Final Year Project Showcase Batch-2020
Year 2024

Department: Civil Engineering Programme: Civil Engineering	
1	**Project Title** Experimental Investigation of Circular Columns Longitudinally and Spirally Reinforced with GFRP Bars Subjected to Concentric and Eccentric Loading
2	**Project Idea** The project investigates the structural behavior of **large-scale circular concrete columns** reinforced with **Glass Fiber Reinforced Polymer (GFRP) bars and spirals** under **concentric and eccentric loading conditions**. GFRP is explored as a **non-corrosive alternative to steel reinforcement**, particularly in environments prone to corrosion. The study tests **large-scale columns** to compare their **load-carrying capacities** and failure mechanisms against steel-reinforced columns, aiming to address design limitations and contribute to the development of GFRP as a sustainable replacement for steel in **reinforced concrete (RC) columns**.
3	**Process** The process for testing the **large-scale circular concrete columns** reinforced with **GFRP bars and spirals** included the following key steps: 1. **Material Selection**: The project used **locally manufactured GFRP bars** with known mechanical properties, as well as ready-mix concrete with a target compressive strength of 27.6 MPa (4 ksi). 2. **Column Design**: The columns had an external diameter of 12 inches and a height of 5 feet, reinforced with six 16 mm GFRP bars and 10 mm spirals spaced at 75 mm. 3. **Experimental Setup**: The columns were subjected to **concentric and eccentric loading conditions**, with varying eccentricities (0 mm, 50 mm, and 75 mm). A theoretical load-moment interaction diagram was developed using Excel, based on equations from existing literature. 4. **Casting and Curing**: The columns were cast and cured using a standard process, ensuring that reinforcement cages were prepared with appropriate spacing and concrete mix design was followed. 5. **Load Testing**: Columns were tested under load using a 6000 kN actuator to evaluate their **load-carrying capacities**. The behavior of both GFRP and steel-reinforced columns was observed under different loading conditions. 6. **Analysis**: Results were compared with theoretical predictions, and load-displacement curves were analyzed to identify failure modes and the contribution of GFRP spirals in enhancing strength and ductility
4	**Outcome** The project found that **GFRP-reinforced large-scale concrete columns** performed well under both **concentric and eccentric loads**, offering comparable **load-carrying capacities** to steel-reinforced columns. GFRP spirals significantly enhanced the **ductility and confinement**, making GFRP a promising alternative to steel, especially in corrosive

	environments. The findings support the use of GFRP in structural applications and contribute to refining design guidelines for reinforced concrete columns.
5	**Evidence (Theoretical Basis)** The **theoretical basis** or **evidence** for this study is grounded in existing research and design equations regarding the behavior of **GFRP-reinforced concrete columns** under loading. Key theoretical points include: • **Corrosion resistance of GFRP**: Studies have shown that GFRP bars are non-corrosive, making them an effective alternative to steel in harsh environments, which extends the service life of structures. • **GFRP in compression**: Although GFRP is more commonly used in flexural elements, the study builds on research suggesting that **GFRP spirals enhance ductility** and **confinement**, improving the performance of compression elements like columns. • **Load-Moment Interaction Diagrams**: The study uses equations developed by Nanni et al. (2014) to generate theoretical **load-moment interaction diagrams** for GFRP-reinforced columns, which predict how these columns perform under varying loading conditions (concentric and eccentric). • **Existing design codes**: While current design codes such as ACI 440.1R-15 and CSA S806-12 do not fully address GFRP's role in compression, past research indicates that with proper confinement, GFRP can contribute significantly to the structural integrity of concrete columns.
6	**Competitive Advantage or Unique Selling Proposition** **1. Cost Reduction and Process Improvement:** GFRP columns lower material and maintenance costs due to their lightweight and non-corrosive nature, enhancing profitability for construction firms. **2. Sustainability and SDGs:** GFRP aligns with SDG 9 and SDG 12 by promoting sustainable materials, significantly reducing the carbon footprint compared to traditional steel. **3. Market Expansion:** GFRP addresses niche markets, such as MRI centers, attracting customers seeking durable and innovative solutions. **4. Superior Performance:** GFRP columns demonstrate adequate load-bearing capacity and enhanced ductility, providing reliable options for challenging structural applications.
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) • GFRP aligns with SDGs 9 and 12 by promoting innovative materials that enhance infrastructure resilience and reduce environmental impact, particularly in regions prone to corrosion or harsh conditions. • By minimizing maintenance needs and extending the lifespan of structures, GFRP supports sustainable economic growth and addresses local environmental challenges, making it a vital solution for future construction practices.
b	**Any Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) • **Carbon Reduction:** GFRP's non-corrosive properties reduce the need for frequent repairs and replacements, lowering overall carbon emissions associated with manufacturing, transportation, and maintenance of traditional steel reinforcement.

