The steel reinforced concrete construction essay

Reinforced concrete is being increasingly used in the construction of important and high cost marine structures in aggressive environments such as found in the Arabian Gulf states. In such highly aggressive and corrosive environments, it is essential to select the corect concrete materials to match the exposure severity and to adopt proper construction practices to obtain a high quality dense and impermeable concrete. The paper outlines the nature of exposure and the deterioration mechanisms in seawater and provides a set of specific recommendations to obtain durable concrete in aggressive marine environments.

There is a number of building materials that have been found to be exceptional when used in the construction of buildings. One of these exceptional building materials is steel reinforced concrete. Steel reinforced concrete is a specific type that has had strong steel rebar or fibers added to it while wet, creating a very strong type of concrete that is able to withstand almost anything when it has dried. Because the results of using steel reinforced are so good for the strength of the building, most modern buildings today use steel reinforced concrete in the construction process.

Steel concrete offer an unparalleled durability and stability to construction. The materials last longer than any other and have an incomparable strength in withstanding fire and severe weather. They are naturally water-resistant, non-combustible, and resistant to wear and tear, rot and insects. Because steel, in particular, is strong and lightweight, it can be better engineered to withstand earthquakes. These factors contribute to homes that are built to last and hold their value.

Corrosion of steel reinforcement in concrete structures is a major problem that has led to costly repair bills for states and municipalities around the world. In search of a more cost-effective solution, researchers have pursued non-metallic reinforcement such as fiber reinforced polymer (FRP) in lieu of steel. FRP reinforcement for concrete can be used in the form of bars, grids, gratings, or external sheets and plates. High strength-to-weight ratio and resistance to electro-chemical corrosion are the two characteristics that make FRP attractive to civil engineers. On the other hand, thermo-mechanical properties of FRP are markedly different from steel reinforcement. For example, the average glass FRP bar available in the market has a tensile strength of 655 MPa, which is approximately 60% higher than Grade 414 MPa steel. The higher tensile strength could potentially lead to more slender sections, if full strength of FRP is utilized. On the other hand, tensile modulus of the same glass bar is only 48 GPa, which is less than 25% of steel. Lower stiffness of FRP causes larger deflections for FRP-reinforced concrete (FRP-RC) beams, and makes the serviceability limit state more critical than the ultimate limit state. Furthermore, linear-elastic response of FRP could result in brittle failure modes. It is well known that failure of conventional steel-reinforced concrete (steel-RC) beams is ductile when the beam is under-reinforced, i. e. when concrete crushes before yielding of steel. That is why most design codes strictly limit the maximum reinforcement ratio to ensure a ductile failure. On the other hand, since FRP reinforcement does not yield, and its snap rupture is brittle and extremely dangerous, it is generally agreed that FRP-RC is best designed as an over-reinforced section.

With regard to the thermal properties of FRP bars, coefficient of thermal expansion varies in the longitudinal and transverse directions depending on the types of fiber, resin, and fiber-volume fraction. Carbon, glass and aramid FRP bars have a typical coefficient of expansion of 8 x [10. sup.-6], -0. 5 x [10. sup.-6] and -4 x [10. sup.-6]/[degrees]C in the longitudinal and 22 x [10. sup.-6], 22. 5 x [10. sup.-6] and 70 x [10. sup.-6]/[degrees]C in the transverse direction, respectively. For reference, concrete and steel have thermal expansion coefficients of 10 x [10. sup.-6/[degrees]F and 11. 7 x [10. sup.-6]/[degrees]C, respectively. The difference in thermal expansion, however, is not expected to cause any significant structural distress.

These issues need to be fully understood by the design community before the use of fiber composites becomes widespread. It is also vitally important to develop diagnostic tools, which would monitor the behavior of FRP-RC structures under service loads and would provide warning for potential failure. Non-destructive evaluation (NDE) methods provide an effective and non-intrusive approach to assess the integrity of a structure while in service. Among the various NDE techniques available, acoustic emission (AE) technology is unique in that it literally listens to the signals emitted from within the structure under service loads. The AE method has been used with success for FRP laminates steel-RC beams pre-stressed concrete beams RC beams retrofitted with FRP plates], and concrete-filled FRP tubes.

An important characteristic of AE signals is the presence of Felicity or Kaiser effects. Felicity effect is the appearance of significant acoustic emission at a stress level below the previous maximum stress. Kaiser effect is the absence of any such detectable signal, until the previous maximum stress is exceeded. Therefore, Kaiser effect can be used to establish the maximum stress levels in the loading history of a structure. While fiber composites are known to show felicity effect, previous studies [6] have shown concrete to exhibit Kaiser effect for stress levels below 75-85% of its ultimate strength. Therefore, it is important to know the extent.

