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Investigation of Fly Ash Geopolymer Concrete Enhanced by Epoxy Resin & Glass Fiber

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Abstract: A polymer binder is used to bond the aggregate in a matrix to create polymer concrete, a composite material. Due to its excellent impact resistance, quick curing time, and high compressive, tensile, and flexural strengths, it is becoming more and more popular as a new building material. This study examines a research project that aims to enhance basic comprehension of the subject matter and supply the information needed for widespread application. As a result, a comparison has been done between polymer concrete and traditional concrete using different amounts of resin and fibre. The mix design of M25 grade concrete is determined and the material amount is estimated in accordance with IS10262:2009. When carrying out an experimental programme Conventional concrete is tested using methods like compressive strength, flexural strength, and workability tests. Polymer resin concrete with fly ash and resin percentages of 3% and 5% is tested, and the results are compared to polymer fibre concrete with glass fibre percentages of 0.5% and 1%.Polymer concrete was created in this experimental programme using glass fibre, epoxy resin, fly ash, and sand. The impact of fly ashand resin (binder) on the hardness, split tensile strength, flexural strength, and compressive strength of epoxy resin-based polymer filler is documented. Epoxy composites provide significant benefits over traditional structural materials, much like any other fiber-reinforced polymer composite. High specific strength, good toughness, strong insulating properties, and good corrosion resistance characterise these materials. Their employment in a variety of applications related to civil, aerospace, transportation, and marine engineering has been promoted by these qualities. Unfortunately, these materials have a substantial absorption of moisture, which can come from ambient moisture as well as direct immersion in regular or seawater while being used.

Keywords: *characterize, structural, absorption, moisture*

1. Introduction

A composite material is created when two or more materials with various qualities are mixed together. Composite materials have several advantages over their individual elements in terms of characteristics. This has served as the primary driving force behind composite material research and development. The component materials can be divided into two categories: reinforcement and matrix. While the inclusion of fibres or particles in a composite enhances its mechanical qualities like strength, stiffness, etc., the matrix's main purposes are to transmit stresses between the reinforcing fibres or particles and to protect them from mechanical and/or environmental damage. The goal is to leverage both materials' better qualities without sacrificing each one's shortcomings. Ceramic, polymeric, or metallic materials can all be used as the matrix material. The composite is referred to as a polymer matrix composite when the matrix is made of polymers. The resin, the reinforcement—such as fibres and particles—and the interface between them are the three constituent parts that primarily define the characteristics of polymeric composite materials.

1.1 Classification of Composites

There are several ways to classify composite materials. Since the geometry of the reinforcement is what gives composites their excellent performance and mechanical qualities, it makes sense to classify materials based on the geometry of a typical unit of reinforcement. There are two main categories of composites:

- Fibrous composites
- Particulate composites

1.2 Components of a Composite Material

In its most basic form, a composite material is one that is made up of two or more components that combine to provide distinct material qualities from what would be produced by those elements alone. In actuality, the majority of composites are made up of a bulk material, or "matrix," and some sort of reinforcement that is added mainly to boost the matrix's strength and stiffness.

1.3 Role of Matrix in a Composite

Many materials have extremely high strengths when they are fibrous, but in order to have these qualities, the fibres need to be linked together by an appropriate matrix. In order to stop abrasion and the development of new surface imperfections, the matrix separates the fibres from one another and serves as a bridge to keep the fibres in place. A good matrix should be able to transmit the load onto the fibres, deform readily when given force, and concentrate stress equally. According to a research on the nature of bonding forces in laminates, there is a chance that the adhesive bond holding the reinforcement and matrix together will break during early stress. The laminates' high strength characteristics can be attributed to the frictional forces that exist between them. A very large number of polymeric materials, both thermosetting and thermoplastic, are used as matrix materials for the composites. Some of the major advantages and limitations of resin matrices are shown in Table-1.1

Table 1.1: Advantages & Limitation of Matrices

Advantages	**Limitations**
Low densities	Low transeverse strength
Good corrosion resistance	Low operationsal temp limits
Low thermal conductivities	Low operationsal temp limits
Low electrical conductivities	Low operationsal temp limits
Translucence	Low operationsal temp limits

