IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
ISSN(e) : 2278-1684, ISSN(p) : 2320–334X, PP : 04-08
www.iosrjournals.org

Advances in Polymer Materials for Sustainable use in Building Facade

Ashmita Rupal[1*], Dr. Sanjay Kumar Sharma[2], Dr. G.D. Tyagi[3]
[1] *PhD Scholar, Civil engineering Department NITTTR, Chandigarh, India*
[2] *Professor & Head, Civil engineering Department, NITTTR, Chandigarh, India*
[3] *Technical Director, Shivalik Agros Poly Products Ltd, Parwanoo, H.P, India*

Abstract— *Polymer materials are one of the rapidly growing and utilized materials amidst the other construction materials. Their usage has revolutionized the design and construction methods towards more efficient, green and sustainable buildings. Both Structural and non- structural applications of polymers and their variants have become very effective being utilized in different building facade components as well as fenestrations for the purpose of new component installation, repair and rehabilitation, protection and strengthening of building components. Among the wide variety, advanced products are elastomers, rigid and flexible foams, adhesives, sealants, coatings, fibre etc. The usage and growth can be attributed to their highly promising and versatile properties they exhibit because of their morphology. Also, a wide range of mechanical properties are possible attributed to their potential to alter microstructure to suit niche applications. In addition, being easily synthesized with the minimal techniques and their application on various surface types due to bond characteristics with several substrates and self-adhesion features makes them further usable. Advances in polymer materials provide the technical know-how and prospects the new possibilities of design styles, shapes and forms in the building construction industry. This paper addresses an overview on advances in polymer material, its application in building facade components as well as its role in developing sustainable infrastructure.*

Keywords*— polymers, composites, building façade, fenestrations, green buildings, sustainability.*

I. INTRODUCTION

The building facade plays an elemental role in the designing of the buildings. Various stake holders such as Architects, Engineers, designers and others have to study many concerns while designing the façade systems keeping in mind eco-friendly issues, view, aesthetic presence, and inhabitant luxury, which makes these aspects for building the facade in a sustainable way. This paper is to review the current practice and advances in polymer materials adding tothe sustainable features for building facade and to explore its role in the developing sustainable infrastructure. This paper confersto both sustainability and economic aspects with reference to the application of new evolved better polymer materials and developed composites over the years.

The facade divides the interior space from the outside environment which is made or composed of different materials [1]. They are the key element while viewing the building from the exterior and has impact on the interior as they possess direct relation to building design, construction usage and building utility and services placement. The facade are not seen as an isolated component in building but as an main and an integral component with significant value in terms of the building's appearance. active and passive technique adopted of building plays important role in facade designing. Appearance,occupant comfort, lighting, indoor air quality index, circulation/ ventilation, other utilities/ services and structurally performing in terms of loadbearing, etc are all the functions the facade exhibit.

The process of interaction, consultation and decision-making of various stakeholders of developing the infrastructure is very important in designing the intricate sub components of the building skin actually. Specifically at the various phases of project i.e. planning, designing, execution and construction. The initial conception, definition of functionalities, design, implementation coordination and assembly. Certain activities mustbe accomplished during all of the stages or phases such as opinion cum feedback on the whole design and demarcation of the functionalities as well as the components value within the build/designed infrastructure and these attributes are well described in Figure 1 below.

Material selection is utmost aspect for designing and constructing the building facade because material will interact with the environment [2].It allows the sunlight to penetrate thru the developed space while harnessing the daylight , natural light and protection from the sun simultaneously, basically designed by the sun path analysis. It shields from the rainwater and other environmental conditions and has to stand through all of them throughout the year with different temperature and weather

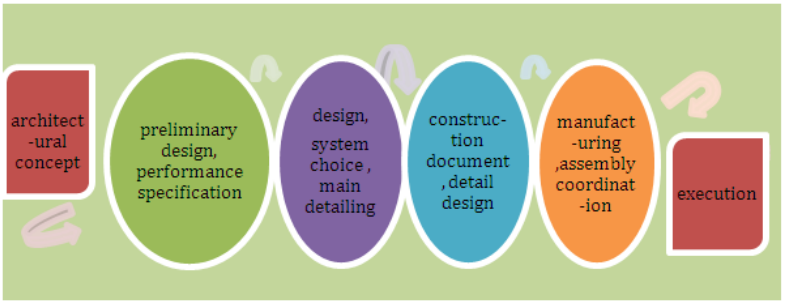

Fig 1. Attributes of building infrastructure

conditions. It also provides thermal and sound and plays an important role in energy and HVAC loads[3]. So, the prerequisites of the material to be used for building facade must fulfil its all the desires which are viewed as the characteristics of the material itself and selection based on different properties considered are mentioned in figure 2. The building material used as façade are generally concrete, glass,natural stone, , timber, clay metal, plastics, polymer material and composites.

