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"A review study & recommendation on Bendable Concrete"

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Abstract

The Concrete material used for construction due to its advantage over other material such as its mold-ability to desire shape and economical as construction material over other material. But due to inability of resistance to tension it fail to fulfill the requirement of some critical situation. So to overcome the lacuna of concrete and improve the flexibility property of concrete it is require to add some additional material. So, the concrete mix with addition with additional material to improve the tensile strength is a Engineered Composite Material abbreviated as ECC and also called as bendable concrete. The bendable concrete material has promise for solving some of the deck durability problems we face, such as premature cracking. We're hoping the ECC will work well, and possibly lower the cost when experience is gained on large scale production. The work by ECC for any structure which has experienced three winters of freezing and thawing cycles, has much better crack control than the normal concrete. The ECC path with sensors to monitor the performance of the material as it is exposed to environmental load. The newly constructed Mihara Bridge in Hokkaido, Japan, has a 5 cm ultra-thin deck of ECC which is expected to open to traffic after short period. The bridge is 40 percent lighter than traditional concrete, and has an expected service life of 100 years.

In this study, the experimental investigation is used to evaluate the behavior of concrete exposed to thermal condition and finding out the most suitable design for ECC to withstand all exposure condition. It is useful to make concrete which can be used at very sever condition.

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1. Introduction

ECC technology has been used already on projects in Japan, Korea, Switzerland and Australia, but has had relatively slow adoption in other place. That's despite traditional concrete's many problems: lack of durability and sustainability; failure under severe loading; and the resulting expenses of repair. ECC addresses most of those problems that comes in the conventional. The ductile, or bendable, concrete is made mainly of the same ingredients in regular concrete absence of the coarse aggregate. It looks exactly like regular concrete, but under excessive strain, the ECC concrete gives because the specially coated network of fibers veining the cement is allowed to slide within the cement, thus avoiding the in flexibility that causes brittleness and breakage. Fiber-reinforced concrete is old concept in construction material but ECC under development for the past 10 years is vastly superior to other fiber-reinforced concretes in development today. In addition to reinforcing the concrete with micro scale fibers that act as ligaments to bond the concrete more tightly, scientists design the ingredients in the concrete itself to make it more flexible by showing in figure 1 Test on Bendable concrete. An expansion joint is a section with interlocking steel teeth that lets the concrete deck move as a result of temperature variations, but major problems occur when joints jam frequently, and scientists expect significant savings by using ECC.

Fig. 1 Bending Test

1.1 Current Problem in concreting

a. Corrosion problem

Reinforcing steel corrosion is the most common cause of failure of concrete structures. Once started, rebar corrosion cannot be stopped by simply waterproofing the surface of the concrete. Steel corrosion in reinforced concrete structures has been a major problem across world today. Steel-rein-forced concrete structures are continually subject to attack by corrosion brought on by naturally occurring environmental conditions such as carbonation and the introduction of chlorides from sources such as salt water, deicing salts, and accelerating admixtures. A combination of the product with other protective systems is required if the level of durability of the concrete structure needs to more than double.

b. Shrinkage Reducing Admixture for Concrete

Concrete shrinkage cracking is a common problem in all types of concrete structures, especially for structures and environments where the cracks are prevalent and the repercussions are most severe. Examples of these are bridge decks, parking garages, marine structures, containment structures, and high performance floors. The product available can be easily dissolved in concrete mix water or dispersed in concrete during mixing.

c. Under Water Concrete

Many under-water civil engineering structures are affected not only by the presence of water or salt but also by water pressure; flow of water, and by the different material's density. These factors could cause cracks, corrosion, and dispersion of concrete particles. The product commonly referred to as a self-leveling agent that increases viscosity when is dissolved in water

d. Other nonstructural defect

Some of the defect occur in concreting that is in the harden concrete like, discoloration, Scaling, Crazing, cracking etc. which spoil the concrete serviceability.

Neither is a user trying to overcome a problem such as cement shrinkage or corrosion or a politician who is being pressured by community concern over environ-mental degradation going to be interested in the problems of the industry. Cements and concretes are changing to better meet the needs of customers ahead of the competition. The construction industry is conservative and the changes have been slow, such as the increase in the alite/belite ratio over the last twenty years and the incorporation of supplementary cementations' materials and various fibers.

