Final Year Project Showcase Batch-2020
Year 2024

Department: Textile Engineering Programme: Textile Engineering	
1	**Project Title:** High Performance Textile Based Composite System for Retrofitting Application.
2	**Project Idea** Pakistan faces considerable challenges due to its high vulnerability to natural disasters, particularly earthquakes and floods. According to the World Bank, approximately 30 million people in Pakistan have been affected by floods in the last two decades, while the region experiences frequent seismic activity due to its proximity to the collision of the Indian and Eurasian tectonic plates. . Furthermore, with Pakistan's urban population expected to rise to over 100 million by 2030, the demand for retrofitting solutions that can strengthen existing infrastructure is urgent. The development of high-performance textile-based reinforcement systems for retrofitting aligns with this critical need. This project proposes an innovative, textile-based reinforcement system designed to enhance the structural integrity of buildings, increasing their resilience to seismic and environmental stressors. By utilizing advanced materials and engaging local communities in the construction process, this initiative can improve both safety and sustainability in Pakistan's built environment. Ultimately, this project can contribute to reducing the vulnerability of millions of people to future disasters, reinforcing national resilience against the growing threat of natural calamities.
3	**Process** **Manufacturing Fabrics:** • Two types of acrylic fabrics and two types of nylon fabrics were produced, each with 3-ply and 6-ply thicknesses, all using a unidirectional weave. • For high-performance applications, Taparan para-aramid fabrics were manufactured with 2, 6, 12, and 24 tows, also using a unidirectional weave. **Composite Fabrication:** • Two sets of composites were tested with epoxy resin and different reinforcements (nylon and acrylic) to measure their tensile strengths. • The same reinforcements were tested with Zepoxy 100 resin to evaluate the impact of the resin on composite strength. • Taparan-reinforced composites were manufactured using Zepoxy resin for retrofitting applications. **Curing and Application:** • Concrete cylinders and beams were cured according to standard procedures. • The cured samples were wrapped with the selected fabrics. • Epoxy resin was applied using the hand layup technique to create the composites. **Testing and Evaluation:**

	• The tensile strength of the composite strips was evaluated. • Composite testing was conducted in two stages: first, with fabric and resin composites alone, and second, with the composites applied to concrete specimens. • Only composites with higher tensile strengths were considered for civil applications.
4	**Outcome** The project examined the impact of commercially available CFRP system (Carbon Fiber Reinforced Polymer) with the developed TFRP (Taparan Fiber Reinforced Polymer) system on both compressive (ASTM C39) and flexural strength (ASTM C78) of materials. The results indicate that CFRP increases the compressive strength of cylinders by 50%, while TFRP offers a more substantial improvement, enhancing compressive strength by 75%. This demonstrates that TFRP provides a 50% greater increase in compressive strength compared to CFRP. Regarding flexural strength in prisms, CFRP leads to a 35% improvement. In contrast, TFRP results in a significant 60% increase, greatly exceeding the performance gains achieved with CFRP. Comparative analysis shows that TFRP enhances flexural strength by 71% more than CFRP. These results highlight TFRP's superior performance over CFRP in both compressive and flexural strength applications.
5	**Evidence (Theoretical Basis)** The effectiveness of reinforcement systems in retrofitting applications is crucial for enhancing the structural integrity and extending the lifespan of existing infrastructure. Traditional reinforcement materials like CFRP, BFRP, GFRP,etc. have been widely used due to their high strength-to-weight ratio and durability. However, the development and application of alternative materials such as Taparan Fiber Reinforced Polymer (TFRP), derived from aramid fibers, present a promising approach to improving performance characteristics. **Compressive Strength Enhancement:** The project conducted reveals that CFRP systems improve the compressive strength of cylinders by approximately 50%. This enhancement can be attributed to CFRP's high tensile strength and modulus of elasticity, which allow it to effectively transfer loads and distribute stresses across the reinforced material. However, TFRP demonstrates a more pronounced effect, with a 75% increase in compressive strength. This substantial improvement is explained by the superior mechanical properties of aramid fibers, which include high tensile strength, rigidity, and resistance to deformation. Aramid fibers' molecular structure, characterized by strong hydrogen bonding and rigid chain alignment, contributes to their exceptional load-bearing capacity and durability. **Flexural Strength Improvement:** In terms of flexural strength, CFRP provides a 35% improvement in prisms. CFRP's efficiency in flexural reinforcement is linked to its ability to resist bending stresses and distribute loads evenly. The CFRP's high tensile strength and low weight allow for effective reinforcement without adding significant mass to the structure. On the other hand, TFRP results in a significant 60% increase in flexural strength, surpassing CFRP's performance by 71%. The enhanced flexural strength of TFRP can be attributed to the

