar characteristics but constructed in a conventional way and with no selection of materials. The houses have been constructed following low environmental impact criteria, including alternative energies for future use and maintenance. In the design phase, the designer can make important decisions to define a bioclimatic design and to establish the future lines in selecting low environmental impact construction materials for the building phase. Both items, design and construction materials, are closely inter-related, the first one depends upon the other, and vice versa.

As a result from the figures obtained in the last phase of study, we have the following conclusion:

- The estimation of the CO_2 emission produced by all industrial activities included in the erection of a building shows that 196 kg of CO_2 is emitted per built square meter in a building with low-environmental impact materials.
- The estimation of the reduction of CO_2 emission achievable by correct material selection used in construction shows that 38 tons of CO_2 were avoided in a construction of 526 m^2, equivalent to a reduction of 72 kg of CO_2 per built square meter.

H. An Investigating Study on a new Innovative Material: Transparent Concrete

Study: Today we are living in a world where energy expenditure and environmental problems have escalated to global scale. In today's developed world our built environment takes energy; energy to make the materials that go into the buildings, energy to construct them (Embodied energy) and energy to heat, cool & light them (Operating energy). The desire of making our life easy and more advanced differ humans from other animals. In this stage of continuous development, concrete comes as a no less than a miracle for human development. Transparent concrete is one of those innovative types of concrete, which do not only break the orthodox image of concrete as dull and pale material but also helps to save energy, which is one of the biggest concerns of the modern world.

Plastic Optical Fiber based concrete allows the use of sunlight for illumination; in the case of emergencies, transparent concrete will provide some relief in the case of daytime power outage for skyscrapers, making evacuation safer and more efficient.

Transparent concrete can be useful to save energy and reduce electricity bill without any fear of compressive strength, TC made with optical fiber provides better transparency than TC with glass rod. However, compressive strength of later was slightly better.

I. An Alternative Material for Tall Building's Glass Façade in Tropical Countries

Study: Facade systems, as one of the most complex elements of building, are largely responsible for both the energy-performance and overall aesthetic qualities of a building. With day-to-day innovation in materials & modern technologies, various different materials other than glass are available which can be used for facade of building. Ethylene Tetra Fluoro Ethylene (ETFE) is one of the most exciting materials in today's design industry and has set the construction world alight with the potential it offers. ETFE cushions have been studied in the pursuit of a replacement to glazing, as a solution to the disadvantages associated with use of glass, such as its fragility, weight and behavior towards heat transmission. Glass presents high transmission of near Infra-Red radiation, causing an increase in cooling requirements during warm weather, and regular cooling due to tropical climatic conditions. The excessive use of glazing also increases the embodied energy and thus elevate the building maintenance cost and affect global environment. This can be minimized by replacing glass panel by ETFE.

J. Design Suggestions for Glass Building Facades Utilized With Algae Energy Sources

Study: Highly-intensified daylight distribution through glass-wall may distract the clear definitions of building parts. Besides, building parts very often are identified with the functions designed within some illumination, opacity and transparency values. On the other hand, currently, there has been a growing interest in energy issues, and the energy problem has occurred in the building. Algae Façade system

producing energy sources through the building components is being appeared as one of new efficient alternatives to resolve the problem, and the proposed system will be able to serve for enhancing the user health and handling sensitivity of environmental change. By utilizing the algae, it is possible to produce environmentally friendly energy resources and utilize an integrative system giving a colour change to the building. In this paper, it made a continuous development of alternative energy due to energy resource depletion and environmental degradation, and to apply the environmentally friendly energy generation in the construction sector and want to present a new application systems for energy efficiency and building envelope. To ensure the comfort of the energy performance and environment via algae, the proposed façade system is expected to be useful for human health and natural environment as well.

III. Conclusion

After studying these research, we are able to identify the building façade materials are used for the facade design globally. Environmental impact which affect the façade material including depletion of abiotic resources, photochemical oxidant creation, global warming, acidification, eutrophication, ozone depletion and human toxicity. Method for the life cycle costing of façade material and also a software for the cost effective green product design. We can benefit to reduce a pollution by the usage of building façade to turn into green façade.

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