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# Flexural Behaviour of Polymer Modified Basalt Fiber Reinforced Concrete- A Review

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***Abstract*—** This paper gives a feasibility review about the flexural behaviour of Conventional Concrete (CC), Polymer Modified Concrete (PMC),Basalt Fibre Concrete (BFC), Polymer Modified Basalt Fibre Concrete (PMBFC). It also includes compressive, split tensile strength, and flexural tests for CC, PMC, BFC,PMBFC. The concept of polymer modification for cement mortar and concrete is not new, since considerable research and development of polymer modification have been performed for the past 70 years or more. As a result, various polymer-based admixtures have been developed, and polymer-modified mortar and concrete using them are currently popular construction materials because of their good cost-performance balance. A recent increase in the use of ecofriendly, natural fibres as reinforcement for the fabrication of lightweight, low cost polymer composites can be seen globally. One such material of interest currently being extensively used is basalt fibre, which is cost-effective and offers exceptional properties over glass fibres. This review paper also discusses the basics of basalt chemistry and its classification.

**Keywords:** Polymer, Basalt fibre,Polymer Modified Basalt Fibre Concrete

## I. Introduction

Developing Countries are trying their best to achieve rapid progress in the fields of industry and housing. Progress involves large-scale construction activities. Cement concrete has been one of the important materials of construction, in spite of its many drawbacks, the newly developed "Polymer Concrete" possessing many superior properties over conventional cement concrete, renders itself as one of the most versatile construction materials. Polymer concrete in particular, is highly suitable in case of pre-fabricated building industry, irrigation structures, and marine structures nuclear power production and desalination plants.Polymer as admixture can improve the properties like higher strength and lower waterpermeability than the conventional concrete Polymer latexes which consistof very small (0.05-5 pm in diameter) polymer particles dispersed in water are usually produced by emulsion polymerization. Theformulations for emulsion polymerization of typical polymer latexes is used as polymer-based admixtures.

Basalt is a natural material that is found in volcanic rocks originated from frozen lava, with a Melting temperature comprised between 1500° and 1700 °C. Its state is strongly influenced by the temperature rate of quenching process that leads to more or less complete crystallization. Perhaps 80% of basalts are made up by two essential minerals; i.e. plagiocene and pyroxene. Analysing the chemical composition it is possible to observe that $SiO_2$ is the main constituent and $Al_2O_3$ is the second one.Basalt fibre, which was developed by Moscow Research Institute of Glass and Plastic in 1953–1954, is a high-tech fibre invented by the former Soviet Union after 30 years of research anddevelopment, and its first industrial production furnace that adopted 200 nozzles drain boardcombination oven bushing process was completed in 1985 at Ukraine fibre laboratory .The base cost of basalt fibres varies in dependence of the quality and type of raw material,production process and characteristics of the final product. As the cost, the chemical andmechanical properties depend from the composition of the raw material. Differences in terms ofcomposition and elements concentration give difference in thermal and chemical stability and more or less good mechanical and physical properties.

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## II. Materials

### A. Cement

Cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragment into a compact whole and solid in the presence of water. Ordinary Portland cement was used in which the composition and properties is in compliance with the Nigerian standard organization defined standard of cement for concrete production .Ordinary Portland 53 grade cement with specific gravity 3.15 was used as the binder.

### B. Styrene Butadiene Rubber Polymer (Sbr)

Styrene butadiene rubber (SBR) is used as polymer modifier in this study. SBR Polymer is the most widely used in concrete. Styrene butadiene, an elastomeric polymer, is the copolymerized product of two monomers, styrene and butadiene. Latex is typically included in concrete in the form of a colloidal suspension polymer in water. This polymer is usually a milky-white fluid. It has high elasticity, good adhesion, water proofing and high chemical resistance. Co-polymers of butidine with styrene (styrene-butadine rubber (SBR)), are a group of large-volume synthetic rubbers. High adhesion occurs between the polymer films that form and cement hydrates.

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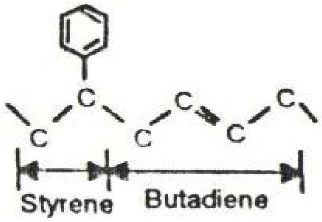


Fig 2.1 Chemical structures of SBR polymer latexes


(a) (b)

(c)

Fig 2.2 (a) (b) - SBR Polymer (c) - Mixing of the polymer in the concrete

*C. Properties Of Sb*

Styrene butadiene, an elastomeric polymer, is the copolymerized product of two monomers, styrene and butadiene. Latex is typically included in concrete in the form of a colloidal suspension polymer in water