	aramid fibers' superior impact resistance and flexibility, which improve the material's ability to withstand bending stresses and recover from deformation. **Comparative Analysis** • The comparative analysis of CFRP and TFRP systems revels the superior performance of TFRP in both compressive and flexural strength applications. TFRP's 50% greater increase in compressive strength and 71% greater improvement in flexural strength compared to CFRP highlight its potential as a more effective reinforcement material. Theoretical considerations, including the aramid fibers' mechanical properties and structural advantages, support these findings. • Aramid fibers, such as Taparan, are known for their high tensile strength, low elongation, and excellent thermal stability. These properties make them highly effective in reinforcement applications where enhanced mechanical performance and resistance to environmental factors are critical. • The improved performance of TFRP can be attributed to its enhanced load transfer efficiency and stress distribution capabilities. The unique characteristics of aramid fibers allow for better integration with the base material, resulting in more effective reinforcement and increased overall strength. • The application of TFRP in retrofitting projects leads to more durable and reliable structures, which is particularly relevant for infrastructure in regions like Pakistan where environmental conditions and structural demands can be challenging. The use of TFRP offers a viable alternative to traditional CFRP systems, providing superior performance and potentially reducing maintenance and repair costs.
6	**Competitive Advantage or Unique Selling Proposition** **1. Indigenous Production Capability:** o Advantage: Utilizes locally sourced textile materials and resins, reducing dependency on international supply chains and import costs. o USP: Provides a cost-effective and self-reliant retrofitting solution by leveraging Pakistan's own manufacturing capabilities, making advanced technology more accessible and affordable. **2. Tailored Solutions for Local Conditions:** o Advantage: Customizes composite materials to meet specific environmental and structural needs of Pakistan, enhancing performance and durability. o USP: Offers high-performance retrofitting solutions specifically designed to address local climatic and seismic conditions, ensuring optimal effectiveness and reliability in local applications. **3. Advanced Material Technology:** o Advantage: Incorporates state-of-the-art Taparan para-aramid fabrics and locally formulated resins, providing superior tensile strength and durability. o USP: Delivers cutting-edge composite technology that sets a new standard in local retrofitting solutions, offering enhanced structural reinforcement compared to conventional materials.

a	**Attainment of any SDG** **1. SDG# 9: Industry, Innovation, and Infrastructure** Developing an indigenous retrofitting system using locally produced textile materials and resins fosters innovation in the construction industry. This project enhances the durability and safety of buildings, which is crucial for a country like Pakistan, where infrastructure development is key to economic growth and resilience. **2. SDG#11: Sustainable Cities and Communities** The project contributes to making cities more sustainable by improving the quality and longevity of existing buildings. This is particularly important in Pakistan, where urban areas are rapidly expanding and require effective retrofitting solutions to ensure safety and sustainability in aging infrastructure. **3. SDG#8: Decent Work and Economic Growth** The project supports local industry growth and creates job opportunities in the manufacturing and construction sectors. By fostering domestic production capabilities, it contributes to economic development and provides skilled employment opportunities.
b	**Any Environmental Aspect** The retrofitting system enhances building resilience to climate-induced stresses, such as extreme weather and seismic activity. This mitigation strategy aligns with climate adaptation objectives by reinforcing infrastructure against environmental risks.
c	**Cost Reduction of Existing Product** To achieve cost reductions with the Taparan Fiber Reinforced Polymer (TFRP) system, the following strategic measures are implemented, 1. Bulk purchasing agreements for aramid fibers and establish local production facilities to lower material and transportation costs. 2. Incorporate of optimized manufacturing techniques to enhance production efficiency and reduce operational expenses. 3. Refine the resin and fiber mixture formulation to ensure that each unit of TFRP achieves the necessary strength while minimizing material costs.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** The primary issue with Carbon Fiber Reinforced Polymer (CFRP) in civil retrofitting is its high cost and potential for brittle failure, which can be a significant concern in seismic regions or for structures subjected to impact. Aramid Fiber Reinforced Polymer (AFRP), specifically Taparan Fiber Reinforced Polymer (TFRP), addresses these issues by offering greater toughness and impact resistance compared to CFRP. TFRP's superior ductility helps improve the durability and resilience of retrofitted structures, making it a more cost-effective and reliable option for enhancing structural performance.
e	**Expanding of Market share**

