Study on effects of different patterns and cracking for wastes FRP (used banner) wrapping on compressive strength of confined concrete

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Abstract.Previous researches have shown that FRP are being introduce into wide variety of civil engineering applications. Fibre Reinforce Concrete (FRP) are also used as repairing method in concrete structures. FRP such as S-glass, AR-glass, E-glass, C-glass, and Aramid Fibre are the common material used in industry. The FRP strips provide the necessary longitudinal and hoop reinforcement. However, there are lots waste materials that can be form as fibre and used in repairing. Banner is a type of waste material fibre that can be used in repairing. In this study, banner will be used as the replacement of the common FRP. The confined concrete (cylinder) of 300mm height and 150mm diameter were cast with M35 grade concrete and tested until it is crack. Next banner are used as the wrapping along the cracking of the concrete with three different pattern that are full wrapping, two band wrapping and cross wrapping using epoxy. Epoxy is a common name for a type of strong adhesive used for sticking things together and covering surface. The objective of this study is to determine the maximum strength and the effect of different patterns wrapping of FRP (banner) on the compressive strength of confined concrete. The results are shows that banner are suitable as a replacement of material for FRP.

1. Introduction
Recently, Waste material or unused material is one of the biggest contributions to environmental pollution. Examples of waste material include municipal solid waste (household trash/refuse), hazardous waste, waste water, radioactive waste and others. According to [1-3], wastes materials are not the prime product for which the initial user has no further use in terms of purposes of production, transformation or consumption of which it will be dispose. Waste material may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products and other human activities.

Banner is an example of waste or unused material. Banner is a flag or other piece of cloth bearing a symbol, logo, slogan or other message as shown in Figure 1.3. It is used in many business ventures, marketing to their potential audience. In Malaysia, banner is widely used to inform the people about the upcoming event. All the details such as name of program, date and venue are printed on the banner.
When the event or program is already underway, the banner become a useless item and will be thrown away or leave it hanging without been used by people.

2. Literature Review
Banner is a type of fibre that is strong enough to withstand any type of temperature. Banner can be used in substituting existing FRP because of the similar properties between each other. In Malaysia, banner is used as an information part to show the upcoming event as shown in Figure 1. Therefore it becomes waste material when the event has been completed.

According to P. Sadeghian[4], many researchers studied the behaviour of concrete members wrapped with external bonded fibre reinforced polymer (FRP) composites and proposed a variety of confined models in the past two decades. This FRP has two different field of application in repair and strengthening of existing reinforced concrete column[5-7]. The first field is to repair and upgrading for earthquake resistance and the second field is to repair of corrosion damaged members where the transverse and the longitudinal reinforced are not dependable.

In a past few decade, FRP were used to strengthen reinforced concrete [8]. FRP is made up by combining two or more materials that is to be form as composite materials. Sadeghian and Fam [4] and Gunasekaran et al. [9] stated that FRP is made up of fibre which will provide composite strength and matrix that gives rigidity and environmental protection as shown in figure 1.

3. Type of FRP
Typical fibre reinforcement used in the composite industry is glass (E-glass and S-glass), carbon and aramid.

3.1. Glass Fibre
Glass fibres are produced by fusing silicate with silica or with potash, lime, or various metallic oxides. The molten mass is passed through micro-fine bushings and rapidly cooled to produce glass fibre filaments ranging in diameter from 5 to 24μm. These filaments are then drawn together into closely packed strands or loosely packed roving. During this process, the fibres are frequently covered with a coating, know as sizing, to minimize abrasion-related degradation of the filaments [10-12].

3.2. Carbon Fibre
Commercial quantities of carbon fibres are derived from three major feedstock or precursors sources: rayon, polycrylonitrile, and petroleum pitch. Rayon precursors, derived from cellulose materials, were one of the earliest sources used to make carbon fibres. Their primary advantage was their widespread availability. The most important drawback was their relatively high weight loss, or low conversion yield to carbon fibre, during carbonization. Carbonization is the process by which the precursor material is chemically changed into carbon fibre by the action of heat. On average, only 25% of the initial fibre mass remains after carbonization. Therefore, carbon fibre made from rayon precursors is more expensive than carbon fibres made from other materials [13-14].
3.3. Aramid Fibre
This fibre has the lowest specific gravity and the highest tensile strength-to-weight ratio among the reinforcing fibres used today. It is 43% lighter than glass approximately 20% lighter than most carbon fibres. In addition to high strength, the fibres also offer good resistance to abrasion and impact, as well as chemical and thermal degradation. Major drawbacks of these fibres include low compressive strength, degradation when exposed to ultraviolet light and considerable difficulty in machining and cutting [11-12, 15].

4. Waste Material As Fibre Reinforced Polymer (FRP)
According to Verma et al [16], the abundant availability of natural fibre such as banana, sugarcane, bamboo etc. gives attention on the development of natural fibre composites primarily to explore value-added applications avenues. Such natural fibre composites are well suited as wood substitutes in the housing and construction sector. Reinforcement with natural fibre in composites has recently gained attention due to low cost, low density acceptable specific properties, ease of separation, enhanced energy recovery.

4.1 Sugarcane Bagasse
According to Hajiha and Sain [17], sugarcane bagasse has a reasonable tensile strength and modulus, thus it has the potential to be used as reinforcement in composites. It has a tensile strength in the range of 170-290 MPa and a modulus elasticity in the range of 15-19 GPa. [18], state that bagasse is a fibrous residue obtained from sugarcane during extraction of sugar juice. As a rough estimate, for every 10 tonnes of sugarcane which is crushed, 3 tonnes will become wet bagasse.