Fig. 2 Prerequisites of selecting a building facade material

II. POLYMER COMPOSITES IN CONSTRUCTION INDUSTRY

Polymer composites (PC) represent a group of material developed by making matrix of polymers mixed or reinforced with other polymers or materials. The structural interaction between the different constituents results in a matrix of more enhanced properties resulting in high performance in a large number of applications [4]. Composite materials have evolved greatly in terms of manufacturing, availability, application from last decade. These class of materials can be used as a sustainable alternative or substitute to the conventional materials The polymer composites application have been comprehensively delve into and that too especially over some years within the frame of buildings and infrastructures.

The incorporation of polymers into conventional construction materials like timber, reinforced concrete (RCC), steel, or masonry fabrications has been in fact researched under a variety of mixing ratios and different strength criteria's, loading conditions etc.[5] Not only development of new materials using polymer composites is considered for new building infrastructure but major application part of these composites adhere to the repair, rehabilitation and strengthening purposes of existing buildings. Due to the historical value of the built infrastructure, strengthening and rehabilitation of buildings and civil engineering infrastructures is becoming even more important and percentage of already existing infrastructure and its rehabilitation poses a good industry for these composites market.

In the instance of polymer composites (PC), environmental eco-friendly apprehensions appear to be a hindrance to its usage in terms of a sustainability as a building material because considering acidification, air pollution, fossil fuel depletion, smog and other things associated with its production. Also recycling ability is limited in polymer composites. But looking at the pros and cons of the materials, the pros outweigh everything and hence evaluating the environmental impact of these in build environment applications such as through

embodied energy and life cycle analysis depicts that the direct and indirect paybacks are more than the other conventional building materials [6,7]. The positives of using these are mentioned in figure 3 below.

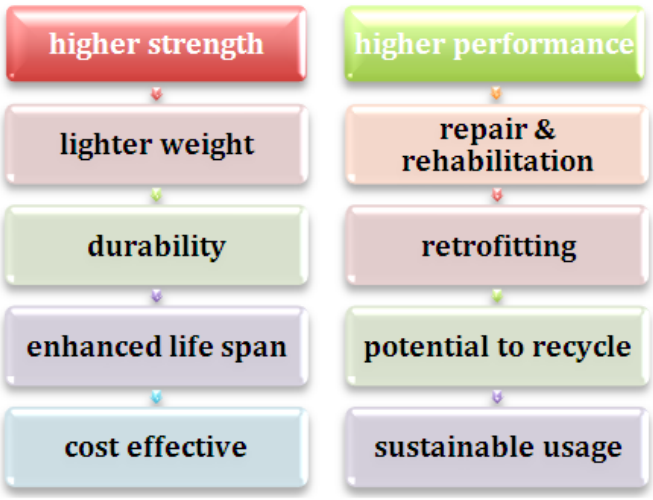

Fig. 3. Benefits of using polymer composites (PC)

These have successfully found their way into application n construction industry and in wide range of applications as material for pipes and conduits, cable sheathing and ducting wires and cables, roofing, flooring,as structural materials such as panelling, polymer concrete , insulation films, membranes, coatings, sheets, paints etc as illustrated in figure 4.So being polymer composites a viable alternative and availability aspect in consideration , various studies regarding the structural, economic achievability of these in various sub fields of civil engineering is available in literature.[8,9]

