# 17th NCB International Conference on Cement, Concrete and Building Materials

"Moving Towards Net Zero Carbon Emissions"

06-09 December 2022, Manekshaw Centre, New Delhi, India

# CONFERENCE PROCEEDINGS

# ABSTRACTS

G20 भारत 2023, INDIA
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# 17th NCB International Conference on Cement Concrete and Building Materials

06-09 December 2022, New Delhi, India

# PROCEEDINGS
## Abstracts

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# CONTENTS

## Proceedings (Abstracts) of 17th NCB International Conference on Cement, Concrete and Building Materials

### TECHNICAL SESSION – I A
### LOW CARBON CEMENTS

## TECHNICAL SESSION – I B
## OTHER BUILDING MATERIALS & BINDERS



## TECHNICAL SESSION – II A
## CEMENT PLANT MACHINERY & PROJECT ENGINEERING –I

## TECHNICAL SESSION – II B
## ALTERNATE/WASTE FUELS AND RAW MATERIALS –I

## TECHNICAL SESSION – III A
## NET ZERO EMISSIONS, CARBON CAPTURE, UTILISATION & STORAGE (CCUS)



## TECHNICAL SESSION – III B
## CONCRETE DURABILITY, DISTRESS INVESTIGATION, REPAIR & REHABILITATION -I

## TECHNICAL SESSION – IV A
## PRODUCTIVITY ENHANCEMENT AND PROCESS OPTIMIZATION- I

## TECHNICAL SESSION – IV B
## PERFORMANCE-BASED DESIGN OF CONCRETE STRUCTURES



## TECHNICAL SESSION – V A
## ADVANCES IN GRINDING SYSTEMS- I

## TECHNICAL SESSION – V B
## LATEST INNOVATIONS & TRENDS



## TECHNICAL SESSION – VI A
## ADVANCES IN GRINDING SYSTEMS –II

## TECHNICAL SESSION – VI B
## CONCRETE DURABILITY, DISTRESS INVESTIGATION, REPAIR & REHABILITATION-II

## TECHNICAL SESSION – VII A
## LOGISTIC, CSR INITIATIVES & TOTAL QUALITY MANAGEMENT



## TECHNICAL SESSION – VII B
## CEMENT PLANT MACHINERY & PROJECT ENGINEERING -II

## TECHNICAL SESSION – VIII A
## ALTERNATE /WASTE FUELS & RAW MATERIALS- II



## TECHNICAL SESSION – VIII B
## SMART CONCRETE, 3D PRINTING & ULTRA HIGH PERFORMANCE CONCRETE

## TECHNICAL SESSION – IX A
## ENERGY CONSERVATION SYSTEMS

## TECHNICAL SESSION – IX B
## ENVIRONMENTAL MANAGEMENT, SUSTAINABLE DEVELOPMENT & SAFETY



## TECHNICAL SESSION – X A
## PRODUCTIVITY ENHANCEMENT & PROCESS OPTIMISATION -II

## TECHNICAL SESSION – X B
## SUSTAINABLE CONSTRUCTION PRACTICES & USE OF ALTERNATE AGGREGATES

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National Council for Cement and Building Materials (NCB), set up in 1962, then known as Cement Research Institute of India, is the apex body in India under the administrative control of Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, government of India, devoted to research, technology development and transfer, education and industrial services for cement, building materials and construction industries. Its multi-disciplinary activities are performed in an integrated and coordinated manner through its units that are located at Ballabgarh (Near Delhi), Hyderabad, Ahmedabad and Project Office at Bhubaneswar. The six corporate centres of the council guide the activities at different units. The Centre and their main areas of activity are:

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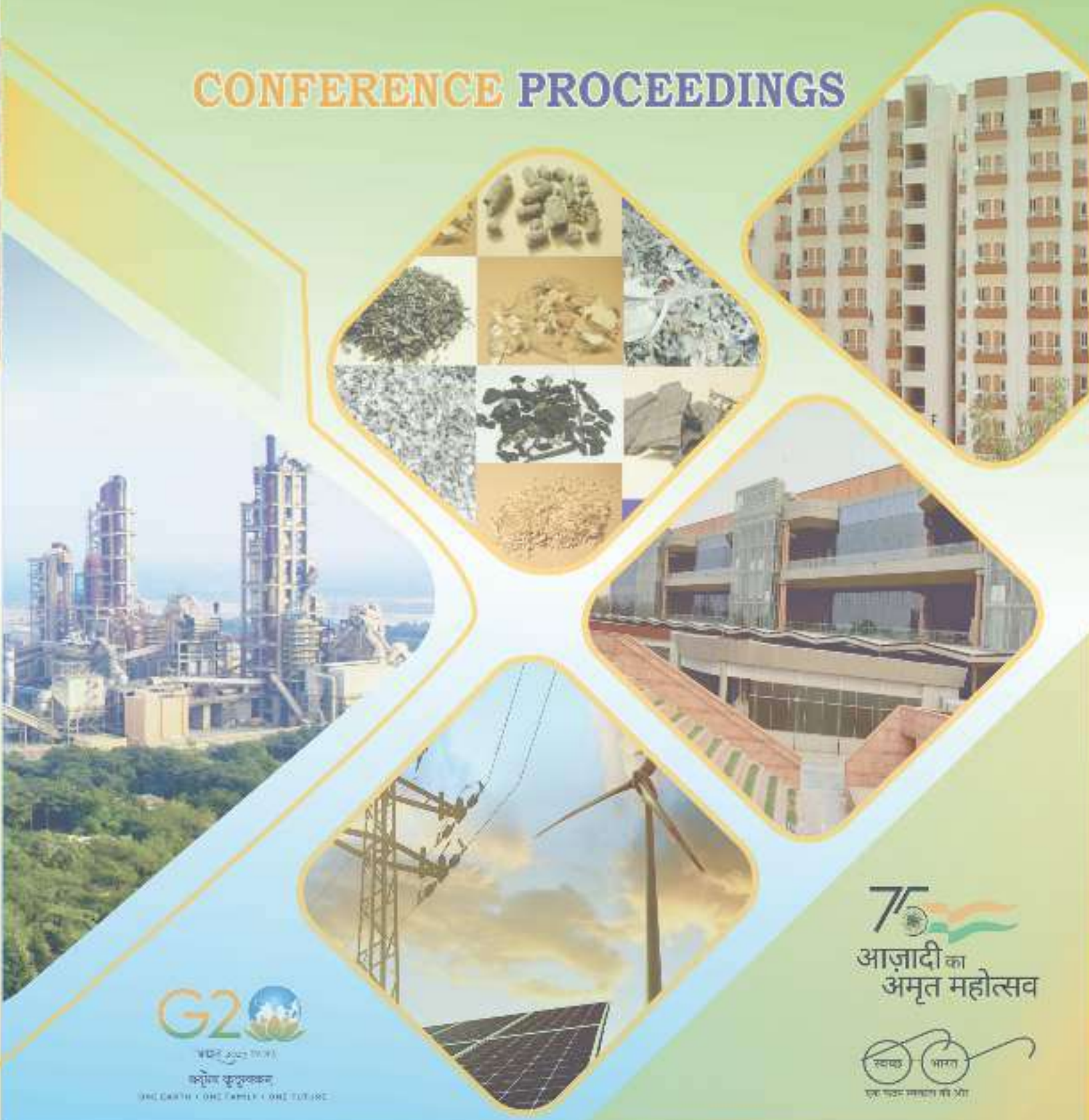
# TECHNICAL SESSION - I A

