ISSN: 0974-5823 Vol. 7 No. 2 February, 2022

International Journal of Mechanical Engineering

Physical property study on Cellulosic Nanocrystals Concrete

Mr. Shreeshail Heggond Research Scholar

Dr. Paritosh Srivastava Professor, Head of Department

Civil Engineering. NIU

Greater Noida, U.P. India

***Abstract*—** In the civil engineering field most used building material is Concrete which is the adaptable to any environment with its versatility in design as per requirements. Concrete is considered as structural element in all building, concrete is most important material in structures as concrete is homogeneous and brittle component and most commonly concrete is considered as carries low stress in tensile. To increase tensile strength many additives have been identified such as fibre reinforced concrete and various plasticizers

Although the various types of fibers are mixed with cement concrete composites to enhance flexural strength, hardiness and shock absorption and are expensive. Cellulose nano material can be investigated for effectiveness in cementious substance. The article is written on basic of experiment analysis consideration by using cellulose fibers as an inexpensive choice to synthetic fiber. Study characterizes the behavior of addition of cellulose nanocrystal in concrete and investigate various properties of concrete. Nano crystal addition will results to reduction of micro cracks due to filling of micro gaps and which will direct to enhancement of static and dynamic concrete properties. Nano material has high surface area to volume ratio, which enhance potential to increase reaction chemical also it will have exceptional properties such as high aspect ratio, high elastic modules, tensile strength, low density that permit effortless water dispersibilty. Nano size of concrete can allowed to enter smaller inter fiber spacing and reaction between cement and cellulose hydration process will be faster, and as a result, the cement react with water as a product of heat of hydration process which leads to better potential fight to avoid cracks with enhancing the concrete strength. It is found that an addition of CNC 2% to 4% by weight of cement

Keywords—CNC, Compressive strength, Split tensile strength

INTRODUCTION

Different types of fibre is been added into cement concrete to enhance the strength, hardness. For instance, the bonding of glass fibers to cement is not tough enough, and the bonding between glass fibers and cement is low as alkaline resistance is low and cannot build flexural properties, shear, and strength. Polymer and Carbon fibers are of high energy consumption course. So the alternative substitute is required to enhance physical and chemical properties of concrete which can be added like carbon and polymer fibers. Natural fibers are also used to enhance the physical and mechanical properties of cement and concrete ingredients. Considering all these features, an ecofriendly and sustainable fibers are introduced experimented on concrete namely Nano fibrillated cellulose. This material is produced from wood- derived fiber (pulp) this is the separated to very small size to nano level and small and this material is most advanced research in the world in present day, As the NFC material is produced from natural plant pulp, it develops very low environmental impact in the preparation of raw material and after use disposal also. It enhances compressive strength and flexural strength of concrete, even workability of concrete gets improved on addition of cellulose nanocrystals.

Depending on the resource or beginning, cellulose consists of different portion of mostly crystalline regions accompanied by some amorphous fractions. Upon isolating the solids regions from the biomass, it results in attain polysaccharide nanocrystals, most commonly in the form of rod-shaped cellulose nanocrystals. Cellulose, the most ubiquitous biopolymer, in the form of Nanocellulose(NC) has gained growing interest among investigator corroborating to its mechanical, physical and biological studies are done in companion with being eco-friendly. NC can be obtained from natural cellulose, with few to tens of nanometers size range at least in one dimension. analytically discussed on nano solid cellulose mixers in the standpoint of rheology, liquid crystal ordering, and colloidal phase behavior. the critical view are made on geometrical dimensions, morphology of CNC completely based on production process, taking out methods, and mechanized environment, which causes variations in components of rheology and colloidal actions. researchers studies says that the rheology and colloidal actions of aqueous CNC components are explained in details by colloidal content portions, the nanocrystalline cellulose rods dimensions and internal particle forces. furthermore, nanocrystalline cellulose components form an ordered liquid crystal state when its concentration meets significant value. Deduced the stability of CNC components in water could be improves by controlling the surface charge, that is degree of replacement of sulfate variants on CNC surface. The research comments that the viscosity of nanocellulose components was leaning by surface charge, where cellulose nanocrystals with low surface charge develops more viscous components, as a result it undergo solidification by frizzing at low density. author conclude the effective volume of NC

components plays a foremost role all over the concentration assortment relevant to liquid crystalline phase configuration once the surface charge concentration of CNCs reaches a target values.

