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# NCB ABSTRACTS

DECEMBER 2015

## *From the desk of Director General*

*I am happy to present this issue of NCB-Abstracts to the scientific community of cement, building materials and construction industries. The abstracts of latest research papers and articles covering the fields of cement research, raw material, environment, plant engineering, concrete and construction fields are put together.*

*Mineralizing effect of jarosite, role of nano materials in construction industry, Jarosite waste as a possible alternate to gypsum, trends of development in green cement and concrete technology, new methods of CO2 reduction, optimum percentage replacement of cement in flyash concrete, creep-induced distress on the flexural behaviour of RC beams retrofitted with NSM, use of bio-mass and co-fired flyash in concrete, sulphate resistance and eco-friendliness of geoplymer concretes etc. are the latest innovative research papers abstracted and presented here.*

*I am pleased to know that the earlier issues of NCB Abstracts were very much useful to the readers and I hope the contents of this issue are also be beneficial to the entire cement and construction community.*

*I wish a very happy, prosperous and innovative New Year.*

**Ashwani Pahuja**
**Director General**

N C B A B S T R A C T S

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# INSIDE



*The activities of National Council for Cement and Building Materials (NCB) are carried out under the six Corporate Centres at NCB's Units situated in Ballabgarh , Hyderabad and Ahmedabad.*

- *Centre for Cement Research and Independent Testing*
- *Centre for Mining, Environment, Plant Engineering and Operation*
- *Centre for Quality Management, Standards and Calibration Services*
- *Centre for Construction Development and Research*
- *Centre for Continuing Education Services*
- *Centre for Industrial Information Services*

## Mineralizing Effect of Jarosite: A Zinc Industry By-product in the Manufacturing of Cement

S K Agarwal, M M Ali, Ashwani Pahuja, B K Singh and Sunil Duggal

Advances in Cement Research, 27(5), p.248-258, 2015 (http//dx.doi.org/10.1680/adcr.13.00102)

**Keywords :** By-product jarosite, mineralizer, lime assimilation, clinkerization temperature, phase development, leaching studies

**Abstracted By: S K Agarwal**

### ABSTRACT

Many industrial by-products contain significant amounts of inorganic ingredients such as oxides of calcium, silicon, alumina and iron along with small and trace amounts of other elements, which can substantially affect the clinkerization reaction. In view of above, various industrial by-products bearing such compounds could behave as mineralizers in cement manufacture. Only small additions of these materials can extensively alter the properties of melt in terms of reactivity and burnability of the cement raw mix. The present paper highlights the mineralizing effect of zinc industry by-product "Jarosite" generated during the extraction of zinc metal through hydrometallurgical process to the tune of about 5.5 lacs metric tonnes per annum. The presence of mineral phases bearing iron, sulphur, sodium, potassium and zinc in jarosite showed its suitability for use as a mineralizer in the development of clinker mineral phases. Different cement raw mixes RM-1 to RM-5, prepared by incorporating 0.5-1.75 wt% jarosite, maintaining clinker parameters LSF:0.92, SM:2.14-2.22, AM:1.09-1.13, potential phases $C_3S$:57.73-58.84, $C_2S$:17.37-17.97, $C_3A$:5.57-6.00 and $C_4AF$:14.06-14.42 and fired at the temperatures of 1300, 1350, 1400 and 1450$^oC$ showed the mineralizing effect of jarosite in terms of rapid lime assimilation and improved clinker mineral phase formation as compared to control mix prepared without using jarosite. The optimum clinkerization temperature was reduced by about 50$^oC$. The physical characteristics of OPC prepared with 1.5 wt% optimized dose of jarosite showed substantial increase in compressive strength at early ages as compared to control cement. As jarosite contains heavy elements such as barium, cobalt, copper, lead, manganese, strontium, zinc and so on, a leaching study was taken up by immersing 28-days hardened neat cement cubes in aggressive mediums such as sulphate (0.33N $Na_2SO_4$), chloride (0.5 NaCl) and alkaline (0.3 NaOH) solutions along with distilled water for 24 months in air tight containers. The leachates contents were found to be in negligible amounts indicating fixation of heavy elements in clinker mineral phases. Therefore, use of jarosite in the manufacture of OPC can result in its gainful utilization associated with savings in thermal energy and environmental sustainability.

### Centre for Cement Research and Independent Testing
### Highlights of Recent Services to Industry

- Feasibility study for the use of jarosite in cement manufacture.
- Establishing limestone consumption factor of cement plants.
- Investigations on utilization of by product sand in the manufacture of cement.
- Utilization of copper granulated slag from Indian Copper Complex, Ghatshila, Jharkhand, in a cement industry
- Expert services for verification of the rock strata encountered during the execution of the under ground drainage scheme.

## Graphene-Cement Composite for Structural Applications
## Role of Nano Materials in Construction Industry: Review

Ahmadreza Sedaghat, Manoj K. Ram, A. Zayed, Rajeev Kamal, Natallia Shanahan
A. Khitab and M. Tausif Arshad

Rev.Adv. Mater. Sci. 38 (2014) 181-189

**Keywords :** Nanomaterials, Ultrahigh Strength, Construction and High performance

**Abstracted By: Dr.Asok Kr Dikshit**

### ABSTRACT

Nanotechnology has tremendous potentials in construction industry. The examples are germ-free laboratories and hospitals, waterproof buildings, urban environmental protection. The important developments made in concrete technology are ultra-high strength concrete, photocatalytic concrete, self-heating concrete, bendable concrete and concrete containing CNTs. Scientists are introducing nanocement in market for potential diverse application. Most commonly, the present commercial cement particle varies in size from 1 to 100 micrometers. It is believed that finer particles (nano) have larger surface area per unit volume, which is very important in cement and concrete technology. Large surface area of binder results in higher early and final strength due to faster and more effective hydration reactions. Several new cement composites are also being developed by incorporating in them titania ($TiO_2$), silica ($SiO_2$), clay, and alumina ($Al_2O_3$) particles of nano sizes. Similarly, nano paints are being developed that significantly boost the resistance of the paints and coatings against the aggressive environments. Paints containing nano titania and CNTs have found to be very effective against the industrial pollutants and car exhausts. Nano Silica concrete incorporates nano silica instead of micro silica particles or well-known silica fumes. This concrete results in higher initial and final compressive strengths, higher workability, and lower permeability. Additionally, higher tensile strength and segregation resistance are also achieved. The new concrete is named as Ultra High Strength Concrete. The advantages of this concrete are numerous: the column sections in buildings can be reduced. The amount of steel reinforcement in concrete can also be reduced. And in highways and railway tunnels, thinner tunnel segments can be constructed leading to a great saving in excavations. It is a well-known fact that nano $TiO_2$ on UV irradiation can be used as an effective way to reduce the contaminants and enhance environmental safety.

## Photocatalytic NOx Abatement by Calcium aluminate Cements Modified with $TiO_2$ : Improved $NO_2$ Conversion

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Cement and Concrete Research, 70, (2015), 67 – 76

**Keywords :** NOx, Calcium aluminate cement, $TiO_2$

**Abstracted By: Dr. Varsha Liju**

### ABSTRACT

$TiO_2$ has gained great attention to facilitate the degradation of inorganic toxic gases and organic pollutants. NOx has been recognized as one of the most serious pollutant causing environmental problem and harmful to the human health. They cause adverse environmental effects like acid rain and ozone depletion. For practical application of photocatalytic degradation of NOx with $TiO_2$, its immobilization to a surface well reached by light radiations is required. In this work calcium aluminate cement modified with $TiO_2$ is used for NOx abatement.

