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Flexural Behaviour Of Gfrp Wrapped Rcc Beams

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ABSTRACT

Fiber Reinforced Polymer (FRP) is a relatively new class of composite material manufactured from fibers and resins and has proven efficient and economical for the development and repair of new and deteriorating structures in civil engineering. FRP composite materials possess superior mechanical properties. It includes impact resistance, strength, stiffness, flexibility and ability to carry loads. To meet up the requirements of advanced infrastructure, new innovative materials/ technologies in construction industry has started to make its way. Any technology or material has its limitations. To meet the new requirements, new technologies have to be invented and put to use. With structures becoming old and the increasing bar corrosion, old buildings have started to demand additional retrofits to increase their durability and life. Use of FRP for confinement has proved to be effective retrofitting and strengthening application. In this paper concrete specimens are wrapped with glass fibre reinforced polymers (bi-directional) to study the effect of confinement in the strength of specimens.

INTRODUCTION

Fiber Reinforced Polymer (FRP) is a relatively new class of composite material manufactured from fibers and resins and has proven efficient and economical for the development and repair of new and deteriorating structures in civil engineering. The mechanical properties of FRPs make them ideal for widespread applications in construction worldwide. The two major components of an FRP composite material is resin and reinforcement. A cured thermosetting resin without any reinforcement is glass like in nature and appearance, but often very brittle. By adding a reinforcing fiber such as carbon fiber, glass, or aramid, the properties are vastly improved. Fiber Reinforced Polymer (FRP) composites are used in a wide variety of applications. FRP composite materials possess superior mechanical properties. It includes impact resistance, strength, stiffness, flexibility and ability to carry loads.

FRP LAMINATE STRUCTURE

FRPs are typically organized in a laminate structure, such that each lamina (or flat layer) contains an arrangement of unidirectional fibres or woven fibre fabrics embedded within a thin layer of light polymer matrix material. The fibres, typically composed of carbon or glass, provide the strength and stiffness. The matrix, commonly made of polyester, Epoxy or Nylon, binds and protects the fibers from damage, and transfers the stresses between fibers.

APPLICATION OF FIBRE REINFORCED COMPOSITES IN STRUCTURES

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FRPs can be used in the concrete structures in the following forms:

- Plates - at a face of structural elements to improve the shear capacity.
- Bars - as reinforcements in beams and slabs, replacing the steel bars.
- Cables- as tendons and post tension members in suspension and bridge girders.
- Wraps- around concrete members to confine concrete and improve the compressive strength.

FIBRE REINFORCED POLYMER COMPOSITE MATERIALS

To meet up the requirements of advanced infrastructure, new innovative materials/ technologies in construction industry has started to make its way. Any technology or material has its limitations. To meet the new requirements, new technologies have to be invented and put to use. With structures becoming old and the increasing bar corrosion, old buildings have started to demand additional retrofits to increase their durability and life.

Use of FRP for confinement has proved to be effective retrofitting and strengthening application. The confinement in seismically active regions has proved to be one of the early applications of FRP materials in infrastructure applications. Confinement may be beneficial in non-seismic zones too, where, for instance, survivability of explosive attacks is required or the axial load capacity of a column needs to be increased due to higher vertical loads, e.g. if new storey's have to be added to an existing building or if an existing bridge deck has to be widened. In any case, confinement with FRP may be provided by wrapping RC columns with prefabricated jackets or in situ cured sheets, in which the principal fiber direction is circumferential. Beams, Plates and columns may be strengthened in flexure through the use of FRP composites bonded to their tension zone using epoxy as a common adhesive for this purpose. The direction of fibers is parallel to that of high tensile stresses. Both prefabricated FRP strips, as well as sheets (wet-layup) are applied. Hence, FRP composites are finding ways to prove effective and economical at the same time.

In today's growing economy, Infrastructure development is also raising its pace. Many reinforced concrete and masonry buildings are constructed annually around the globe. With this, there are large number of them which deteriorate or become unsafe to use because of changes in use, changes in loading, change in design configuration, inferior building material used or natural calamities. Thus repairing and retrofitting these structures for safe usage of these structures has a great Market.