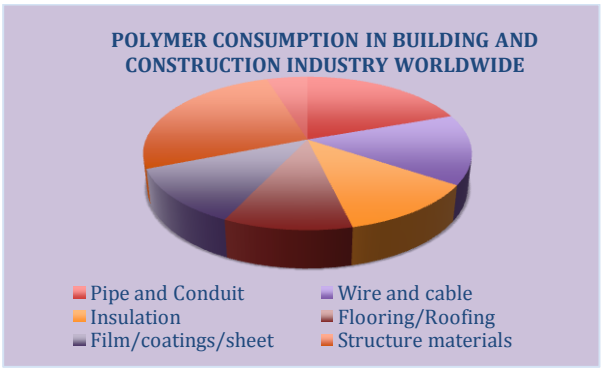

Fig 4. Polymer consumption in building and construction industry

However, the long-term effects of using polymer composite materials needs to be more extensively researched and studied. Different aspects such as the sustainability of the constituent materials, by-products of their production, and the probability to recycle them needs to be evaluated in order to regulate the usage of the composite materials as a part of the sustainable environment.

III. APPLICATION AS FAÇADE MATERIAL

There are various important specifications and key properties when considering the use of polymer composites for construction applications specially at building façade components. By building façade we mean the outer skin of the built infrastructure which include roofs, walls, fenestrations (any kind of opening in the buildings for example doors, windows, skylights etc).

Polymer composites have bring about numerous benefits to various stake holders as designers, builders contractors and occupants also. Their resistance to environmental elements is one of the important and practical implication for their usage hence requiring very little maintenance.For example earlier exterior of house needed painting over the recurrent years but now there is a complete range of polymeric building materials availableas tiles, coatings, window frames, fascia boards, and even insulated roofs with materials having good U -value and SRI (solar reflectance index) values , which have different options available as can be in any colour needed

requiring no painting or maintenance.[10] Different application of polymeric and its composite materials as façade materials is discussed in further section.

Polymer foams or cellular plastics or expanded polymers are the foams made by composition of polymer matrix and a gas or fluid phase. ***Special foams are structural foam, Syntacide foam , reinforced foam***. Various special engineering foams are available and developed for different structural application as load bearing components using polyolefins or polycarbonate or adding some solid phase such as ceramic , fibres , spheres dispersed in the multiphase material matrix.

Basically the structural foam depicts the constructions whose surfaces are solid phased and the cores are cellular ones. They have desired strength to weight ratios account to its configuration. They are used to provide enhanced performance at reduced material costing structurally,

Polystyrene(PS) usually used as insulation material especially in roof , masonry wall insulation. They have good dimensional stability , having high compressive and flexural strength with good grade fire retardant specification in particular.

Polyvinyl Chloride (PVC), having two variations rigid and flexible PVC foams areused in sandwich panel structures and as layer in coated fabric floorings. Having high tensile strength and non-crumbling under impact and good chemical resistance is good choice for use as a façade material.

Polyurethaneis produced by different techniques such as spraying, foam-in-place and continuous slabbing. Different manufacturing gives different application range as foam in place is used for filling the cavities, holes , voids where spraying helps in places where thin layer is to be deposited for the purpose. Curtain wall panels, insulation of wall, roof or other utilities such as industrial pipes, storage tanks fall in application places of PU foams.[11]

Epoxyis one of the versatile material being used in construction industry ranging from the manufacturing of the adhesives, primers and sealers, , paints, coatings plastics, , flooring and in other products such as used for bonding concrete. Its compatibility with wood, masonry ,metal, steel and other conventional materials adds to its usage. This wide application can be attributed to high corrosion resistance , high mechanical properties and good adhesion to all types of fibres[12].

Fibre reinforced polymeric materials (FRPs)are the materials developed incorporating the fibres in the polymer phase by dispersing in it resulting into the material of combined properties of both amalgamated materials. Fibres can be any crystalline or amorphous material.Some examples are glass fibre , carbon fibre ,other filaments and strands also. The benefits of using FRP are that they are light weighted, aesthetically tailored as per needed, mainly used for strengthening purpose because of good durability in different environments and majorly because of the freedom to achieve the desired properties by inducing fibre by choice and direction and at different location of phased material [13]. Different variants of FRP application areas are architectural frame, cladding , enclosures , domes , seismic retrofitting's , refurbishment of existing structure , in -situ repair and rehabilitation, pool linings , fabrication of modular structures etc.

