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Behaviour of Concrete Utilizing CNSL resins and Metakaolin as a Partial Replacement of Cement

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Abstract:
The behaviour of concrete utilizing Metakaolin as a partial replacement of cement along with marble powder and fly ash have been investigated by several researchers in the recent years.In the present experimental study, investigations have been carried out to study the behaviour of concrete utilizing Metakaolin and CNSL Resins as a partial replacement of cement. The experimental work consisted of casting of cube and beam samples samples with various combinations of Metakaolin and CNSL Resins. The percentage replacement of Metakaolin and CNSL Resins were 5%, 10% , 15% for both.

1. INTRODUCTION

The problem faced in today's world is the deterioration of buildings caused by corrosion of concrete. Corrosion of concrete starts with the reinforcement steel which is embedded inside the concrete. The corrosion of reinforcement steel occurs due to the penetration of moisture, chlorides which are present in the surrounding environment. These penetrate and propagate to the reinforcement steel bars and cause damage of steel reinforcement resulting in the reinforcement bars to rust and then further deterioration of concrete. Firstly, the aggressive agent get transferred to the steel reinforcement and induces to corrosion initiation and then, the growth of corrosion takes place leading to the damage of the building due to induced cracks. The corrosion process of the steel bars in the concrete results in the rusting of the reinforcement and this rust increases day by day result in the reinforcement bar to become thick. The increased thickness of the reinforcement creates a pressure on the concrete and cracks are developed in the concrete due to the generated pressure. And then the complete deterioration of the building takes place due to the prorogation and expansion of the crack. Corrosion of concrete can be prevented by providing a thick covering of dense and highly impermeable concrete. Dense concrete cover can be prepared by lowering or minimizing the water to cement ratio of the mix. There is various factors responsible for corrosion like cover thickness of concrete reinforcement, condition of reinforcement, quality of concrete, porosity of concrete, effects of environment and other chemicals, freezing and thawing condition etc.

Literature shows that metakaolin can be used to modify the properties of concrete and CSNL resins can be used to produce acid resistance concrete.

2. Literature review

2.1 John (2013) analysed the effects of Metakaolin on the strength of concrete M30 was made using 53 grade OPC and the other mixes were prepared with the replacement levels of 5%,10%,15%, upto 20% (by weight) for Metakaolin. Various experiments are carried out to find the compressive strengths, flexural strengths and split strength of concrete. Results shows that the increase in metakaolin content improves the compressive strength, split tensile strength and flexural strength upto 15% replacement.

2.2 Bansal et al (2015) carried out experimental study of using metakaolin and marble powder as a partial replacement of cement. In this study partial replacement of cement was done at 0%, 3% , 5%, 9%, 12%, 13% with metakaolin and 0%, 10% (constant) with marble powder. Compressive and tensile strength was evaluated and compared with conventional concrete of M30 grade. Results show that there was increase in compressive strength, split tensile strength upto 9%.

2.3 Srivastava et al investigated on concrete containing silica fumes and metakaolin as a partial replacement of cement. Replacement range for silica fume and metakaolin was 0-10% and 0-25% respectively. Experimental result indicated that increase in the proportion of metakaolin resulted in increase in the compressive strength of concrete. The optimum dose of silica fume and metakaolin in combination was found to be 5% and 15% (by weight) respectively at both 7 and 28 days compressive strength.

2.4 Jiang Tong Ding etal (2002) investigated the effects of Metakaolin and silica fumes on the properties of concrete. Experimental investigation with seven concrete mixtures of 0, 5, 10, 15% by mass replacement of cement with metakaolin and silica fume, at a water cement ratio of 0.35 and sand to aggregate ratio of 40% was carried out. It was found that it reduces drying shrinkage and reduce the chloride diffusion rate with the use of metakaolin and silica fume.

2.5 C.C Ugoamadi(2013) while doing research, picked cashew nuts and processed them for extracting the resin content. The final compressive strength for the CSNL Resin was 55MPa and for the polyster resin, ultimate strength was 68 MPa. The tensile strength of CSNL resin having ultimate tensile strength of 44MPa was far better than the polyster resin having 39 MPa as ultimate tensile strength. Tensile and compressive strength tests performed showed that composites formed with CSNL resin could be compared to those which are formed with polyster resin.