Photocatalytic $TiO_2$ having average particle size 21 nm composed of 75% anatase and 25% rutile was used. Calcium aluminate cements (CAC) of two types were included in the study (1) Iron rich dark cement, d-CAC (with 17 wt% $Fe_2O_3$) (2) Iron lean white cement, w-CAC (with 0.1 wt.% $Fe_2O_3$). PCE based SP was also used for good workability. Cement aggregate ratio kept at 1:3 by weight and c:w ratio 1:0.37. $TiO_2$ concentration was varied from 1%, 3%, 5% and 10% with respect to cement. Two different curing conditions were used, half of the moulds were kept at curing condition - I ie. 20°C and 95% RH and rest of the moulds were kept at curing condition II - 60°C and 100% RH for 24hrs and shifted to 20°C and 95% RH later.

$TiO_2$ incorporation resulted in increase in water demand due to increase in surface area. Higher the amount of $TiO_2$ more was the PCE requirement. But addition of $TiO_2$ resulted in decrease of setting time. Iron rich dark cement, d-CAC showed a setting time of 26min and with iron lean white cement, w-CAC setting time was 20 min whereas the corresponding plain CACs showed a setting time of 15 min and 5 min respectively. The compressive strength of plain w– CAC (47MPa) is more than d – CAC (35 MPa) and the incorporation of $TiO_2$ yielded greater compressive strength compared to control samples.

In the NOx abatement studies it was noted that 10 wt % $TiO_2$ resulted in 48% of NO conversion in d- CAC and 65% in w – CAC. Calcium aluminate cements are good materials as sorbent agents for $NO_2$ as compared with other binding matrices and thus improves the overall NOx abatement rate achieved.

## Jarosite Waste as a Possible Alternate to Gypsum in Portland Cement Manufacture

Suresh K, Sharma J.M, Kuchya M, Kashyap I.P, Pandey S.P and Chowdhury S

Cement International, Vol 10, 4, p.90-97 (2012)

**Key words:** Industrial by-product "jarosite", mineral gypsum, $SO_3$ content, setting time, compressive strength

**Abstracted By: S K Agarwal**

**ABSTRACT**

Globally, the cement industry uses over 60 million tonnes of mineral and chemical gypsum as set retarder for cements. In view of conserving natural resources, the present paper highlights the investigations on utilization of industrial by-product "jarosite", a solid residual waste generated by zinc industry and contains 30 mass% of $SO_3$ along with 3.5 mass% $Na_2O$ as an alternate to mineral gypsum and anhydrite in controlling cement setting.

In order to investigate the role of jarosite as set retarder, different OPC and PPC samples were prepared by substituting mineral gypsum from 0 to 100% by jarosite while maintaining a total $SO_3$ content of around 2.2 mass%. The performance evaluation of above cement samples showed negligible effect of jarosite replacement on standard consistency of the OPC and PPC pastes, insignificant effect on setting time having higher substitution level except at 100%, where it results in lower setting times for both OPC and PPC. Cement samples with 100% jarosite proportion show reduction in 1-day compressive strength, but no significant change at later strength at most of the gypsum replacement levels. The leaching studies indicate no appreciable leaching or toxicity caused by jarosite additions and the test results comply with the US-EPA limits. The present study showed that the substitution of mineral gypsum by jarosite up to 80% did not affect the properties of the cements and therefore has a promising potential to replace natural gypsum fully or partially in cement manufacture.

## Cement Substitution by a Combination of Metakaolin and Limestone

M. Antoni, J.Rossen, F. Martirena, K. Scrivener

Cement and Concrete Research, 42 (2012), p. 1579-1589

**Key Words:** Blended cement, $CaCO_3$, alumina, monocarboaluminates, compressive strength, Hydration

**Abstracted By: S K Agarwal**

**ABSTRACT**

Supplementary Cementitious Materials (SCM) are commonly used to reduce the clinker factor of cements. However, above a threshold substitution of about 30%, these materials reduce the mechanical properties of cement, particularly at early ages. The present paper investigates the coupled substitution of metakaolin and limestone in Portland cement keeping in view that extra alumina provided by the metakaolin will react with more limestone resulting in formation of monocarboaluminate and hemicarboaluminate instead of monosulfoaluminate leaving more room for ettringite formation and thus allowing better mechanical properties to be maintained at higher levels of substitution. The cement blend containing 10% metakaolin and 5% limestone has higher strength at all ages than the 100% Portland cement. This paper shows that 45% of substitution by 30% of metakaolin and 15% limestone results in better mechanical properties at 7 and 28-days as compared to neat Portland cement. Even 60% substitution (40% metakaolin & 20% limestone) yields 93% strength of neat PC. The hydration studies show that calcium carbonate reacts with aluminates in metakaolin, forming significant amount of hemicarboaluminate at 1-day to react faster in the system with limestone than the binary metakaolin and Portland cement system. Limestone also reacts faster in the system with metakaolin than the binary limestone/Portland cement blend.

# MgO Expansive Cement and Concrete in China: Past, Present and Future

Liwu Mo, Min Deng, Mingshu Tang, Abir Al-Tabbaa

Cement and Concrete Research, 57 (March 2014), p. 1-12

**Key words:** Thermal shrinkage, calcination, periclase, MgO expansive additive (MEA), delayed expansion

**Abstracted By: S K Agarwal**

## ABSTRACT

China employs MgO as an expansive additive to compensate thermal shrinkage of mass concrete. To mitigate the shrinkage cracking of concrete, many measures have been developed i.e. incorporation of fibers into concrete, use of low hydration heat Portland cement, partially replacing Portland cement with SCM such as fly ash, limestone etc, addition of shrinkage-reducing chemical agents, expansive additives, incorporation of super-absorbent polymers etc. Compensating shrinkage with expansion produced by MgO has not only proved to be effective in preventing thermal cracking of mass concrete but also reduced the cost of temperature control measures and speed up the construction process. This approach was first developed in China in 1970 when it was discovered that the thermal shrinkage of mass concrete was effectively compensated for by the delayed expansion due to the slow hydration of the periclase (MgO) contained in the PC clinker eliminating thermal shrinkage cracking. This paper reviewed the history, performance, industrial manufacturing and application of MgO expansive cement and concrete, the state-of-the-art progress in the field of MgO concrete in China.

The expansion properties of MgO could be designed variably, through adjusting its microstructure by changing the calcining temperature and residence time. When calcined at higher temperatures or for longer duration, MgO undergoes crystal growth, resulting in larger grain size of MgO, less crystal defects, and smaller specific surface area, leading to lower hydration reactivity of MgO and thus slower expansion. In comparison to the traditional expansive cement or additives such as sulfoaluminate, aluminate clinker or CaO-based expansive additive which are widely used in Japan, USA and China, MgO has many advantages which includes its chemically stable hydration product, namely $Mg(OH)_2$, relatively low water requirement for the hydration of MgO and its designable expansion properties. Research on MgO expansive cement and concrete in China covered a wide range of different aspects, including the preparation, hydration, and expansion properties of MgO cement (cement containing high MgO content) as well as MgO expansive additive (MEA), performance of MgO concrete etc

MgO cement or expansive additive has been mainly used to compensate thermal shrinkage of mass concrete. MgO concrete can be prepared through either mixing with MgO cement or incorporating MgO produced by calcining magnesite at the temperature of 9000-1200$^{o}$C as an expansive additive (MEA). MgO cement has limited applications due to dead burnt nature of periclase whereas the reactivity of MEA could be designed by adjusting the calcining conditions. MEA has significant potential in controlling not only thermal shrinkage at later age but also autogenous shrinkage or drying shrinkage of concrete at relatively early ages to prevent concrete cracking. The effect of expansion produced by MgO on the performance of the concrete depends on its influence on the microstructure of concrete. Appropriate expansion contributes to the densification of concrete whilst excessive expansion may destroy the microstructure of concrete causing their deterioration. Therefore, proper type as well as appropriate addition content of MEA is important for its effective application in controlling shrinkage.