To overcome such lacunas, here the ECC is best solution for very important work where long term quality is important. And also the project life cycle cost to be reduces. Engineered Cementations Composites abbreviated as ECC. This material is capable to exhibit considerably enhanced flexibility. ECC material has the strain capacity of more than 3% and thus acts more like a ductile metal rather than like a brittle glass. ECC material has a strain capacity of more than 3% to 5% compared to 0.01% of normal concrete and thus acts more like a ductile metal. ECC is reinforced with micromechanically designed polymer fibers. PVA Polyvinyl alcohol (PVA) fiber is considered as one of the most suitable polymeric fibers to be used as the reinforcement of engineered cementations composites, showing an extensive strain hardening behavior of the composites, can be used to reduce resources and funds for rehabilitation of structure.

At the starting this fiber concrete can be double the cost as compare to conventional concrete but as it can amplify the duration of structure, it will be less costlier than the conventional concrete, Conventional concretes are almost un-bendable and have a strain capacity of only 0.1%. Internal micro-cracks are inherently present in the concrete (due to drying shrinkage) and its poor tensile strength is due to the propagation of these cracks (under loading), eventually leading to brittle failure of the concrete.

1.2 Key points

The key points in ECC are listed below

1. Able to bend like a metal Stronger, more durable, lasts longer. Non brittle, containing only two percent by volume short fiber
2. 500 times resistance to cracking and 40% lighter. And reduce environmental impact. Reduce or eliminates steel reinforcement
3. Reduce Project cost by reducing the life cycle cost and minimum maintenance cost. Faster in precast and on site construction.
4. 37% less expensive, 40% less energy consumption, 39% less CO2 Production.
5. It is used in first time in Michigam.

1.2 Application of Bendable concrete

Bendable concrete have good engineering property to sustain all kind of combination of load at any exposure condition. Having greatest application in civil engineering project.

1. Joint less construction for deck slab.
2. Underground construction subject to variation in loading. Reversible loading due to exposure.
3. Underwater construction for sustaining the high pressure. Precast construction material.
4. Decorative work and fine work.

2. Literature Review

For studying the bendable concrete it is need to review the previous work on bendable concrete. A new type of fiber-reinforced bendable concrete will be used for the first time in the University of Michigan scientists hope that their new material will find widespread use across the country. U-M's ECC technology has been used already on projects in Japan, Korea, Switzerland

and Australia, but has had relatively slow adoption in the other part. Said engineering professor Victor Li, whose team is developing the engineered cement composites.

1. Material properties of a new hybrid fiber-reinforced engineered cementations composite, this paper explores experimentally the mechanical properties of a new hybrid fiber-reinforced engineered cementations composite (ECC) material reinforced with 1.75% polyvinyl alcohol (PVA) fiber and 0.58% steel (SE) fiber. The development of this new ECC aims to achieve better impact resistance. A series of experiments were carried out to determine the compressive strength, Young's modulus, modulus of rupture, and tensile characteristics of the new material properties of the ECC reinforced with 1.5% PVA fiber and 0.5% SE fiber, which is denoted as the reference mix in this paper and has been claimed to be the most promising composition of fibers for impact resistance was also tested in this study for comparison and for determination of effect of fiber volume fraction on the material properties.

2. Evaluation of Engineering Cementations Composites (ECC) With Different Percentage of Fibers -Bhaumik Merchant, this study has explored experimentally the mechanical properties of a new hybrid fiber-reinforced engineered cementations composite(ECC) It is found that enewECC_M2mixexhibitsimproved compressive strength, Young's modulus, ultimate flexural strength, flexural strain, tensile strength at first crack and ultimate tensile strength than the ECC_M1 material. However, it is also found that the phase of strain hardeningofECC_M2is slightly shorter than that of ECC_M1.Itcan be seen from this study that increasing the volume fraction of SE fibres in hybrid fibre-reinforced ECC produces greater strength, but increasing the amount of the PVA fibre does not results in stronger strain capacity. it is found that the tensile characteristics of both ECC mixes are rate dependent, and the tensile strength at first crack and the ultimate tensile strength increases with the increase of the strain rate, whereas the strain capacity decreases with the increase of the strain rate. Material properties of a new hybrid fiber-reinforced engineered cementations composite

3) A comparative study on Conventional concrete and Engineered Cementations Composites by Yingzi Yang, En-Hua Yang, and Victor C. Li This paper reports on the development of ECC, taking into account environmental sustainability considerations. ECC is representing a unique class of high-performance fiber-reinforced cementations composites possessing high tensile and durability properties. With the ultra-high volumes of fly ash up to 85% by weight of cement replacement, are proposed in this research paper while micromechanical modeling is applied in the material design process, main focus of this study is placed on the fly ash content effect on material microstructure and mechanical properties altering process. Experimental results shown that HVFA ECCs, while addition high volumes of recycled fly ash, which can retain an approximately 2 to 3% of long-term tensile ductility. Significantly, both the free drying shrinkage and crack width are reduced with an increasing volume of the fly ash amount, which results in the improvement of long-term durability of structures made by HVFA-ECC.