	• **Energy Efficiency:** The lightweight nature of GFRP allows for easier handling and reduced energy consumption during transportation and installation, contributing to a more energy-efficient construction process.
c	**Cost Reduction of Existing Product**
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) • **Current Issues:** Traditional concrete reinforcement with steel often leads to corrosion, requiring extensive maintenance and repairs, which increases overall project costs and extends construction timelines. • **Suggested Improvements:** Implementing GFRP reinforcement can eliminate corrosion-related issues, resulting in lower maintenance requirements and reduced lifecycle costs. The lightweight nature of GFRP also streamlines the construction process, allowing for faster installation and improved overall efficiency, ultimately leading to a superior and more durable product.
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market • **Strategy:** Promote GFRP as a superior alternative to traditional steel reinforcement in corrosion-prone environments, emphasizing long-term cost savings and durability to attract more clients. • **Current Issues:** The dominance of steel reinforcement limits options for clients seeking durable solutions.
f	**Capture New Market** (e.g. Niche market or unaddressed segment) • **Niche Opportunities:** Target markets like healthcare facilities (e.g., MRI centers) where non-metallic materials are preferred, and sectors focused on sustainability. • **Unaddressed Segments:** Many construction sectors have yet to adopt GFRP, providing an opportunity to establish it as a standard for eco-friendly construction practices.
g	**Any Other Aspect**
7	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service) • **Construction and Engineering Firms:** Seeking innovative, durable materials for sustainable infrastructure projects. • **Healthcare Facilities:** Hospitals, especially those with MRI centers, requiring non-metallic reinforcement. • **Government Agencies:** Focused on public infrastructure with an emphasis on longevity and reduced maintenance costs. • **Educational Institutions:** Universities involved in civil and structural engineering, interested in incorporating GFRP in research and curriculum. • **Contractors and Builders:** General contractors looking for cost-effective and reliable reinforcement solutions.
8	**Team Members** (Names along with email address) — Saad Ahmed (ahmed4301092@cloud.neduet.edu.pk) Javeria Hashmi (hashmi4302816@cloud.neduet.edu.pk) Areef Jawaid (jawaid4301446@cloud.neduet.edu.pk)

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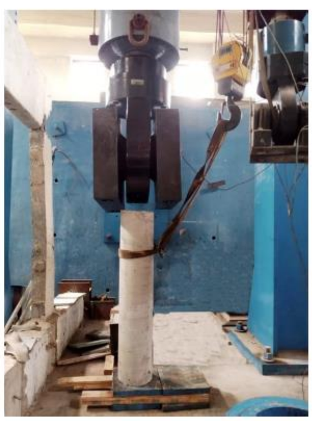
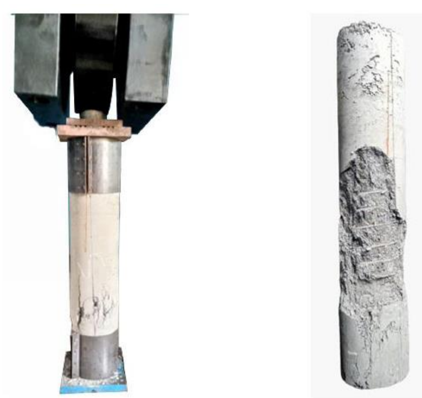
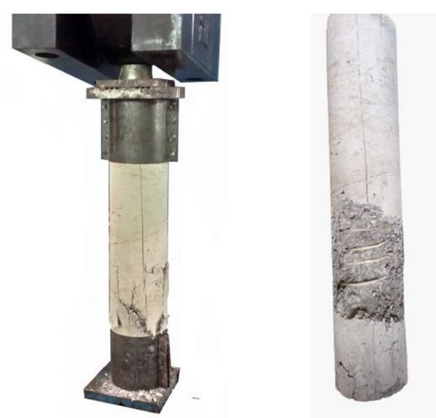
11	**Video (If any)**	Please provide the link of the video

Pictures (to be pasted below)

	
Reinforcment cages	Casting of specimens
	
Pilot testing	Testing of specimen
	
Tested specimen of steel RC column	Tested specimen of GFRP RC column