	The existing market primarily offers standalone components, lacking a cohesive and high-performance solution tailored to the specific needs of retrofitting applications. This fragmentation forces stakeholders to import complete retrofitting systems from international suppliers, leading to higher costs and logistical challenges. This project addresses the market gap by developing a comprehensive, locally-produced retrofitting system that integrates indigenous fabrics and resins into a cohesive FRP composite solution.
f	**Capture New Market** This project endeavors to explore the emerging market for technical textiles in the domain of fiber-reinforced polymer (FRP) applications. The primary objective is to develop a cost-effective, indigenous retrofitting system for building infrastructure in Pakistan, utilizing locally sourced materials.
g	**Scope and Potential** The technical textile industry, specifically through the application of Fiber Reinforced Polymer (FRP) reinforced fabrics, offers a transformative potential for improving civil infrastructure in Pakistan. The country is currently facing substantial challenges in its infrastructure sector, characterized by the urgent need for repair and modernization. As outlined in the Pakistan Economic Survey 2022-2023, there exists a significant infrastructure deficit requiring extensive investment for upgrades to roads, bridges, and buildings. FRP reinforced fabrics present a viable solution to these issues. The global FRP composites market in civil engineering was valued at approximately USD 9.2 billion in 2022, with a projected compound annual growth rate (CAGR) of around 7% from 2023 to 2030. This growth is driven by the materials' superior performance characteristics, including a strength-to-weight ratio five to ten times greater than traditional materials like steel. Such properties are particularly beneficial for reinforcing existing structures and enhancing new constructions. In Pakistan, where infrastructure deterioration is a critical concern, the application of FRP reinforced fabrics could have a significant impact. The National Highway Authority of Pakistan (NHA) estimates that over PKR 1 trillion is needed for infrastructure upgrades, including bridge and road rehabilitation. FRP technologies could notably extend the lifespan of these structures, with research indicating that FRP composites can enhance the load-bearing capacity of reinforced concrete bridges by up to 50% and prolong their service life by over 30 years. Moreover, the use of FRP materials aligns with Pakistan's sustainable development goals as outlined in the Pakistan Vision 2025, which advocates for modernizing infrastructure while promoting environmentally friendly practices. FRP composites are characterized by their durability, low maintenance requirements, and reduced environmental impact compared to traditional materials. Their implementation could result in lower lifecycle costs and a diminished environmental footprint.

7	**Target Market** Our target market for Fiber-Reinforced Polymer (FRP) systems for civil structures includes, 1. **Government Infrastructure Projects**: Various government departments involved in infrastructure development, such as the National Highway Authority (NHA) or the Public Works Department, might be interested in FRP systems for strengthening and rehabilitating bridges, highways, and public buildings. 2. **Construction Companies**: Both large and small construction firms involved in new builds or renovations could be interested in using FRP systems to enhance the strength and durability of structures. 3. **Engineering and Consulting Firms**: Firms specializing in structural engineering and consulting may use FRP systems in their designs and recommendations for improving the performance of civil structures. 4. **Architectural Firms**: Architects looking for innovative materials to meet aesthetic and structural requirements might incorporate FRP systems into their designs. 5. **Educational Institutions and Research Organizations**: Universities and research centers focused on civil engineering and materials science might be involved in studying and promoting the use of FRP systems. 6. **Real Estate Developers**: Developers working on large-scale residential, commercial, or mixed-use projects could consider FRP systems for their benefits in terms of longevity and maintenance. 7. **Maintenance and Rehabilitation Specialists**: Companies that specialize in the maintenance and rehabilitation of aging infrastructure may use FRP systems as part of their service offerings.	
8	**Team Members** (Names along with email address)	Inisa Fatima (insiafatima49@gmail.com) Shafia Shazad (shafiashahzad521@gmail.com) Wajiha Abid (wajihaabid80@gmail.com) Sultan Ullah Baig (sultanbaig1236@gmail.com)
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11	**Video (If any)**	Please provide the link of the video

Pictures

Failure of Concrete Cylinders

Control Specimen (Without Reinforcement and Resin)


CC1


CC2


CC3

CFRP (Sika Wrap 230 C + Sikadur 30)


CFRP - C1


CFRP - C2


CFRP - C3

TFRP (T25 Taparan uni-directional Fabric + Sikadur 30)


TFRP - C1


TFRP - C2


TFRP - C3

Failure of Concrete Prism

Control Specimen (Without Reinforcement and Resin)


CP 1


CP 2


CP 3

CFRP (Sika Wrap 230 C + Sikadur 30)

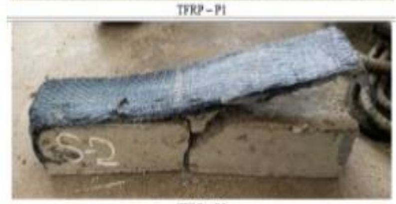

CFRP – P1

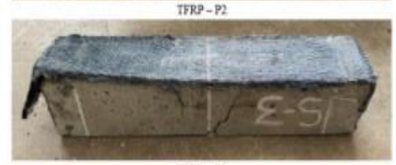

CFRP – P2


CFRP – P3

TFRP (T25 Taparan uni-directional Fabric + Sikadur 30)


TFRP – P1


TFRP – P2


TFRP – P3