Generally, factors like adhesive strength, fatigue resistance, heat resistance, chemical and moisture resistance, etc. are taken into consideration while choosing resinous binders, alsoknown as polymer matrices. The mechanical strength of the resin ought to match the reinforcement's. It must withstand the service conditions and be simple to employ in thechosen fabrication method. In addition to these qualities, the resin matrix has to have theability to penetrate and wet the fibre bundles that serve as reinforcement, filling in any deadair gaps and providing the physical attributes that can improve the performance of the fibres.

1.4 Classification of Polymer Concrete

There exist three principal classes of polymer concrete materials:

- Polymer-Portland Cement Concrete [PPCC]
- Polymer impregnated Concrete [PIC]
- Polymer Concrete [PC]
- Polymer Portland Cement Concrete [PPCC] : A monomer, pre polymer of dispersed polymer is incorporated into a Portland cement mix and a polymer network formed in situ during curing of the concrete.
- Polymer-Impregnated Concrete [PIC]: Previously formed concrete is impregnated with a monomer which is subsequently polymerized in situ. Polymers enhances the Strength Characteristics of the original concrete.
- Polymer Concrete [PC]: It is also known as Resin Concrete. A polymer is used to bind an aggregate together.

1.5 Epoxy Resin

Epoxy resin is a prepolymer with a low molecular weight that may be treated in a range of ways. These resins have two key benefits over unsaturated polyster resins: reduced shrinkage during cure and the ability to be partly cured and stored in that form. But compared to polyester resins, typical epoxy resins have a higher viscosity and are more expansive. The cured resins exhibit excellent adhesion to a range of substrates, superior mechanical and thermal characteristics, high chemical and corrosion resistance, and good electrical properties. High cure times and subpar performance in hot-weight conditions are their main drawbacks.

1.5 Glass Fibre

In FRC, glass fibre in the form of filaments is also frequently utilised. Glass fibres can be cut into short fibres and are supplied in a continuous roving form. Glass fibres possess a high fracture strain and tensile strength. These fibres' modulus of elasticity is modest, though. Moreover, alkali solution in cement-based composites may readily attack regular borosilicate glass fibres (E-glass) and soda-lime glass fibres (A-glass). Because of this, they are not as strong and ought to be handled carefully. About 16% to 20% of zirconia [ZrO_2] is included inalkali-resistant glass fibres, or AR glass, which shields the fibres from strong alkali assault.

The most common type of glass fibre utilised in composites with cement is AR glass. Glass fibres' limited resilience to cyclic and sustained stresses is one of its drawbacks.

2. Problem Identification

Conventional concrete contains water, aggregates, Cement with variant proportions and known to be weak in tensile strength, brittle and easily erodible by chemicals and highvelocity water flow. This is Becoming an ever growing problem in today's society with the need for the least amount of maintenance and longer lasting structures. Polymer concrete has increased strength characteristics as well as improved resistance to environmental factors and a faster curing time. With such improved properties, polymer concrete became a fast growing area of research. Polymer concrete is a composite material which results from polymerization of a monomer/aggregate mixture.

2.1 Objective of the Study

Based on the review of the literature it was observed that the production of fly-ash will keep on increasing in coming years which needs large area to store which creates a problem for its safe economic disposal and causes environment hazards .A vast utilization of fly ash is only possible in civil engineering fields as a replacement to earth material as its properties are quitesimilar to that of the natural earth. To use the fly ash a replacement of earth or geo-material it is essential to stabilizing it using some proper stabilizing agent.

The aim of the present work are-

- To fabricate Fly ash polymer composite at different proportions of Glass fibre & epoxy resins.
- To make recommendations to promote utilization of industrial waste.
- Evaluation of mechanical properties of both epoxy & glass fibre composites such as tensile strength, Compressive , & Hardness etc.

