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Fibre Reinforced Polymer & Plastics: Applications in Construction

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Abstract: ***This work is basically for applications of fibre reinforced polymers (FRP) in civil engineering, To illustrate and highlight the advantages that are achievable in the strengthening and static improvement of structures by using fibre reinforced polymers (FRP), Plastic in comparison with the Traditional components or material. Along with possible future development in their applications to replace them with traditional components***
Keywords: FRP, Formwork, GPC, GFRP, CFRP

I. INTRODUCTION

1) FRP has several applications in construction sector. Due to their high technical properties, a composite provides best performance when used in the upgrade, restoration, repair or seismic strengthening of simple and complex structures. Considering the examples of carbon fiber reinforced polymer (CFRP) reinforcement used in framed structures:

a) Wrapping of columns using continuous sheets. The composite material is impregnated in situ and bonded to the columns. This reduces the transverse expansion of the compressed element by confinement, therefore increasing its compressive strength.

b) Flexural and shear strengthening of beams realized by surface bonding of the impregnated material in situ or pultruded laminates; in some cases, the anchorage of sheets can be improved with the use of FRP rebars.

2) Use of Plastic in formworks is also one of the latest trends in construction sector as it serves the purpose of lighter, cheaper and efficient formwork as well as management of plastic waste at the same time.

3) Use of GPC and FRP in construction of beams is also done because we know that Ordinary Portland Cement concrete (OPCC) is one of the most commonly used and oldest building materials in the world that's why order for this material is expected to increase in the future due to the increasing demand for infrastructure in many developing countries but production of just a ton of cement causes release of one ton of carbon dioxide in the atmosphere; this is due to the calcination of limestone and burning of fossil gas during the manufacturing of cement. Due to which use GPC with GFRP bars or CFRP bars can be done for construction of beams.

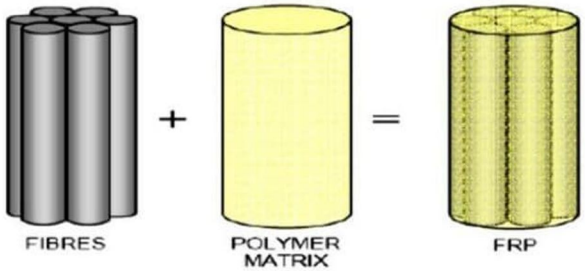

Figure 1: Composition of FRP

II. ADVANTAGES OF FRP COMPARED TO TRADITIONAL MATERIALS

The real advantages of using FRP as an alternative to traditional methods should be evaluated from both technical and economic points of view. Technically speaking, composite materials have significant advantages, most importantly their light weight along with high mechanical properties, resistance to aggressive chemical agents and impermeability to water. The use of steel, widely adopted in conventional construction, has several disadvantages, such as reduced durability caused by its vulnerability to chemical agents and corrosion. Moreover, the steel has little reversibility, whereas FRP is completely reversible since adhesive materials that transfer stresses can be removed.

Further important characteristics of composites include the following:

1) Unlimited capacity to be molded (fabric impregnated in situ) and perfect adaptability to the original shape of the structural element that needs to be reinforced, stiffened and/or integrated (eg, frame knots, masonry vaults, etc);
2) Simple application methods with absence of complex preparation;
3) Non-invasive application. Their installation does not disrupt the original material of the structure;
4) Very brief time required to reach full mechanical performances of the applied reinforced composite.
5) Durability.

From an economic standpoint, the following are the main factors contributing to their competitiveness with respect to conventional materials:

a) Time saving;
b) Flexibility;
c) Low labor costs;
d) Low tooling and machinery costs on the construction site because of the light weight and manageability of tools and material used. The advantages of strengthening reinforced concrete with FRP compared to conventional methods can be seen in the 65% drop of total costs of application because of reduced labor needed and ease of installation in situ;
e) Possibility of restoring a structure without interrupting its utilization by users. A typical example is the upgrade of piers and/or motorway bridge pillars damaged by unusual events (i.e., large/exceptional vehicle impact) with FRP. In this case, the work is generally carried out while the structure is still in use or with a limited and temporary closure of a traffic lane. This results in cost benefits and reduced effects on users and consumers.