LITERATURE

Qiaoling Liu et al., 2019 Calculated quantity of CNC is added in concrete ti enhance the properties and cement composites are studied in this study. As a encouragement, study unearth the this substitute in cement paste can enhance the properties, considerably concrete is taken into account for curing circumstances stated when a sudden shrink in temperature and humidity occur. The voids distributions of cement demonstrate that the adding up of CNCs enhances the filling of microstructure; the void configuration modification in cement matrix have occurred. Nitrogen adsorption outcome show that almost no hydration products, as well as C-S-H gel, are created in cement pastes without any adding of CNCs under excessive conditions. A rapid reduce in temperature and humidity leads to a complexity in the configuration of CSH. The adding up of CNCs has an excellent effect in improves the hydration of cement and preventing concrete from cracking under extreme circumstances. CNC has potential for application prospects in concrete structure under low temperature but not in an surrounding that increases freezing

Statistical analysis was performed to determine if the nano-composites achieved significantly greater strengths than the control samples. The t-test was adopted for this purpose. This test is one of the powerful tools in manipulating the mean of a normally scattered population where the specimen size is small and the standard deviation is unidentified. The t-test was performed to see if the differences in the mean of each sample set were statistically different. P-value method was used for determining the hypothesis experimentation. No hypothesis can be discarded if the P-value is less than the worth level of 0.05. This would signify that the composite strength was significantly greater than the control sample strength.

The 28-day flexural strengths achieved by the 0.1% and 0.2% CNT/CNF samples are presented in Figures 7 and 8, respectively. Table 4 shows that the percentage flexural strength gains, as compared to the control samples, are impressive (27% - 53%) for 0.35 w/c ratio, although the gain is not as high as in the compressive strength samples. There is no clear indication of a particular combination of CNT/CNF and w/c ratio that resulted in better flexural strength production at 28 days. All nano reinforced samples performed better in flexural strength than the corresponding control samples.

Mohammad Reza Dousti Cellulose nanocrystal (CNC) particles are extremely smaller than previous conventional (macroscopic) cellulosic additives. Even though CNC particles have been recently used in general cement for strength improvement, they have never been implemented in oil well cement slurries. This dissertation provides a comprehensive study which examines the effect of CNC particles on the results of oil well cement paste. With the information available from past studies regarding the effect of other cellulosic additives on cementitious systems, and with recognizing the influence of CNC on a variety of host materials (composites), this study aims to explore the impact of this nano scale additive on overall performance of oil well cement paste and shed more light on how this innovative additive could address a number of concerns.

Cao, Y., Zavaterri, P., The article explains how the adding of cellulose nanocrystals (CNCs) modified the performance of concrete. the research shows the flexural strengths of cement and concrete with diffident concentrations of cellulose nanocrystals about 18% to 32% superior than the cement and concrete without nanocrystal and the study hypothesize that this enhance can be accredited to the boost in DOH of cement pastes if the CNCs are added. Based on experimental analysis and interpretation, two processes are projected to explain the raise on DOH: (1) Steris stabilization is accountable for leaving space the cement particles. This mechanism is also explained by water dipping additive to develop workability. This spreading effect is confirmed by rheological dimensions for cellulose cement pastes, in which a abridged yield stress is investigational with low attentiveness of CNC. (2) The cellulose system exploring to exhibit advantage due to mechanism this will be compared to diminutive circuit spreading: Short circuit spreading explain how we can use CNC materials to show a conduit for water transporting all the way through hydration products ring to the un-hydrated cement particle and thereby civilizing hydration. The B3B flexural strength enhance with CNC absorption reaching a maximum at 0.25 vol % of nanocrystsl. At senior concentrations of CNC the characteristics decreases. This can be described by the agglomeration of CNC so as to acts as a stress concentration in the cement paste. This peak of 0.25% is also steady with the rheological outcome that show that for upper CNC loadings the yield stress enhanced appreciably due to the agglomeration.