3. Experimental Work & Methodology

Fly ash has been used in various architectural and industrial applications on large scale. Hence Consumption of this huge amount of fly ash greatly reduces the difficulties met by coal based TPPs for its dumping. Analysis on the performance of FA at various states is essentially required before its usage. So to understand the characteristics features of FA, experiments cannot be performed on field domain. There is no any alternate option except researchlaboratory test to assess its importance. The research conducted in laboratory provides a calculative approach to govern several parameters that come across during practice. Brief description of the types of material used, sample preparation and its characterization through SEM, XRD, and FTIR, Mechanical and surface properties like Compressive strength, Hardness and wear resistance, Thermal conductivity measurement and others are outlined in this section.

3.1 Chemical Properties of Ordinary Portland Cement

Portland cement consists of the following chemical compounds

(a) Tricalcium silicate	$CaO.SiO_2$ (C_3S)	40%
(b) Dicalcium silicate	$CaO.SiO_2$ (C_2S)	30%
(c) Tricalcium aluminate	$CaO.Al_2O_3$ (C_3A)	11%
(d) Tetracalcium aluminate	$CaO.Al_2O_3.Fe_2O_3$ (C_3AF)	11%

There may be small quantities of impurifies present such as calcium oxide (CaO) and magnesium oxide (MgO). When water is added to cement, C_3A is the first to react and cause initial set. It generates great amount of heat. C_4AF is comparatively inactive compound.

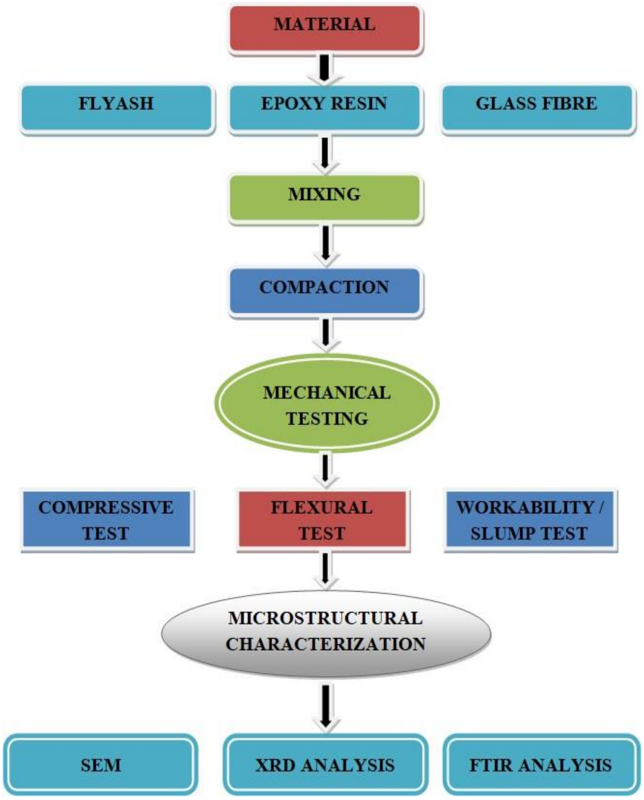

Fig-3.1 Flow Chart of Experimental Method

4. Results Analysis & Discussion

4.1 Composition of Fly-Ash

Fly ash consists primarily of oxides of silicon(Sio2),, aluminum(Al2o3), iron (Fe2O3).and calcium(CaO). Magnesium, potassium, sodium, titanium, and sulfur are also present to a lesser degree. When used as a mineral admixture in concrete, fly ash is classified as either Class C or Class F ash based on its chemical composition The chemical composition of Fly ash is tabulated in table 4.1.

Table 4.1: Compositional Analysis Of Fly Ash

Compounds	SiO_2	Al_2O_3	CaO	MgO	P_2O_3	Fe_2O_3	SO_3	K_2O	LOI
Composition(%)	54.5	26.5	2.1	0.57	0.6	-	-	-	14.18

4.2Test Results for Flexural Strength

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield.

