International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

The Modification in Concrete through Partial Replacement of Cement with Utilization of Industrial Waste

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Abstract: ***Construction Industry is based upon concrete, which by large depends on cement. The cement production generates carbon dioxide emission of same magnitude at cement plant –an input to global warming and wide spread air pollution. The modified concrete production through partial replacement of cement withutilization of industrial waste has been reviewed from environmental conservation point of view. In India, the adequate utilization of Industrial waste as Fly-ash from Thermal Power Station, Ceramic dust from Ceramic Industry, Glass powder waste from Glass Industry and Marble dust from MarbleIndustry have been successfully carried out towards partial replacement of cement in concrete production of M30, M35, and M50 grade with desired strength criteria. In Malaysia,the utilization of agricultural waste as Palm Oil Fuel Ash [POFA] from local Palm industry has been successfully used as partial replacement of cement in concrete production with equal strength of conventional concrete. In Australia, fly-ash based concrete has been executed in construction of River Bridge, fly-over and Road, successfully. Two modified concrete products namely Geo Polymer Concrete [GPC], Glass Fiber Reinforced Concrete [GFRC] have been developed in India without losing any strength parameters like- Compressive strength,Split Tensile strength, Flexural strength & Workability [Slump Test] at Research cum Lab stage and yet to be proved at commercial scale. The general cum specific property, utilization, application, cost and eco-friendly aspects of GPC, GFRC along-with scope for other Indian agricultural waste utilization issues have been discussed.***

1. Introduction

We all are living in concrete age presently. Concrete is most widely used material as back-bone of Construction Industry. The global market of concrete is of 100 Billion Dollar, with position of India at third place, after U S A & China [3].

Cement is the major component of concrete, as chief binder, since it's discovery in 1824 by Joseph Asp-din of Leeds, Yorkshire, England. The large growth in industrial development is generating vast amount of waste material. The cement production through cement plant has been costly in two respects namely- Price due to rapid industrialization and Leading source of Carbon dioxide emission into atmosphere at equivalent rate of cement production to Global Warming. The global production of cement was 2200 Million Tones as well as equivalent carbon dioxide emission in 2016. The trend of global cement production and carbon dioxide emission for the past 48 years is illustrated as Fig.1.

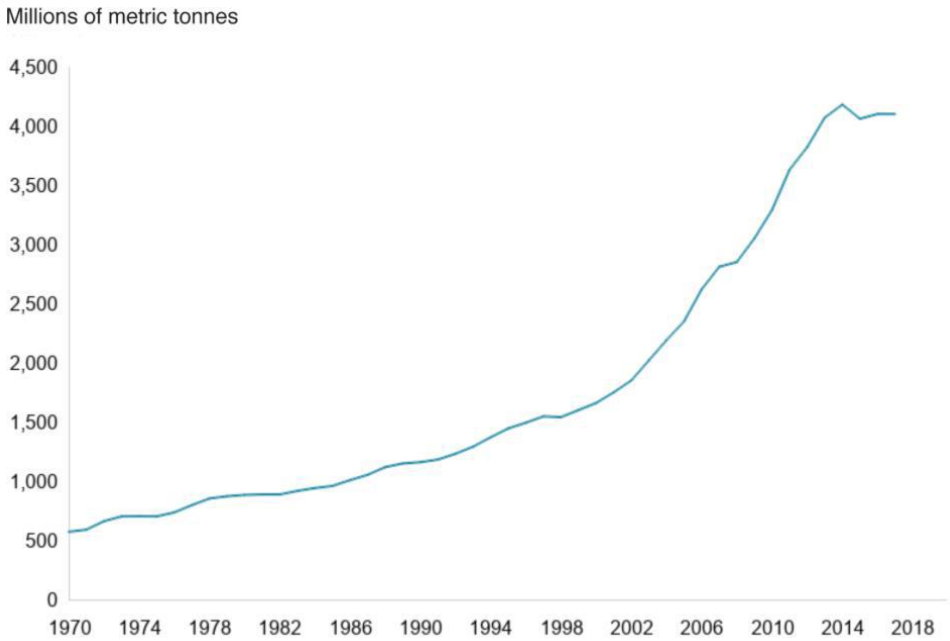

Figure 1: Global Cement production and Carbon dioxide emission during 1970-2018

Therefore, there is an urgent need by construction industry to look alternative means for partial replacement of cement in concrete production, without comprising strength characteristics at optimum to reasonable price in the market, following principle-"necessity is the mother of invention".