Dianah Mazlan, The cement mortar mix used in this study were prepared by mixing the CNCs aqueous suspension together with sand and cement at 0.45 water/cement ratio19. Te quantity of CNCs liquid suspension added to cement composites was from 0% to 0.8% by quantity of cement contented. Te spreading performance of the CNC in aqueous deferment was found to be supplementary constant compare to the powder form.

considerable impact of CNC on cement mortar which the CNC have precious the curing routine of the cement mortar. bind curing with polyethylene layer was the most effectual technique, obvious through the maximum compressive strength recorded. Moreover, the compressive strength of the cement mortar increased 40% to 45% from its unique strength when 0.44% of CNC were additional. In adding up, the effect of CNC adding up also definitely affected the flexural strength of cement mortar that improved about 18% when up to 0.44% CNC were further added. in conclusion, the addition of CNC create to amend the inner configuration of the composite where the structure of calcium crystals that would make stronger the structure continual even after

the curing method ended. Further study on the additional potentials of CNC in improving cement mortar should be examine systematically due to its promising characteristics and the opportunity of being applied in real-world manufacture project.

SCOPE OF WORK

For making concrete with high flexural strength reinforcement are added to it. Such huge use of reinforcement can be minimized to a little extent by adding cellulose nanocrystal. Since addition of cellulose nanocrystals to concrete can improve flexural strength. Moreover it can replace carbon and other polymer fibers which are uneconomic when compared to CNC's.

CNC as major components for various promising applications. It provides awareness to inspire further research facility in this field. though the literature of NC, generated from a number of natural production sources using special approaches, has been intensively studied more the period 20 years, few challenges must be beat, predominantly in the fields of surface and end-reducing modifications, the improvement of environmentally-friendly processes of extraction at lower cost with reduced energy-consuming processes as well as the up-scaling production. It is demonstrated in the present review that NC shows the prospective to be truly green nano components with a number of exceptional helpful features such as great surface area, tailorability of surface chemistry, improved mechanical characteristics, anisotropic shape, among others, making it an excellent material for widespread variety of applications in the ground of biomedical field and material science, it shows a high potential for growing industries. With the materialization of cost-effective business sources of NC, a room for new applications and upgrading of the existing ones, which can be employed in various industries that require materials with advanced properties, still exists and such topic is of particular interest for the future. Therefore, further research activities need to be conducted to fill current gaps through the practical transition from laboratory scale to industrial or commercial production, and achieve the feasibility of the final materials and introduce them in the market, in particular,

(1) Maximize the production process and improve methods to produce new Nano Cellulose produced materials

(2) Application life cycle evaluation to environmental aspects of Nano cellulose produced materials

(3) Reduce the energy- and time-consumption of the NC-produced materials. Despite the above-mentioned challenged, we expect that NC-produce materials will certainly get better the people's quality of living in the future through the enhancement of the next generation of concrete.

METHODOLOGY

From the literature studies the nano material used in concrete are Nanosio2, CNC which are most effective and productive in term of strength, density and economical aspect, the testing process of fresh and harden concrete is done with respect to IS guideline and i.e IS 456.2000, IS 10262.2009,SP 23, and IS 516 2013.

