

Application of Sustainable Cement Alternatives in Concrete

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Abstract: Considering sustainability as issue which means creating or maintaining changes in a balanced structure. Concrete is considered as the main constituent of the building industry and its main component is cement but cement releases almost 5 % of Co₂ of the world wide emission. To use sustainability as the prominent resources in order to conserve future generation and to find the alternative materials of cement as it emits more Co₂ while production. Cement can be replaced by many materials like fly ash, slag, silica fume, metakaolin, egg shell powder, rice husk ash etc. Cements alternative materials such as by-products are been researched upon.

Index Terms: High Strength Concrete, Metakaolin, Super plasticizers, Workability, Compressive strength

I. INTRODUCTION

In Construction, Concrete is used in infrastructure. In 1980 SCC was developed to create concrete capable of flowing freely so there is no need of vibrations and to implement this, two principals are applied. Firstly, cement is replaced by admixtures and secondly the improvements done in properties of concrete (Charin, 2018). SCC has more strength as compared to normal vibrated concrete (NVC) approved by tests where as SCC is more costly and produce cracks therefore metakaolin clay used in means of stronger concrete. Metakaolin abundant natural clay which is replaced by this Portland cement by weight. It also covers various architectural applications. (Lee, 2017) In recent years researchers established that the economy in construction & the properties of concrete improve due to pozzolanic material. The metakaolin has negative effect on concrete which will be reduced by superplasticizers as well as positive effect. The RHA used as a partial replacement produce cheaper material for durable construction and environment consideration. Different tests results made after 10 days curing on industrial waste. The more strength is determined in samples of metakaolin. (Zhou, 2016) Whereas, in 21st century, an upcoming trend to construct building with law priced pioneering material which is only possible by replacing main contents which have improved the workability & inclined ecological balance which is the foremost challenge, MK is amorphous clay due to higher percentage of silica. (Abdulmatin, 2017) Concrete has achieved its reputation of being one of the most versatile, strong and economic materials in construction industry. Its reputation is plagued, only, against issues of carbonation, shrinkage, sulfate and acid attacks and chloride ion ingress affecting the long-term life of concrete.

Therefore, the combined usage of industrial waste materials has been considered the new way to improving the loop holes in the performance of concrete against adverse environments (Onuaguluchi, 2012).

The aggregate vitality utilization is significantly expanding everywhere throughout the world. A significant part of the vitality request can be ascribed to building vitality utilization and a critical extent of this vitality is for warming cooling purposes. Enhanced development procedures and improved material innovation can incredibly diminish the vitality utilization expected to an agreeable indoor temperature. Sensible heat storage & latent heat storage systems are used to do so and to incorporate building and construction materials and techniques that help conserve energy consumption during the building process and buildings life span (Cao, 2016). Copper extraction and purification is known to produce copper tailings from slag smelting procedures and concentrating operations. Thus, copper could be considered a viable replacement for cement in concrete.

The changes in concrete are monitored with interval of time to concentrate the properties of hydrated cement (Torkaman, 2013). Since, the production of cement and cement-based composites is not considered to be an ecological and environment friendly process, in the building construction industry, the carbon dioxide emissions in the whole process need to be estimated and reduced. After which, strategies need to be manifested while increasing or maintaining the mechanical properties of the material in terms of strength and ductility (Fantilli, 2012)

The eco-mechanical qualities of the SCCs are exploited and analyzed under various tests. First test involves the creation of two SCCs with similar ecological properties but dissimilar mechanical properties. The same concrete mix is then used to create twelve other cylinders which can define the gross structural response and post-peak ductility. The post- and pre-peak responses procured through the processes can be used to propose a new global eco-mechanical ratio (Fantilli, 2012)

It is a well known fact that pore structure of concrete includes air voids, capillary pores and gel pores. However, research conducted before has concluded that pore structure of conventional concrete, affects physical mechanical properties including permeability and frost resistance. In addition to this, presence of cement, in concrete, produces a large amount of green house gases during the pyro-processing of clinker. Furthermore, the concrete industry has the reputation of using substantial amount of energy and natural resources. Also, deteriorating environmental conditions can affect the formation of concrete microstructure.

Revised Manuscript Received on October 20, 2019.

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Therefore, industrial by-products can be considered to curb the effect of cement in concrete and make it capable of sustaining serious environmental conditions (Duan, 2013). In recent years, Industries are going to take care of environment by testing new products. This is only happens due to ignoring waste from different industries (Torkaman, 2013). Cement is a major construction material but its production results in increasing the greenhouse gases & Co₂. Many researches and case studies in many countries led us to a more environment friendly replacement. Various materials bottom ash, metakaolin, fly ash, egg shell powder, Rice husk ash, silica fume can be used as a concrete binder due to their compressive, tensile and elastic modular properties.