Table 4.2: Flexural Strength at 7 days for 0% Fly-Ash

S.no	Type Of concrete	Flexural strength Results in N/mm^2		
		Prism 1	Prism 2	Prism 3
1	CC-M25	6.75	7.5	10.5
2	PRC – 3% Resin	9	8.62	12
3	PRC – 5% Resin	9.75	10.87	13.5

5. Conclusion

The results of experimental study on polymer concrete with epoxy resins & glass fibre have been discussed.

- This investigation contains an experimental observation in which the comparison between Conventional concrete, polymer resin concrete and Polymer fibre concrete has made. As per the results obtained, increases the compressive strength and flexural strength by polymer resin in normal concrete. Increase of resin content from 3% to 5%had improved in workability and also in compressive strength and flexural strength. Addition glass fibre to the polymer concrete improves the compressive strength.
- All the batches gain their maximum strength around the age of 28 days. At the age of7 days all the batches reached at least 80% of the 28-day compressive strength under the adopted curing method.
- Increasing fly ash content reduced the voids and increased the compressive strength for polymer concrete. Nevertheless they argued that the strength level of the resin itself will contribute to the overall compressive strength of polymer concrete. Epoxy resin has the greater degree of toughness and bond strength. Therefore, with increasing fly ash epoxy based polymer concrete shows increasing strength.
- It can be seen from Figure 1 to Figure 4 that both types of PC show the flexural strength is decreasing with increasing flyash content for both types of polymer concrete.

References

[1] S.Prema, S.Sakthivel, C.Sankar, J.Vasantha kumar, S.Vijay, , *"Comparative Study on Polymer Resin Concrete",* International Journal of Chemtech Research, Vol.10 No.8, pp 656-661,2017

[2] Mohamed R .Mohamed, Sewench Noor ALdeen , RawabiI Abdulrazzaq*" A Study of compression strength and flexural strength for Polymer Concrete,"* Iraqi Journal ofScience, 2016, Vol. 57, No.4B, pp: 2677-2684

[3] Marinela Barbuta and Maria Harja, *"Experimental study on the characteristics of polymer concrete with epoxy resin"*, Journal of materials in civil engineering, ASCE, pp: 53-59,2008.

[4] Mirium Paul , P.Ravikumar" *Significance of polymer concrete and mix design approach – Overview,"* International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 5, Issue 7,July 2016

[5] G. Martínez-Barrera, C. Menchaca-Campos, and O. Gencel, *"Polyester polymer concrete: effect of the marble particle sizes and high gamma radiation doses,"* Construction and Building Materials, vol. 41, pp. 204–208, 2011

[6] Beutel.A.Manalo,*"Optimal Mix Design for Epoxy Resin Polymer Concrete",*https://eprints.usq.edu.au/29176/1/Beutel_A_Manalo.pdf, 2015

[7] Akkar, S., H. Sucuoglu and A. Yakut (2005) "Displacement-based fragility functions for low- and mid-rise ordinary concrete buildings," *Earthquake Spectra*, 21(4), 901-927.

[8] Arlekar, J. N., S. K. Jain and C. V. R. Murty (1997) Seismic response of RC frame buildingswith soft first

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storeys. Proceedings of the CBRI golden jubilee conference on natural hazards inurban habitat. New Delhi.

[9] Asokan, A., (2006) Modelling of Masonry Infill Walls for Nonlinear Static Analysis of Buildings under Seismic Loads. M. S. Thesis, Indian Institute of Technology Madras, Chennai.

[10] ATC 58 50% Draft, (2009) "Guidelines for Seismic Performance Assessment of Buildings, Applied Technology council", Redwood City, CA.

[11] BCDBSS (1987) Bulgarian Code for Design of Buildings Structures in Seismic Regions. Bulgarian Academy of Science Committee of Territorial and Town System at the Council of Ministers. Sofia. Bulgaria.

[12] Cornell, C. Allin, Fatemeh Jalayer, Ronald O. Hamburger and Douglas A Foutch, (2002) "The Probabilistic Basis for the 2000 SAC/FEMA Steel Moment Frame Guidelines", *Journal of Structural Engineering* 128(4), 526-533.