Thus int this project we started study on the basic materials needed for casting of Cellulose Nano crystal Concrete which constitute of Cement, Fine aggregate, Coarse aggregate, Super plasticizer and Cellulose Nano fibres Crystals, quality of water for construction works are same as drinking water. This is to ensure that the water is reasonably free from such impurities as suspended solids, organic matter and dissolved salts, which may adversely affect on properties of concrete, The cement used for preparing concrete is the OPC. This study OPC of grade 53 and chosen coarse aggregate for Cellulose Nano Crystal Concrete is typically found in angular shape, well graded and smaller in maximum size than the conventional concrete. Typical conventional concrete could have maximum aggregate size of 20mm or more. Super plasticizer is essential for achieving high strength concrete. The job of Super Plasticizer is to impart a high degree of flow ability and deformability,

Cellulose nanocrystals are unique nanomaterials derived from the most abundant and almost inexhaustible natural polymer, cellulose. Cellulose nanocrystals primarily obtained from naturally occurring cellulose fibers are biodegradable and renewable in nature and hence they serve as a sustainable and environmentally friendly material for most applications The main sources of cellulose required for generation of CNCs are plants; however, algae, bacteria, and some sea animals are also capable of producing cellulose in large quantities. As the emerging industrial extraction process to achieve greater yield of CNC has not yet developed in India so it was hard to obtain these material

Concrete mix design for M50 Grade: IS 10262-2009

- ✓ Volume of concrete = 1 m^3
- ✓ Volume of cement = 480/(3.15x1000) = 0.152 m^3
- ✓ Volume of water = 140/1000 = 0.140 m^3
- ✓ Volume of all aggregates = [1-(0.152+0.140+0.00727)] = 0.700 m^3
- ✓ Mass of coarse aggregate = 0.700×2.77×0.567×1000 = 1099.96 kg
- ✓ Mass of fine aggregate = 0.433×2.67×0.726×1000 = 828.38 kg

We have made an attempt to design concrete of grade M-50. The mix design has been carried out for the material details specified. The no. of cubes and beams casted for the present study are listed in the table 4. Casting and curing of cubes and beams are done as per the standard procedure. For the curing process we opt for water immersion curing technique, after curing for 7 and 28 days we have performed compressive strength test on concrete cubes and Third point flexural test on concrete beams both with and without CNCs. Investigation has been carried out for the effect of CNCs in the enhancement of the flexural strength by adding different percentage of the CNCs. For the present experimental work 2%, 3%, 3.5% and 4% of CNCs by weight of cement is carried out.

Concrete samples of cube 150x150x150mm and cylinder of 300x150mm dia are prepared and tested for 3, 7, 14, 21, 28, 100, 200, 365 and 500 days curing and sundried samples

RESULT AND DISCUSSION

Tested for workability and results of workability are shown in following table

Duration	Slump cone test results				
	CC	2%	3%	3.5%	4%
Slump Value	113	130	146	157	181

Table 1 Slump value for concrete with CNC

Conventional concrete workability is found to be less workable compared with concrete with Cellulose Nano Crystal as boost the addition of CNC flowability of fresh concrete will increases with strength characteristics

Concrete cube samples are tested under Compressive testing machine following results are given as

Compressive Strength of CNC concrete

Duration of testing	Compressive strength of CNC concrete				
	CC	**2%**	**3%**	**3.50%**	**4%**
3 Days	24.62	25.04	27.75	32.56	23.66
7 Days	34.43	32.81	32.61	38.8	26.09
14 Days	40.09	41.75	40.93	49.16	37.59
21 Days	43.82	53.82	45.72	57.69	42.98
28 Days	56.27	63.44	65.53	70.64	58.09
120 Days	57.85	67.81	67.85	71.47	62.89
200 Days	59.21	68.00	70.18	72.1	64.73
365 Days	61.38	67.53	69.81	72.92	66.04
500 Days	62.04	67.94	71.07	73.44	67.85