4.2 Banana Fibre
Chandramohan and Marimuthu [19], stated that banana fibre obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fibre with relatively good mechanical properties. The "pseudo-stem" is clustered, cylindrical aggregation of leaf stalk bases. The extraction of fibre from the pseudo-stem is not common practice and much of the stem is not used for production of fibres.

4.3 Used Banner
Banner is flag or other piece of cloth bearing a symbol, logo, slogan or other message. It is use as a promotion for the upcoming event or any other details that are relevant for a program. Figure 2 below shows the example of a typical banner that is mostly found in Malaysia. The most commonly used material is a heavy weight vinyl technically known as PVC. The weights of the different banner substrates from as light as 255 gram to 623 gram per square yard, and may be double or single sided. Grommets can also be added in order to facilitate hanging of the banner. Banner tapes are also used to protect the lamination of the banner, fasten the hems neatly and adhere to various surfaces. Large banners (which can be so large that they cover the side of a building) are printed on a special mesh material so that the wind can pass through them.
5. Material
Good and quality materials used in this study will ensure a good result or building.

5.1 Concrete
Concrete mix design of grade 35 is used in the preparation of concrete cylinder with the height of 300mm and diameter of 150mm. There are total of 21 concrete cylinder need to be cast. Table 1 shows the summary of concrete mix design.

| Water Cement Ratio | 180 kg/m³ |
|--------------------|-----------|
| Water              | 180 kg/L  |
| Cement             | 450 kg    |
| Fine Aggregate     | 530 kg    |
| Course Aggregate   | 1240 kg   |

5.2 Used Banner As FRP
The banner is then cut to several lengths to make it easier to be patch with epoxy for this study. There were 3 type of cutting with different dimension for this research as shown in figure 3.

6. Testing Method
This study had conducted 3 testing which is slump test, compression test and tensile test.
6.1 Slump Test
Slump test was conducted to determine the workability of the concrete mix. This test must be conducted before concrete is poured into the moulds. This test was conducted for each mixture to ensure that the concrete quantities of materials used, and designed in accordance with the ruins.

6.2 Compression Test
The concrete cylinder were cast and cure for 28 days. It then were taken out from the curing tank. Excess water was wiped out from the specimen. The specimen is then placed vertically on the platform of compression testing machine. The load were apply continuously and uniformly without shock at the rate of 315 KN/min and continue until the load is half of the maximum load. The concrete cylinder is then taken out and repair by using FRP method with 3 different pattern. It then were placed again after being repaired and testing until it fails. The final load that it can withstand is then recorded. Figure 4 shows the concrete cylinder test after being repair.

![Figure 4. Concrete cylinder testing after being repaired](image)

6.3 Repair Pattern
After the concrete cylinder is being loaded with half loading it then were taken out and the cracking was check. Then the specimen were repaired using FRP. 3 batch of FRP wrap pattern crack repaired were used to see which is the most effective to be use worldwide. It then being test again to see which batch can withstand more loads. Figure 5 shows the type of wrapping pattern that will be considered to use in the study.

![Figure 5. Wrapping pattern (A) Full wrapping pattern, (B) Cross wrapping pattern, (C) 2 band wrapping.](image)
6.4 Tensile Test
Tensile strength were conducted in this study to know the tensile between CFRP and Banner. There were four specimen that is shaped look like alphabet ‘I’ were used for this test. One layer of CFRP were used to get it maximum tensile. Next, banner with 1 layer, 2 layer and 3 layer were used to determine the layer that can archive the same maximum value as one layer CFRP. The machine is then stretched the specimen as in Figure 6 and the data were recorded in graph mode.

![Figure 6. Tensile test were conducted.](image)

7. Result and Analysis

![Figure 7. Wrapping pattern between banner and CFRP.](image)

By referring to the Figure 7 it shows three type of wrapping style which is full wrap, 2 band wrap and cross wrap. For full wrap pattern, the value for used banner is 26.8 MPa while CFRP is 36.8 MPa. There are difference by 10 Mpa for this type of wrap. For 2 band wrap pattern, used banner value are 22.7 MPa and CFRP is 28 MPa. the difference value are 5.3 MPa. Lastly for cross wrap pattern, used banner value are 16.5 MPa and CFRP are 31 MPa. The difference between this two specimen are 14.5MPa.
From the Figure 8, it shows that one layer of CFRP have the maximum value of load that it can withstand is 0.31kN with the extension of 9.32mm. Next for one layer of used banner, it can only withstand the maximum load of 0.10kN with the highest extension of 13.33mm. This reflect the result in the Figure 5.1 of this study when the used banner were attached to the concrete cylinder have a lower strength than the CFRP. The tensile test had been proved that one layer of used banner is weaker than one layer of CFRP.

From this graph, the 2 layer used banner specimen can withstand maximum load of 0.33kN with maximum extension of 23.20mm. This shows that 2 layer of used banner can have the same strength of one layer of CFRP. Lastly this graph also gives the result of three layer used banner which is 0.53kN with maximum extension of 25.78mm. This specimen gives a better result than one layer of CFRP. It can be conclude that 2 layers is enough to repair an ordinary crack and 3 layer can be used to repair a major crack.

8. Conclusions
Banner is a suitable material to replace CFRP for concrete repairing based on the data receive. However a deeper study needs to be conducted to know the properties of banner before it can be widely used in the industry.

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