[13] Christiana Dymiotis, Andreas J. and Kappos,Marios K. Chryssanthopoulos (2001) "Seismic Reliability Of Masonry-In-filled RC Frames" *Journal of Structural Engineering*, Vol.127, No. 3, 296-305.

[14] Agrawal, M. S., Vanarotti, M. B., & Yashwant, K. M. (2022). Research on Emotion in Artificial Life and Artificial Intelligence: Dealing with Issues. *Telematique*, 860-864.

[15] Pandey, P., Lamba, A., & Agrawal, S. (2021). A Review on Study of Multilevel Car Parking. *International Research Journal of Modernization in Engineering Technology and Science. https://www. irjmets. com/uploadedfiles/paper/volume_3/issue_12_december_2021/17422/final/fin_irjmets1638433809. pdf*.

[16] Mahant, M. V., Agrawal, M. S., & Lamba, M. A. (2021). Experimental Study on Dolomite Bricks with Positive Permanent Linear Change.

[17] Agrawal, M. S. (2022). IMPACT OF HEAVY METAL ACCUMULATION IN GROUND WATER DUE TO LEACHATE & ASSESSMENT OF RHEOLOGICAL PROPERTIES. *Journal of East China University of Science and Technology*, *65*(2), 318-326.

[18] Agrawal, M. S. (2022). A STUDY ON SEWAGE TREATMENT & GROUND WATER CONTAMINATION IN RAIPUR CITY. *Harbin Gongye Daxue Xuebao/Journal of Harbin Institute of Technology*, *54*(5), 187-191.

[19] Sinha, M. A. K., Verma, M. D. K., & Agrawal, M. S. (2020). Intelligent Transport System In India. *Solid State Technology*, *63*(6), 13123-13126.

[20] Pathak, A., Singh, V., Darjee, M. A., & Agrawal, M. S. (2017). A Seismic Behavior of Building in Earthquake Zone in Nepal.

[21] Lamba, M. A., Agrawal, M. S., & Dubey, M. A. (2021). ANALYSIS OF USE OF SUGARCANE BAGASSE ASH FOR THE PRODUCTION OF GEO POLYMER CONCRETE. *International Research Journal of Modernization in Engineering Technology and Science*, *3*.

[22] Agrawal, M. A., & Lamba, M. A. (2023) ANALYSIS AND DESIGN OF G+ 3 BUILDING IN DIFFERENT SEISMIC ZONES USING E-TABS.

[23] Shori, A., & Lamba, A. (2019). Performance of Concrete using Red Mud as Replacement Material with Basalt Fiber.

[24] Padhy, M. A. P., Lamba, M. A., & Tamrakar, M. G. (2022). Impact of Process Limits on Cable and Curve Additive Production Process. *Telematique*, 512-522.

[25] Lamba, M. A., Tamrakar, M. G., & Gaur, M. H. (2022). A comparative analysis on CI turbine act and emissions resorting to a novel antioxidant preservative. *Telematique*, 523-535.

[26] Sahu, M. K., Padhy, M. A. P., & Lamba, M. A. (2022). Preliminary Study on Interpretation Motion Traits of Moored Well-proportioned Wheeled vehicle for hauling-substitute in Common Waves. *Telematique*, 497-511.

[27] Lamba, A. (2022). FORMATIVE DESIGN OF HIGH-RISE SYSTEM IN STEEL STRUCTURE. *Harbin Gongye Daxue Xuebao/Journal of Harbin Institute of Technology*, *54*(6), 49-56.

[28] Lamba, M. A. (2022). In-Structure Response Spectra Considering Nonlinearity Of RCC Structures: Experiments And Analysis. *Yantu Gongcheng Xuebao/Chinese Journal of Geotechnical Engineering*, *44*(5), 97-103.

[29] Lamba, A. (2020). A Study On Geo Polymer Concrete Using Sugarcane Bagasse Ash. *Solid State Technology*, *63*(6), 13127-13134.

[30] Jaiswal, S., & Agrawal, S. (2021). Design of Horizontal and vertical alignment of Expressway for the speed of 150kmph–'A Review'.