There are several situations in which a civil structure would require strengthening or rehabilitation due to lack of strength, stiffness, ductility and durability. Some common situations where a structure needs strengthening during its lifespan are:

- Seismic retrofit according to current code requirements.
- Upgraded loading requirements; damage by accidents and environmental conditions.
- Initial design flaws
- Change of usage.

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Depending on the desired properties, usage and level of damage in structural members, these can be repaired and/or strengthened by several widely used methods some of widely used repair techniques are presented below.

Concrete jacketing can be applied to locally damaged or heavily damaged structures. When concrete is slightly damaged, the loose concrete is removed the surfaces are roughened and the dust is cleaned. Now depending on the amount of concrete removed, some additional ties or reinforcement can be added and jacketing is carried out i.e. new concrete is filled. Non shrinkage concrete or concrete with low shrinkage properties should be used. Special attention is paid to achieve a good bond between old and new concrete.

Jacketing should also be applied in cases of heavily damaged columns or in cases of insufficient column strength. This is actually a strengthening procedure but can be used for repair purposes. The additional concrete and reinforcement added contribute to increase in strength.

Concrete jacketing has a lot of limitations. The jacket should be of minimum 100mm thickness. The sizes of members are increased and the free available usable space becomes less. Also adding a huge dead mass and increasing the stiffness which reduces the efficiency of the structure. Its durability has also been often found to be limited. Furthermore the whole process is slow and takes lot of time for completion.

Jackets may also be made of steel. It is a popular technique to use steel plates bonded with epoxy to external surfaces of columns, beams and slabs. This technique is simple and effective as far as both cost and mechanical performance is concerned but suffers major disadvantages. Corrosion of steel plates hurdles its use in structures in/near river, lake and sea. Furthermore difficulty in manipulating heavy steel plates in tight construction sites, need for scaffolding, and limitations in available plate lengths which results in need of joints. Sometimes steel's high young's modulus causes it to take large portion of axial load resulting in premature buckling.

EXPERIMENTAL RESULTS

After 28 days curing specimens are wrapped with 1.2 mm thick glass fibre mat (bi-directional) by using epoxy polymers. Specimens are tested after 7 days of wrapping.

Table 1 Compressive strength of concrete cubes

Type of specimen	Compressive strength in N/mm^2		
	M20 Grade	M30 Grade	M40 Grade
Unwrapped specimens	32.24	42.62	51.86
Wrapped with GFRP mat	47.68	63.24	76.28

Table 2 Split tensile strength of concrete cylinders

Type of specimen	Split tensile strength in N/mm^2		
	M20 Grade	M30 Grade	M40 Grade
Unwrapped specimens	3.82	4.54	5.2
Wrapped with GFRP mat	6.42	7.61	8.74

Table 3 Flexural strength of concrete prisms

Type of specimen	Flexural strength in N/mm^2		
	M20 Grade	M30 Grade	M40 Grade
Unwrapped specimens	3.96	4.58	5.42
Wrapped with GFRP mat	5.92	7.15	8.02

CONCLUSION

The mechanical properties of FRPs make them ideal for widespread applications in construction worldwide. Use of FRP for confinement has proved to be effective retrofitting and strengthening application. The confinement in seismically active regions has proved to be one of the early applications of FRP materials in infrastructure applications. Confinement may be beneficial in non-seismic zones too, where, for instance, survivability of explosive attacks is required or the axial load capacity of a column needs to be increased due to higher vertical loads, e.g. if new storey's have to be added to an existing building or if an existing bridge deck has to be widened. In any case, confinement with FRP may be provided by wrapping RC columns with prefabricated jackets or in situ cured sheets, in which the principal fiber direction is circumferential. Beams, Plates and columns may be strengthened in flexure through the use of FRP composites bonded to their tension zone using epoxy as a common adhesive for this purpose. Strength of concrete members confined with GFRP mat is improved by 1.7 times than the strength of unwrapped specimens.

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