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RESEARCH ARTICLE

CARBONFIBERS IN THE CIVIL STRUCTURE -A REVIEW

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ABSTRACT

Many new raw materials have been discovered and many ground-breaking composite have been developed, of which not all but some have proved to be a phenomenal success. Carbon fiber is one of these materials, which is usually used in combination with other materials to form a composite structure. The properties of carbon fiber, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion makes them one of the most popular material in civil engineering possessing strength up to five times that of steel and being one-third its weight, we might as well call it 'the superhero' of the material world. Carbon fibers are a type of high-performance fiber available for civil engineering application. It is also called graphite fiber or carbon graphite, carbon fiber consists of very thin strands of the element carbon. Carbon fibers have high tensile strength and are very strong for their size. Due to the rigidity and chemical inertness of carbon fibers, the increase of carbon fiber fraction leads to both conductivity enhancement and mechanical performance reduction. As a result, it is an urgent need to find a balance between the mechanical property and the electrical conductivity. In this paper, a study has been made how carbon fiber is used in civil structure.

INTRODUCTION

In buildings and civil engineering field, the reinforcement of structures among others is the first area of application of Carbon Fibers with favoured advantages of lightweight and high strength. To increase durability of concrete structures such as bridges by covering them with Carbon Fiber sheets is being recognized as an effective reinforcement measure to increase resistance against earthquakes. This technology is used in various part of the world, among others in Japan. On the other hand, serious efforts are made in many countries world over to develop technology to use CFRP for building material. Construction planning of bridges with CFRP as the main structural material are in progress in many part of the world. Application to reinforcement of concrete, to the cables for suspension bridges and as the substitute for steel frames are under serious study and CFRP is expected to be a qualified building material in the future.

Over the ages as we have evolved, so has our engineering and researching skill sets. Even today, we are constantly innovating, researching and developing technology in pursuit of a sustainable future. Throughout this evolution, researches and engineers have found themselves in constant search for new and better materials to optimally manage the performance cost tradeoff in the construction sector. Many new raw materials have been discovered and many ground-breaking composite have been developed, of which not all but some have proved to be a phenomenal success. Carbon fiber is one of these materials, which is usually used in combination with other materials to form a composite. The properties of carbon fiber, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion makes them one of the most popular material in civil engineering possessing strength up to five times that of steel and being one-third its weight, we might as well call it 'the superhero' of the material world.

In fact, carbon fiber might be the strongest material. Carbon fibers have high elastic modulus and fatigue strength than those of glass fibers. Considering service life, studies suggests that carbon fiber reinforced polymers have more potential than agamid and glass fibers. They also are highly chemically resistant and have high temperature tolerance with low thermal expansion. and corrosion resistance.

Each fiber is 5-10 microns in diameter. To give a sense of how small that is, one micron (um) is 0.000039 inches. One strand of spider web silk is usually between 3-8 microns. Carbon fibers are twice as stiff as steel and five times as strong as steel, (per unit of weight). . The most important factors determining the physical properties of carbon fiber are degree of carbonization (carbon content, usually more than 92% by weight) and orientation of the layered carbon planes (the ribbons).

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Carbon fiber-reinforced composite materials are used to make aircraft and spacecraft parts, racing car bodies, golf club shafts, bicycle frames, fishing rods, automobile springs, sailboat masts, and many other components where light weight and high strength are needed. Carbon fiber's high strength, light weight and resistance to corrosion make it an ideal reinforcing material.

Several structural engineering applications utilize carbon fiber reinforced polymer because of its potential construction benefits and cost effectiveness. The usual applications include strengthening structures made with concrete, steel, timber, masonry, and cast iron; Retrofitting to increasing the load capacity of old structures like bridges; to enhance shear strength and for flexure in reinforced concrete structures. Other applications include replacement for steel, pre stressing materials and strengthening cast-iron beams.