Table 1:Properties of SBR

| Properties | Description |
|---|---|
| Appearance | White emulsion |
| Specific Gravity | 1.03 ± 0.02@ 25°c |
| Freeze/Thaw Resistance | Excellent |
| Chloride Content | Nil |
| Flammability | Non-flammable |
| Compatibility | Can be used with all types of Portland cement |

*D. Advantages In SBR*

- It improve the adhesion or bond strength in the concrete
- It decrease the pores in the concrete, compare to the conventional concrete
- It increase the strength & durability of the concrete
- It improve the mechanical properties of repaired concrete

*E. Basalt Fibre*

Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped fibres. Basalt fibre has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes

*F. Properties Basalt Fibre*

- Fast and effective mixing
- Does not float or sink
- Excellent compatibility with concrete with excellent adhesion
- Smooth finish

Table 2: Properties of Basalt Fibre

| Property | Values |
|---|---|
| Colour | Bronze |
| Specific gravity | 2.65 |
| Melting point | 1350°C |
| Elastic modulus | 89 GPa |
| Diameter | 12 to 30 mm |

*G. Application Of Basalt Fibre*

- Alternative crack control material in commercial and industrial flooring, slabs
- Suitable for aggressive saline environments

*H. Advantages In Baslat Fibre*

- Non corrosive/ non-conductive/ non magnetic
- High Tensile strength relative to steel, AR gassfibres and polypropylene
- Low weight (Density 1/3 of steel)
- No sharp ends protruding from concrete after mixing
- Abrasion resistance improved
- Longer lifetime and lower life cycle costs
- Improves freeze thaw resistance1.5to2times
- Increases chemical resistance due to up to 95% reduction of shrink age crack

*I. Chemical Composition Of Basalt Fibre*

Several basalt compounds may vary, but especially the $SiO_2$ content may vary largely. Only $SiO_2$ percntages above 46% ('acid basalt') are suitable or fibre production

Table 3 chemical composition of Basalt Fibre

| Compound | Weight % in Basalt |
|---|---|
| $SiO_2$ | 51.6-57.5 |
| $Al_2O_3$ | 16.9-18.2 |
| CaO | 5.2-7.8 |
| MgO | 1.3-1.7 |
| $Na_2O$ | 2.5-6.4 |
| $K_2O$ | 0.8-4.5 |
| Fe2O3 | 4.0-9.5 |

(a)

(b)

(c)

Fig 2.2 (a)-Basalt Fibre (b)-Chopped Basalt Fibre (c)-Chopped fibre in Concrete mix

*J. Fine Aggregates*

River sand of size below than 4.75mm conforming to zone II of IS 383-1970 is used as fine aggregate. Laboratory tests were conducted for fine aggregate to determine its physical properties as per IS: 2386 part (III),River sand is normally preferred over crushed sand since in the former particle shape is fully water worn by attrition which helps in reduction of water content of mix and also lesser resistance to pumping.

Table 4: Properties of Fine aggregate

| Property | Values |
|---|---|
| Specific gravity | 2.62 |
| Bulk density (kg/cum)<br>(a) Loose<br>(b) Compacted | <br>1601<br>1670 |
| Fineness modulus | 2.70 |
| Grading | Conforming to Zone II |
| Water absorption (%) | 1.64 |

*K. Course Aggregates*

The maximum size of aggregates is generally limited to 20mm.Aggregate of size 16 to 20 mm is desirable for structures having congested reinforcement. Wherever possible size of aggregates higher than 20 mm could also be used. Well graded cubical or rounded aggregates are desirable. Aggregate should be have uniform quality with respect to shape and grading.

Table 5: Properties of coarse aggregate

| Property | Value |
|---|---|
| Specific gravity | 2.65 |
| Bulk density (kg/cum)<br>(a) Loose<br>(b) Compacted | <br>1592<br>1706 |
| Fineness modulus | 7.13 |
| Water absorption (%) | 20 |
| Impact value (%) | 18 |
| Crushing value (%) | 20 |
| Voids (%) Loose<br>compacted | 39.20<br>35.60 |

## III. Literature Review

Studied about the potential of polymer modified concrete as a structural material. Polymers with different kinds of fillers are used as construction materials. They have good binding properties and good adhesion with aggregates. They have long-chain structure, which helps in developing long-range network structure of bonding. In contrast, cement materials provide short-range structure of bonding. As a result, polymer materials usually provide superior compressive, tensile and flexural strength to the concrete compared to Portland cement[1][2][5]. Some polymer materials may selectively provide higher tensile and flexural strength to the structure compared to compressive strength. In addition, they provide good adhesion to other materials as well as resistance to physical damage (abrasion, erosion, impact) and chemical attack. Structures in hostile environments, inaccessible for repair, or subject to impact, cyclic, or dynamic loading could benefit from PMC. Aging infrastructure can be repaired using