## Deformation and Mechanical Properties of Quaternary Blended Cements Containing Ground Granulated Blast Furnace Slag, Fly ash and Magnesia

Liwu Mo, Meng Liu, Abir Al-Tabbaa, Ming Deng and Wai Yuk Lau

Cement and Concrete Research, 71 (May 2015), p. 7-13

**Key words:** Blended cement, Magnesia, mechanical properties, shrinkage, heat of hydration

**Abstracted By: S K Agarwal**

### ABSTRACT

Cement based materials normally undergo various types of volumetric shrinkage such as thermal shrinkage, drying shrinkage, autogenous shrinkage etc that may lead to cracking under restrained conditions. Many strategies have been developed to mitigate autogenous shrinkage e.g inner curing, substitution of Portland cement (PC) with supplementary cementitious materials (SCM). Expansion provided by the hydration of expansive components, e.g. calcium aluminate ($C_3A$), calcium sulfate aluminate (CSA), CaO and MgO, was widely used to compensate for the shrinkage of cement-based materials. The present paper highlighted study of development of non-shrinkage quaternary blended cements through blending of slag, fly ash with Portland cement containing relatively reactive MgO-base expansive agent (MEA).

In the present study, a control PC and two types of expansive PCs incorporating 5% and 8% MEA were used. Quaternary cement blends were prepared replacing above PCs with mix of 20 and 40% slag and 20 and 35% fly ash. These cement blends were studied for mechanical strength, deformation, heat of hydration, pore size etc.

The isothermal calorimetry curves of the different types of cement blends showed that the addition of MEA insignificantly influenced the hydration of cement at early age. For the blended cement, the incorporation of slag and fly ash reduced the hydration heat liberation. The autogenous deformations of neat PC paste exhibited significant shrinkage at first 6 hrs and reached to -1000 microstrains at 115 hrs whereas with the addition of 5% and 8% MEA in PC, the autogenous shrinkage was found to be greatly reduced to the level of -720 and 195 microstrains respectively indicating effective compensation of autogenous shrinkage due to hydration of MgO. For the blended cements, regardless of the addition of MEA, the shrinkages was less than that of corresponding PC and was reduced considerably with the replacement level of slag and fly ash. Moreover, PC containing 8% MEA, 40% slag and 20% fly ash showed gentle expansion of the order of 200 microstrains. The results of flexural and compressive strength showed slight reduction in flexural strength and more decrease in compressive strength in MEA induced PC samples. The incorporation of slag and fly ash decreased the strength of cement blends at early age whereas at later ages increased significantly, being close to or even higher than that of PC mortars. At 90-days, all the blended cement mortars made incorporating 8% MEA in PC had higher strength as compared to their counterpart PC. With increasing curing age from 3 to 90-days, the blended cement mortars exhibited more increase in flexural and compressive strength than that of corresponding PC mortars. The study on the pore structure of cement mortars showed that at 28-days, most of the pores in the mortars made with PCs were with a pore diameter range of 0.02-0.2µm whereas pore diameter of blended cement prepared with PC containing 8% MEA had more pores with size less than 0.02µm. Therefore, quaternary blended cements with low hydration heat release, low atogneous shrinkage at early age and high mechanical strength at later ages were prepared by mixing slag and fly ash with expansive PC containing MgO.

# TRAINING SCHEDULE
**January 2016-March-2016**

## Cement Technology

| | | |
|---|---|---|
| 1. Advances in Pyro-processing in Cement Industry | 05-06 January 2016 | NCB-H |
| 2. Advances, Operation and Optimization of Air Pollution Control Equipment | 12-13 January 2016 | NCB-B |
| 3. Quality Management System and Internal Audit for Laboratory as per IS/ISO:1702 | 16-19 February 2016 | NCB-H |
| 4. Quality Orientation for Marketing Executives in Cement Industry | 23-25 February 2016 | NCB-B |
| 5. Advances in Refractory Engineering Practices | 15-17 March 2016 | NCB-B |

## Concrete and Construction Technology

| | | |
|---|---|---|
| 1. Concrete Mix Proportioning and Acceptance Criteria | 19-21 January 2016 | NCB-H |
| 2. Design, Construction and Quality Control Practices for Concrete Roads for Highway & Low Volume Roads | 3-5 February 2016 | NCB-B |
| 3. Repair and Rehabilitation of Concrete Structures including Water Proofing Materials and Techniques | 01-03 March 2016 | NCB-B |
| 4. Use of Blended Cements in Concrete Construction | 08-09 March 2016 | NCB-H |

## SIMULATOR BASED COURSES

| | | |
|---|---|---|
| 1. Operation, Control and Optimization of Modern Grinding System based on Vertical Roller Mills | 19-21 January 2016 | NCB-B |
| 2. Operation, Control and Optimisation of Kilns | 23-26 February 2016 | NCB-H |

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## Role of Dispersion of Multiwalled Carbon Nanotubes on Compressive Strength of Cement Paste Composite

J. Bharj, S. Singh, S. Chander, R. Singh

International Journal of Mathematical, Computational, Physical and Quantum Engineering Vol:8 No:2, 2014

Keywords : Portland Cement, Carbon nanotube (CNT), Sonication and Compressive Strength

**Abstracted By: Dr. A K Dikshit**

### ABSTRACT

Carbon nanotubes (CNT) showing outstanding mechanical properties have been the subject of many investigations as reinforcement for several composite applications. They are also highly flexible and capable of bending in circles and forming knots. The dispersion of CNTs in the cement matrix possesses the major problem when dealing with high performance cementitious composites. The strong van der Waals forces make it difficult to achieve desired level of dispersion as CNTs tend to agglomerate and form bundles. The effect of dispersion of MWCNTs on compressive strength of MWCNT-Cement composite has been experimentally investigated for both MWCNT-Cement composite in powder form and MWCNT cement composite in hydrated form. The outstanding mechanical properties of carbon nanotubes (CNTs) have generated great interest for their potential as reinforcements in high performance cementitious composites. The main challenge in research is the proper dispersion of carbon nanotubes in the cement matrix. The present work discusses the role of dispersion of multiwalled carbon nanotubes (MWCNTs) on the compressive strength characteristics of hydrated Portland cement paste as per IS 1489. Cement-MWCNT composites with different mixing techniques were prepared by adding 0.2% (by weight) of MWCNTs to Portland cement as per IS 1489. Rectangle specimens of size approximately 40mm × 40mm ×160mm were prepared and curing of samples was done for 7, 14, 28 and 35days. An appreciable increase in compressive strength with both techniques; mixture of MWCNTs with cement in powder form and mixture of MWCNTs with cement in hydrated form 7 to 28 days of curing time for all the samples was observed.

# Trends and Development in Green Cement and Concrete Technology - (Review Article)

Mohammed S. Imbabi, Collette Carrigan and Sean McKenna

International Journal of Sustainable Built Environment 1 (2012), p.194-216

**Key Words:** Green cement, green house gases (GHG), waste derived fuel (WDF),carbon negative cement, supplementary cementitious materials (SCM), alkali-activated cement

**Abstracted By: S K Agarwal**

## ABSTRACT

The cement industry contributes nearly 6% man-made carbon emissions in the atmosphere in-spite of adopting process efficient technologies and faces a number of challenges that include depleting fossil fuel reserves, scarcity of raw materials and growing environmental concerns linked to climate change. In order to minimize $CO_2$ emissions, various technical and legislative measures such as improved process technologies, development of formulations that reduce or eliminate $CO_2$ emissions, imposing $CO_2$ taxes, quarrying and extraction taxes etc were taken but did not bring desired results due to increased industrialization, population growth and economic activity particularly in developing countries where a three to fourfold increase in demand is projected by 2050. For the environmental sustainable cement and concrete industry, in addition to improvements in process efficiency and reliance on blended cements, moving to less carbon intensive fuels, developing clinker substitution using low carbon materials having cementitious properties and carbon reducing cement formulations and production process are needed and probably offer the safest, most economical Carbon Capture and Storage (CCS) technology. The present paper summarizes the waste substitute that is currently being used to reduce the carbon footprint of a range of Portland-based cement, co-incineration of waste derived fuels (WDF) and next generation of green alternative cements such as calcium sulfoaluminate cement.