III. PERSPECTIVES FOR THE APPLICATION OF FRP IN CONSTRUCTION

Structural safety is always required, especially in seismic areas where social and economic concerns are very high. More resources are continually being devoted to the retrofit and upgrade of existing structures. The use of FRP is thus becoming more widespread as an optimal innovative system able to reduce the seismic vulnerability of reinforced concrete structures. The application of the FRP system does not increase the structural weight. It ensures an effective confinement of concrete. It can also perfectly adapt itself to complex shapes, increase the strength of critical regions of columns and can modify the strength hierarchy of the structure, inducing ductile controlled mechanisms of collapse.

The effectiveness of the FRP system for guiding and controlling the structural collapse can be also useful to optimize controlled "demolitions". This reduces demolition risks in regards to adjacent buildings, roads, etc.

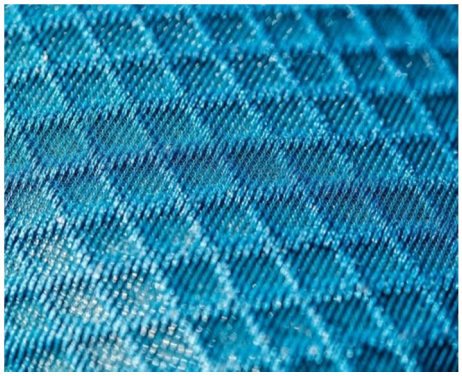

Figure 2: A microscopic look at FRP Fibers

More so than the conventional methods and materials, the use of the FRP is especially suitable for difficult and complex applications either on load bearing members (i.e., beams, columns, etc) or on secondary elements (i.e. infill and partition walls) of structures having strategic interest and identified as sensitive objectives (in case of explosion risk, terrorist or attempted attacks, etc). In such situations, the adoption of FRP can help to limit damages to persons and structures.

The FRP technology is also very effective in cases of urgency: for safety and temporary preservation of structures damaged during special events.

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IV. PLASTICS IN FORMWORK

Considering the latest issues in construction system or industry like labour problem and the cost of formwork system at desired location, reusability and waste management thought or need to develop an alternative formwork system to help the industry not only to reduce construction cost but also design a system that is easy to install, dismantle and handle.

Hence plastic in the formwork system currently is the only option that provides following Advantages: Distinct Feature of Desire/plastic Formwork Systems

1) Cost Effective
2) Labour Friendly
3) Eco Friendly
4) Low in Maintenance
5) Versatile

A. Details

This system is made from special grade plastic and hence no chemical reaction takes place or the material sticks to it. Because of this property you cannot get any patched on the RCC finish. Also the gap between two plates is so negligible that neither water nor cement gets leaked out at the time of RCC and it gets cured from the bottom of the plate, which also enhance the final quality of RCC casting. Comparatively our foam systems are very less in weight compared to conventional M.S. Plate (1/4th) and Plywood (1/2). Due to easy plugging systems and easy to fit makes this foam shuttering system most labour friendly.

Figure 3: Worker easily carrying 6 slabs of plastic formwork

By using Desire systems one need not nail or apply oil to the plates before casting RCC. Due to auto levelling of plugging systems the plates are automatically levelled. Hence 30 % time saves in assembling and also while dismantling the same. You can cast Slab, Beam & Column, etc. A lot of the parts in the Desire system are supportive to each other and you can cast a beam from 9 inch to 21 inch by this same plate by simply adjusting the locking systems. Desire formwork systems are made from Petroleum waste and it's long lasting and gives more than 100 repetitions. After every usage of Desire foam systems once can easily clean the plates with water. Where as in M.S. Plate one has to apply oil to clean the M.S. surface plates. In Desire plates if any breakage occurs by mishandling it can be very easily sealed by low voltage hot air gun.