## LOW CARBON CEMENTS

# CONFERENCE PROCEEDINGS



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# COMPARATIVE STUDY BETWEEN THE FLOW BEHAVIOUR OF $LC^3$ AND OPC SYSTEMS: THE THIRST OF CLAY

**Ashirbad Satapathy, Manya Gupta, Gopala Rao Dhoopadahalli & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

Limestone calcined clay cement ($LC^3$) has gained popularity in recent times due to its reduced carbon footprint, cost-effectiveness as well as comparable mechanical and durability performance as that of conventional cement types. Nevertheless, a major concern with the utilisation of $LC^3$ systems lies in achieving the desired workability. This study intends to provide a deeper insight into the effect of variation in the water-to-cement (w/c) ratio on the admixture requirement and the flow characteristics of the $LC^3$ systems as compared to that of Ordinary Portland Cement (OPC) systems. A modified PCE-based admixture was used to prepare the cement paste samples, and Marsh cone flow and mini-slump spread tests were carried out. It was observed that the flow behaviour, as well as the saturation admixture dosage, was similar for the $LC^3$ and OPC systems at w/c ratios between 0.45 to 0.60. However, at a w/c ratio lower than 0.40, a substantial increase in the admixture dosage, along with a severe dip in the fluidity of the $LC^3$ paste samples, was observed.

# LABORATORY TRAILS FOR DEVELOPING CEMENT USING CLINKER & FLY ASH WITH CEMENT GRADE, LOW GRADE, HIGH MGO LIMESTONE

**Pankaj Kejriwal, Sundaram Srinivasan, Laxmaiah Munjala, Y K Singh, S K Pandey & Sanjay Kr. Chourasia**

*Star Cement Limited, India*

The cement industry is one of the major emitters of anthropogenic carbon dioxide into the atmosphere, accounting for approximately 5–8% of the total carbon dioxide emissions. Rapid and continuous development in the construction and infrastructure sector in the near future will further drive up the collective cement demand. The increased demand will distress the already depleting natural resources required for cement production and environment. Supplementary cementitious materials offer the most promising means to meet the demand by optimising resource utilisation, along with economic and environmental benefits. Therefore, looking into the problem forecasted as above we did several trials with various permutations and combinations replacing clinker with different grade of limestone. Trial report were very encouraging as per the detailed data provided in following tables.

# PROSPECTS OF UTILIZATION AND MANAGEMENT OF LOW-GRADE LIMESTONE FOR INDIAN CEMENT INDUSTRY: AN OVERVIEW

**Vinod Shrivastava, Pravin Tiwari, G P Pandey, Pravesh Sharma, Saranya Gautam & Manish Kumar Singh**

*Prism Johnson Limited, Satna*

Limestone is one of the basic raw materials for the infrastructural development of a country, more so in a developing country like India. India is the second largest producer of cement in the world. Production of cement is totally dependent on the availability of natural resources such as limestone, clay and other required raw materials. With the extensive industrial expansion and essential infrastructural developments in the country, the demand of limestone is increasing unabated day by day. Madhya Pradesh is richly endowed with huge deposits of limestone but majority of the deposits available for cement manufacture are either marginal or low grade. Most of the deposits of limestone are magnesia rich (MgO >5%) and silica rich (SiO2 >15%) low-grade materials owing to their depositional environment and goes to waste due to inefficient mining operation and ineffectual management of these precious natural resources. According to an estimate it has been assumed that with the present rate of production and consumption of cement, available reserves of limestone would not exceed for more than 40 to 50 years in India. Although, the conversion ratio of limestone to cement has gone down in our country but proportionally demand of cement has increased 1.5 to 2 times in the last 15 years. Further due to demand of high quality of cement (43 and 53 grade OPC and PPC) in current market, the consumption of high grade limestone has also increased concurrently. To meet out the demand and supply it has been observed that the extraction of high-grade limestone further increases the mines rejects in case of low grade limestone deposits. The rates of depletion of reserves of limestone will lead to severe resource scarcity in the near future. This is especially true for the Indian cement industries. The aim of this article is to focus on mitigation of wastage generated as low grade or sub-grade resources during mining and the need to improve sustainability of these limited resources by their effective management and proper utilization in clinker manufacturing by adopting dry beneficiation, differential grinding, sieving and effectual blending techniques.

# DEVELOPMENT OF SUSTAINABLE WATER RESISTANT COMPOSITE BINDER FROM FGD GYPSUM

**Neeraj Jain, Soumitra Maiti, Jaideep Malik & Aakriti**

CSIR-Central Building Research Institute, Roorkee

Development of sustainable water resistant composite binder has been carried out using flue gas desulphurized (FGD) gypsum and fly ash (FA)- byproducts of coal-based thermal power plants. FGD gypsum was calcined at 150 ± 5 ºC for about 4 hours to get β-hemihydrate plaster. Trial mixes of composite binders with different compositions of β-hemihydrate binder (50 – 75 %) and fly ash (15 – 40 %) were formulated with addition of fixed amount of OPC (10 %) and activators. The physio-chemical and mechanical properties of sustainable binders were determined and the binder mix (P4) containing FA (30 %) and β-hemihydrate plaster (60 %) was recommended due to its economic value. P4 shows compressive strength of 10.25 MPa (28 days) and 9.25 % of water absorption. This binder was characterized by X-ray diffraction, scanning electron microscopy and thermal gravimetric analysis. The durability of the binders was performed under extreme weather conditions to study the effect of hot and cold weather on the binder strength Thus development of binder achieves the dual goal of waste mitigation and cost efficient alternative to cement in construction industry for internal as well as external applications.