2.6 L.K. Aggarwal et al (2007) developed epoxy- cardonal resin using epicholohydrin, bisphenol and cardanol. After the evaluation he found that epoxy-cardanol resin showed comparitively better properties than the epoxy resin regarding elongation, bond with steel, tensile strength and lowering of transmission of water vapour in the film. Paints having micaceous iron oxide in the epoxy cardanol resin gave the best performance and after that comes the zinc phosphate type paints.

2.7 Ana Maria Aguirre- Guerrero etal (2016) tested the performance of two hybrid kind geopolymer mortars made of alkaline activated FA and MK as defensive coatings against the chloride induced rusting in RCC. In both cases, the coated, portland cement(OPC)- based concrete (substrates) were subjected to accelerated techniques such as impressed voltage and wetting/ drying cycles in the company of 3.5% NaCl solution. The open circui t potential and linear polarisation involving techniques were used to monitor the corrosion. To protect the structures that are open to marine locations, the geopolymer type mortars can be used.

2.8 M.Criado et al, (2013) examined the inhibitive consequences of two mixes of organic composites, disodium beta- glycerol phosphate or GPH with sodium 3-aminobenzoate (3AMB) and glycerol phosphate with sodium N-phenylanthranilate (PhAMB), on the rusting of carbon steel reinforced bars implanted in carbonated chloride- polluted OPC and alkali-activated FA(Fly Ash) mortars.

3. MATERIALS AND METHODOLOGY

3.1 Materials: In this systematic experimental study, various ingredients like cement, metakaolin CNSL resins fine aggregates, coarse aggregates, water and glass fibre were used to obtain concrete mixes, suitability of which were checked at laboratory by performing various tests. The properties of materials obtained in the laboratory are as follows:

3.1.1 Cement: The ordinary Portland cement (OPC) of 43-grade was used for casting the specimens of all the concrete mixes

3.1.2 **Metakaolin:** Metakaolin which is generally available in white or off white colour is obtained from the clay mineral called kaolinite.It is a very fine white powder having the particle sizes smaller than that of cement. China clay or kaolin are used for the manufacture of porcelain and are rich in kaolinite. Primary and secondary sources rich in kaolinite are used for the production of metakaolin.

Figure 1: Metakaolin

3.1.3 CNSL Resins:-

CNSL powder is a mixture that is non-porous, self-hardening and relatively plastic in nature. Selected fillers with requisite setting agents are made into powdered form and mixed with liquid resinous material to form CNSL powder which is generally grey in colour. The CNSL powder has accurate composition and more effectiveness. The CNSL powder resin is greatly demanded in market due to the top features. The CNSL resins procured from Ahmedabad was used for the research work throughout.

Figure 2: CNSL Resins Powder

3.1.4 Fine Aggregates: Fine aggregates used for the experimental processes were available locally. The fine aggregates that are to be used should be free from organic matter and dirt and dust. The fine aggregates that are to be used should also be free from clay, silt etc. The sieve analysis test of fine aggregates were carried out. The fineness modulus of the fine aggregates was found to be as 2.95. The specific gravity of sand was found to be as 2.4.

3.1.5 Coarse Aggregates: Coarse aggregate of size 20mm and 10mm was used in this study which was procured from the local coarse aggregate supplier as per IS: 383-1970. Coarse aggregates used for the experimental procedures were locally available. The coarse aggregates used for the experimental work should not contain any type of dust, soil, clay, weeds, organic matter etc. The fineness modulus of fine aggregates was found out by sieve analysis.

3.1.6 Water: Water is the very important for carrying out the experimental work. Water plays an important role in the hydration of cement and thus an important role for concrete too. Water used for the experimental work was tap water available in the lab. Water used for casting should be clean and free from impurities such as soil, dust, dirt and organic matter.