B. Comparison

Table 1: Comparison of Plastic, Traditional and Steel Formwork

Item	Plastic Formwork	Traditional Formwork	Steel Formwork
Recycled	40%	No	10%
Water resistant	Yes	No	No
Deformation condition	No	Yes	Yes
Stripping process	Easy	Moderate	Difficult
Size	Any size can supply	Restricted	Restricted
Corrosion resistant	Excellent	Bad	Bad
Available time	More than 100 times	8 times	100 times

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Figure 4: Plastic Formwork

C. Summary

This system gives more than 100 repetitions; hence running cost is low. The final RCC work will get a smooth finish with minor joint line which does not require plaster. One can do putty and paint it. If you don't do plaster and hence it is cost effective. Hence it is very easy to install, dismantle, transport from one place to another. Its replace plywood's which consumes trees and M.S. which consumes iron ore from our planet earth. Our products help in preventing this precious metal from our earth.

V. GEO POLYMER CONCRETE (GPC) AND FIBRE REINFORCED POLYMER (FRP) IN BEAMS

Geo Polymer concrete is a new type of concrete without the use of cement. Nowadays we can find it in some structures like environmental friendly railway sleepers, modular retaining walls, and sustainable buildings that use sustainable CFRP-reinforced recycled concrete for cleaner eco-friendly construction with new and alternative materials. Researchers are now giving immense attention to the sustainable construction by motivating to form beams with GPC and FRP. Alkalinity of the concrete protects the steel reinforcement from the corrosion. Some structures have successfully countered the harsh climates (marine system bridges and garages) and exposure to salts and combination of moisture, temperature, and chlorides which decrease the alkalinity of the concrete then result in the corrosion of steel reinforcement. Because fibre-reinforced polymer (FRP) bars are noncorrosive and nonmagnetic, the issue of steel corrosion and the electromagnetic interface can be eliminated. Additionally, FRP bars have excessive tensile stress, making them proper to use as a structural reinforcement.

A. Observation Made upon Research and Experimentation

After several research and experimentation done by S. Kumaravel, S. Irugnanasambandam and others on flexural behaviour of Steel Reinforced-Reinforced Geo Polymer Concrete (SR-RGPC) beams. Load-deflection characteristics gained from Steel Reinforced–Reinforced Ordinary Portland Concrete (SR-ROPC) and SR-RGPC beams are almost similar. Ultimate load-carrying capacity of SR-RGPC beams was a little bit higher. First cracking load of SR-RGPC beams is better as compared to that of SR-ROPC beams, which shows better load-carrying capacity. Failure of SR-RGPC beams is more ductile in manner than SR-ROPC beams, accompanied by crushing of concrete in the compression zone, and SR-RGPC beams exhibit a higher number of narrow cracks compared to the SR-ROPC beams.

Whereas for GFRP and CFRP there properties found were:

Table 2: Properties of FRP Bars

Type	Bar Diameter	Area A_f (mm^2)	Ultimate tensile stress f_{fu} (MPa)	Elastic Modulus E_f (GPa)	Ultimate strain (%)
GFRP bars	6	28	1280	46	2.7
CFRP bars	6	28	2000	148	1.4

The crack formation observed in CFRP-RGPC beams were more than what was observed in the GFRP-RGPC beams, and the crack width in the GFRP-RGPC beams was wider as compared to that of in the CFRP-RGP.

VI. CONCLUSIONS

Hence we conclude that,

A. Use of FRP in close future would be more eminent as impermeable to water, lighter, reduced cost of labour, helpful in restoration of structures without interrupting the utilization by user or require temporary closure of utilization or traffic.

B. Plastic in formwork until now has proven a promising option in reducing cost of construction as well as an efficient way to recycle plastic without compromising with quality, even today there are certain problems that needs to be solved before replacing traditional material used for formwork completely with plastic formwork but few years down the line with research it may replace traditional formwork material like timber and MS steel.