# CEMENT ADDITIVES: FOR ACHIEVING LOWER CLINKER FACTOR & FOR CEMENTS WITH NICHE PROPERTIES - CASE STUDIES

**Pinaki Poali, Samit Samanta & Gopal Bihani**

*Endura Construction Chemicals*

Cement additives are substances added in very small proportions typically < 0.2 % to the cement mill to improve, mill thru-puts, to achieve lower clinker factor in blended cements, for improved concrete performance of cements or even for specific special premium cements with special USPs like corrosion resistance, lower setting times or for reduced water permeability in the resultant cement mortars and concrete (water repellent /permeation resistant cements). At RMC - CCB Pen of Prism Johnson Limited, research team has been working on cement and concrete chemicals for creating effective performance oriented cement additives and concrete admixtures. The present paper illustrates case studies about two types of cement additives. One of Case study discusses the Cement additive used for achieving lower clinker factor in PPC (increased fly ash absorption. The other case discusses the cement additive used for manufacturing of special cement with water repellent property. The Properties of the resultant cement in terms of the effect on compressive strength, permeability and sorptivity of the mortar and Concrete cubes has been discussed in some details

# SUITABILITY ASSESSMENT OF LINZ DONAWITZ (LD) SLAG FOR FABRICATION OF CEMENTITIOUS BINDER

**Jyoti[1] & S K Singh[2]**

[1]*Academy of Scientific and Innovative Research (AcSIR), India*

[2]*CSIR- Central Building Research Institute Roorkee, India*

Linz Donawitz (LD) slag is a non-reactive and crystalline slag generated during steelmaking processes. Previous studies have found that the presence of calcium silicates, portlandite (free lime), and calcium ferrite contribute to its cement-like qualities. However, its application in fabrication of cementitious binders is found dimensionally unstable when exposed to moisture or carbon dioxide. In addition, its usage in cements is limited due to its non-reactive crystalline form. The aim of the current study is to characterize LD slag in terms of hydraulic characteristics and pozzolanicity for assessing its suitability to be used as a cementitious binder. The pozzolanicity was analyzed through different techniques involving slag activity index, hydraulicity test and Frattini test. The LD slag was ground to fine powder through ball milling for use in this study. Mortar cubes were prepared with blending of 70% ordinary Portland cement with 30% ground LD slag followed by activating with chemical activators sodium hydroxide (NaOH) and sodium silicate ($Na_2SiO_3$) solutions. The results revealed that the LD slag is pozzolanic in nature as corroborated through Frattini test. The study also shows that improved slag activity index is achievable by employing sodium silicate activator. Among the two activators i.e., NaOH and $Na_2SiO_3$, the sodium silicate activator (pH 12) was found to enrich the reactivity aspect of LD slag, which in turn causes the compressive strength to increase significantly. Based on the results from different techniques, it can be concluded that sodium silicate can be applied to upgrade the reactivity, pozzolanicity and strength properties of LD slag. Therefore, the LD slag can be utilized as a sustainable binder provided the pozzolanic and hydraulic properties are characterized in a proper manner.

# QUALITATIVE ASPECTS OF LIMESTONE COLLECTED FROM DIFFERENT ZONES OF INDIA: FORMULATION OF PORTLAND LIMESTONE CEMENT FOR SUSTAINABLE DEVELOPMENT OF INDIAN CEMENT INDUSTRIES

**Sandeep Kumar Gupta, Pinky Pandey, Ashish Goyal, S K Chaturvedi & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Indian cement manufacturers are making various blended cement to minimize greenhouse emissions ($CO_2$) and promote sustainable growth as well. Portland Limestone Cement (PLC) is yet another blended cement which is used in Europe, America, Canada, and other countries. PLC is being produced by intergrinding clinker, limestone, and gypsum. The current study aims to assess the use of limestone in PLC production in India, for which we collected seven limestone samples (LE1, LE2, LN1, LN2, LS1, LS2 and LW1) from four zones of India where cement plants are located. Comprehensive research for these samples was carried out in terms of chemical analysis, X-ray diffractometry-XRD, petrography, thermal analysis (DTA/TGA), and grindability index-GI. The chemical study demonstrated a wide range of Loss on ignition-LOI (23.49 to 46.08 per cent), Alumina-$Al_2O_3$ (0.16 to 8.26 per cent), and Lime-CaO (28.74 to 50.05 per cent). The high $Al_2O_3$ content in limestone is also enhancing the hydration reaction of PLC. LS2 has a high total carbonate content (TC) as it contains high CaO. XRD and petrology suggested that all seven limestone samples dominantly consisted of calcite and quartz. LN2 also contains dolomite as an essential mineral, along with calcite and quartz. Petrology of LN1, LN2, LS1, LS2 and LW1 revealed that they will provide micro globular carbonate grains while intergrinding with clinker to prepare PLC. DTA and TGA suggest a large endothermic peak (due to calcite) was observed in LS2, which was also verified with chemical analysis, XRD, and petrography. The GI and petrological features show that LN2, LS1, and LW1 are softer. It is concluded that PLC can be produced by all the available limestone samples except LN1 and LN2, as LN1 is highly siliceous and LN2 is Calcitic dolomite, and the TC content was 51.32 and 67.48, respectively. Furthermore, from LN2, Portland dolomite cement (PDC) can be produced.