Review Works

Carbon fibers, which are a new breed of high-strength materials, are mainly used as reinforcements in com-posite materials such as carbon fiber reinforced plas-tics, carbon-carbon composite, carbon fiber reinforced materials, and carbon fiber reinforced cement. Carbon fibers offer the highest specific modulus and highest specific strength of all reinforcing fibers. The fibers do not suffer from stress corrosion or stress rupture failures at room tempera-tures, as glass and organic polymer fibers do. Espe-cially at high temperatures, the strength and modulus are outstanding compared to other materials [1]. Car-bon fiber composites are ideally suited to applications where strength, stiffness, lower weight, and outstanding fatigue characteristics are critical requirements. They are also finding applications where high temperature, chemical inertness, and high damping are important. Carbon fibers also have good electrical conductivity, thermal conductivity, and low linear coefficient of ther-mal expansion [2].

The two main sectors of carbon fiber applications are high technology sector, which includes aerospace and nuclear engineering, and the general engineering and transportation sector, which includes engineering com-ponents such as bearings, gears, cams, fan blades, etc., and automobile bodies. However, the requirements of two sectors are fundamentally different. The large scale use of carbon fibers in aircraft and aerospace is driven by maximum performance and fuel efficiency, while the cost factor and the production requirements are not crit-ical. The use of carbon fibers in general engineering and surface transportation is dominated by cost constraints, high production rate requirements, and generally less critical performance needs. This necessitates two dif-ferent approaches in the areas of production as well as research for two sectors. A number of achievements have been made in the past in the area of cost reduc-tion as well as fiber quality improvement. After all thedevelopments, we have been able to achieve 90–95% of the modulus of perfect graphite (º1025 GPa), a ma-terial with highest absolute and specific modulus of all the materials known [1, 3]. However, carbon fiber in its current strength level range is 15–20 times be-low the theoretical strength limit. A common rule of thumb is that the strength of a fiber should be about 10% of the modulus of a single crystal. Thus, possi-ble strength for carbon fiber is estimated to be about 100 Gpa. Though the theoretical tensile strength of sin-gle crystal of graphite is 150 Gpa [1], highest of all the materials known. Commercial high-strength car-bon fibers have a maximum strength of 7 Gpa. Further, axial compressive strength of carbon fibers has been reported to be only 10–60% of their tensile strength [4] and transverse compressive strength 12–20% of ax-ial compressive strength [5]. Compressive strength of carbon fibers is lower than of inorganic fibers but still higher than that of polymeric fibers [6].

Compressive properties dictate the use of carbon composites in many structural applications. Recently, a lot of research has been done on compressive proper-ties and morphology of carbon fibers. Apparently, there still seems to be a lot of room for improvement in the properties of carbon fibers. In this paper, we have dis-cussed the developments made in the past and suggested possibilities for further improvement in the future. Sug-gestions for future research focus on improvement in the mechanical properties of carbon fibers, as a chal-lenge from the requirements of high technology sector. Increased oxidation resistance at high temperatures is also one of the critical requirements for some high-tech applications [3, 7], but has not been discussed here.

In 1978, purposely took cotton fibers and later, bam-boo, and converted them into carbon in his quest for incandescent lamp filaments [1, 8]. Interest in carbon fibers was renewed in late 1950s when synthetic rayons in textile forms were carbonized to produce carbon fibers for high temperature missile applications [9, 10].

Carbon Fibers Based New Construction

There are existing 4 types of carbon fiber: cellulose based carbon fibers, PAN-based fibers, pitch based fibers, and vapor grown carbon fibers. The first three types use different raw materials, and the last one is different from the others by production technology. This thesis I will consider the production of the two most common and most the suitable for our purposes types of carbon fibers, PAN-based fibers and pitch based fibers. Cellulose based fibers are worse than PAN-based and pitch based fibers in its properties. Vapor grown fibers show outstanding properties, but they are very expensive for construction.