CASE STUDY

STEEL REINFORCED CONCRETE

1. Introduction

Civil infrastructures are generally the most expensive investments in a country. Concrete has been used extensively in the construction of these infrastructures so much that its usage signifies the growth and development of a nation. However, the act of abandoning concrete structures in the midst of construction activities might jeopardize design efforts towards achieving a strong, safe, durable and economical structure. One of the major factors for deterioration of concrete structures in this situation is the attack from surrounding environment. This is obvious since both strength development and durability status of reinforced concrete depends not only on the compositional constituents but also on the characteristics of the immediate environment, specifically exposure conditions and principal factors of deterioration associated with surrounding environments include; rainfall, alternate wetting and drying, temperature variations, ground moisture and presence of aggressive chemicals in the soil. Continuous actions of these agents affect weak spots on the concrete surface and the reinforcing steels, thereby, rendering both materials vulnerable to deteriorational defects with possible irreversible damages and. The formation and gradual propagation of cracks for instance, can easily weaken concrete and instigate reinforcement corrosion with eventual deflections as well as partial or total collapse. In addition, dissolution of atmospheric carbon dioxide (CO2) in the pore water often forms carbonic acid. This reduces pH value of concrete to a level at which the passive layer surrounding the steel reinforcement is no longer sustained and. As a result, the reinforcing steels are exposed to corrosive activities with consequent loss in general performance. Furthermore, the formation of salt deposits on the surface of exposed concrete, known as efflorescence is another form of attack, at least rendering the concrete surface aesthetically undesirable and making it difficult to achieve desired bonds between the affected surfaces and finishes and. In fact, the appearance of efflorescence on concrete surfaces was fully attributed to environmental circumstances.

The present investigation therefore seeks to evaluate the performance of concrete and reinforcement after being subjected to bare environmental conditions for 6 years. The aim is to expose the level of detriment caused on reinforced concrete structures especially in an abandoned situation. However, in order to achieve and maintain both structural and environmental similarities between the structure erected for this investigation and structures in the real situation, physical inspections on some abandoned projects were conducted and reports substantiated accordingly.

Fig. 1. RC model structure exposed to natural environment.

2. Durability assessments

The corrosion condition of the embedded steel bars was evaluated by concrete carbonation and half-cell potential tests. The minimum carbonation depth was found to be 5 mm. Since the clear concrete cover was 20 mm, passive environment surrounding the steels seems to be intact posing no threat to the embedded steel reinforcement. The carbonation result was further supported by the half-cell potential test result which was evaluated from the delineated areas of possible corrosion activities. In this case, the highest value of potential is more positive than −200 mV and according to ASTM C876-9, if the potential recorded are more positive than −200 mV, there is a greater than 90% probability that no steel corrosion in that area at the time of measurement. Thus, it can be concluded that the probability of embedded reinforcement corrosion in the present case is still very low. Therefore, provided there is sufficient concrete cover to reinforcing steels and that the concrete is non-porous as well as being free from cracks, corrosion may not be perceived within an exposure period such as 6 years. Performance may however be endangered where any of the aforementioned conditions was not met, since structural performance is extremely influenced by corrosion.

In addition, the exposed bars were observed to entertain general corrosion rather than pitting corrosion. Thus, the corrosion is still at surface layer level with little or insignificant mass loss. However, the entire surfaces of the exposed bars were covered with the corrosion products (100%).

3. Conclusion

Strength and durability characteristics of reinforced concrete structures are seriously affected by the actions of environmental factors such as acidic rain water, alternate wetting and drying, temperature variations and ground moisture. Considering the fall in compressive strength from 32. 1 N/mm2 to 23. 35 N/mm2 corresponding to the second and final coring tests, up to 27. 6% strength loss could therefore be registered in the concrete of an exposed structure within a period of 5 years. A 7% ultimate strength loss in exposed steel reinforcement may occur within similar years of exposure. However, there is a greater than 90% probability that no steel corrosion exists in the embedded reinforcement. Meanwhile, mechanical and durability properties are not the only victims of long-term exposure; visual inspections have further revealed the menace of abandoned structures to neighborhood. Incompatibility due to ugly scenes of these structures in the midst of habitable buildings and the adherent attitude to such places by drug addicts, hoodlums and reptiles are worth threatening.

CASE STUDY

FIBRE REINFORCED POLYMER

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 nonstructural applications. Most of the applications of the GFRP products in Malaysia fall into the category of non-structural application.

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 layup, 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 layup 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.

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. 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.