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# TECHNICAL SESSION - I B

## OTHER BUILDING MATERIALS & BINDERS

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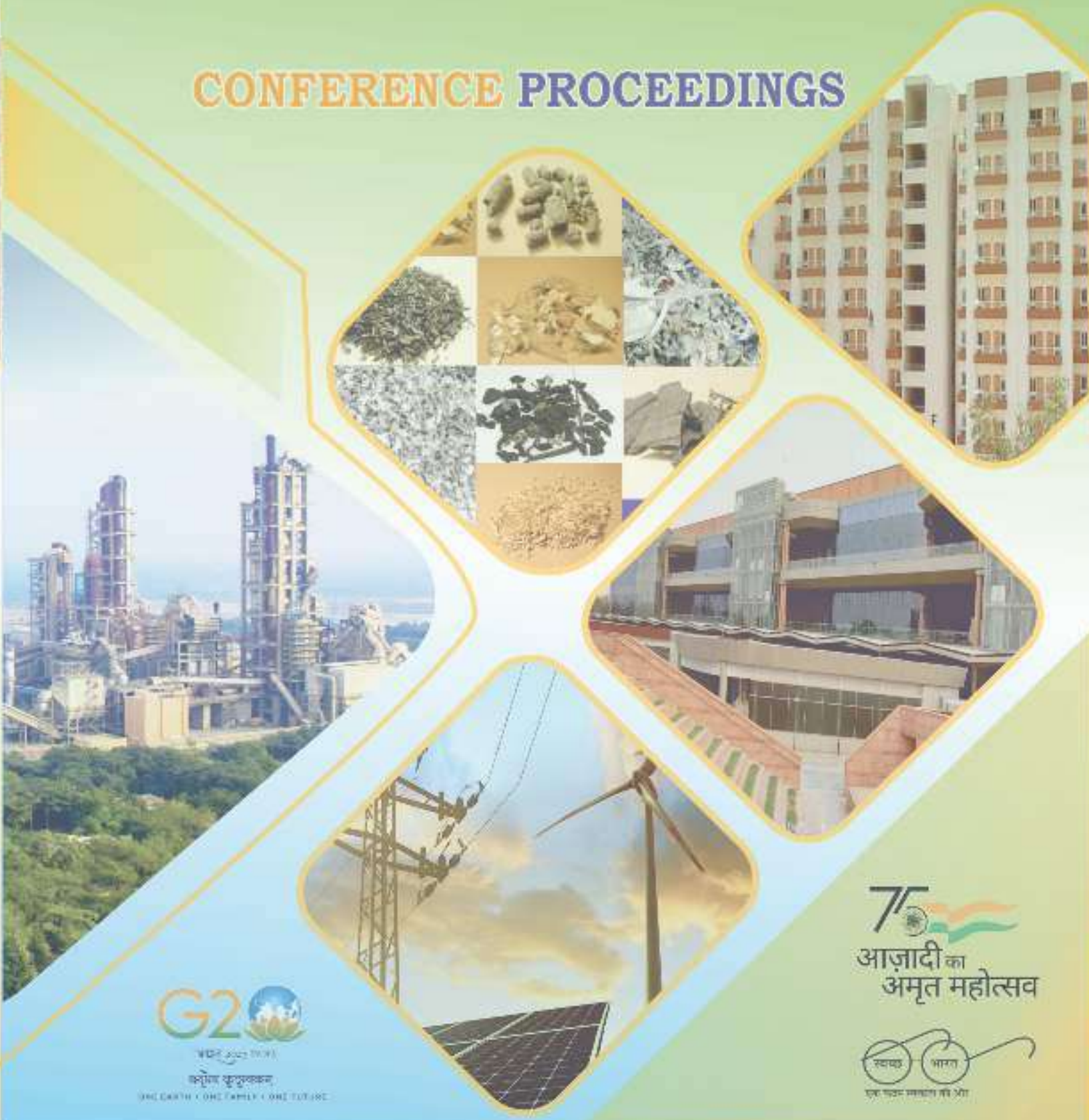

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# MINERALOGICAL AND MORPHOLOGICAL ATTRIBUTES OF HYDRATED ALUMINATE PHASE INCORPORATING SILICA NANOPARTICLES

**Aarti Solanki[1,2], U Sharma[1], L P Singh[1,2] & S R Karade[1,2]**

*[1]CSIR- Central Building Research Institute, Roorkee*

*[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad*

Tricalcium aluminate ($C_3A$) is the most reactive phase and it majorly controls the first 24 hr hydration mechanism of the cementitious system. In the present paper, a detailed morphological study of $C_3A$ in the presence and absence of silica nanoparticles (n-$SiO_2$) at different time intervals (10 min, 1 hr, 6 hr, 24 hr, 2 days, and 10 days) has been studied. Mineralogical and morphological modifications in hydrated products formed during hydration were examined through XRD and FESEM techniques, respectively. XRD results reveal the formation of meta-stable calcium aluminate ($C_2AH_8$ and $C_4AH_{13}$ or h-AFm) and katoite ($C_3AH_6$) phases at 2θ ~11° and ~32° at the very initial stage (10 min) and the intensity of these peaks increases as the hydration process, respectively. While, in n-$SiO_2$ incorporated $C_3A$ samples, no h-AFm peak was observed and a new peak appeared at 2θ ~33° at 2 and 10 days of hydration, which shows n-$SiO_2$ retard the formation of h-AFm phases and promotes the formation of siliceous-hydrogarnet and C-S-H/C-A-S-H phase. Micrographs of pure hydrated $C_3A$ show hexagonal-plate-like morphology at the very initial stage (10 min and 1 hr of hydration), which could be hydrated hydroxy-AFm. However, cubical-katoite with some polyhedral-katoite is observed at 24 hr of hydration showing the conversion of meta-stable h-AFm phases into stable cubical or polyhedral-katoite. On the other hand, in the n-$SiO_2$ incorporated $C_3A$ system, a gel-like hydrated product along with cubical or polyhedral-katoite is observed. This study presents a detailed morphological alteration in the n-$SiO_2$ incorporated $C_3A$ system at an early stage of hydration, which will help in understanding the influence of other admixtures (such as superplasticizers, accelerators, and retarders) in the n-$SiO_2$ modified cementitious system.


# FEASIBILITY STUDY ON USE OF FGD GYPSUM REPLACING NATURAL MINERAL GYPSUM IN OPC & PPC - A CASE STUDY

**Satyendra Kumar, Pravesh Kumar Sharma, Dinesh Agrawal & Manish Kumar Singh**

*Prism Johnson Limited, India*

Indian cement industry is the second largest cement producer in the world coming next to China. In the 2019-20 survey, the cement installed capacity in India was about 537 million tons per annum[2*] with the production of 334 million tons of cement along with consumption of gypsum of 13.0 to 17.0 million tons out of which 3.0 to 5.0 million tons was imported[6*]. The cement production is projected to increase to 491 million tons in the year 2024-25 and by 2030 production is estimated to double if it grows at a normal rate of 6% leading to a proportionate increase in the demand for cement, thereby increasing the gypsum requirements to 19.6-24.6 million tons, which shall be met by increasing Imports burden. Looking at the high landed cost of imported Natural Gypsum and the lesser availability of high-purity natural gypsum in India, it is the greatest challenge for Indian Cement Industries to get prepared for the coming threat. This needs to be explored and investigated for an alternate source of cement grade Gypsum which is one of the main pillars of Cement Sustainability. Gypsum is an essential raw material for Cement production to regulate the setting time as retarder, which can be sourced as chemical gypsum and from TPP using high Sulphur coal / Petcoke as fuel with Flue Gas Desulphurization (FGD) systems, which generate FGD Gypsum. Compared to Chemical gypsum FGD[13*] can be said to be more preferable considering its consistency in quality and its lesser negative impacts on cement quality.