II. LITERATURE STUDY

It has been detailed in review study that the cement content, soil piece and degree have noteworthy impact on properties of cement and SSB. The BP recouped from block brick work squander is by all accounts and in fact reasonable material for generation of CSMB unit. In view of this, this examination is sought after with principle target of detailing the blend with max reused material and least concrete substance.

III. EXPERIMENTAL METHODOLOGY

Various experiments were performed to check various properties of these materials. Keeping in the mind the various points like physical properties of aggregates, particle size distribution of aggregates, chemical and physical properties of cement and various admixtures. Mix proportions and fresh

properties of concrete. There sample preparation and testing were also done with various physical tests like sorptivity, bulk of dry density, water absorption and void content of concrete and mechanical tests like compression test and splitting tensile test.

IV. RESULTS

After these various experimental procedures done the results of various properties of material w.r.t the:-

Setting time and workability-Pozzolanic addition to concrete increased both initial and final setting time indicating slow hydration process as compare to the artificial pozzolanic used and their addition of pozzolana with the cement will have negative effect on the concrete workability.

Physical properties-It indicates that the use of pozzolana results in the denser microstructure with low porosity and absorption characteristics which contribute to the durability of the concrete by preventing their chemical solutions.

Mechanical properties-It comprises of two properties-compressive and splitting tensile test. Compressive strength of the mixture of pozzolana and concrete is decreased whereas relative strength is high of these mixtures. These pozzolana shows very important property with magnesium sulfate that the use of artificial pozzolana had no significant contribution to concrete as compare to those with natural pozzolana (pumice).The degradation of concrete is lower than that of concrete with artificial pozzolana (fly ash).

Table1: Comparison of Methodology and Result of various research studies

Type of Mix	Cement Replacing Material	Admixture	Curing Conditions	Comparing Criteria	Result	Reference
Conventional Concrete	Slag & Fly ash	Polycarboxylic	120 Days	Synergetic reaction between clinker phases, limestone and calcined clay help in attaining compressive strength, Porosity Reserve alkanity, pH	Carbonation coefficient value of concrete varies depends on the type mineral additive& extent of clinker substitution.	Vineet Shah et al
Conventional Concrete	fly ash and carbide lime	SP, NaOH	3,7 and 28 Days	XRD analysis, EDX analysis through scanning electron Microscope, Compressive strength	Adding of NaOH solution improved the dissolving of FA particles into the binder of CL-FA. It improves the reactivity between CL-FA. It also improves the compressive strength of concrete	Saofee Duera mae et al

Conventional Concrete	Calcium Carbide and Bottom Ash	polycarboxylate	28, 60, and 90 days,	Abrasion resistance, compressive strength, tensile strength and elastic modulus came out as same as conventional concrete, it also solved the environmental issues.	Various properties like abrasion resistance, compressive strength, tensile strength and elastic modulus came out as same as conventional concrete, it also solved the environmental issues.	Akkad ath Abdul matin et al
Conventional Concrete blocks	Calcium Carbide and fly Ash	polycarboxylate	7, 28 and 60 days	Waste materials such as CCR & Fly ash were taken as a binder in place of portland cement for development of environment friendly concrete	Calcium carbide residue, fly ash sample can be used as a good environment friendly binder in place of portland cement.	Charin NAM ARAK et al
Conventional and geopolym er concrete	paraffin Rubitherm and LDPE, EVA	SP	28 Days	Thermal properties, MPCM-concrete density and porosity, compressive strength and thermal conductivity were tested in this study.	The thermal conductivity of GPC is lesser than PCC. The thermal conductivity of the MCPM- concrete decreases with the use of microcapsules	Vinhuy Cao et al
cement stabilized masonry block	Fly ash, silica fume and GGBS	--	28 Days	Physical and chemical properties of materials are analysed Dry density, moisture absorption, compressive strength	Based on the test results, the minimum cement content requirement is fixed as 6 % for making CSMB units and from the economic point of view and environment considerations. FA can be the preferred pozzolanic substitution of cement for making CSMB units.	Vinay Kumar B M et al
Conventional Concrete	Silica-breccia, fly ash, GGBS and Metakaolin	--	7 & 28 days	The research program has focused on durability and strength in first stage whereas in second mechanical properties are examined in relation to MK for comparison	It is found that the mix having high silica and alumina content have high compressive strength. SB with a particle size <75 and 45 mm shown as imbalance chemical reaction.	Assem A.A Hassan et al
Conventional Concrete	Waste glass powder and sludge	--	7, 28 & 90 Days	The research program has focused on fresh concrete properties, mechanical and micro structural properties, Porosity and XRD pattern were examined	WGP 20 shows the highest level as a result which is advantageous while mixing and WGS 20 is the lowest and satisfies the result. WGS 20 has the highest factor of mechanical properties in the strength when kept for longer duration than OPC & WGP 20. WGP4 & WGP 5 reduces the total porosity and have positive influence.	Hyeon gi Lee et al