2. Methodology & Objectives

The evolved methodology is based upon conventional approach as relevant literature review cum evaluation of strength characteristic of concrete with suitability of waste material as potential alternative of partial replacement of cement. The objectives are as follows:-

- Mechanism/process of Carbon dioxide emission from Cement plant towards promoting Global Warming.
- Documentation of suitable waste material for partial replacement of cement in modified concrete production with application.
- Assessment of modified concrete product with respect to strength characteristics.
- Characteristic and allied aspects of modified concrete product.

3. Literature Review

Cement was discovered and patented by Joseph Asp din accidently and by chance in 1824. He had observed the calcanization of limestone underlined by clayey layer under high burning temperature, produced the binding material for building purpose in construction activity. The first cement plant in India was established at Porbander [Gujarat] in 1913. There are 200 cement plants in India up-to 2019.

Indian cement plants by majority [94 %] produces cement through clinkering and grinding process. The clinkering releases exothermic energy at high burning temperature of 1300-1500ºC with generation of cement dust and carbon dioxide emission [1, 3&13]. These are the major source of air pollution & global warming and illustrated as Fig.2.

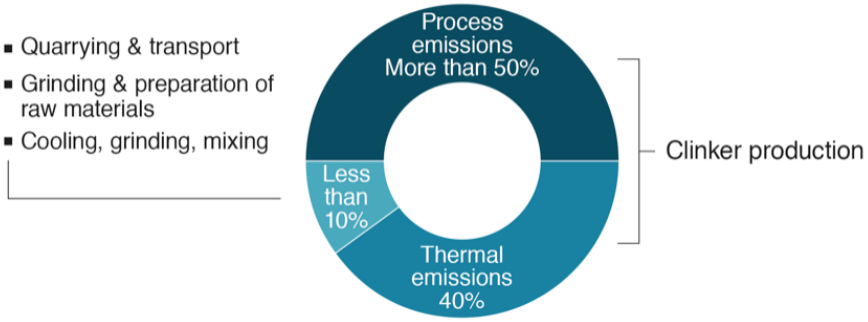

Figure 2: Carbon dioxide emission through clinkering process in Indian cement Plant

The concrete is mixture of set proportion of cement [as binder material], Fine aggregate [sand] and Coarse aggregate [broken stone pieces] and water in accordance to different grade from M 10 to –M 80 as per their utility and market demand. The strength characteristics of concrete namely: compressive strength, split tensile strength, flexural strength and workability are quality indicators of conventional concrete [9]. The evaluation of conventional concrete in India is carried through BIS Code provision and is as follows [2, 12]:-

- IS 456 [2000]: Plain & Reinforced concrete, Code of Practice BIS, New Delhi.
- IS 383 [1970]: Specification for coarse and fine aggregate from natural sources for concrete, Code of Practice BIS, New Delhi.
- IS 1489-Part I [1991]: Specification for Portland Pozolana Cement, fly-ash based [THIRD Revision] Code of Practice BIS, New Delhi.
- IS 10262 [1982]: Concrete Mix design-guidelines [FIRST Revision]Code of Practice BIS, New Delhi.
- IS 10262 [2009]: Concrete Mix proportioning guidelines [FIRST Revision] Code of Practice BIS, New Delhi.
- IS 516 [1959]: Indian Standard methods of test for strength of concrete,Code of Practice BIS, New Delhi.
- IS 5816 [1999]: Split tensile strength of concrete-method of test,Code of Practice BIS, New Delhi.

Waste material from specific industry has application in partial replacement of cement for concrete preparation, and is economical only, if the source of industry and construction site are nearer to each other or involving minimum cost of transportation, as well as Governmentalincentives. Fly-ash from Thermal Power Station, Marble dust cum quarry waste from marble Industry, Blast Furnace Slag waste from Steel Industry have proven application for partial replacement of cement to concrete production in India. Fly ash has been successfully used in partial replacement of cement at Australia towards construction activity of River- Bridge, Fly-over and Road [12]. Agricultural waste as Palm Oil Fuel Ash [POFA] from Palm Oil industry in Malaysia has been successfully used in partial replacement of cement for GPC [10]. Similarly in India, the agricultural waste from Rice cultivation area [Rice-husk] and Sugarcane Industry [remains of sugar cane] has been studied on line of POFA In Egypt, class F fly-ash is used up to 30 % by volume as replacement of cement for HVFA [High Volume Fly Ash] concrete [7].

There are two popular modified concrete products with partial replacement of cement, as per literature review presently, namely: Geo Polymer Concrete [GPC] & Glass Fiber Reinforced Concrete [GFRC]. The father of GPC is Davidovt Joseph [1978]-a French, Material Scientist, who invented Geo-polymer. GPC is mixture of sodium hydroxide [Caustic Soda], sodium-aluminum silicate as inorganic polymers along-with Fly ash and water in confidential proportion for production of M30 & M50 grade conventional concrete [11]. It is opposite to ordinary Portland cement in terms of chemical composition. GFRC

has partial cement replacement by glass powder- a waste from Glass Industry. The glass powder is added with varying percentage of 2, 4, 8, 16 & 20 for preparation of GFRC. It is architectural precast concrete used for exterior design of building façade panels [4].