This Paper discusses the studies carried out at Prism Johnson Plant, to assess the feasibility of use of FGD Gypsum. As a part of these studies, a comparison of Optimum gypsum requirements of OPC &PPC (fly ash Based) products has been done with the use of FGD and Natural Mineral Gypsum, which indicated some clear advantages of using FGD Gypsum. The paper also further discusses the effect of the use of FGD Gypsum in OPC & PPC on the Physical Properties of cement Mortars (e.g. Water demand, Setting time & strength development at early and later ages. A comparison is also made on the M20 concrete properties. The paper finally also indicates the advantages derived at Plant scale usage of FGD Gypsum indicating even potential to reduce costs.

# SELECTION AND USE OF NATURAL SHALE AS SCM

**Raghunathan Swaminathan, Biju Karukkunnammal, Shivakumar M, Shanmuga Priya T & Thirumalini Selvaraj**

*FLSmidth Pvt Ltd, Kelambakkam, Tamilnadu*

Based on their geographic availability, the most prevalent shale clays in the southern parts of India are being identified in this study, and their usefulness as SCM is being investigated. Calcareous rich shale and Silica-rich shale were chosen as the two types of shale clays to be analysed using X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) techniques to determine the mineralogical phases and their composition. SCMs high in kaolinite or montmorillonite are currently widely accessible on the market. The shale samples that were gathered for this study displayed mixed clay behaviour, which hasn't gotten much attention in recent studies. In the current investigation shale clay was calcined up to 1000°C, and the loss on ignition for clay-rich shale was around 5-6% and calcite-clay rich shale around 14-15%, respectively. Clay-rich shale had a specific gravity of 2.3 and calcite-rich shale had a specific gravity of 2.2–2.4. When compared to clay shale, the calcite-clay rich shale exhibits great burnability due to the presence of Ca-MgO at a percentage of 15-20%, which is supported by XRF analysis. In clay-rich shale, XRD analysis revealed the presence of minerals such as illite, montmorillonite, quartz, calcite, and Magno-calcite. In addition, clay-rich shale displayed the absence of Ca-MgO peaks with high quartz grouped minerals, namely pyrophyllite generated when calcined up to 600°C. Furthermore, calcined shale up to 800°C exhibited the absence in the kaolinite and Ca-Mg peaks that reported less pozzolanic compared with calcite rich clay that acts as a binder and SCM. Moreover, the low calcined calcite rich shale has shown promising results to investigate colour control properties and its structural formations during industrial kiln production.

# FEASIBILITY STUDIES OF CLAY NEAR PALI REGIONS (RAJASTHAN) FOR LC$^3$ PRODUCTION

**Sunil Kumar Saxena & Mukesh Kumar**

*J K Lakshmi Cement Ltd, Rajasthan*

With limited availability of conventional SCMs, use of calcined clays - available in large quantities as alternate SCM's has provided an opportunity to reduce clinker factor in cement production and therefore its production costs. There are abundant reserves of low-grade China clays that can serve as excellent SCM's. Limestone calcined clay cement (LC$^3$) provides an opportunity to use these low grade clays and limestone rejects in a profitable manner without harming the environment. LC$^3$ has provided an excellent opportunity to reduce costs especially in the cases where clinker has a high production cost or the quality is not very good for making high quality cement or being imported. Additionally, where pozzolana is not available or is expensive than clinker, LC$^3$ becomes a viable option.

Under this technical study, 9 clay samples from 3 mines Dariyao Kanvar (DK), Rajasthan (R) and Shyam Soni (SS) near JK Lakshmi cement Ltd, Sirohi, Rajasthan (India) were investigated for determining their suitability as an SCM in LC$^3$. Samples were characterized by using following techniques X-ray diffraction (XRD), X-ray fluorescence (XRF) and thermogravimetric analysis (TGA). The lime reactivity for all the clays were determined individually. Also, blends of low- and high-grade clays were prepared in 1:1 ratio and their lime reactivity were observed. Grades A and B from all the 3 mines show kaolinite content of more than 40% and show suitable pozzolanic reactivity in the lime reactivity test and hence they all are suitable for LC$^3$ production. Whereas overburden from all the 3 mines is not suitable for LC$^3$ production. But they can be blended with other clays in a certain proportion to be able to provide sufficient reactivity. This can be further explored with laboratory testing.

# TO UTILIZE WASTE BED ASH AS SYNTHETIC GYPSUM IN PORTLAND WHITE CEMENT MANUFACTURING

**R K Singh, Arvind Gupta, Vinit Purohit & Kareena Kumari**

*UltraTech Cement Limited-Birla White, India*

The goal of this study is to investigate the feasibility of replacement of natural gypsum with synthetic gypsum prepared by waste Bedash (SG-BA) used as set retarder in Portland cement. Bed ash is completely of no use after being processed in Thermal Power Plant (TPP) therefore, in this paper, we have researched & presented a sustainable way to utilize the waste bedash by preparing synthetic Gypsum (SG-BA) and adding it to cement production. Alternative raw materials (synthetic gypsum) are used so as to reduce energy consumption and lessen $CO_2$ emissions during production, along with providing comparable performances. The introduction of SG-BA in Cement production implements a saving of naturally occurring marine or mineral gypsum. SG-BA is not only showing gypsum properties as well as it is easy to grind. The selected SG-BA, clinker, and marine gypsum are grinded in the lab ball mill (LBM) to produce Portland cement of desirable specific surface area. The characterization and elemental analysis of bedash are of high importance. The higher $SO_3$ content makes bed ash suitable for partial replacement of the natural gypsum. Earlier petcoke was being used by TPP for power generation and $SO_3$% content was estimated on the higher side, but since 2019 after the petcoke ban in India, $SO_3$% content in bedash is estimated to be on the lower side (due to use of low-sulphur coal). The concentration of anhydrite (11%) and lime (15%) is high and there is a possibility to convert this free lime into synthetic gypsum by adding $H_2SO_4$. SG-BA contains 18% soluble $SO_3$ which reacts with the Clinker $C_3A$ Phases and results in the formation of $C_3A.CaSO_4.32H_2O$ (Ettringite) phase detected by using X-ray diffraction analysis. This paper consists of study based on different proportions of replacement of Marine Gypsum by SG-BA added in Portland cement with 25%,50%,75%, 100% respectively. In this study, we observed that the sample containing 25% replacement of Marine Gypsum reflected better properties in terms of Blaine, compressive strength, and whiteness as compared to neat white cement. This introduction of SG-BA in white cement lead us on the roadmap of sustainability by effectively utilizing waste as the part of ingredient with green and environment friendly character. There is also implication of saving natural reserves of Gypsum by replacing with SG-BA.