The global cement production increasing constantly particularly in China and India due to high infrastructural and housing demand. A conservative estimate for every 1 Kg of cement produced gives a by-product of 0.9 Kg of $CO_2$, this equates to 3.24 billion tons of $CO_2$ per year corresponding to annual global production of 3.6 billion tons of cement in 2012. The predicted $CO_2$ emissions from around 2 billion tons per year in 2010 to 4.8 billion tons by 2050 were found to be underestimated by 124% as around 3.24 billion tons of $CO_2$ emitted per year in 2012. By 2050, the emissions will have increased by almost 5 times the value in 1990 if no change is made to current production methods. In order to improve energy efficiency and reduce carbon emissions, the approaches that have been adopted can be summarized below:

- Manufacturing process in cement production has continued to be optimized and automated, using best available technologies.
- Co-incineration of waste material in cement kilns such as tyres widely used in Japan and USA, sewage sludge, waste oil, WDF etc. The use of other fossil fuels such as biomass can be an effective fuel substitute.
- Use of Supplementary Cementitious Materials (SCM) such as fly ash and pulverized fuel ash (PFA), granulated BF slag, silica fume, limestone in the production of Portland Limestone Cement (PLC), natural and artificial pozzolana:by-products of iron and steel industries and classified as Recovered Mineral Components (RMCs) in cement production. PLC containing up to 20% limestone can reduce energy requirement and carbon emissions by about 10%. In cement production, nearly 0.432 kg of $CO_2$ is avoided for per kg use of SCM.
- Development of novel, resource efficient cements such as calcium sulfoaluminate cement, calcium aluminate ($CaAl_2O_4$) and calcium alumina-silicate cements, super-sulfated cements, magnesium-oxide based cement as a "carbon negative cement" with less energy requirement and $CO_2$ emission. The cement is referred to as carbon negative cement because the $CO_2$ it produces in the manufacturing process is recycled back into the process. New search is underway to develop magnesium-based cement that absorbs more $CO_2$ than it produces during manufacturing process.
- Sequestrated carbon cement: Cement from $CO_2$- Other carbon negative cement developed by Calera Corporation and based on the process where calcium and magnesium in sea water interact with captured $CO_2$ rich gases filtered through sea water to produce high quality cement, which is snow white, air permeable and stronger than regular OPC.
- Alkali activated cements/geopolymers: Competitive with OPC in performance and cost and their production emits 95% less $CO_2$ than OPC.

## Incorporation of Trace Elements in Portland Cement Clinker: Thresholds Limits for Cu, Ni, Sn or Zn

N.Gineys, G.Aouad, F.Sorrentino and D.Damidot

Cement and Concrete Research, 41 (2011), 1177-1184

**Key Words:** Threshold limit, clinkerization reaction, mineralizing effect, cement hydration, compressive strength

**Abstracted By: S K Agarwal**

### ABSTRACT

Cement industry all over the world had adopted the policy of promoting industrial wastes as raw materials and fuel to preserve natural resources. These materials contain certain trace elements that could be incorporated into cement phases during clinkerization reaction and could affect the properties of cement. The present paper highlights the threshold limit of trace elements i.e Cu, Ni, Sn and Zn on the formation of clinker mineral phases and then on the reactivity of cements thus prepared. These elements were studied due to their frequent presence in raw materials and fuels and could have deleterious effects if their concentration continues to increase in cement.

Studies reported showed the mineralizing effect of CuO due to considerable reduction in melt temperature favoring lime assimilation during clinkerization reaction. Cu is mainly concentrated in ferrite phase followed by alite, aluminate and belite phases. The incorporation of Cu in cement hydration indicated that Cu delayed the hydration at early ages resulted in reduction in early strength. Ni is preferentially concentrated in ferrite phase, followed by alite, aluminate and belite. During cement hydration, Ni seemed to have little effect on cement hydration and hence did not change the compressive strength. Zn improves the formation of clinker by decreasing the clinkering temperature and favors the combination of free lime between 1000 and 1100$^{o}$C. The distribution of Zn into clinker phases is very contradictory. The incorporation of Zn induced a delay on cement hydration and reduced the early compressive strength for Zn content higher than 1.0 wt% in clinker. The study showed that little Sn was incorporated into $C_3S$ and no Sn was detected in $C_2S$. In contrast, analyses revealed that Sn was mainly incorporated in the interstitial matrix. However, the incorporation of Cu, Ni and Zn has different effects on the grindability of clinker.

In the present investigation, XRD and SEM-EDS studies of the clinker samples prepared by incorporating different doses of trace elements in the form of oxides (CuO, NiO, $SnO_2$ and ZnO) in raw meal showed the presence of Cu and Zn strongly modified the phase assemblages of clinker whereas in case of Ni and Sn, insignificant effect was detected. A decomposition of $C_3S$ to $C_2S$ and free lime were detected in the presence of high contents of Cu in clinker. A decrease in $C_3S$ and/or increase in $C_2S$ and free lime content appeared when the Cu content incorporated in clinker was greater than 0.35 wt%. In addition, γ-$C_2S$ was detected when Cu concentration exceed this threshold limit. Zn seemed to react preferentially with alumina and consequently modified the stability of $C_3A$. For Zn, the decrease in $C_3A$ content and /or formation of $Ca_6Zn_3Al_4O_{15}$ was observed when Zn content was higher than 0.7 wt%. Incorporation of threshold limits of 0.5 wt% Ni and 1.0 wt% Sn led to the formation of new phases $MgNiO_2$ and $Ca_2SnO_4$ in respective clinker samples. Indeed, it seemed that the threshold limit of Cu is affected by the $C_3S$ content of the clinker whilst the threshold limits of Zn and Sn are affected by the interstitial phase content. Concerning Ni, its threshold limit could be linked to the Mg content.

The present study revealed that the respective threshold limits for Cu, Ni, Zn and Sn were equal to 0.35, 0.5, 0.7 and 1.0 wt%. The threshold limit of Cu is affected by the rate of cooling of the clinker and the threshold limit was found to be increased from 0.35 to 0.50 wt% when clinker is quenched under ambient temperature. The reactivity of the doped cements at the threshold limit was studied by calorimeter and compressive strength measurements. No effect on cement hydration was observed. Only a decrease in early compressive strength was observed for cements doped with Cu and Sn. However, up to 7 days of hydration, their compressive strength is equal to or higher to that of the reference. Consequently, the doped cements seemed to be at least as reactive as the reference.

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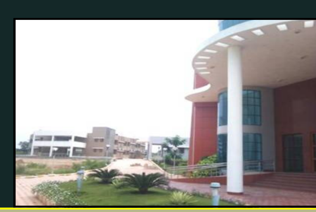

## Cultivating Positive Project Team

Aderienne E Keane

"Cultivating Positive Project Teams: Accelerating time to Team Formation" by Adrienne E. Keane, University of Pennsylvania, keanapmp@gmail.com under Master of Applied positive Psychology (MAPP) capstone Projects.

Keywords: Positive project teams, high performing teams, positive psychology, positivity, positive, team, appreciative inquiry, team building

**Abstracted By: Kapil Kukreja**

### ABSTRACT

High technology project teams must form, innovate, execute and deliver complex solutions at continually increasing speeds to meet the project requirement. A Japanese proverb states, "*None of us is as smart as all of us*". Which elaborates the importance of TEAM. This paper explores how building team positivity, connectedness and efficacy can accelerate team formation and establish an expansive environment for ongoing collaboration and innovation. Tuckman & Jenson formulated a model of team formation in 1965 and 1977 which states that a group of members transforms into team in stages. These stages are "*forming*", "*storming*", "*norming*" and "*performing*". In a later analysis Tuckman & Jensen (1977) added a fifth stage, "*adjourning*", to acknowledge the importance of the consideration of team endings. ***Forming*** is the stage when all group members come together with very little knowledge of each other, ***Storming*** is the stage when members start to challenge and disagree on how they want to work together, ***Norming*** is the stage when the group forms as an entity and becomes cohesive. Group members accept the group and accept the idiosyncrasies of fellow members. Harmony becomes important to the group this is the phase when a group start to transforms in a team. ***Performing*** is the performing stage, the group identity and relationships have formed allowing group members to now assume roles that enhance the performance of the group and focus their energies into the work to be done, ***Adjourning,*** This phase needs to promote effective means of terminating the work and separation from the group. Positivity, connectivity and collective efficacy have been positively correlated to team satisfaction and positive team outcomes. By building these team capacities we can accelerate team formation and establish a more expansive team environment for ongoing collaboration and innovation.