4) Reported by Victor C. Li, Michael Leech et al**,** ECC design has been built on the basis of the relationship between the material microstructures, properties, processing and materials performance. This concept of material microstructures modeling was worked out very well in creating the various versions of ECC that can be prepared by using different materials as self-consolidating, casting, extrusion, and spraying. This research describes the initial attempt in creating greener ECCs, ECCs that maintain the extreme tensile ductility characteristics, but which also incorporate adopting various environmental considerations in the design and development of these materials for infrastructure applications. Sustainable ECC material design adopts the microstructure design tailoring based on various social, environmental, and economic aspects. Concrete and ECC show very significant differences in both fresh and mechanical properties. ECC production is resulting in a greater environmental burdens than concrete due to high content of cement usage of standard ECC, and the inclusion of various synthetic fibers. The analysis suggests that the reduction in the usage cement content of ECC and PVA fibers may be the possible methods of increasing the economy and sustainability of greener ECC material. In this research one type of bottom ash and Two types of fly ash i.e. Fine fly ash is representing a two special type Class C fly ash and class F fly ash .The Class C fly ash with particle size of average 2μm and high calcium content, whose particle size is much smaller than general class F fly ash of average 13 μm are investigated, and the Fine fly ash is representing a

special type of Class C fly ash with high amount calcium content, and particle size of average 2 μm which is much are much smaller than class F fly ash of average 13 μm and the bottom ash of average particle size 50 μm is used. Bottom ash, due to its low pozzolonic reactivity, this leads to both lower early but long-term strength in the ECC. Mapping of the greener ECC properties to the required properties for specific interest of infrastructural applications resulted to a minimum performance reduction in the performance of infrastructure, while greatly enhancing the life and sustainability indices.

5. Investigations on mechanical performance of cementations composites micro-engineered with poly vinyl alcohol fibers By Saptarshi Sasmal et al gives the study about ECC as polyvinyl alcohol fiber (PVA), being hydrophilic, has the capability to strongly bond with the cement matrix in the presence of water. Water which helps in developing the hydration product is also essential for the development of chemical bonding between the PVA fiber and the matrix. PVA fiber has two important characteristics when embedded in a cement matrix, viz. chemical bond and interface friction. The present study employs a micro-mechanics based approach and brings out a clear understanding on the behavior of PVA fibers inside cement matrix. Flexure and fracture studies are carried out on the cementations composites engineered with PVAs where the volume fraction and length of PVA fibers, the water cement ratios (w/c) and sand to cement ratios (s/c) are the parameters. Results from flexural strength show that when water-cement ratio is varied from 0.3 to 0.4, gain of absolute strength shifts from the first crack to post crack. Lesser w/c ratio provides high strength but, the ductility could not be achieved whereas higher w/c ratio helps to activate chemical fibers, hence strain hardening phenomenon in PVA incorporated cement composite is achieved. The fracture studies depict that with clear understanding of mechanical behavior and feasible tailoring thereafter, it is possible to develop the constituents to achieve the high fracture energy.

6. The influence of bending crack on rebar corrosion in fly ash concrete subjected to different exposure conditions under static loading by Idrees Zafar et. al. in this the present study an effort was made to clarify the performance of pre-cracked fly ash concrete against corrosion under different exposure conditions. A total of twenty specimens from two different concrete mixes were tested against three different exposure conditions for 106 days. It was observed that the crack filling ability of concrete is more sensitive to crack width than fly ash replacement and exposure conditions. Under submerged conditions the fly ash concrete showed greater pitting corrosion, while under wet and dry cycle conditions, the corrosion damage was found to be less penetrating as compared to normal Portland cement concrete.

7. A new test method to study the influence of pore pressure on fracture behavior of concrete during heating by Roberto Felicetti et al, stated fracture behavior of concrete at high temperature is one of the factors governing explosive spelling, namely the expulsion of chunks due to both pressure build-up in the pores and stress induced by thermal gradients and external loads. In this context, a special experimental setup has been developed aimed at performing simple indirect-tension tests under different levels of sustained pore pressure. A cubic specimen is heated on two opposite faces, whereas the lateral sides are sealed and thermally insulated, so as to instate a mono-dimensional thermohygral transient field. In the splitting test, fracture develops along the symmetry plane, where both temperature and pressure are monitored by means of a customized probe. The results show that pore pressure has a significant influence on the mechanical response of heated concrete, though the concurrent contribution of external load and thermal strain is required for triggering explosive palling.