Oxidation

The acrylic precursor is stabilized by controlled low temperature heating (200-3000C) in air to convert the precursor to a form that can be further heat treated without the occurrence of melting or fusion of the fibers. To achieve this end, a slow heating rate must be used to avoid run-away exotherms occurring during the stabilization process, exacerbated by the PAN precursor which is a poor conductor of heat. Stabilization can be achieved isothermally by heating at a constant temperature, but this is time consuming. A more practical method is a stepwise increase in temperature. A third method is one-step stabilization, with temperature increasing along a tubular furnace. In the oxidation stage, the PAN fiber will increase in density from 1180kg/m3 to about 1360-1380kg/m3 for the oxidized PAN fiber (OPF).The density of OPF must be at least 1360kg/m3, as otherwise, the fiber will tend to pull apart and break on entering the LT furnace. The upper OPF density limit for the production of carbon fiber varies with the manufacturer and some manufacturers will use a value as high as 1400kg/m3.(Morgan 2005)

Gases such as HCN, H2O, CO2, CO, NH3, nitrites and miscellaneous tars are evolved during the oxidation of PAN and it has been the usual practice to pass these hot gases at about 3000C over a heated platinum group metal deposited directly onto a high surface area material coated on a porous ceramic monolith block. (Morgan 2005).Oxidized PAN is treated with a water based .Antistatic finish, dried and collected after plaiting into boxes positioned on a plaited table with longitudinal and transverse movements to plait the OPF neatly into the boxes without entanglement.

Low temperature carbonization

Some workers have found that the presence of moisture in the OPF can reduce the strength of the carbon fiber produced and dry the OPF prior to entry into an LT furnace. The LT furnace can best be described as a tar removal furnace and normally comprises a multi zone electrically heated slot furnace, purged with N2to prevent ingress of air and providing sufficient N2flow to remove evolved tars and gases. The temperature in the furnace is gradually increased in the zones to a final temperature of about 9500C, a temperature above which the tars are decomposed leading to the deposition of a sooty product on the fiber, which causes the filaments to stick together and the carbon fiber properties to plummet.

High temperature carbonization

Basically, the high temperature furnace elevates the temperature in a uniform manner to increase the fiber modulus, and a smaller fiber will give a higher modulus for a given residence time, but lesser yield. The product formed during carbonization is a good conductor and imposes no limitation on the heating rate by heat transfer. Heating rates above 20 0C per minute and temperatures above 1500 0C will impair the strength of the resulting carbon fibers.

The presence of Na in the precursor does, however, pose problems in the HT furnace, either by forming elemental Na, or combining with the HCN released in the carbonization process to form NaCN. Consequently, a precursor with little or no Na is preferred.

To prevent ingress of air, a flow of inert gas is introduced at either end of the furnace to produce a gas seal. A body flow of inert gas should be applied at the inlet end to remove any liberated Na via an outlet branch pipe, but the flow should be controlled to maintain an optimum concentration of HCN within the muffle, since the HCN has been found to have the beneficial effect of healing surface flaws on the fiber by cracking to carbon. Sufficient body flow at the outlet end is applied to ensure that waste products exit via the outlet branch pipe.

Surface treatment

It is convenient to use an electrolytic surface treatment process, which permits a good measure of control to be exercised. A suitable water soluble electrolyte is chosen, giving a solution that is readily conductive. The carbon fiber is made the anode and passed close and parallel to graphite cathodes without to Surface treatment. It is convenient to use an electrolytic surface treatment process, which permits a good measure of control to be exercised. A suitable water soluble electrolyte is chosen, giving a solution that is readily conductive. The carbon fiber is made the anode and passed close and parallel to graphite cathodes without touching.

CONCLUSIONS

Carbon fibre plates are thin, strong and flexible, they can be designed and installed to provide a cost effective solution which does not detract visually from the original design of the structure. It has high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and one of the most popular material in civil engineering. It possess strength up to five times that of steel and being one-third it weight. It has more applications in civil engineering, military, sporting goods, in medical, in automobile industry, etc. so use of carbon fiber in construction is always effective and provide high strength to the structure.

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