ADVANCED COMPOSITES IN MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRACT: Durability problem due to corrosion of steel is one of the main issues that need to be addressed by the construction industry. The repair and maintenance cost is very expensive as compared to the initial cost of the structure. Therefore, a more durable and strong construction material is needed for the future application in the construction industry. In view of that aspect, Advanced Composites material or known as Fibre Reinforced Polymer (FRP) composite, made of either glass or aramid or carbon fibres embedded in resin matrix, came into view as a potential material for civil engineering application. Glass Fibre Reinforced Polymer (GFRP) is the cheapest compared to aramid and carbon fibres and can be manufactured into different shapes depending on the types of application. The FRP has the advantages among others of high-strength-to weight ratio, corrosion resistant, long service life, maintenance free, high impact resistance, and non-conductive. This paper is intended to highlight some of the application and potential use of FRP products, in particular the GFRP, in the Malaysian construction industries. The use of GFRP products can be divided into two categories i.e. as structural or non-structural applications. Most of the applications of the GFRP products in Malaysia fall into the category of non-structural application.

Keywords: Deterioration, Glass Fibre Reinforced Polymer, durable, construction

1. INTRODUCTION

Strength and durability are the main criteria that need to be considered in the design and selection of materials to ensure the structure will last for its intended design life. Nowadays, many structures throughout the world are suffering from corrosion problem. Many reports have highlighted the seriousness of the problem of deteriorated infrastructure all over the world such as in Canada, the USA and Europe (Khabari and Zhao 2000). The cost to rehabilitate and retrofit existing deteriorated infrastructure worldwide reached billion of dollars. Thus, for many years, civil engineers and researchers have been putting effort searching for alternatives material to steel to cater the high cost of repair and maintenance of structural damaged by corrosion and heavy use.

The search for the new durable material finally materialized when the Advanced Composites material which also known as Fibre Reinforced Polymer (FRP) was found to be applicable in some areas of civil engineering. The FRP, which is made of a combination of continuous fibres embedded in resin matrix, is likely to be a good alternative to the conventional materials in some applications. The fibres provide the strength and stiffness while the resin matrix, namely polyester and vinylester, binds and protects the fibres from damage, and transfer the stresses between the fibres. The FRP is not only possesses high tensile strength but also highly durable and corrosion resistance. In addition, other features of FRP are ease of installation, versatility, anti-seismic behaviour, electromagnetic neutrality, and excellent fatigue behaviour. Carbon, aramid and glass fibres are the three type of fibres commonly used in the manufacturing of FRP products. In the early days, the FRP is being developed and studied for aerospace application. However, due to the advantages associated with the FRP, it has been used and looked into in many different areas including agriculture, appliances and business equipments, building and construction, civil engineering, transportation and many others (Holloway and Head, 2001).

The FRP products can be manufactured in various structural shapes and forms depending on the type of applications. In civil engineering applications the FRP products can be manufactured in the form of rebars, plates, fabrics, and structural sections. It can be used as concrete reinforcement to replace steel, strengthen the existing structure, and as structural member. Generally, the FRP products made of glass fibre is the most widely used in the construction industry because the cost is the cheapest among the three types of fibre available in the market. The possible applications of the Glass Fibre Reinforced Polymer (GFRP) products are among others as cable tray, ladder, handrail, doorframe, gratings, secondary structures, and water storage tanks. Many studies have been conducted not only in Malaysia but also throughout the world as to the see the possible application of FRP in the construction industry. This paper will briefly discuss some of the GFRP products available in the local market and their possible applications in the Malaysian construction industry.

2. DATA GATHERING

The aims of the study conducted are to gather information on the types of GFRP products available in the local market, their possible applications, and also the local manufacturers. The scope of the study is not only limited to the applications of GFRP products in the construction industry but also in other areas. In this study, the data were collected through various sources including a survey, information obtained from the Internet, visit to industries, and discussion with the FRP manufacturers. At present, the study is still ongoing and further new information will be gathered. All data reported and discussed in this paper is strictly based on the information gathered from the study.