PMC. Although polymer concrete might initially seem a bit more expensive when compared to conventional materials because of the monetary cost per unit weight it will appear extremely feasible when judged on its low maintenance requirements, its durability and other parameters.[4][9][10]

Studied about the thermal and mechanical properties ofbasalt fibre reinforced concrete were investigated [17][18]. The volumefractions of basalt fibre of (0.1, 0.2, 0.3, and 0.5% by total mixvolume) were used. Properties such as heat transfer, compressive andsplitting tensile strengths were examined. Results indicated that thestrength increases with increase the fibre content till 0.3% then thereis a slight reduction when 0.5% fibre used.[19]

Fiber reinforced inorganic materials, such as concrete or mortars are expected to present goodmechanical properties under high dynamic loading conditions, such as those induced by earthquakesFurthermore, basalt fibers, which are being increasingly investigated in structural applications, are alsoexpected to present good performance under high strain-rate conditions.[17][20]

Studied about the polymer based admixture, Rheomix 141 is styrene-butadiene co–polymer latex, specifically designed for use with cement composites. It is used in mortar and concrete as an admixture to increase resistance to water penetration, improve abrasion resistance and durability [11][12][13].This study includes the behavior of polymer cement concrete in the hardened state. The variables studied include the grade of concrete and dosage of polymer. Five different grades of concrete M20 to M60 with polymer quantities starting from 5% to 10% were used in that work.[6][7][8[ The various mechanical properties like compressive strength, splitting tensile strength, flexural strength, stress–strain characteristics, and modulus of elasticity and permeability characteristics of concrete have been improved.[14][15][16].

Reviewed about the applicability of the basalt fiber as a strengthening material for structural concrete members through variousexperimental works for durability, mechanical properties, and flexural strengthening. The basalt fiber used in this study was manufactured inRussia and exhibited the tensile strength of 1000 MPa, which was about 30% of the carbon and 60% of the high strength glass (S-glass) fiber.When the fibers were immersed into an alkali solution, the basalt and glass fibers lost their volumes and strengths with a reaction product onthe surface but the carbon fiber did not show significant strength reduction. From the accelerated weathering test, the basalt fiber was found toprovide better resistance than the glass fiber. However, the basalt fiber kept about 90% of the normal temperature strength after exposure at 600$^{o}$C for 2 h whereas the carbon and the glass fibers did not maintain their volumetric integrity. In the tests for flexural strengtheningevaluation, the basalt fiber strengthening improved both the yielding and the ultimate strength of the beam specimen up to 27% depending onthenumber of layers applied. From the results reviewed herein, two layers of the basalt fiber sheets were thought to be better strengtheningscheme. In addition, the strengthening does not need to extend over the entire length of the flexural member. When moderate structuralstrengthening but high resistance for fire is simultaneously sought such as for building structures, the basalt fiber strengthening will be a goodalternative methodology among other fiber reinforced polymer (FRP) strengthening systems[19][20]

## IV. Conclusion and Future Work

This study given the idea about the use of polymer and their behavior in the various mechanical properties like compressive strength, splitting tensile strength, flexural strength.

This study is mainly focused on polymer modified concrete to have a dense microstructure, smaller discontinuous pores, less porous transition zone, better bond between the aggregate and the cement matrix, and bridgedmicro-cracks with respect to conventional concrete.

The cost of producing PMC should not be compared to the cost of the production of conventional concrete on short run. Although, PMC has higher initial production cost it should be compared with the sum of the initial production cost of conventional concrete plus the cost of the expected repair works during the service life of the structures, especiallythose exposed to severe aggressive environment.

Basalt fibres can be considered environmentally friendly and non-hazardous materials. It is not a new material, but its applications are surely innovative in many industrial and economic fields, from building and construction to energy efficiency, from automotive to aeronautic, thanks to its good mechanical, chemical and thermal performances. Hence, basalt fibre has gained increasing attention as a reinforcing material especially compared to traditional glass fibres.

The base cost of basalt fibres depend on the quality and the chemical composition of the raw material and this leads to have several kind of fibres with different thermal, chemical andmechanical properties.Basalt fibres within polymer (i.e. thermoplastic, thermoset and biodegradable), metallic andconcrete matrices exhibit promising properties. Due to this, these fibres have the potential to be the next generation materials for structural application for infrastructure, automotive industry andconsumer applications.

The future study is to cast the different type of beam like Controlled beam ,Polymer Modified Concrete(PMC),Basalt Fibre concrete(BFC),Polymar Modified Basalt Fibre Concrete Beam(PMBFC) and to study the structural behavior and to compare the result between the conventional Concrete and to find the various mechanical properties like compressive strength, splitting tensile strength, flexural strength, stress–strain characteristics, and modulus of elasticity and permeability characteristics of concrete

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