# A STUDY ON UTILIZATION OF PAPER MILL LIME SLUDGE IN THE MANUFACTURE OF CEMENT UNDER CIRCULAR ECONOMY

**A K Dikshit, B B Sahoo, Varsha Liju, Munish Kumar, Ravendra Singh & S K Chaturvedi**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

The path forward for the cement industry is clear to embrace sustainability through circular economy. These two trends at the core of planning for the future will help cement players to achieve considerable productivity gains. Lime sludge (LS) is one of the industrial wastes produced in paper and pulp industries during paper manufacturing which is generally disposed outside for land filling and creates adverse impact on environment. The chemical composition lime sludge sample contains CaO in around (52-55) %, $SiO_2$ (1-4) %, $Al_2O_3$ and $Fe_2O_3$ make up less than 1% by weight. Minor alkalis of $Na_2O$, $K_2O$ and $SO_3$ content are less than 1 wt%. XRD profile and TG/DTA results showed that all lime sludge samples have major calcite ($CaCO_3$) phase. Investigation by optical microscopy of microstructure and morphology revealed that calcite grains are presents as rounded shape agglomerated form. Portland cement clinker has been prepared using lime sludge from 30-50% by weight replacement of limestone and these clinkers are compared with clinkers made off conventional raw materials. Burnability investigation of clinkers are showing free lime content with the limit specified by Indian standards. Mineralogical characterizations using X-Ray Diffraction and Optical microscopy are showing desirable clinker phases formation with required quantity. The characterizations of all obtained results are encouraging for replacement of limestone in the cement and construction industry by using lime sludge which is technically suitable and economically viable for waste management in favour of circular economy.

# TRANSITION FROM LINEAR TO CIRCULAR ECONOMY IN GYPSUM IN INDIA

**Anand Bohra, S K Chaturvedi & B N Mohapatra**

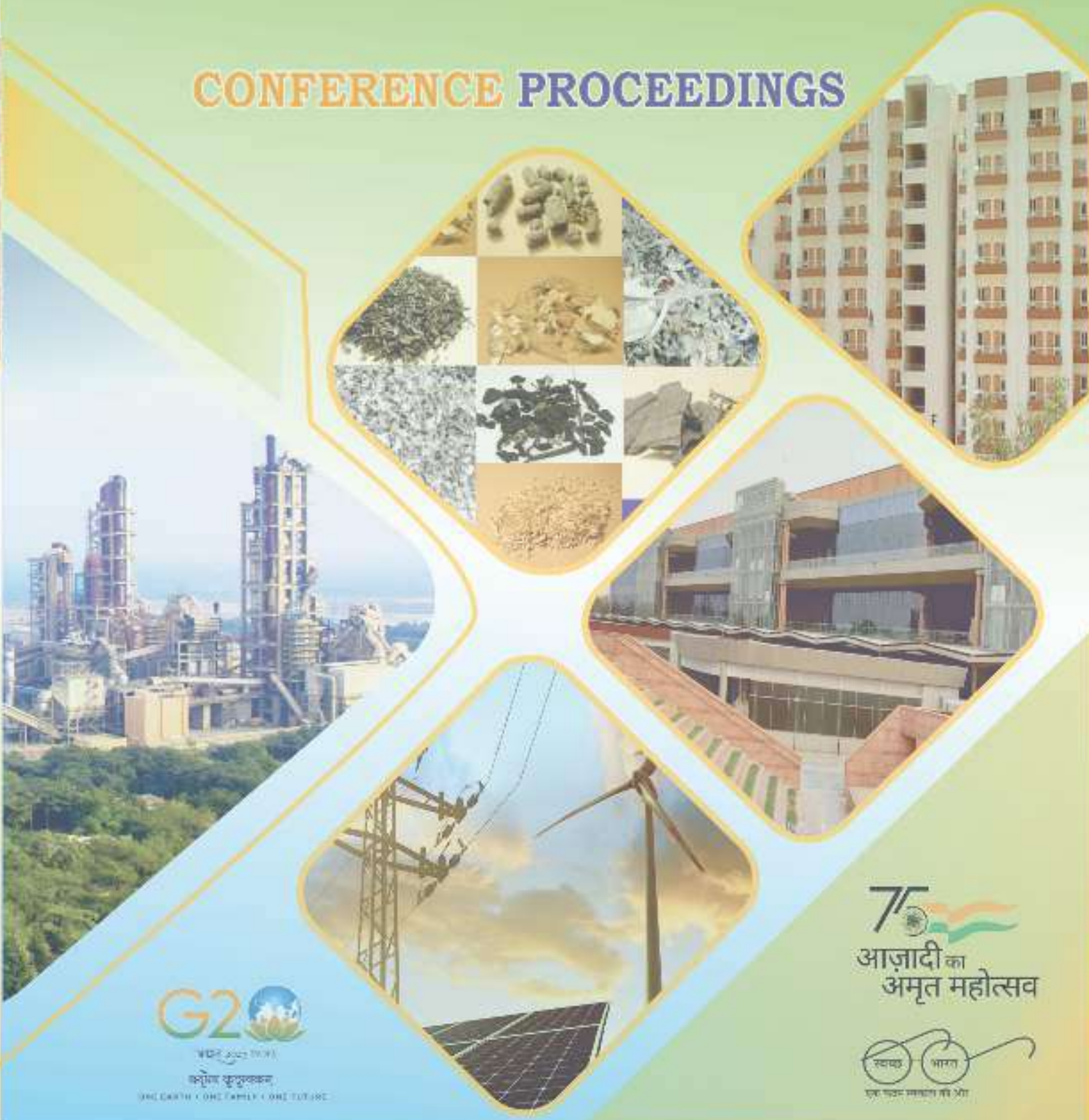
*National Council for Cement and Building Materials, Ballabgarh, Haryana*