C. As the requirement of cement and concrete tends to go up due to infrastructural advancement in developing nations , production of cement takes a huge toll on our environment hence making of beams with GPC and FRP which provides equivalent result to that of SR ROPC may result in nature friendly constructions in future.

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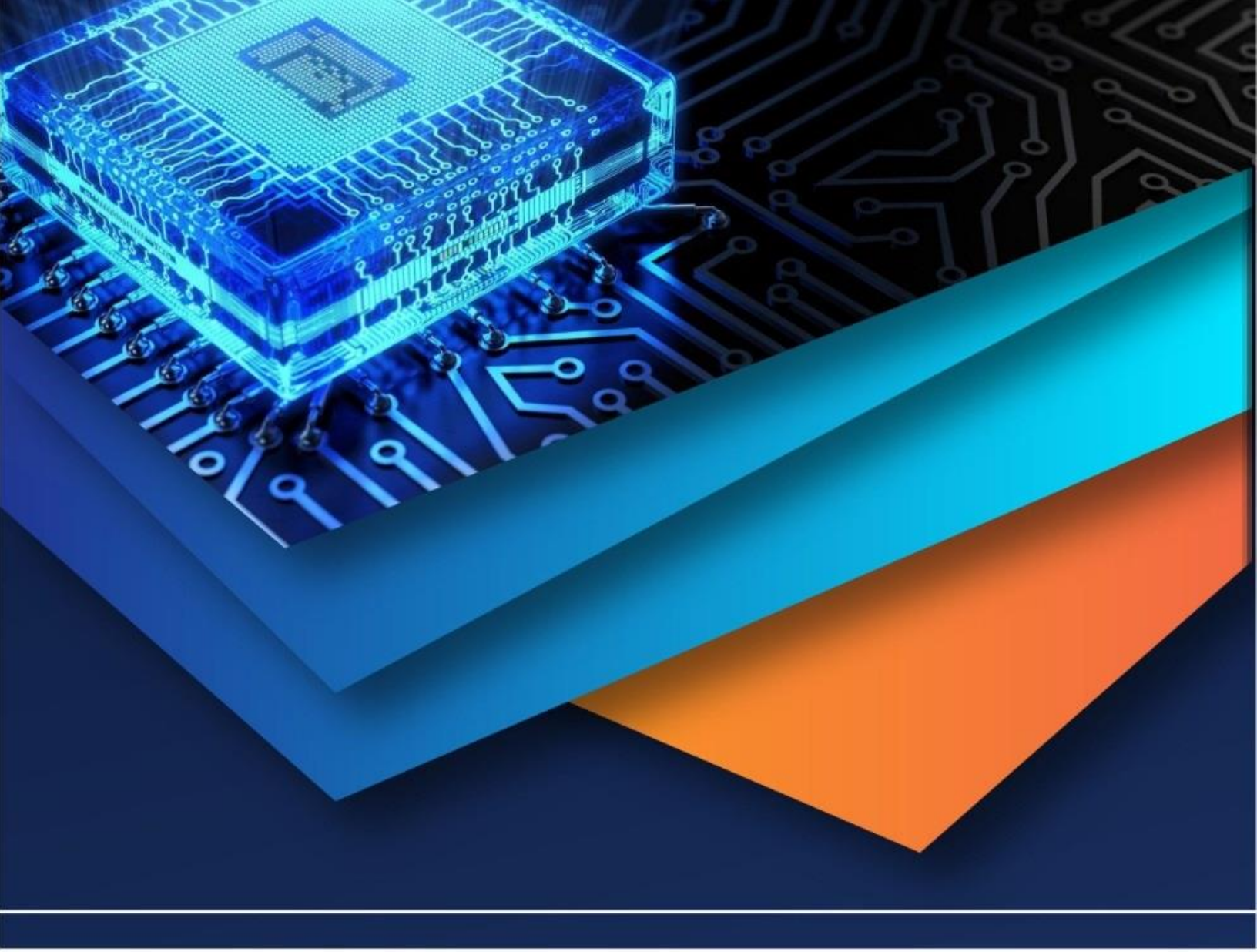

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