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NANOTECHNOLOGY IN CONSTRUCTION MATERIALS AND FIBRE COMPOSITES

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ABSTRACT:

This paper deals with how to improve the strength of construction materials and introducing fiber as a composite in concrete. Nanotechnology deals with understanding, controlling and manipulating matter at the level of individual atoms and molecules in the range of 0.1–100 nm (10-9 m). It creates materials, devices, and systems with new properties and functions.

The role of nanotechnology in the conceiving of innovative infrastructure systems has the potential to revolutionize the civil engineering practice and widen the vison of civil engineering. The properties like self-sensing, self-rehabilitation; self-cleaning, self-vibration damping, self-structural health monitoring and self-healing are the key features. To execute these, the gap between nanotechnology and construction materials research needs to be bridged. Further the details of application oriented nanotechnology-enabled materials and products that are either on the market or ready to be adopted in the construction industry and also their possible consequences over the time is elucidated.

Nanotechnology can be used for design and construction processes in many areas since nanotechnology generated products have many unique characteristics.

Concrete- Fly ash not only improves concrete durability, strength and, importantly for sustainability, reduces the requirement for cement.

Glass- Because of the hydrophobic properties of TiO_2, it can be applied in antifogging coatings or in self-cleaning windows Nano-TiO_2 coatings can also be applied to building exteriors to prevent sticking of pollutants, and thus reduce a facility’s maintenance cost.

And the next idea is based on fiber composites - As we all know composite is a combination of two or more different materials, it has superior properties than its constituents. Our research paper is based on Combinations of different FIBRES Because of the variety of available reinforcement and matrix materials, as well as the ability to combine them in wide range of volume fraction; composites can be produced with a broad range of elastic modulus, strength, and toughness combinations.

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The flexibility of tailoring to a specific need is one of the most important attributes of composites. Another advantage over conventional material is that composites can be designed to exhibit specific properties in specific directions (their anisotropy can be beneficial).thus the composite here to be discussed is basalt fiber and asbestos fiber.

Basalt is an igneous rock formed by cooling of magma and lava. It is present in abundance and occupies around one-third of the earth's crust. Basalt fiber is a fibrous material made from basalt rocks. It comprises the minerals like plagioclase, pyroxene and olivine. The main reason behind the usage of basalt fibres is their key properties like thermal resistance, mechanical strength, chemical resistance and ecological friendliness. The composition of basalt rocks should meet the requirements in order to manufacture a good quality basalt fiber. For example, the percentage composition of silicon dioxide should be about 46% (acid basalt) for the basalt rock which is to be converted into basalt fiber. Advantages of basalt fibres include its high tensile strength, high value for modulus of elasticity, better chemical resistivity, large operating temperature range, eco-friendliness and recyclability.

Asbestos fibres are made of natural crystalline fibrous minerals these fibres are largely in success for fiber-reinforce materials result for the compatibility between the fibres and cement matrix. **Asbestos fibres** relatively have high modulus of elasticity and strength, which permits effective dispersion of large fiber volume and enhance the bond between cement matrixes. These fibres are utilized with fiber-reinforced materials suitable in low cost housing and infrastructure.

Asbestos fiber is used in concrete mixtures to reduce cracking. The concrete contains between 2% and 10% asbestos by weight. Spotting asbestos in concrete products can be difficult. Since the fibres were evenly distributed throughout the concrete mixture and are set to a hardened matrix Permeability is avoided due to the asbestos matrix interlocking property. Fire resistant property is improved.

And another **Composite** is a combination of shape memory alloy fibres, nylon, Polyphthalamide and glass fibre.

In the past decade, Shape Memory Alloy (SMA) has become more popular and prevalent is been used in various engineering fields. The **SMA** has a tendency to change its shape when it undergoes any phase change. This is called as Shape Memory Effect. In detail when the SMA is heated to its Austenite phase the shape memory effect kicks in and the alloy deforms, and when the phase is changed like when the heat is reduced or it is cooled the SMA returns back to its original shape.