For sustainable development in India, there is an urgent need to follow the principles of Industrial symbiosis in the industrial processes, under which the scraps, wastes or by-products of one industry can become the raw materials for another. This will not only help in reducing the dependence on natural resources but also help in gaining economic advantage to the industry. Gypsum is one such area in India, where the linear economy model of by-product gypsum utilization has resulted in unutilized legacy phosphogypsum stock of 64.65 million tonnes (mt) at phosphoric acid plants in India. In future, this unutilized gypsum stock will increase further due to the expected generation of Flue Gas Desulphurization (FGD) gypsum in huge quantities from thermal power plants. Therefore, it is very essential to transit from the linear to circular economy in Gypsum in India, which will result in huge environment as well as ecological benefits. Gypsum is required in many sectors like Construction (Cement industry, gypsum boards, glass fibre reinforced gypsum panels, gypsum plaster, fly ash lime bricks, floor screeds, road construction), agriculture, in manufacture of Plaster of Paris, pottery, ceramic industry, water treatment processes, manufacture of ammonium sulphate, paints, textiles etc. The challenges faced in areas of quality, policy, logistics, lack of infrastructure, promotion etc. for complete utilization of by-product gypsum have been discussed. The untapped potential of by-product gypsum utilization in various sectors like use of gypsum in agriculture for sodic soil reclamation, utilization of legacy stock in cement industry on mission mode, improvement in quality of by-product gypsum by standardization and usage in building materials industry has been identified. Based on the measures required to tackle the various challenges and utilization of untapped potential of gypsum, a comprehensive action plan for transition from linear to circular economy in gypsum in India has been formulated. The strategies and policy measures required to implement the action plan to achieve circular economy in Gypsum have been recommended for various government departments. It is estimated that the focused implementation of proposed action plan would result in significant decrease in unutilized gypsum legacy stock in the next five years and it would cease to exist by 2027-28 if the proposed action plan is effectively implemented.

# TECHNICAL SESSION - II A

## CEMENT PLANT MACHINERY & PROJECT ENGINEERING - I

# CONFERENCE PROCEEDINGS



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# INSIDE THE VRM CONCEPT A HOLISTIC APPROACH

**Thomas Schmitz & Markus Hastrich**

*Thyssenkrupp Industrial Solutions AG, BU Polysius, Beckum, Germany*

The vertical roller mill takes a holistic approach to modern grinding systems in terms of its simple and compatible design. Put simply and briefly, the vertical roller mill remains one of the leading grinding systems in the market in terms of its simple and compatible design structure. Requirements by plant operators for a reliable solution have been converted into a highly efficient grinding system. The reduction in mechanical components lessens the probability of failure and maintenance work, which is the philosophy behind the VRM concept. A further key role in cutting downtime is played by the mill foundation, which has been optimised to reduce vibrations.

The high content of preassembled components, around 50 per cent of the mill system, a reduction in mechanical parts and sensor technology inside the mill atmosphere, exceptional damping characteristics and operational continuity are the resulting sum. Describing the key concepts behind the technology, the presentation shares also notable operation experiences and results from cement mills in Guatemala and raw mills in Saudi Arabia. Apart from mechanical and civil simplification, general process and mill configuration, the implementation and application of data processing lead to an increase in availability. The knowledge of the grinding forces is extremely important as forces occur as a result of the grinding work. Databased intelligent systems are mandatory for future predictive maintenance.


# STUDY ON PERFORMANCE IMPROVEMENT OF CALCINER USING CFD SIMULATION

**Basavaraj K[1], Sagar Gulawani[1], Jayateerth V Joshi[2], Sanjeev Srivastava[2] & Raju Goyal[2]**

*[1]Aditya Birla Science & Technology Company Pvt Ltd., Navi mumbai*
*[2]Aditya Birla Group, Technical & Performance Monitoring Cell, UltraTech Cement Limited, Mumbai*

In cement industry, calciner is the main equipment where almost 92-95% calcination reaction takes place which convert limestone ($CaCO_3$) into quicklime (CaO) and carbon dioxide $CO_2$. This involve complex flow and temperature distribution caused by firing of coal and calcination reaction which are essential for determining calciner performance. One of UTCL Separate Line calciner was facing the issue of high temperature variations across calciner outlet passage for long. This temperature variation was led to huge coating formation at calciner outlet resulting in increased draft causing energy losses and production loss. The coating was dominant in half section of calciner. In this study, Computational Fluid Dynamics (CFD) was applied to understand the effect of flow dynamics on combustion and calcination phenomena inside the calciner. Temperature and velocity flow distribution in calciner domain and calciner outlet was analyzed. A suitable modification at calciner outlet was suggested to improve flow distribution in calciner which eventually helps to improve heat distribution in calciner domain and at outlet which in-turn reduces coating as well as exit gas temperature.

# IN-HOUSE FABRICATION AND ERECTION OF PRIMARY HAMMER CRUSHER FOR TPP

**Rajesh Keswani, Prahlad Kumar Kabra, Mukesh Kumar & Sunil Kumar Saxena**

*J K Lakshmi Cement Ltd, Rajasthan*

Existing Coal feeding circuit have a Secondary Crusher in the circuit. After banning of the Pet coke in Thermal Power Plant by the hon'ble Supreme Court as a part of measure to fix $SO_2$, NOx & SOx standards to prevent pollution, J K Lakshmi Cement Limited, Sirohi, Rajasthan are using SA Coal/Indonesian/ Columbian, Australian Coal in TPP. This coal contains big size lumps in it and due to the big size lumps present in this coal, frequent damage in Vibrating Screen pads occurs further leading to Coal line jamming which ultimately effects the efficiency of TPP. To minimize and curtail the damage in Vibrating Screen pads due to big size coal which was lowering the efficacy of TPP and jamming the coal lines. JKLC has in-house fabricated primary hammer crusher and implemented the same. This eliminated stoppage of vibrating screen, reduced the maintenance cost.

# CLINKER COOLING SOLUTION

**Ravi Saksena[1] & Anurag Johari[2]**

*[1]KHD Humboldt Wedag, Cologne, Germany*

*[2]Humboldt Wedag India Pvt. Ltd., India*

A sustainable clinker cooler technology is the driving factor for the efficient and reliable performance of the entire cement plant and is an essential component for the industry. As on date when Industry is committed for turning the stone around for decarbonisation in order to achieve the "net zero" in cement production as targeted, continuous developments and improvements in the existing system is need of the hour. Over the last decades, extensive research and developments work has been carried out for innovated and developed important technological solutions for clinker cooling, to deliver coolers that not only offer improvements over the conventional functions of clinker cooling and transport, as well as provides best available solutions for sustainable and continued advantages in terms of installation and operating costs resulting in optimum cost of ownership.