Table 2 Compressive strength of CNC concrete

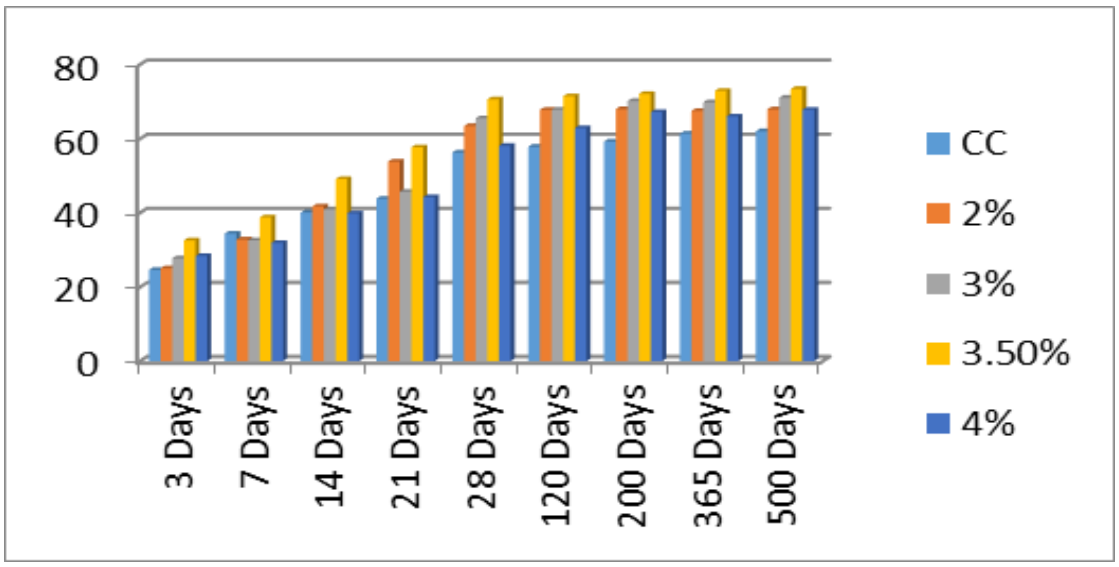

Fig. 01 Relative graph of compressive strength

From the test results it shows maximum increase in the strength is at 3.5% addition of CNC by the weight of cement.

Split tensile strength of concrete with various proportion of nano silica for 150mm dia and 300mm height cylinders

Duration of testing	Split Tensile strength of Cellulose Nano Crystals Concrete				
	CC	**2%**	**3%**	**3.50%**	**4%**
14 Days	4.1	3.94	4.06	4	3.82
28 Days	5.63	6.7	6.41	6.59	6.15
120 Days	5.85	6.1	6.79	6.77	6.21
365 Days	6.15	6.31	6.8	7.07	6.21
500 Days	6.52	6.8	7.19	7.59	6.9