The alloy used for research was Nitinol, a **Nickel–Titanium SMA** where a thin steel wire were used for comparison. These two specimens were cast into thin concrete beams and were allowed to cure. After cured they were heated and the phase change from Marten site to Austenite occurred in the SMA. As a result the SMA contracted and compressed the beam. The SMA fibres are randomly oriented and allow pre-stressing to occur along all three axes. This is ideal for thin, curved specimens.

Synthetic Polyamides is described from the generic term called nylon. . Nylons are characterized by the amide group (CONH) which forms part of the polymer main chain. In terms of chemical structure, nylons may be divided into two basic types: those based on diamines and dibasic acids (A–A/B–B type); and those based on amino acids or lactams (A–B type).Nylons are described by a numbering system that reflects the number of carbon atoms in the structural units. A–B type nylons are designated by a single number.

Nylon 6, 6 and nylon 6 are widely used with high commercial importance because they offer a good balance of properties at an economic price. Other nylons (6, 9; 6, 10; 6, 12; 11; and 12) command relatively higher prices. Nylon 6, 6 is formed by the step-growth polymerization of **hexamethylenediamine** and **adipic acid**. Nylons are used in applications requiring durability, toughness, chemical inertness, electrical insulating properties, abrasion and low frictional resistance, and self-lubricating properties.

Polyphthalamide (PPA) is a thermoplastic synthetic resin in the polyamide group. It is made out of a combination of terephthalic & isophthalic acid. By the addition of aliphatic polyamides to PPA, the melting point and the glass transition temperature decreases and this results in the formation of PPA blends. They can be made much more useful by enhancing their properties. It can be done by reinforcing agents like glass fibre.

Fiberglass is a lightweight yet extremely strong and robust material. When compared to carbon it is weaker in strength properties and stiffness, but it is less brittle and the raw materials are less expensive and can be easily moulded. It has high surface area to weight ratio but more is the surface area it I more susceptible to chemical attacks. By trapping air in them the can be made as good **thermal insulator**.

Since glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity. In contrast to carbon fiber; glass can undergo more elongation before it breaks.

Fibre-reinforced polymer (FRP), also Fibre-reinforced plastic, is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, or aramid, although other fibres such as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Composite materials are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct within the finished structure. Most composites have strong, stiff fibres in a matrix which is weaker and less stiff. The

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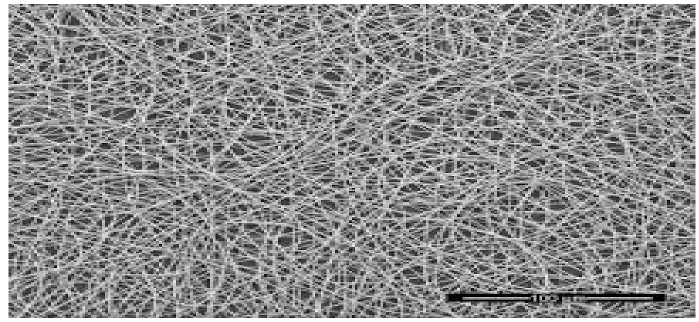
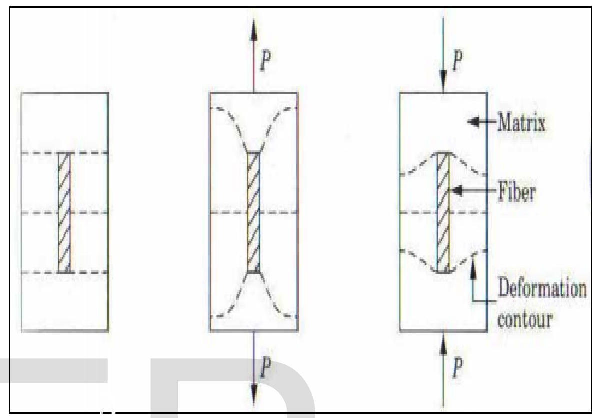
objective is usually to make a component which is strong and stiff, often with a low density.

Commercial material commonly has glass or carbon fibres in matrices based on thermosetting polymers, such as epoxy or polyester resins. Sometimes, thermoplastic polymers may be preferred, since they are moldable after initial production. There are further classes of composite in which the matrix is a metal or a ceramic. For the most part, these are still in a developmental stage, with problems of high manufacturing costs yet to be overcome .