3. RESULTS AND DISCUSSION

3.1 Types and Applications of FRP products

The application of FRP in civil engineering can be classified into three areas namely, applications for new construction, repair and rehabilitation applications, and architectural applications. FRPs have been used in the new construction such as footbridge and demonstrated exceptional durability and effective resistance to effects of environmental exposure. In the area of repair and strengthening, worked have been carried out on wrapping the damaged bridge piers to prevent collapse, and wrapping reinforced concrete columns to improve the structural integrity. This type of application is particularly beneficial foe earthquake prone area. In the architectural area, FRP can be used in many applications such as cladding, roofing, flooring, and partitions (Vicki and Charles, 1993).

The type of FRP products produced will be determined by the manufacturing methods or process. Several methods are available in producing the FRP products such as the hand lay-up, filament winding, and pultrusion process. Many local manufacturers have been using the hand lay-up technique in producing the FRP products due to cheaper cost of production. However, the quality of the product should be of the main concern by the manufacturers. The filament winding method requires a special filament winding machine and generally used to manufacture tubular structures. Not many local manufacturers have the filament winding machine because it is relatively very expensive. Other than the hand lay up and filament winding methods, the pultrusion method is generally used to produce continuous prismatic shapes such as I-beams, angles, channels, rods, plates and tubes. These types of structural shapes are generally suitable to be used in civil engineering application as structural member. A number of local manufacturers have used the pultrusion method to produce various structural profiles. Figure 1 shows some of the GFRP sections that can be used in the construction industries.

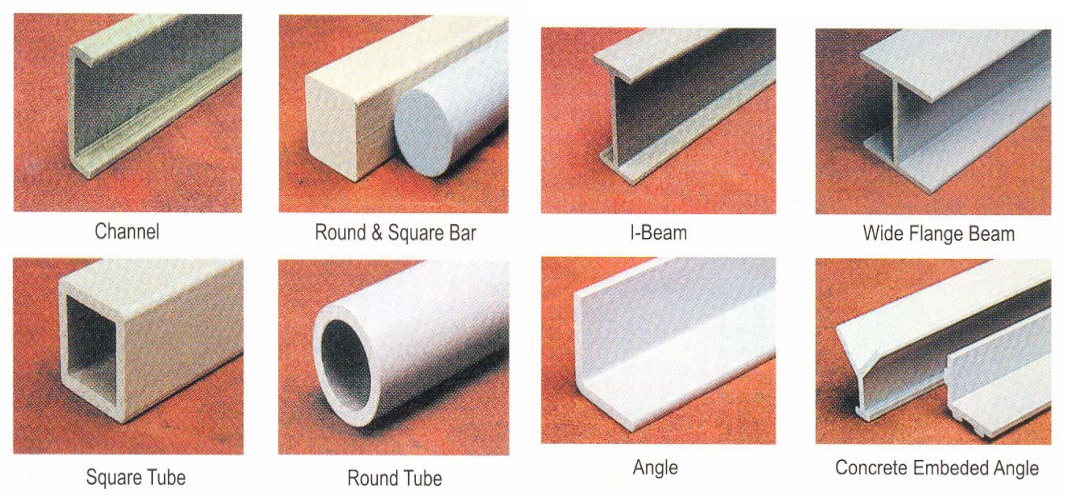


Fig 1: Various structural shapes of FRP products

Since corrosion is one of the main problems faced by the construction industries, the use of durable and lightweight GFRP products will be very beneficial. Due to exposure to saltwater components for offshore structures such as oil platform, handrails, and ladder are very likely to experience corrosion problem. Thus, the GFRP products as shown in Figure 1 are greatly needed and useful for offshore application. Not only the corrosion problem can be eliminated or minimized but also the long-term maintenance cost of the structures will be reduced substantially. As for structural application where the member will carry loads, a pedestrian footbridge can be constructed using GFRP sections. Quite a number of pedestrian footbridges constructed using FRP have been reported throughout the world. Figure 2 shows an example of the application of the GFRP sections to construct the GFRP footbridge at the Universiti Teknologi Malaysia.