4. Result& Discussion

The modified concrete products have been tested for their strength parameters at various Indian labs, under partial replacement of cement, as per available standard and norms. All the concrete have tested at higher than 45MPa strength for 28 days of curing and exceeded 50MPa at 90 days of curing.

- Mechanism / process of Carbon dioxide emission from cement plant ,promoting global warming :-

90 % Carbon dioxide emission from cement plant has the source –clinker production and associated exothermic reaction, as illustrated as Figure 2. The mechanism of Carbon dioxide emission is based upon following chemical reaction [12].
Limestone + clay + Heat [1300ºC] = one Ton of cement generates roughly one Ton of Carbon dioxide.

- Documentation of suitable waste material for replacement of cement, aggregate in modified concrete production with application:-

There are seven waste materials with proven records for partial replacement of cement, aggregate in modified concrete production of desired strength. The six waste materials belong to Industrial and one remaining belongs to Agricultural category.

The six Industrial waste materials are concerned with Industries namely: Thermal Power Units, Iron & Steel, Marble, Glass, Ceramic and Old cum demolished building. The Thermal Power Station generates FLY-ASH [12]. It has been extensively used as partial replacement of cement for large scale construction activity at Australia. The Iron & Steel Industry generates BLAST FURNACE SLAG, which has been used as partial replacement of cement in India with limited application at Telengana [3].The Marble Industry generates MARBLE DUST & MARBLE POWDER at quarry site and has been used as partial replacement of cement at Rajasthan [6]. The Glass Industry generates broken to un-used glass pieces, which are converted into GLASS POWDER, has been used as partial replacement of cement at West Bengal [5].The glass waste of fine size up to 0.6 mm [equivalenttoFINE AGGREGATE as sand-having size more than 0.5 mm with milled through Los angles abrasion apparatus] by 25 % [by weight] replacementto sand has increased compressive strength as 2.6 to 4.3 % and Flexural strength as 2.2 to 4.0 % for modified concrete at Bagdad [Iraq] [8].The Ceramic Industry generates CEAMIC WASTE, has been used as partial replacement of cement at Gujarat [5]. The old and discarded to demolished building generates huge CONSTRUCTION WASTE in urban area and has been used as partial replacement of FINE AGGREGATE [smashed in to fine to powder grade as sand] at Chhattisgarh [14].

The Agricultural waste as Palm Oil Furnace Ash [POFA] from Palm Industry at Malaysia has been used as GPC in construction activity [10]. The abundance of Agricultural wasteas RICE HUSK [Rice cultivation] BAGASSE [Sugar Industry] have been successfully proved for partial replacement of cement in modified concrete production.

- Evaluationof strength characteristics of modified concrete product :-

There are two popular modified concrete products namely- Geo Polymer Concrete [GPC] and Glass Fiber Reinforced Concrete [GFRC].

GPC is prepared, just 24 hours before it's use, since the involved process is exothermic with generating huge amount of heat. It uses with varying fly-ash of >30 % for M30, M50 grade of conventional concrete [3].

GFRC is obtained with use of 2%, 4%,16% % 20% of fine glass powder for M30 grade of conventional concrete, following BIS Code 10262 [2009] [4]. It has low weight and provides decrease super-imposed loads on the structural components of Building. It has higher flexural and split tensile strength than conventional normal concrete with excellent application in thin wall casting. It is cost effective, safe with high durability. The fiber glass is embedded in cementation matrix, illustrated as **Fig.3.** [4]. It acts as principal load carrying members, while the surrounding matrix acting as load transfer medium in desired location and orientation. It has quick installation with low maintenance. It solves the cracking problem in concrete due to shrinkage in stress. It has increase freezing-thawing resistant- a good application for construction in glacier area. National Toxicology program warns the use of Fiber glass product as possible Cancer hazard by inhalation.

Figure 3: GFRC, as physical appearance

The self compacting concrete of M30 & M35 grade by replacement of 5%,10%,25% &30% ceramic waste powder along-with 25% Fly-ash has been worked out with following compressive strength, split tensile strength and flexural strength of conventional concrete [6]

The optimum of 15% marble dust has been replaced by cement for M30 grade conventional concrete [6].

- Characteristic and allied aspects of modified concrete product:-

The general cum specific property, utilization, application, cost and nature of eco-friendly for modified concrete products GPC, GFRC are summarized as Table 1.