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Conventional and geopolym er concrete	GGBS, sodium hydroxide and Fly ash, sodium silicate	polycarboxy late	1 to 28 days	In this research, different materials were formed and were mixed like GPC and PCC mixing method then the tests like slump test, compressive strength test, XRD pattern and SEM were performed.	In this research, it is been investigated that the physical and mechanical properties of GPC & PCC depends on the effect of MPCM & PCM in solid and liquid form.	Shima Pilehv ar et al
Conventional Concrete	calcium aluminate cement	--	28 Days	Elastic modulus, split tensile strength test, compressive strength test, micro structural studies and stress strain relationship were performed in this study	A reduce loss in the strength and increased peak strain at both elevated surface has been depicted a stress- strain response.	Wasim Khaliq et al
Conventional Concrete	silica fume	polycarboxy late	28 Days	This research study focused on hydration of cement, In this, monitoring system has been used, which records the regular observations of all tests performed. The setting and hardening of concrete has been explained through the active acoustic monitoring system.	To monitor the setting and hardening process of early age of concrete in an acoustic method, later for the purpose of analysis, the wave velocity and attention coefficient are recorded for analysis.	Jinrui Zhang et al
Self Compacting Concrete	10 to 30 %	CONPLAST SP 430 G8	7,28 and 91 Days	Workability of fresh concrete, Water absorption, Mechanical properties of concrete	The maximum strength is achieved upto 2 to 4 % by replacement of 10 % Metakaolin cement with cement and after increasing metakaolin upto 20 %, it starts decreasing slightly	Prof. Shriram H. Mahure, et al (2014)
Conventional Concrete	0%, 10% and 15%	5%, poly-carbox ylate	1, 3 days, 7 Days, 14 and 28 days	Workability properties, Compressive strength properties, transport properties and durability performance	Transport properties estimated regarding water infiltration, gas penetrability, water retention, electrical resistivity, and ionic dispersion were enhanced to 50%, 37%, 28%, 450%, and 47%, respectively. The compressive strength is achieved by 15 % Metakaolin	M. Shekar chi, et al
Blended cement	15-20 % MK with 5 to 10 % Rice husk Ash	---	30 to 180 Days with interval of 30 days	Various Hydration characteristics as Compressive strength , Porosity, Density	The RHA used as a partial replacement produce cheaper material for durable construction and environment consideration. Different tests results made after 10 days curing on industrial waste. The more strength is determined in samples of metakaolin. Purposes tackle the issue of its transfer in this way keeping the condition free from contamination.	M.R. Shatat (2013)

Hydration Characteristics of Cement	4,6,10,15 %	---	10 to 100 Days	Hydration Characteristics of Cement, Impact of consideration of nano-metakaolin (NMK) to conventional Portland Cement, Water Content and Lime content	The hard mixes containing 4%, 6% and 10% metakaolin demonstrated higher compressive strength when contrasted with those of the flawless OPC glue. The various properties are enhanced upto 10 % metakaolin replacement after 10 %, it is slightly slower	S.M.A. El-Gamal (2014)
Conventional Concrete	5,10,15,20 %	---	7 and 28 Days	impact of calcination temperatures on metakaolin, Strength properties of metakaolin concrete, Comparison of Cost	Expanding measure of perceptual extent of MK in solid blend appears to require higher dose of super plasticizer to guarantee longer time of functionality. 15 % Metakaolin is optimum content for high strength	K. Rajasekhar et al (2015)
Conventional Concrete (Pier)	5,10,15 %	--	28 Days	Compressive strength was calculated at different extents of metakaolin by utilizing M-25 design mix for circular pier and rectangular pier. To know the response of both piers circular as well as rectangular.	The maximum strength is achieved at 10 % replacement. The circular piers have more load carrying capacity than rectangular piers. The strength properties can be enhanced by using metakaolin.	Irfan Arif Bashir (2017)

V. CONCLUSION

Considering about the majority of the outcomes in this investigation, researchers established that the economy in construction & the properties of concrete improve due to pozzolanic material. Self compacting concrete needs high segregation resistance as it is highly flow able concrete and this only can be achieved by Super plasticizers & admixtures which relates to traditional vibrated concrete which is environment friendly and Expanding measure of perceptual extent of MK in solid blend appears to require higher dose of super plasticizer to guarantee longer time of functionality.

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