Fig 2: GFRP footbridge at the Universiti Teknologi Malaysia

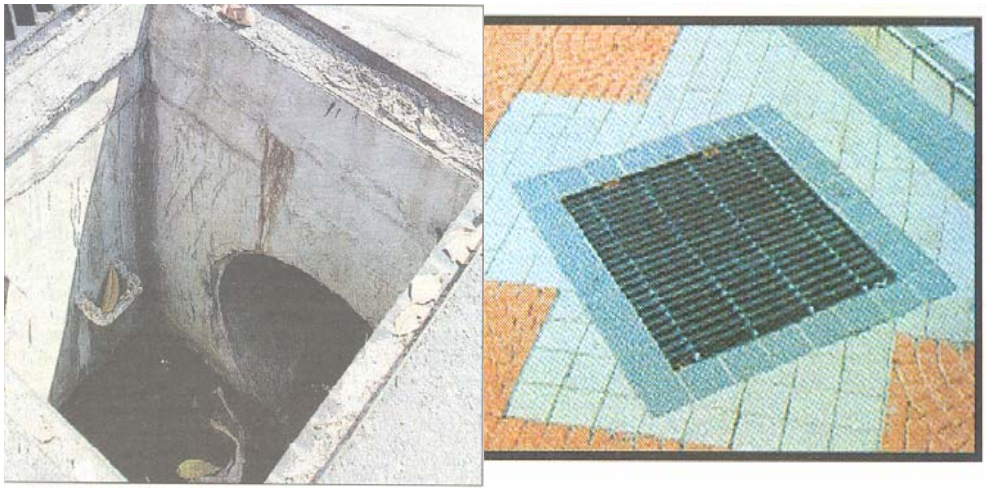
Data gathered from the study shows that the use of FRP products in Malaysia can be divided into two groups, i.e. structural and non-structural applications. Most of the applications fall into the category of non-structural application. From the visit to the

manufacturers in various states, it was found that, for smaller companies, most of the GFRP products were manufactured using hand-lay-up technique. On the other hand, some of the larger companies have the facilities of either pultrusion machine, or compression moulding machine, and filament winding machine. Table 1 shows possible areas of applications for the GFRP/FRP products.

Table 1: Applications of the GFRP/FRP products

Area	**Applications**
Building and Construction	External and internal cladding; permanent and temporary formwork; partitions; cabins; domes; structural and decorative building elements; gratings
Civil Engineering/Infrastructure	Structural and non-structural items as required for bridges, piers, wharfs, utility and services, traffic signs and signposts; water tanks
Consumer Products and Leisure	Garden and industrial furniture, sanitary ware, sporting goods, fishing rods and archery equipment; notice boards; seating benches and playground equipment; modular swimming pools slide; surf and sailboards
Marine	Canoes and boats, yachts, hovercraft
Transportation	Automotive, bus truck, seating, bodywork and partitions

Based on the current trend and feedback from the manufacturers it is believed that the use of GFRP products in the construction industry will increase in the future due to their advantages that can be exploited to solve some of the problems faced by the construction industries. It was also reported that the consumption of FRP increases by about 5 to 7 percent from the year 1996 to 1998. Many applications of GFRP can be seen at present time. As an example, the GFRP gratings are being used as manhole cover to solve problem of missing steel manhole cover. The missing steel grating, as shown in Figure 3 (a), was due the fact that steel can be recycled. Since GFRP is not recyclable, at present, then the problem of missing steel grating can be solved and this will ensure the safety of the public. Figure 3(b) shows the use of GFRP grating as manhole cover near Pantai Telok Cempedak, Pahang. The missing signage along the federal road or highways is also a problem as shown in Figure 4. The GFRP plate can be used as signage and can solve the problem of missing signage.