Table 03: Split tensile strength of concrete

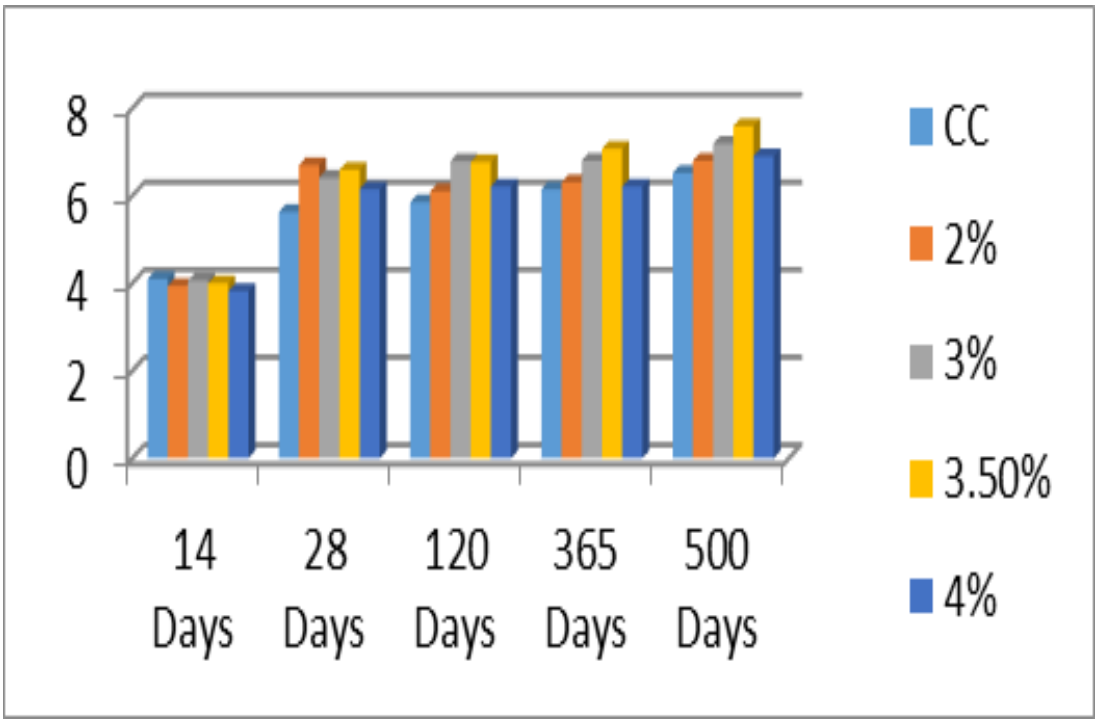

Fig. 02 Relative Graph of split tensile strength

Addition of 2 to 4% CNC's in concrete improved the compressive strength near to 6 to 20.17% but the addition of 3.5% of CNC gives highest compressive strength to 21.07% and highest split tensile strength to 18%. Addition of CNC in high performance concrete

significant raise in the flexural strength. Concrete samples with 3.5% of CNC show 31% raise in flexural strength and that of concrete with 2% CNC gave 18% raise of flexural strength. Addition of CNC have larger impact on strength of concrete.

CONCLUSION

Concrete is found low workable when Cellulose Nano Crystal is not added and hence split tensile strength given was less, by the addition of CNC in conventional concrete improves the workability properties like Slump value and compaction factor and which also improves the compressive strength and split tensile strength. the CNC in concrete enhance hydration process of cement hence concrete will attain better strength in short duration of curing. The CNC addition in concrete act as reinforcement of nano size which enhance flexural properties of concrete because of reinforcement

As nano particles well dispersed in concrete increases the viscosity of the fresh phase of concrete, resist segregation and improves workability of concrete.

CNC Accelerate the hydration process. Which improves bonding between aggregates and cement paste. enhances the concrete properties like toughness, shear, tensile strength and flexural strength.

REFERENCES

1. R. Jaraboa, E. Fuentea, M.C. Montea, H. Savastano Jr. b, P. Mutjec, C. Negroa , "Use of cellulose fibres from hemp core in fibre-cement production. Effect on flocculation, retention, drainage and product properties" Industrial Crops and Products 39, page no. 89– 96, 2012 nic Theses and Dissertations. Paper 759, 2009

2. Ning Lin, Alain Dufresne, "Nanocellulose in biomedicine: Current status and future prospect", European Polymer Journal, Pages 302–325, October 2014

3. João Paulo Saraiva Moraisa, Morsyleide de Freitas Rosab, Men de sá Moreira de Souza Filhob, Lidyane Dias Nascimentoa, Diego Magalhães do Nascimentob, Ana Ribeiro Cassalesb, "Extraction and characterization of nano cellulose structures from raw cotton linter" Carbohydrate Polymers, Volume 91, issue I, Pages 229–235, January 2013

4. Sarah J. Peters, Todd S. Rushing, Eric N. Landis, and Toney K. Cummins, "Nanocellulose and Microcellulose Fibres for Concrete", Transportation Research Record: Journal of the Transportation Research Board, vol. 2, page 25-28, may 2010

5. Sarah June Peters, "Fracture Toughness Investigations of Micro and Nano Cellulose Fibre Reinforced Ultra High Performance Concrete ", Electronic thesis and dissertations, Aug. 2009

6. Yizheng Cao, W. Jason Weiss, Jeffrey Youngblood, Robert Moon, and Pablo Zavattieri," Performance-Enhanced Cementitious Materials by Cellulose Nanocrystal Additions", Production and Applications of Cellulose Nano materials, page 135-136, 2013