3.2 Methodology:

Table 1: Various mix proportions

Specimen	Coarse Aggregates in kgs	w/c ratio	% replacement of cement by Metakaolin	% replacement of cement by CNSL Resins powder	Fine Aggregates In kgs.	Water in kgs	Cement in kgs
0M+0C	15.45	0.45	0	0	7.1	2.45	5
0M+ 5C	15.45	0.45	0	5	7.1	2.45	5
0M+ 10C	15.45	0.45	0	10	7.1	2.45	5
0M+15C	15.45	0.45	0	15	7.1	2.45	5
5M+0C	15.45	0.45	5	0	7.1	2.45	5
5M+5C	15.45	0.45	5	5	7.1	2.45	5
5M+10C	15.45	0.45	5	10	7.1	2.45	5
5M+15C	15.45	0.45	5	15	7.1	2.45	5
10M+0C	15.45	0.45	10	0	7.1	2.45	5
10M+5C	15.45	0.45	10	5	7.1	2.45	5
10M+10C	15.45	0.45	10	10	7.1	2.45	5
10M+15C	15.45	0.45	10	15	7.1	2.45	5
15M+OC	15.45	0.45	15	0	7.1	2.45	5
15M+5C	15.45	0.45	15	5	7.1	2.45	5
15M+10C	15.45	0.45	15	10	7.1	2.45	5
15M+15C	15.45	0.45	15	15	7.1	2.45	5

Table 2: Test specimens and dimensions

Test	Shape and dimensions of the specimens	Time duration (in days)
Compressive strength	Cube : 150mm×150mm×150mm	7
Flexural strength	Beam :100mm×100mm×500mm	28

4.0 Result and Discussion:

4.1 Workability: Workability of control concrete and the concrete containing metakaolin and CNSL resins was determined slump cone test (slump test as per Indian standard procedure IS:1199-1959).

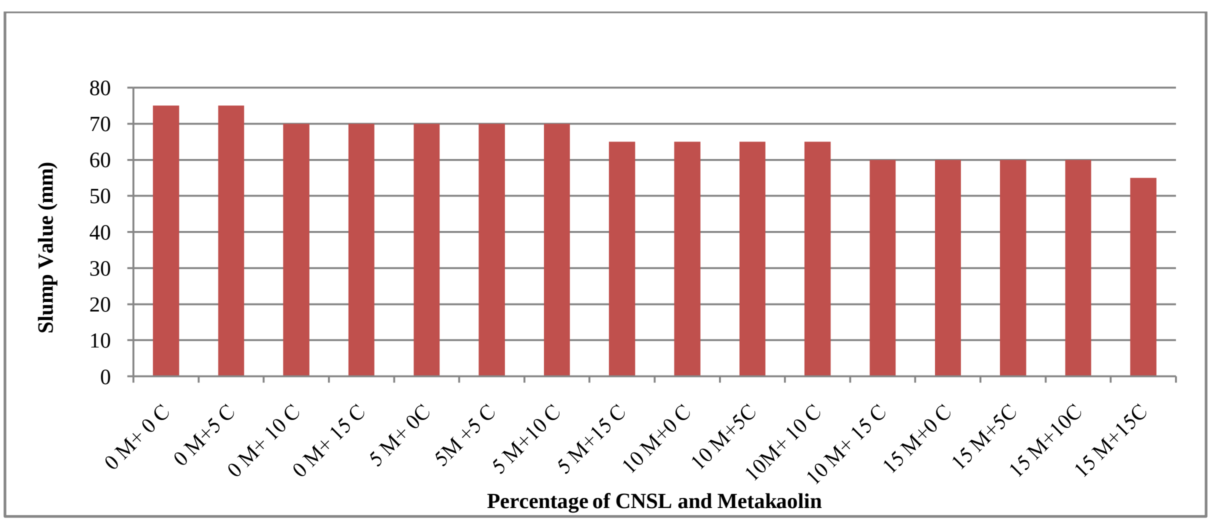


Figure 3: Graph showing Slump loss for various combinations

The figure shows the slump loss for various combinations of mixtures in mm.It can be seen from the graph that the value of slump loss for controlled mix and 5% CNSL is 75mm which means the mixture is easily workable and fluid. The slump value for 10% and 15% CNSL slightly decreases down to 70mm and remains contant till 5% Metakaolin+ 10% CNSL means a slightly less fluid slump than before. The slump further decreases down to 55mm at 15Metakaolin+15 CNSL which indicates a dry mix.