(a) (b)

Fig 3: (a) Missing manhole cover (b) GFRP grating for manhole cover

Fig 4: Missing part of the signage

3.2 FRP fabricator in Malaysia

Most of the findings from the study indicated that the use of the GFRP products in Malaysia was mainly in the area of non-structural applications. Quite a number of local manufacturers are actively involved with the manufacturing of the GFRP products. According to the local manufacturers, from discussion during the visit, most of the raw materials including the fibres and resin are imported from overseas such as China, Japan, Europe and the USA. Thus, the cost of the current GFRP products may be slightly higher when compared with the other conventional materials. However, in the coming years when the demand for the GFRP products increase, the price will obviously start to decrease.

In general, most of the local manufacturers are using glass fibre to manufacture their products. Table 2 shows the number of fiberglass manufacturers or fabricators in Malaysia collected to date from the study. A wide range of GFRP products were recorded including water tank, pultruded sections, plates, domes, gratings, partitions, ceiling, door, signboard, pipes, and many others. The result of the study shows that most of the GFRP fabricators are

found in the states where the industrial areas are located such as in the state of Johor, Selangor, and Kuala Lumpur.

Table 2: Fibreglass fabricators in Malaysia

State	Number	Percentage (%)
Johor	30	25.9
Selangor	38	32.8
Kuala Lumpur	13	11.2
Pulau Pinang	7	7.6
Negeri Sembilan	4	3.4
Perak	5	4.3
Trengganu	5	4.3
Sarawak	5	4.3
Sabah	4	3.4
Kedah	3	2.6
Pahang	2	1.7
Melaka	8	6.9

The use of GFRP water tanks has been known quite sometime in the Malaysian construction industry. The water tanks, either rectangular or cylindrical, can be manufactured to accommodate different capacity of water ranging from hundreds to thousands gallons. In relation to that, it is important that an engineer who involved in such project must have adequate knowledge in terms material properties and the design process to ensure the safety and serviceability of the water tanks. For the exposed water tank, the outer surface should be gel coated to protect from ultraviolet effect from the sunlight. Table 3 shows the distribution of water tank fabricators in Malaysia gathered in this study. Unlike the number of fiberglass manufacturers, which include all type of products, the state of Selangor shows the highest water tank fabricators compared to other states. From the discussion with the manufacturers, some of the manufacturer not only produced water tank for local use but also to be exported to Middle East countries. There is a big demand from those countries due to various environmental problems if the water tank is made of pressed steel. This shows a good sign for the future use of the GFRP products in the construction industries. Table 4 shows the percentage of GFRP products for different applications produced by local manufacturers.

Table 3: Water tank fabricator in Malaysia

State	Number	Percentage (%)
Johor	4	7
Selangor	22	38
Kuala Lumpur	6	11
Pulau Pinang	2	4
Negeri Sembilan	2	4
Perak	3	5
Trengganu	2	4
Sarawak	5	9
Sabah	4	7
Kedah	1	2
Pahang	2	4
Melaka	3	5

Table 4: FRP products produced locally

Types of Products	Percentage (%)
Domes	12.25
Water Tank	11.22
Door/Window	12.25
Ducting	3.6
FRP Pipes	2.4
Grating/Structural/Plating	3.6
Roofing/Ceiling	2.4
Sewerage	2.4
Wall Panel	1.2
Tiles	1.2

In the earthquake prone countries the use of FRP products can also play an important role in minimizing the total damage. As an example, currently the use of glass as partitions, widows or walls for high-rise buildings will pose a great danger once the glass breaks due to earthquake. Thus, the use of GFRP panel will generally be able to reduce the risk of injuries to public during the event of earthquake. The visit to one company that produced artistic GFRP panel, which is difficult to break as compared to glass, revealed that the use of such panel in Malaysia is still very limited. Most of the products manufactured by the company were exported to different countries such as the United States of America. According to the manufacturer, this may be due to lack of information and promotion to the players in the construction industries.

4. CONCLUSIONS

The Glass Fibre Reinforced Polymer products were found to be applicable as structural and non-structural applications in the construction industries. Durability problems faced by the construction industries and problem related to public safety can be solved or minimize with the use of this material. The different types of FRP products available and applications indicated the future potential of GFRP to be used widely in the construction industry.

5. ACKNOWLEDGEMENTS

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