## New Methods of $CO_2$ Reduction from Cement Industry

David St Angelo, Joule, USA

International Cement Review, May 2014

& Low Carbon Technology for the Indian Cement Industry by WBCSD & IEA

Keywords : $CO_2$ Sequestration, Bio-catalyst, Algal, Cement Industry

**Abstracted By: Anand Bohra**

### ABSTRACT

The continuous increase in the level of Green House Gases like $CO_2$ in the atmosphere is a cause of major concern. Presently, Indian cement industry is emitting around 6.8% of total anthropogenic $CO_2$ from all industrial sectors in India with nearly 0.719 tonne of $CO_2$ for every tonne of cement produced. One very promising approach for reducing $CO_2$ emissions is Carbon Sequestration, the process of capture and long-term storage of atmospheric $CO_2$. Carbon sequestration using algal synthesis is a process in which the $CO_2$ emissions are captured and transformed into biomass which can be used as fuel, instead of wasting or storing $CO_2$ underground. Micro-algae used in this process, grow suspended in water and convert $CO_2$ into $O_2$ and biomass in the presence of sunlight. Presently, cement industry is trying to utilize this technology and develop algal farms for $CO_2$ absorption in a cement plant. However, this Algal based sequestration process is slow and involves complex biomass growth. To overcome the shortcomings, some institutes are developing a new bio-catalyst, which will consume $CO_2$ under sunlight and as a product of photosynthetic metabolism, continuously produce fuel molecules including hydrocarbons for diesel and jet fuel. The entire process – from photon capture and $CO_2$ mixing to product generation and initial separation – takes place in a Solar Converter system. It has the potential to produce up to 94,635 litre of ethanol or 56,781 litre of diesel per acre annually, for around US$50/barrel.This technology is presently at demonstration stage.

## NOx Emission Reduction at the Vidal Ramos Plant

Mario Henrique Interlenghi & Carlos Roberto Moreira da Cunha, Votorantim Cimentos, Brazil

International Cement Review, Cement Plant Environmental Handbook, Second Ed, Chapter-6, Page 137

**Keywords** : Cement plant, NOx emissions, Process Modification, SNCR

**Abstracted By: K R Pundareeka Nath**

### ABSTRACT

Vidal Ramos Plant located in Santa Catarina State, Southern Brazil installed in 2011 with capacity 3000 TPD kiln with 5 stage preheater and with ILC. The main fuel is petcoke and a mix of shredded tyres and industrial waste also used. Following the global trend the Brazilian government came up with stringent emissions limits for gaseous emissions. NOx (as $NO_2$) emission limits as per Brazilian regulations for dry kilns installed after February 2007 is 650 mg/$Nm^3$ at 10% $O_2$ (with or without Alternate fuels) and for the kilns installed before Feb 2007, with AF it is 1000 mg/$Nm^3$ and without AF it is 800 mg/$Nm^3$. To meet the emission limit Plant opt for installation of SNCR.

Temperature mapping was done on a stable kiln to identify the appropriate point for urea injection. Various adjustments and optimizations were done to reduce NOx, mainly (i) adjustment of kiln inlet Oxygen, (ii) distribution of fuel between kiln & precalciner (iii) new meal split from the third and fourth stages (iv) intensity of burning and (v) secondary air optimization. The meal split from the fourth stage cyclone between lower and upper ducts was set to 75% of valve opening where 26% of NOx reduction achieved. A highest reduction of 39% was achieved when valve opened to 80% at the top however due to build-up formation at smoke chamber and riser duct, the valve was opened to 75%. After assessing effect of meal splits the location for injection nozzles were installed below the tertiary air intake.

It was observed with using of alternate fuels up to 7 tph (i.e around 27% of TSR) NOx emissions were reduced by around 30% and with constant rate of urea injection in SNCR, AFR flow increased to 8 tph and reduced the NOx emission to 640 mg/Nm3. The use of alternate fuels is an efficient way to reduce NOx and also saves fuel bill.

## Mining Project Evaluation: An Approach Through Discounted Cash Flow Model

*Suryanshu Choudhury*

Mining Engineers' Journal, August 2015, Vol. 17, No. 1, Page no. 27-32

***Key Words*:** DCF – Discounted cash flow, PV - Present value, NPV- Net Present Value, IRR- Internal rate of return

**Abstracted by: Richa Mazumder**

### ABSTRACT

This paper presents an application of discounted cash flow techniques to mining project evaluation process for copper cobalt mine located at Central Africa. The project evaluation task is carried through economic evaluation of the project using a tool called cash flow analysis. These cash flows are typically estimated on an annual basis and discounted back to the present moment in time to determine the discounted cash flow (DCF) of the project. Economic evaluation is the method used to determine the economic viability of a project. Discounted cash flow analysis is a forward-looking methodology which requires forecasts be made with respect to technical and economic conditions which will prevail in the future. The Discounted Cash Flow (DCF) model is a model that is used widely in the analysis of any type of projects and specifically for the estimation of the Present value (PV), Net Present Value (NPV) and internal rate of returns (IRR) of cash flows associated mainly in project investment.

Mining investment is renowned for the risks that it entails like business risks and financial risks. From the investment standpoint the unique combination of risks and uncertainties associated with mining has, historically made it difficult area for decision makers. The characteristics of the mineral industry itself are its capital intensity, high fixed costs and long period of production, the exploitation of non-renewable sources and the usual exposure to inflationary and political risks. Since discounted cash flow analysis is fully capable of assessing the profitability of various levels of expansion, associated with various levels of additional ore discovery, it remains the preferred method for valuing properties which are at the stage of a bankable feasibility study.

## The Organic Option

Turboden Srl, Italy

International Cement Review, September 2015/Pg Nos. 111,112 and 114

**Keywords :** Organic Rankine Cycle, WHR, thermal oil, saturated steam

**Abstracted by: Prateek Sharma**

**ABSTRACT**

Thermal power contained in the cement waste heat streams such as kiln combustion gas and clinker cooler air can be converted into electric power using organic Rankine cycle (ORC) turbogenerators. The heat contained in the exhaust gases (preheater exhaust gas: 300-400°C and clinker cooler air: 250-350°C) is typically transferred indirectly via a thermal oil/saturated steam or pressurised water circuit to the ORC plant. Often two separate heat exchangers are installed, with different technical features due to the different characteristics of the exhaust gas (sticky gas from the preheater and abrasive dust from the clinker cooler).

ORC technology offers several advantages compared to traditional steam-based Rankine cycle WHR. The use of an organic working fluid enables efficient use of a medium-to-low temperature thermal source, such as the unexploited heat commonly available in cement production processes. The ORC module is designed to automatically adjust itself to the operating conditions. Variations on exhaust gas temperatures and flows will not affect the functionality of the system, just the power output. ORC systems control is carried out via remote monitoring (no need of supervision under normal operating) and annual maintenance is minimal. The ORC's flexibility allows the use of different heat carriers like thermal oil, pressurized water and saturated steam. Different organic fluids can be used according to the temperature level and power size. As the efficiency of cement production processes is expected to increase further into the future, exhaust gases will have lower temperatures, making an even stronger case in favour of ORC technology. The typical size of ORC systems ranges from 1-15MWe and they are therefore suitable for cement plants with clinker production capacities of 2000-10,000 tpd.

ORC technology is now widely used in the cement sector. Brescia-based Turboden has installed more than 260 ORC plant since the 1990s and units currently in operation have an uptime of over 98 per cent. Success stories have included Holcim's Alesd plant, Romania, and the company's Rohoznik facility in Slovakia, Italcementi's Ait Baha works in Morocco etc.