8. Correlation between the Barcelona test and the bending test in fiber reinforced concrete by Eduardo Galeton et al, suggest the Barcelona test. Which is abbreviated BCN is an alternative method to characterize the post-cracking behavior of fiber reinforced concrete (FRC). Given its simplicity, the reduced scatter of the results and low material consumption, the BCN may represent a suitable method for the quality control of FRC. For that, a correlation between the results of the BCN and the bending test is currently required since the latter is considered the reference for the characterization of the material and for deriving the constitutive design equations. The objective of this paper is to propose such correlation following an approach that takes into account the intrinsic variability of FRC. An experimental program involving 21 mixes of conventional and self-compacting FRC with either steel or plastic fibers was performed. Several analyses were conducted

both for selecting the most relevant parameters and for maximizing the degree of correlation between the tests. The highest correlation coefficient between tests was obtained for the mixes with plastic fibres. In such case, the formulation proposed is able to predict the results with accuracy up to 75%. The correlation found is an interesting tool towards a simple and reliable quality control of FRC based on the BCN mainly oriented to large scale concrete production.

9. Investigations on mechanical performance of cementations composites micro-engineered with poly vinyl alcohol fibers by Saptarshi Sasmal et al, this the present study employs a micro-mechanics based approach and brings out a clear understanding on the behavior of PVA fibers inside cement matrix. Flexure and fracture studies are carried out on the cementations composites engineered with PVAs where the volume fraction and length of PVA fibers, the water cement ratios (w/c) and sand to cement ratios (s/c) are the parameters. Results from flexural strength show that when water-cement ratio is varied from 0.3 to 0.4, gain of absolute strength shifts from the first crack to post crack. Lesser w/c ratio provides high strength but, the ductility could not be achieved whereas higher w/c ratio helps to activate chemical fibers, hence strain hardening phenomenon in PVA incorporated cement composite is achieved.

3. Research Objectives

From above review and previous work on ECC or bendable concrete it need to study more experimentally to design and test under various working condition. So the preliminary objective of the study is as

I. To critically assess the problems arise in bendable concrete and design the most suitable concrete proportion.

II. To find out the challenges regarding improvement by doing various test on designed concrete to asses experimentally under various exposure condition. evaluate the behavior of concrete exposed to thermal condition

III. Developing models for the proposed work for validation of results.

4. Methodology

Experimental investigation used to complete the work to fulfill the research objective. The methodology adopted to complete the work is start from the research review to find out the previous work on bendable concrete. As the material is advanced and people are not started very much work on this bendable concrete, it need to work on some standard benchmark. From previous work done I have to find out some problem about the bendable concrete and to solve the problem by change in design or change in the material. After finding out the problem, the design will be done accordingly by using code of designing the ingredients in the concrete. To

After selecting the design, the various test will be done on the specimen casted to testing. The testing will be conducted on specimen at various exposure condition. Here the test will be carried out under various combination of loading.

4. Scope of Research

One of the most useful material almost at all the places in civil engineering project is a concrete material, but due to some lacunas in this material to withstand under various sever condition, it is need to overcome that weakness. Under that circumstances the bendable concrete is best option to solve such problem. Also the various advantage of the bendable concrete over conventional concrete make useful. The ECC material useful for no seepage condition also as it may be reduces the cracking and through this we have to reduce the corrosion in reinforcement. It can be used in repairing work by checking the adhesive property. The ECC material can be use as a smart material for detecting the expansion in the structure as it goes straining under load by studying strain under time period.

5 Outcome

Through this experimental investigation the probable outcome will be expected that the concrete passes all exposure test and with targeted strength.

1. Finding the most optimize mix design by evaluating the performance of the bendable concrete under various exposure condition.
2. The behavior of bendable concrete under thermal exposure and ascertain the suitability of bendable concrete under temperature variation.

3. Designing the bendable concrete mix with economical point of view so to reduce the initial cost of ingredients.
4. Developing the experimental model for designing, mixing and testing of bendable concrete.
5. Finding out the possible alternate material for expensive ingredient for bendable concrete and any treatment if require to suit it.

6. Summary

From above study related to the bendable concrete and improvement in ECC material through experimental investigation for assessing the resistance to thermal exposure and its behavior under different loading, we have to assess the suitability and conformity of ECC for different work. The bendable concrete is most useful constriction material in civil engineering project under very critical condition like bridge deck slab construction, road ways pavement, we can reduced still reinforcement and avoid congestion due to still bars. Also we can avoid the cracks so it resists the seepage of water through the concrete and avoiding the corrosion in reinforcement. It may be act as a zero seepage work and at high tension.

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