Polymer Concrete- cement concrete being one of the largest utilized building material needs clear refinements in terms of durability , strength , toughness ,chemical resistance and environmental degradations. As polymers possess property of alkali attack resistance by cement paste their usage overcome the one of the main problems of reinforced cement concrete that is the lack of durability. Many researches are going on in natural and synthetic fibre to manufacture substitute for asbestos-cement [14].Different variants are being researched all over the labs and some of them already being in existence are ***Polymer impregnated concrete (PIC)***, ***Polymer cement concrete*** ,***Fibre Reinforced Concrete.*** By use of synthetic fibres different concrete are used for cladding and light walling, planking, permanent shuttering, linings etc [15].

Adhesives and Sealantsare another widely used materials and many different types of adhesives are available. Basically thermoplastic adhesives and thermoset adhesives is the categorization of these materials. Phenolic adhesives are used in wood bonding and fenestration works. Putty like ,cured, non-cured gaskets and mastics are different forms of sealants available in the market.

IV. CONCLUSION

In a nutshell it can be concluded that the polymers composites are now one of the elemental engineering building materials. The fast growth of these composites from thelast noticeable timeline is because of the factors of

- ***TECHNOLOGICAL ADVANCEMENTS***
- ***AVAILABILITY***
- ***FLEXIBELE AND EFFICIENT MANUFACTURING METHODS***
- ***ENSEMBLE OF DESIRED PRODUCT SPECIFICATION***
- ***RECENT MARKET TRENDS***

So, the purpose of this paper is to review and outline the polymer and polymer composites in the construction industry, highlighting the properties and application which make them a versatile building material and good alternate choice of material by present several examples of materials and their application.

REFERENCES

[1]. Chester R. J. and Baker A. *A. Environmental durability of F/A-18 graphite/epoxy composite*. Polymers and Polymer Composites, 1996, 4, No. 5, 315 – 323.

[2]. Halliwell S. M. *Reinforced plastics cladding panels*.Proceedings of the Conference on Composites and Plastics in Construction, Watford, 1999, Paper 20.

[3]. Nair, C.P.R., *Advances in addition-cure phenolic resins.* Progress in Polymer Science, 2004. 29(5): p. 401-498.

[4]. Campbell, F.C., *Structural Composite Materials*. 2010, Ohio: ASM International.

[5]. Hollaway, L.C. *The evolution of and the way forward for advanced polymer composites in the civil infrastructure*. 2003. Elsevier Ltd.

[6]. Leeming MB. *UK experience of plate bonding with advanced composite materials, Recent advances in bridge engineering, evaluation management and repair*. Proceeding of the US- Europe Workshop on Bridge Engineering. Barcelona: CIMNE; 1996.

[7]. Seible F. *Advanced composite materials for bridges in the 21st century*, Proceedings of the First International Conference on Composites in Infrastructure (ICCI'96). Tucson, Arizona Jon; 1996. p. 17–30.

[8]. Triantafillou TC. *Composite materials for civil engineering construction*. Proceedings of the First Israeli Workshop on Composite Materials for Civil Engineering Construction, Haifa, Israel; 1995. p. 17–20.

[9]. Netravali, A.N. and S. Chabba, *Composites get greener*. Materials Today, 2003. 6(4): p. 22-29.

[10]. Singhaputtangkul, N., et al., *Criteria for Architects and Engineers to Achieve Sustainability and Buildability in Building Envelope Designs.* Journal of Management in Engineering, 2013. 30(2): p. 236-245.

[11]. Han, B., et al*., Life cycle assessment of ceramic façade material and its comparative analysis with three other common façade materials.* Journal of Cleaner Production, 2015. 99: p. 86- 93.

[12]. Azari, R. and R. Palomera-Arias, *Building Envelopes: A Comparison of Impacts on Environment,* in AEI 2015. 2015, American Society of Civil Engineers. p. 230-236

[13]. Pulselli, R.M., E. Simoncini, and N. Marchettini, *Energy and emergy based cost–benefit evaluation of building envelopes relative to geographical location and climate.* Building and Environment, 2009. 44(5): p. 920-928.

[14]. Duflou, J.R., et al., *Do fiber-reinforced polymer composites provide environmentally benign alternatives? A life-cycle-assessment-based study.* MRS Bulletin, 2012. 37(4): p. 374-382.

[15]. Handbook-MIL-HDBK M.. 17-3f: Composite materials handbook, volume 3-polymer matrix composites materials usage, design, and analysis. US Department of Defense; 2002.

[16]. .