Furthermore, in these composites the reasons for adding the fibres (or, in some cases, particles) are often rather complex; for example, improvements may be sought in creep, wear, fracture toughness, thermal stability, etc.

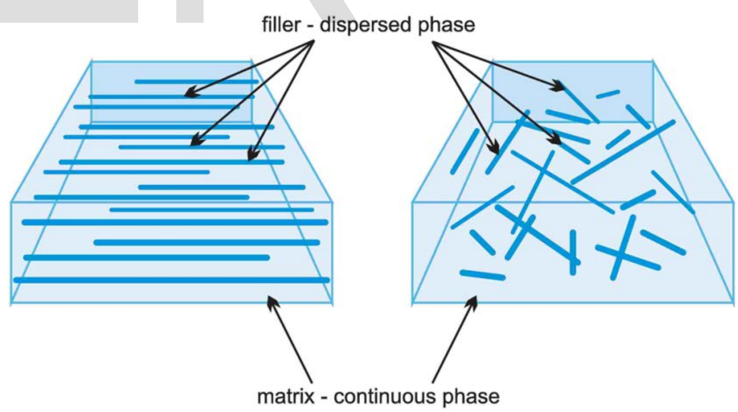


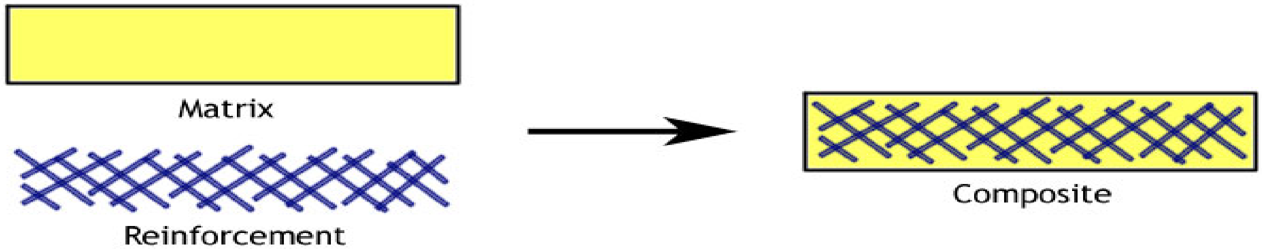
FIBRES IN MICROSCOPIC VIEW



Interaction of fibre-uncracked matrix.
Left to right: unloaded, tension and compression.

Without fibre-reinforced With fibre-reinforced





KEYWORDS:

- NANOTECHNOLOGY
- CNT DEPOSITION
- NANO SILICATE GLASS
- FIBRE RENFORCED CONCRETE
- SHAPE MEMORY ALLOY
- SHAPE MEMORY EFFECT
- POLYPROPYLENE
- FIBRE GLASS
- BASALT FIBRE
- ASBESTOS FIBRE
- FIBRE COMPOSITE
- MATRIX & REINFORCED PHASE
- FLY ASH & FINE AGGREGATES
- NYLON FIBRES
- FIRE RESISTANCE
- WATER RESISTANCE
- DURABLE CONCRETE

INTRODUCTION:

Nanotechnology can be used for design and construction processes in many areas since nanotechnology generated products have many unique characteristics. These characteristics can, again, significantly fix current construction problems, and may change the requirement and organization of construction process in concrete and glass.

As we all know composite is a combination of two or more different materials, it has superior properties than its constituents. Our research paper is based on Combinations of different FIBRES. The main reason behind the manufacture of composites is not only to enhance the properties of different fibres but also to overcome their disadvantages.

Composites are combination of two materials in which one of the materials called the reinforcing phase is in the form of fibres, sheets or particles and is embedded in the other material called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough, material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material.

For example, the design situation may demand both the strength and toughness, which have inverse relation, and are not exhibited by one material. When no single conventional material is able to satisfy the competing design specifications for a given application, the solution may be a composite material.

Because of the variety of available reinforcement and matrix materials, as well as the ability to combine them in wide range of volume fraction, composites can be produced with a broad range of elastic modulus, strength, and toughness combinations. The flexibility of tailoring to a specific need is one of the most important attributes of composites.