### Centre for Mining, Environment, Plant Engineering & Operation– Highlights of Recent Services to Industries

- prepared Techno-Economic Feasibility Report for Setting up a 1 mtpa Clinkerisation Unit at Bissel, Kenya and 2 x 0.6 mtpa Grinding Units at Kisumu, Kenya and Arusha, Tanzania.
- prepared Detailed Project Report for Capacity Enhancement of Cement Grinding Section of a cement plant in South India.
- prepared Techno-Economic Feasibility Report for Modernization of Packing Plant, for a cement plant in South India.
- completed Mandatory Energy Audit under Bureau of Energy Efficiency for cement plants.
- carried out diagnostic study for minimizing coating formation in kiln of a cement plant.
- carried out feasibility studies for using plastic waste in cement kiln for a cement plant.
- carried out estimation of WHR potential of a cement plant.

*NCB has completed the project on "Development of System Design for Storage, Handling and Firing of Different Types of Alternate Fuels/ Wastes in Cement Plants". The best practices on handling and storage of waste alternative fuels like shredded tyres, ETP sludge, organic waste and spent wash from sugar industry, waste oils and waste paints were studied, and the guidelines for identification of proven technologies was prepared. Accordingly, system design flow-sheets for handling, storage and firing of different types of alternate fuels were prepared.*

## $CO_2$ Mineralisation

*John & Charles Kline, Kline Consulting LLC, USA*

International Cement review, April 2015, Page no. 112-116

***Key Words***: $CO_2$ mineralization, sequestration

**Abstracted by: Richa Mazumder**

**ABSTRACT**

Mineral carbonation or $CO_2$ mineralisation is the capture and permanent sequestration of $CO_2$ as a mineral carbonate. This process is naturally occurring around the world as rocks weather. Certain minerals in the rocks combine with $CO_2$ from the atmosphere to form natural mineral carbonates. The mineralization of $CO_2$ has several perceived benefits over $CO_2$ sequestration like the $CO_2$ is permanently and irrevocably bound in the carbonate mineral, there is little possibility of re-release and therefore no leakage and corresponding monitoring required once the mineral is carbonated and the carbonate minerals can also be stored above ground if desired and even used in certain beneficial applications such as aggregate substitutes and if pure enough for chemical processes. The elements of maximum interest for mineral carbonation are also elements well known to the cement industry: the oxides of calcium, sodium, potassium and magnesium. These are the 5-8$^{th}$ most abundant elements in the earth's crust. (Oxygen and silicon are first and second, respectively, followed by aluminium and iron).

Carbon capture via mineral carbonation can be used as a means to permanently sequester $CO_2$. The main issues with this technology are the availability of the base minerals to be carbonated and the slow reaction times. The most-likely natural minerals are silicates of calcium and magnesium and more specifically olivine, serpentine and wollastonite. These minerals need to be mined and reduced in size and most likely to be catalyzed to be able to sequester $CO_2$ at appreciable rates. Pure carbonates of calcium and magnesium can have commercial value. However, the claims of producing 'low-carbon' building materials and low-carbon cement in particular are unlikely to be commercially viable.

Still mineral carbonation may be a viable alternative in situations where the necessary precursors prevail. For example, mining operations that produce a sufficiently-fine raw material rich in calcium or magnesium silicates that can be easily processed. In cement plants, waste overburden, dolomitic limestone could provide some elements of interest. Waste ashes from power plants and other combustion processes that are unsuitable for use in concrete are also candidates. Although these materials are probably not available in a large enough quantity to make a significant reduction in $CO_2$ emissions, they could become part of a grouping of projects tailored to specific needs and situations.



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## Optimum Percentage Replacement of Cement in Fly Ash Concrete

B. K. Nandi, B. Chattopadhyay, A. Gangopadhyay

Civil Engineering and construction review, volume 28, No.7, July 2015, pg. 42 to 248

**Keywords :** Fly Ash, Concrete , $Ca(OH)_2$

**Abstracted By: Amit Prakash**

**ABSTRACT**

Now a days disposal of Fly Ash (industrial solid waste) is becoming unmanageable. The optimum percentage replacement of fly ash in fly ash (FA) concrete are determined by authors in following three steps. First the theoretical values of $Ca(OH)_2$ liberated during hydration from Portland cement are determined. Secondly, from report of cement samples and applying Bogue's equations percentage of $C_3S$ & $C_2S$ present in cement are calculated theoretically and $Ca(OH)_2$ values liberated from OPC are ascertained. Lastly, requirement of $Ca(OH)_2$ for saturation of Fly Ash during replacement is theoretically determined. Percentage replacement values are theoretically arrived at which $Ca(OH)_2$ liberated by cement are very close to $Ca(OH)_2$ required by FA for completing reaction with $SiO_2$ present.

In mix design of FA concrete, water content is calculated by taking into account of replaced FA (active portion as 80% of FA) and considering water(W) /cementitious material(CM) = 0.42. CM is calculated as = cement+0.8 X FA . In the remaining inert portion (20%) is considered as sand. Theoretically determination shows that for every 100gm of $C_3S$ 49gm of $Ca(OH)_2$ and for every 100gm of $C_2S$, 22gm of $Ca(OH)_2$ will be available for reaction with $SiO_2$ of FA. Also theoretically it is calculated that from 100gm of OPC (GR 43) 23.94gm of $Ca(OH)_2$ will be liberated. Author has done sample calculations considering different % replacement of cement by Fly Ash (0 to 30%) at different replaced cement / FA ratio (1:1 to 1:3). Also, results are obtained experimentally from titration. It is found that $Ca(OH)_2$ values from theoretical estimation are very close to experimentally determined. Maximum advantage can be obtained if highest percentage replacement of cement were deployed using 1:1 replaced cement; FA ratio. The 28 days compressive strength of FA concrete is slightly higher than control concrete for all proportional replacement.

View of Abstractor: The optimum % replacement of cement in fly ash concrete is different for different grade of cement. Also there are other benefits of using fly ash in concrete like low permeability, lower porosity, less chloride penetration more durable etc. Also use fly ash in concrete will be economical and reduce carbon emission. The use of Fly ash should be encouraged.

## Report and Recommendation of JCI Special Technical Committee on the Great East Japan Earthquake Disaster and Activity

H.Mihashi, S.Sogo, K.Maruyama and Y.Kitsutaka

Concrete Journal, Vol.-52, No.-6/2014/Pages- 503 to 509

**Keywords :** Concrete Structures, Damage of Earthquake, Damage of Tsunami

**Abstracted By: Bharti Meena**

**ABSTRACT**

The Tohoku Earthquake (The Great East Japan Earthquake) which occurred on 11th March 2011, was extraordinarily disastrous (of magnitude 9, which would happen once in one thousand years or so). To know about the various damages and their extent to buildings, roads, coastal concrete structures and to the Fukushima Daiichi Nuclear Reactor and recommendations for measures for restoration and reconstructions, the Japan Concrete Institute (JCI) established Special Technical Committees on Material Production and Construction.

According to the report the general aspect of damages were breakage of railway viaduct & poles, breakage of non-structural members of buildings and the damages to the building which also includes its differential settlement. Also the Tsunami caused collapse of wooden buildings, few RC buildings and cause leaning of buildings because of breakage of piles and/or of liquefaction some wharf in port subsided. The Fukushima Dachii Nuclear Power Plant was affected and damaged by hydrogen explosion, radio active rays and heat emission and leakage of radioactive materials. The prepared report also included the issues on the estimation of current status of concrete, reinforcing steel and other materials affected by the disaster, their repair and reinforcement of damaged and deteriorated concrete materials and structures, methods to prevent the diffusion of radioactive materials from the affected power plant, provision of new technologies for reconstruction, utilization of construction materials with comparatively low-level of radio active contamination.