SN	Parameter	GPC	GFRC
1	General Property	Inorganic polymer	Engineering material
2	Specific Property	Resistant to Thermal Insulation	Exterior building of façade panel &architectural precast concrete
3	Utilization	Artistic & archeological building	Secondary Loading like balcony
4	Application	Protects building from conductivity and photo-sensitivity	Protects building from cracks in concrete & environmental damage
5	Cost	Low in comparison to normal concrete	Low in comparison to normal concrete
6	Eco-friendly	Low water solid ratio	Non-decaying material

5. Conclusion

The basic ingredients of concrete are:Cement, Aggregate [Coarse & Fine] and Water. The cement production has same amount of Carbon dioxide emission into atmosphere-a great concern of global warming. It has trend of increasing price-as exerting stress on the economy of construction project. The alternative for partial replacement of cement for concrete production with maintaining it's strength criteria, leads to the following consideration:-

- Utilization of Industrial waste material as partial replacement of cement, sand for good quality of concrete production under sustainable environment.
- Scope for utilization of Agricultural waste from wheat, rice and sugarcane cultivation area for improved quality of concrete production.
- GPC as proven building material requires to be encourage for it's utilization in mega construction projects.
- GFRC as engineering material requires tobe encouraged for construction activity at location of prime urban centers.
- Reduce dependence on utilization of cement in concrete production in order to curb on global warming.

6. Acknowledgement

The authors would like to express their gratitude to authorities of Dr. C V Raman University, Kota, Bilaspur [CG] for rendering the necessary assistance. The views expressed in the paper are the views of the authors and do not of the organization, to whom they belong.

References

[1] Gupta P K, Singh T N [1996]: Documentation of Land-use in karstic mining area through digital analysis of IRS data. Proceeding-Indo-US Symposium/Workshop on Remote SensingApplications, 6-9 October 1996, CSRE, I I T Powai Bombay [ed. By M G Srinivas] pp 463-468.

[2] Indian Standard-516-1959 [1959]: Indian Standard Methods of tests for strength of concrete-Code of Practice, Pub. BIS, New Delhi.

[3] Jeet P, Pitroda J K [2020]: Geo-Polymer Concrete of next generation. Int. Journal of Emerging Trends & Innovative Research, June 2020, Vol.7 Issue No.6 pp 609-617.

[4] Kacha S Rakesh, Pathak B Vyon, Rushab A Shah [2013] : Utilization of Fibers in construction industries for properities improvement of concrete, Int. Journal for Science Research & Development, Vol.1 Issue 0 pp 1943-1951.

[5] Prudhvi K, Sai Prasad K, Shrikant Reddy K, Kumar Manoj, Vinay D [2016]: Laboratory Study on compressive strength of concrete with glass powder as partial replacement of cement.Int. Journal of Emerging Trends & Innovative Research, May 2016, Vol.3 Issue No.5 pp 272-277.

[6] Partik D V, Vaniya S R, Parikh KB [2016]:Effects of ceramic waste powder in self compacting concrete properties. Int. Journal of Emerging Trends & Innovative Research, June 2016, Vol.3 Issue No.6 pp 50-58.

[7] Rashad A M [2015]: A Brief on High volume class F Flyash as cement replacement-A guide for Civil Engineers Int. Journal of Sustainable Built Environment,4,pp 278-306.

[8] Rawaa K Aboud [2018]]: The effects of Petroleum products on reactive Powder Concrete using waste glass as partial replacement for fine aggregate. Int. Journal. of science & Research, Vol.7 Issue 1 Jan. 2018, 5p.

[9] Roshan K, Roshan R, Bhawani S, Akshay N K [2015]: Influence of marble dust as partial replacement of cement in normal curing concrete.. Int. Journal of Emerging Trends & Innovative Research, April 2015, Vol.2 Issue No.4 pp 1142-1147.

[10] Sinha Gaurav, Sharma P, Chauhan J S [2020] Strength studies by using fly-ash and quarry dust by geo-polymer concrete.Int. Journal of Emerging Trends & Innovative Research, June 2020, Vol.7 Issue No.6 pp 1540-1544.

[11] Salih Moslih Amer [2015]: New geo-Polymerization process for high strength alkali activated binder with granulated blast furnace slag, PhD thesis, Engineering Faculty, University of Putra, Malashiya,57p.

[12] Shetty M S[2012]: Concrete Technology-theory &practice VII edition Pub. S Chand & Co. New Delhi.

[13] Shiyan Ahmed [2018]: Geo-polymer concrete and it's application, Webinar 1 May, 2018, Australia Road Transport [Aust-road] 81p.

[14] Supe Jayant J [2019]; Demolished concrete aggregates an effective alternative to future of construction for low cost housing Proceeding BITCON,2019 pp 138-145.