Another advantage over conventional material is that composites can be designed to exhibit specific properties in specific directions (their anisotropy can be beneficial). The only drawback of the composites is that these are often more expensive than the conventional materials. Application of composite material in civil infrastructure system is not only technologically sound but also economically justifiable. The economic impact to evolve from the use of composite infrastructure is:

1. Reduction in installation and construction cost

2. Reduction in maintenance cost

3. Reduction in insurance liability

4. Market expansion for the raw

5. Development and sale of the service equipment for inspection of composites structures.

Composition: Most fibre-reinforced composites consist of fibres, matrix and interfaces and are collectively responsible for the unusual characteristics of composites.

: The first man made polymer reinforcing fibres were nylon and polyester. The most frequently used fibres are of glass, boron, carbon, ceramic, metal etc. For any class of fibre reinforced composites the ones with highest specific strength and modulus values generally have all their fibres aligned in one direction, (unidirectional fibre reinforced composites). If the loading directions are known (and always the same) then the composites can be designed and fabricated so that the strong and stiff fibre direction coincides with the loading direction. In this case the "weakness" in the perpendicular directions is not a problem. If, however, the loading direction is not known, or varies with time, then a nearly isotropic composite is required. The fibres must be arranged so that a portion is oriented in several directions within the material. This type of fibre architecture yields properties that are between those of the "strong" and "weak" directions in aligned fibre composites.

In most unidirectional fibre reinforced composites the fibres do not run continuously from one end of the component to the other. If the fibre length is significantly less than the component dimensions, then the material is known as a discontinuous fibre reinforced composite. When a discontinuous fibre with a high elastic modulus is embedded in a low modulus material, and the resulting composite is loaded in the fibres direction, the fibres carry a higher load than does the matrix. This is the principle of fibre strengthening.

Matrix: Like fibres, matrix materials can be polymers, ceramics, or metals; often it is a resin such as polyester, or epoxy that binds the fibres together, transferring load from broken fibres to unbroken ones and between fibres that are not oriented along lines of tension.

Also, unless the matrix chosen is especially flexible, it prevents the fibres from buckling in compression. In terms of stress, any fibres serve to resist tension, the matrix serves to resist shear, and all materials present serve to resist compression, including any aggregate (some composites use an aggregate instead of, or in addition to, fibres). The primary purpose of the matrix materials is to provide lateral support to the fibres and transfer loads.

They also are a source of toughness in the composites, since the majority of fibre materials are brittle. Cracks that have propagated through a brittle fibre are stopped when their tips encounter tough matrix materials. An exception to ductile matrix material is ceramic matrix materials, which are inherently brittle. Composites using ceramic matrices, such as reinforced concrete, are used in compressive load applications play an important role in determining the properties of composites.

An interface is a surface formed by the common boundary of the reinforced fibre when they are in contact. It constitutes the bond in between and is mainly responsible for transferring the load from matrix to the fibre. Shocks, impact, loadings or repeated cyclic stresses can cause the laminate to separate at the interface between two layers, a condition known as delamination. Individual fibres can separate from the matrix e.g. fibre pull-out. Consider 1 cm3 of a unidirectional composite made from 25 m diameter, continuous fibres embedded in a matrix. If the fibres are arranged in a square array and are on average 50 m apart, the volume fraction of fibres is approximately 20%. The total fibre matrix interface area is approximately 314 cm2 compared to the 6 cm2 external surface area.

The typical fibre volume fraction in composites is two to three times the above amount, and the interfacial area increases proportionally.

MATERIALS AND METHODS:

Here the materials used for composites are shape memory alloy fibres, polypropylene fibre, basalt fibre, glass fibre, asbestos fibre, fly ash and nylon. And in nanotechnology lead oxide, nano silica, aluminates are used. Nanomaterials are prepared by CVD method

Chemical vapour deposition (**CVD**) is a chemical process used to produce high quality, high-performance, solid materials. The process is often used in the semiconductor industry to produce thin films. In typical CVD, the substrate is exposed to one or more volatile which react and/or decompose on the substrate surface to produce the desired deposit. Frequently, volatile by products are also produced, which are removed by gas flow through the reaction chamber. Polymerization by CVD, perhaps the most versatile of all applications, allows for super-thin coatings which possess some very desirable qualities, such as lubricity, hydrophobicity and weather-resistance to name a few.CVD of metal-organic frameworks, a class of crystalline Nano porous materials, has recently been demonstrated.