4.2 Compressive Strength: Samples of size 150x150x150mm were casted. The samples were kept for curing for 7 days. The samples were then tested for compression after 7 days of curing.

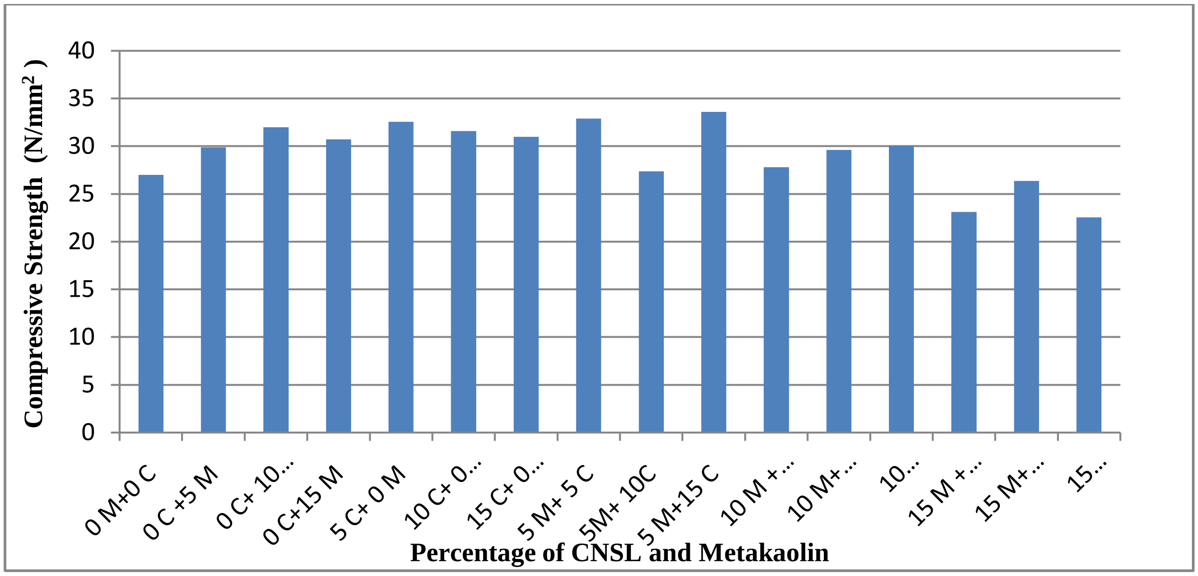
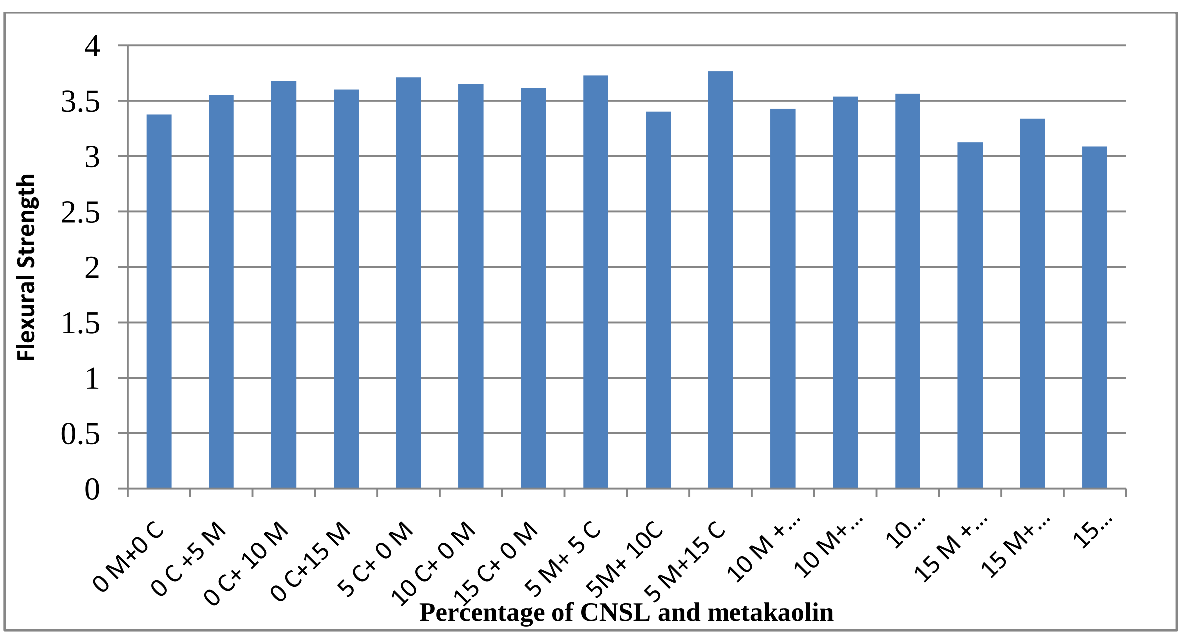