The committees recommended countermeasures for Earthquake such as strengthening of existing concrete structures, development of earthquake-resistant strengthening technologies which are more effective and easier to use, countermeasures for Tsunami as to clarify the tsunami's load and mechanism of action on structures to develop the design method corresponding requirement which are requirement to make structure ductile and not likely to fall down or collapse, Measures to be adopted for material production and construction and also recommended for the development of evacuation manual for construction site.

View of Abstractor: As to solve a problem the knowledge of the aspects related to problem such as it's causes, affected areas, the remedial measures and preventive measures that should be adopted for future are necessary, in the same way the committees established by JCI solved their purposes. The efforts made by the committees and the suggested countermeasures related to restoration reconstruction and safety over the future have contributed for the earliest reconstruction of the affected area.

## Development of Accelerated Mix Design Method for Concrete Using PPC or OPC with Flyash

Early prediction of 28 days compressive strength results through existing codal provision is not possible for concrete mixes having Pozzolana like flyash due to the effect of their physical and chemical properties on the rate of strength gain. Hence, NCB taken up this research study focused on development of accelerated curing regime and simple deterministic equation for accurate prediction of compressive strength using PPC or OPC with flyash. Studies on concrete specimens prepared by using different brands of PPC and different sources of flyash mixed with difference brands of OPC were carried out. Accelerated curing of concrete specimens was carried out using different temperature regime for different duration. Flyash ranging from 20 to 45% was added by weight of cementitious materials in the mixes. Mathematical model for early prediction of 28 days compressive strength of concrete are developed separately for the mixes having flyash up to 35% and the mixes having flyash content >35% to 45%.

### Creep-induced Distress on the Flexural Behavior of RC Beams Retrofitted with NSM

Yail J. Kim and Faud Khan

ACI Structural Journal July-August 2015; Volume 112; No 4; P493-504

**Keywords :** carbon fiber-reinforced polymer (CFRP); sustained load; near surface-mounted (NSM); strengthening
**Abstracted by: Manvender Singh**

**ABSTRACT**

Constructed reinforced members can be strengthened with carbon reinforced polymer. It improves the load-carrying capacity and serviceability. This strengthening can be done in two ways i.e. Externally Bonded or Near-Surface Mounted (NSM) Strengthening. In externally bonded strengthening, CFRP sheets are bonded to the tensile soffit of a member with an adhesive. While in NSM CFRP strengthening, CFRP rods or strips can be inserted into a precast groove along the tensile soffit of a RC member. There is insignificant increase in dead load & minimal alteration of existing structural geometry in NSM strengthening.

In this paper, the authors investigated the behavior 11 RC beams (1 control & 10 strengthened with NSM CFRP strips [1or2]) subjected to sustained loads. Test program conducted comprised two phases: short term & long term. Short term beams were simply supported and monolithically loaded in four-point bending. Long term beams were loaded for various levels (25%, 50% & 75% of strengthened capacity) of sustained load for 4000 hours and released thereafter. Then, these beams were tested for residual capacity.

The short-term NSM CFRP strengthened beams failed by intermediate crack-induced CFRP debonding. The short-term strengthened beams exhibited improved flexural behavior in comparison to an unstrengthened control and an increase in load-carrying capacity of up to 70.9 % was achieved. The long-term strengthened beams failed by end-debonding failure at the CFRP termination. The residual load-carrying capacity of the beams was influenced by the sustained load levels. Also, there was decrease of up to 28.3% & 36.8% in yield and ultimate loads when compared to that of short-term counterparts.

View of the Abstractor : NSM CFRP increases the flexural capacity of the strengthened beams, while the ductility of these beams reduces after strengthening and get affected by the long-term loads in conjunction with local bond deterioration of the NSM CFRP. The sustained load is a critical factor determining the failure mode of the strengthened beams.

## Anti Washout Under Water Concrete

Anti washout underwater concrete is considered for use in a diverse range of work underwater. Anti washout underwater concrete is different from other concrete in terms of its property in fresh state. It requires to prevent the concrete from segregation while placing under water. The viscosity of concrete is increased and its resistance to segregation under the washing action of water is enhanced by mixing an anti washout admixture with the concrete. The tremie and concrete pump placing methods are adopted for construction. NCB developed three underwater concrete mixes for Koteshwar Hydroelectric Project of THDC (India) Ltd. Koteshwar having slump = 150 mm at 30 minute & initial setting time = 2-3 hrs. having 15 % washout. Dosage of high range water reducer, anti washout admixture and accelerator was optimized in order to ensure fresh concrete property conforming to the specification.

# Durability of High and Ultra High Strength Concretes Subjected to Aggressive Chemical Environments

By K.V.Harish, J.K.Dattatreya and M. Neelamegam

The Indian Concrete Journal (ICJ), Volume-88, No.12, December 2014

**Keywords :** Durability, Porosity, Permeability, aggressive chemical environments, Ultra High Strength Concrete

**Abstracted By: Brijesh Singh**

## ABSTRACT

In the past one decades, ultra-high strength concretes (UHCs) are being used in lieu of high strength concretes (HSCs) for applications demanding higher tensile strength such as prestressed bridges, thin sections and others, and longer service life with zero or least maintenance cost. Concrete used to such applications are often subjected to aggressive chemical attacks due to the penetration of chlorides, sulphates, moisture etc. from atmosphere, there by indicating the need for highly durable concrete. The paper studied covers the comparison of durability parameters for three different types of concretes namely HSC, High Performance Concrete (HPC) and UHSC. The durability tests conducted include water absorption, porosity, chloride permeability and strength / weight loss due to exposure to different chemical solutions. The material used for producing HSC, HPC and UHSC included Ordinary Portland Cement (OPC), silica fume, flyash, sand and coarse aggregates along with poly-carboxylate based superplasticizer. The curing for HSC and HPC was normal water curing until test while the USHC was subjected to combination of low and medium temperature curing for increased cement and pozzolanic reactivity. The strengths for this study in case of HSC, HPC and UHSC were just above 50 Mpa, between 50-80 MPa and greater than 80 MPa respectively. The test results of study conducted indicated that the water absorption and porosity of UHSC were substantially lower than that of HSC. In acid resistance test, the 90 day strength loss of UHSC was lower than that of HSC by 44 percent, 62 percent and 48 percent under hydrochloric, nitric and sulfuric acid attacks, respectively, with sulfuric acid causing the highest deterioration. Similar trends were observed in sulphate resistance test also, with the "alternate drying and wetting" method causing higher deterioration than the "continuous immersion" method. In the salt resistance test, all the concrete showed nominal damage. In the chloride permeability test, the HSC was in the "very low" range while HPC and UHSC were in the "negligible" range. Overall, the UHSC showed superior performance than others and therefore, it is anticipated to perform well in applications demanding long term durability.

View of Abstractor: From this paper, it is seen that:

- Higher porosity was observed in case of HSC as compared to HPC and UHSC concrete. The porosity determined by the saturated immersion method was slightly higher than that obtained by boiling water method.
- The sulphate resistance of the concretes investigated by the wetting and drying method resulted in more deterioration then the full immersion method. The sulphate resistance of concrete investigated by these two methods showed that the strength and weight loss of HPC of UHSC was lower than that of HSC.
- Of the various acids selected for investigation, sulfuric acid seems to have maximum deteriorating effect. There was not much difference in the severity of attack by hydrochloric acid and nitric acid.
- The results from the salt resistance test indicated that the HSC and HPC showed higher strength and weight loss than that of UHSC, though the extent of salt attack was seem to have minimal affect of concrete properties.
- In the Rapid Chloride ion permeation Test (RCPT), the performance of HPC and UHSC was better than HSC.
- From this study, it can be concluded that overall, the UHSC possess best performance in terms of durability as compared to HSC and HPC, owing to the use of specialized mixture proportions and optimized heat curing cycles, and hence, can be used in lieu of HSC of HPC in situations where long terms durability is required in aggressive environments.