And **for SMA (shape memory alloy)** the following procedure is carried out , Several attempts have recently been reported that SMA fibres were dispersed into an epoxy or an aluminium matrix in order to enhance strength and toughness by shrinkage of the SMA above a transformation temperature. However, information on using such a material in structural elements in the form of short fibres is scare. Cement, FA, and silica sand mixed in a 20L mixer in dry condition for one minute. Water & HRWRA added to dry mixture over another 3 minutes till a homogeneous consistency is produced.

Then SMA fibres are added gradually and mixed for another 3 minutes for uniform distribution.Specimens are made by directly pouring into moulds without compaction. All specimens are demoulded after 24 hours and cured inside sealed plastic bags to avoid mixing water loss due to evaporation until testing age. For polypropylene the importance of measuring the concrete moisture is to determine the gas permeability. The formula is used for dry concrete and moisture concrete, respectively:

Where $\mathbf{K_o(T)}$ is the oxygen permeability calculated for dry concrete, $\mathbf{K_o(F)}$ is the oxygen permeability calculated for moisture concrete, $\mathbf{K_T}$ is the gas permeability calculated by Torrent permeability test, and **þ** is the electrical resistivity by Wenner method (**kΩ cm**). It is clear that concrete with the amount of polypropylene fibers of 0.5, 1.5 and 2 kg M3 have more acceptable **KT** than other compositions considered in this study. Therefore, it can be said that permeability is the main factor that is responsible for diffusion of chloride ion as an aggressive element in concrete.

For **basalt fibre** the manufacture requires the melting of the quarried basalt rock at about 1,400 °C (2,550 °F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. There are three main manufacturing techniques, which are centrifugal-blowing, centrifugal-multirole and die-blowing. They also have a high **elastic modulus** resulting in excellent **specific strength**—three times that of steel.

RESULTS AND CONCLUSION:

The activities in Nano related products for the construction industry are not well marketed and are difficult for industry experts to identify. A large-scale and visible initiative from nano-science and nanotechnology in the construction area could help seed construction related nano-technological development. Focused research into the timeous and directed research into nanotechnology for construction infrastructure should be pursued to ensure that the potential benefits of this technology can be harnessed to provide longer life and more economical infrastructure.

SHAPE MEMORY ALLOY:

Generally, the workability decreases due to addition of SMA fibre.

- Only a slight to no increase in compressive strength was found out by adding SMA fibres.
- The tensile capacity improved by the SMA fibre addition.
- An overall enhancement in the flexural capacity of the composite was observed due to addition of SMA fibres.

NYLON FIBRE:

- With the addition of 1.0% volume fraction of nylon fibres in M30, there was an increment of the compressive strength up to 10% at 28 days strength.
- With the addition of 1.0% volume fraction of nylon fibres in M30 concrete there was an increment of the split tensile strength up to 25% at 28 days strength.
- With addition of 1.5% volume fraction of nylon fibres in M30 concrete there was an increment of the flexural strength up to 18% at 28 days strength.

POLYPROPYLENE FIBRE:

- According to the results of compressive strength tests, the concrete compressive strength increased proportionately with the increase in volume ratios of propylene fibres, the highest strength values were seen in the volume ratios of 1.5 kg m3 and 2 kg m3.
- The presence of polypropylene fibres had caused delay in starting the degradation process by reducing

permeability, reducing the amount of shrinkage and expansion of concrete.

- In general, the samples with fibres content of 1.5 kg m3 showed optimum results in comparison with other samples in this study.

BASALT AND ASBESTOS FIBRE:

- Thus by considering all the above parameter we conclude that basalt fibre provides tensile and flexural strength to the cement matrix.
- While asbestos fibre concerns on permeability, fire resisting property and it is used concrete in order to reduce cracking.

Since both fibres are cheap and abundantly available this composite can be used in construction.

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