Figure 4: Graph showing 28 days compressive strength for various combinations

The figure shows 28 days compressive strength for various combinations of mixture at a water cement ratio of 0.49. It can be seen from the graph that the value of compressive strength for controlled cubes is 27 N/mm^2. The values for compressive strength at 5% Metakaolin is 29.866 N/mm^2which increases at 10% Metakaolin and decreses slightly at 15% Metakaolin. Thus the value for compressive strength slightly decreases at maximum metakaolin content i.e 15%. The value of compressive strength for 5% CNSL is 32.577 N/mm^2 which decreases down slightly at 10% and then at 15% CNSL. The value of compressive strength for the combined cubes at 5 % Metakaolin+ 5 % CNSL is 32.902% which slightly decreases at 5% Metakaolin +10% CNSL and again increases at 5% Metakaolin + 15% CNSL. The value of compressive strength at 10% Metakaolin +5% CNSL is 27.815% which slightly increases at 10% Metakaolin+ 10% CNSL and than at 10% Metakaolin+ 15% CNSL. The value of compressive strength at 15% Metakaolin+5% CNSL is 23.128 N/mm^2 which slightly increases at 15% Metakaolin+ 10% CNSL and then decreases down at 15% Metakaolin+ 15% CNSL.

4.3 Flexural Strength: The figure shows 28 days flexural strength for various combinations in N/mm^2. We can see from the graph that the flexural strength of 5% Metakaolin is greater than that of controlled and flexural strength of 10% is slightly higher than that of 5%.



Metakaolin is greater than that of controlled and flexural strength of 10% is slightly higher than that of 5% . However, we can se that the flexural strength of 15% Metakaolin sample decreases slightly. The flexural strength slightly decreases from 5 to 10% CNSL and then again decreases at 15% CNSL. In the combination mixes, it can be seen that the flexural strength decreases from 5%Meta+ 5%CNSL to 5% Meta+10% CNSL and then again increases at 5% Meta+ 15% CNSL. For 10% Meta+ 5 % CNSL the flexural strength is slightly less as compared to 10% Meta+ 10% CNSL and the flexural strength of 10% Meta+15% CNSL is slightly higher. The flexural strength is slightly higher at 15% Metakaolin+10% CNSL as compared to that of 15% Metakaolin+5% CNSL. The flexural strength again decreases at 15% Metakaolin+15% CNSL.

5. Summery and Conclusion:

- The slump becomes less fluid as the mixture changes from controlled to 10% CNSL and then to 15% CNSL.The value of the slump remains constant till 5% Metakaolin+ 10% CNSL which means a less fluid slump.
- The values of compressive strength for combined cubes increase with increase in the percentage of metakaolin and CNSL resins.
- The flexural strength increases as the mixture changes from controlled mix to 5% Metakaolin and then to 10% Metakaolin. The flexural strength decreases at 15% Metakaolin. The flexural strength decreases from 5 to 15% CNSL. The flexural strength decreases at 5% Meta+ 10% CNSL. The flexural strength decreases at 10% Meta+ 10% CNSL. The flexural strength decreases at 15% Meta+ 15% CNSL.

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