# Use of Biomass and Co-fired Flyash in Concrete

Christopher R. Shearer and Kimberly E. Kurtis

ACI Materials Journal ,V 112, No 2, March – April 2015 V112,Np2

**Keywords:** biomass, co-fired fly ash, permeability

**Abstracted By: Puneet Kaura**

## ABSTRACT

Use of biomass firing and co-firing as a potential fuel source for the generation of electricity had seen surge around the world but application of residue waste generated from the same into the concrete is still at its budding stage. Limited research has been conducted on pathways for the use of the by-products of processes (biomass ash and co-fired fly ash) as a Pozzolanic material in concrete. Presently, no standard and guidelines recommends the use of co-fired fly ash and biomass ash into the concrete because of which its lack application in construction industry. The study is basically conducted to contemplate the application of biomass ash and co-fired ash in concrete. Primarily, properties like hydration kinetics and permeability of concrete mixes for seven different ash samples were studied at w/c=0.40 and 0.485 respectively. It was seen that all the mixtures in cooperating coal and co-fired fly ash had generated less heat of hydration in comparison to plain cement control mix and no significant differences were observed between coal ashes and co-fired ashes whereas biomass ash hydration behavior was found to be different in comparison to all. Permeability studies conducted at an age of 28 days had indicated concrete mix consisting of coal and co-fired had allowed more charge to pass through them but results at 91 days showed the permeabilities of coal and co-fired fly ash mixtures were significantly reduced by 25% to 47 % when compared to control mix. Even the strength gain in mortar mixes consisting of coal ash and co –fired ash is considerable in comparison to control mix whereas biomass ash was not able to yield any satisfactory result in comparison to all mixes.





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## Sulphate Resistance and Eco-friendliness of Geopolymer Concretes

N.P.Rajamane, M.C.Nataraja, J.K.Dattatreya, N.Lakshmanan and D.Sabitha

Indian Concrete Journal Vol.86, No.-1/ Jan 2012/Pages-13 to 22

**Keywords**: Geopolymer concrete, PPC Concrete, Fly Ash (FA), Embodied Energy, Embodied $CO_2$ Emission (EC)

**Abstracted By: Sahil**

### ABSTRACT

Concrete is the most widely used construction material all over the world. Cement is the primary ingredient in concrete, which in turn forms the foundations and structures of the buildings we live and work in but Portland Cements are highly internal-energy-intensive and cause emission of green house gas during their production and also these Portland Cement based Conventional Concrete are less durable in some of the very severe environmental conditions. Therefore the need of hour is to decrease the environmental impact of concrete and to valorize industrial by product to find alternatives concrete. This paper include the study of Geo Polymer Concrete (GPC) and Portland Pozzolana Cement Concrete (PPCC) when treated in different exposure condition and their eco-friendliness by computing Embodied Energy (EE) and Embodied $CO_2$ Emission (EC) per unit volume of concrete.

The experimental study includes the testing of three concrete mixes, one PPCC mix having 72% OPC & 28% FA and two GPC mix having 75% GGBS & 25% FA and 50% GGBS & 50% FA and effect on compressive strength and effect of sulphates over weight and strength loss is observed. In the context of compressive strength it is clearly seen that the rate of gain of strength is more in case of GPC when compared to PPCC which is quite useful in faster construction of structures, moreover, the GPC do not require any external curing and only ambient conditions are enough for the geopolymerisation reaction and subsequent strength gain. In contrast, PPCC need always careful curing through exposure to moisture or water. When treated with $Na_2SO_4$, there was noticeable weight loss in both the concrete but the values were very low and therefore the specimen had maintained their integrity with very minor distress seen on the surface when examined visually. The PPCC had strength losses of 9% to 39% in contrast to lower strength loss of 1.4% to 21.3% indicated by GPC, depending upon the type of sulphates and exposure period for sulphates. More loss in the PPCC may be attributed to the fact that $Na_2SO_4$ attacks the cement hydration product to form gypsum and ettringite which are expansive in nature causing cracks in the matrix. When treated with $MgSO_4$ both the specimen had maintained their integrity with very minor distress on the surface but the loss of strength is significant in both the cases. The loss in strength in PPCC may be due to the more predominant leaching action in case of $MgSO_4$ than other sulphates and the destruction of C-S-H gel due to decalcification results into reduced cohesion in Hydration Cement Paste (HCP) and lowered bond between HCP and aggregate and finally conversion of C-S-H into M-S-H. In the case of GPC the release of alkalis from GPC could be considered as major reason for the deterioration of strength on attack by $MgSO_4$. Data and discussion on ecological parameters demonstrates that the GPC had 43% to 53% less Embodied Energy (EE) and around 70% to 75% less Embodied $CO_2$ Emission (EC) when compared to PPCC and thus overshadows the cost of production of GPC.

View of Abstractor: In India, use of GPC is still at very small scale. Lack of knowledge and proper guidelines are restricting us for fully utilizing it. Also by varying the proportion of pozzolanic materials used and the material itself, we can further study the various engineering properties of GPC.

## Use of Efficiency Factors in Mix Proportioning of Fly ash Concrete

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The Indian Concrete Journal , Vol. 89, Issue 1, Jan 2015, pp. 73-79

**Keywords** : Concrete, fly ash, compressive strength, efficiency factors

**Abstracted By: Subham Jain**

### ABSTRACT

Use of fly ash as a partial replacement for cement results in significant improvement in concrete properties. In spite of following empirical procedure given in IS 10262-2009, it is possible to quantify the effect of fly ash in concrete by determining the cementing efficiency factors. Efficiency factor (K-value) is defined as the part of the pozzolanic material which can be considered as equivalent to Portland Cement having the same properties as the concrete without the pozzolanic material (K=1 for Portland Cement).

In this study, Efficiency factor (K-value) was calculated on the basis different mix design trials which included:
Cement OPC 43 with Blaine's Fineness (325 $m^2$/Kg), Fly Ash with Blaine's Fineness (250 $m^2$/Kg) (relative low quality) and ordinary fine aggregate & coarse aggregate locally available were used. 5 sets of concrete mixtures at w/c ratios of 0.4, 0.45, 0.5, 0.55 and 0.6 were prepared with each set had mixtures at five fly ash replacement percentages- 0 (control mix), 20, 30, 40 and 50% of the total binder content and at three binder contents. Total 55 concrete mixes were found suitable and their 28 days compressive strengths were determined. Relationship between $\log_e$ (compressive strength) and w/c for control concrete were prepared and using the method of least squares the equation was obtained i.e. $\log_e (S) = 5.4164 - 3.142 (w/c)$ . From the equation obtained and $\log_e$ (strength) of fly ash concrete mix, the value of the equivalent w/c was calculated and ultimately, efficiency factor (K-value) was estimated at different w/c ratios and at different percentage replacements.

Efficiency Factor (K-value) has been estimated as, $(w/c)_{equivalent} = w'/(c'+Kf)$ where w', c' and f are water, cement and fly ash contents respectively in the fly ash concrete.

It was found that efficiency of fly ash is dependent on the replacement percentage and decreases with increase in the replacement percentage. It was also noticed that efficiency values reduces drastically beyond 30% replacement.

Views of the Abstractor: This study can be useful for effective utilization/quantification of fly ash in concrete and may serve as guideline to optimize the percentage replacement of fly ash at different w/c ratios and tends to decrease the number of mix design trials. It is observed that efficiency of fly ash in concrete depends on number of parameters like type of cement and fly ash, w/c ratio, strength requirement age, replacement level, coarse and fine aggregates properties etc. Efficiency factor may serve as guide but it shall not be considered a constant value and evaluation of the same requires a considerable amount of judgment and understanding on the part of the designer.

## NCB's SIMULATOR BASED TRAINING

With the aim of providing comprehensive training on various aspects of kiln and mill operation, eight training courses on Advanced Simulator Trainer were organized at NCB's Ballabgarh and Hyderabad Units for 41 professionals from various cement industries of India and neighboring countries in the year 2014-15. The participants were trained on Operation, Control and Optimization of Modern Grinding System based on Roller Press, Vertical Roller Mills; Ball Mills; Operation, Control and Optimization of Modern Precalciner kilns.