Latest generation of coolers, relies on the walking floor principle for the clinker transport. The walking floor moves the clinker towards the discharge end of the cooler by alternating movement patterns of the lanes. The shear friction between the clinker bed of the opposed moving lanes disable the movement of the clinker bed while retracting each of the lanes. The key features of this generation of clinker cooler are to maintain high heat recuperation while decreasing the maintenance cost. With no conveying elements within the clinker bed because of the autogenous protection of the dead clinker layer and the new cassettes design the lowest possible wear is achieved. Additionally, the improved cassettes design and new metal-to-metal-contact type lateral sealing of the lanes prevent clinker fall through, thus there is no need of any clinker transport underneath the cooler. This aspect saves building height of the cooler and also building height of the whole clinker production line. An innovative approach for modernizing the existing portfolio of clinker coolers to align the future goal of cement industry by means of providing efficient, reliable and sustainable machine enabling all the stake holders of the industry to contribute and support the target of the nation for "net zero emission"

# RECUPERATE, COOL AND SUSTAIN

**R Madhusudan & N Soundararaj**

*IKN Engineering India Pvt. Ltd., India*

We would have heard, "slow and steady will win the race". Another side of this proverb; is that "fast and consistent will always win the race". We are talking about the fascinating news from Incredible India at this juncture! Under this pandemic, IKN has supplied the IKN Pendulum cooler parts as promised. The joint baseline study, installation, hot commissioning, and Performance guarantee test were completed successfully during this pandemic. The Dalmia Bharat group carefully evaluated and chose the IKN pendulum cooler to replace their outdated air beam technology cooler for their 4700 TPD operating line in the Dalmiapuram plant.

# UTILIZING CURVED CONVEYOR TECHNOLOGY FOR EFFICIENT LONG- DISTANCE MATERIAL TRANSPORT

**Markus Rehbock & Alexander Tigges**

*BEUMER Group, Germany*

Amid growing demands to reduce their environmental footprint, cement companies have begun to explore ways to conduct their cement plant operations more sustainably. One area of interest is the efficient transport of the raw material (limestone) from mines to plant, especially over long distances. Here, cement companies more often turn to Overland conveyors due to their reliability, efficiency, and low total cost of ownership over time.

There are tremendous benefits in utilizing state-of- the-art material handling systems to transport limestone, especially over long distances. With decades of experience in material handling, BEUMER Group prides itself to being able to support cement customers in finding the optimal material handling solution for all applications. Various conveyor types can be utilized to transport mined material. But especially for longer distances, the advantages of utilizing a single- flight curved overland conveyor, U-shape conveyor, or pipe conveyor, opposed to a set of shorter straight conventional conveyors with transfer towers are significant. This paper describes the fundamentals and capabilities of state-of-the-art conveying systems and compares both conventional conveyors and curved trough conveyor technology. In addition, an in-depth case study analysis will be presented to illustrate the possibilities to reduce total cost of ownership and minimizing operating expenses, by using a single- flight overland conveying system.

# CORRELATION OF CHEMISTRY AND PROCESS PARAMETERS ON FORMATION OF ALITE IN PORTLAND CLINKER

**Jaiprakash Varti[1], Suresh Palla[2], Suresh Vanguri[2], Ramchandra Rao[2], S K Chaturvedi[2] & B N Mohapatra[2]**

*[1]Ambuja Cement Ltd*

*[2]National Council for Cement and Building Materials, Ballabgarh, Haryana*

Digital transformation can make industries more efficient, profitable and sustainable to enable them for better response to the global challenges such as environmental concerns, shortage of natural resources and utilization of industrial waste etc. Combination of advanced data science software's and advanced analytical techniques such as X-ray Diffraction can play important role in the clinker manufacture to enhance productivity, resource conservation and economical feasibility. The work reported in this paper aims to establish correlations between formation of clinker phases $C_3S$, $C_2S$, $C_3A$, $C_4AF$ & free lime with chemistry, fineness of raw mix, kiln tph, kiln rpm, inlet oxygen level, CO level, burning zone temperature and cooling characteristics. The present study evaluated the actual clinker mineralogy by XRD with clinker chemistry in the range of 85.08 to 96.96 percent. It is observed that chemistry of clinker plays a critical role for the desired level clinker mineralogy formation. Also, LSF alone doesn't show any significant impact in $C_3S$ formation and the combination of LSF, SM and AM are critical for desired clinker mineralogy. The results also indicated that at optimum levels of LSF, SM and AM, more than 15% of $C_3S$ was observed than the Bogue equation values. The optimum levels of LSF, SM and AM are in the range of 85.66 to 89.35, 2.28 to 2.42 and 1.37 to 1.61. Parameters related to clinkerization process like kiln feed tph, kiln torque, burning zone temperature, inlet CO, $O_2$ and rpm of kiln were also found to be crucial, but secondary to the raw material and clinker chemistry for formation better clinker mineralogy. Quality of raw materials was found to be predominant contributor in the clinker mineralogy. To estimate the actual clinker mineralogy, advanced analytical tools coupled with analysis software's such as XRD and Reitveld techniques can be utilized for better quality control.

# RECENT TRENDS IN INDIAN CEMENT INDUSTRY – A PRAGMATIC APPROACH

**A K Dembla, Sandeep Zutshi & Deepti Varshney**

*KHD Humboldt Wedag India Pvt. Ltd., New Delhi*

The Indian Cement Industry has consistently demonstrated high manufacturing capability through adoption of the state of art technologies and best in class processes. Over 40 per cent of the current installed capacity has been implemented over the last decade incorporating automated processes and latest plant machinery. An environmentally conscious business leadership has placed India amongst the most energy and resource efficient manufacturers of cement in the world. The Indian Cement Industry has established itself as a global leader in environmental and socially responsible manufacturing. It is largely by virtue of efforts put in place by the core sectors such as cement that India is well on track in meeting its Nationally Determined Contributions targets and staying compliant with the Paris Agreement pledge.

The Indian Cement Industry is a frontrunner in the mission for change and has been implementing significant technological measures to ensure a greener future for the Country and the society. It is the only sector to have voluntarily devised a Low Carbon Technology Roadmap aimed at reducing its direct $CO^2$ emission intensity by 45% till 2050 from a 2010 baseline. Over the years, the Indian Cement Industry has nurtured blended types of cement to the extent of 73% starting from to 28% in 1992, which again highlights the remarkable contribution being made by the Cement Industry in the transition towards the green growth of the sector.Not only this the industry has seen many trends over the decades which has contributed for its state today and supposed to model the shape as envisaged by 2050.This paper deals with the current status of the industry and the various trends it has witnessed and the contributions made by various stakeholders to firm foot the industry.

# OPTIMISATION OF CEMENT MILL (VRM), A CASE STUDY

**Anil Kumar Popuri [1], KPK Reddy[1], Saurabh Bhatnagar[1] & Sandip Samanta[2]**

*[1]National Council for cement and Building Materials, Ballabgarh, Haryana*
*[2]Star Cement Limited, Assam*

The rising energy cost in cement manufacture has spurred developmental efforts towards more effective energy conservation measures. Of late, to contain energy cost as well as make cement manufacture more and more environmentally benign, waste energy management, adopting power cogeneration system based on waste heat recovery, is gaining importance. Such a development assumes considerable significance and potential in cement industry in order to achieve cost economy and environmental excellence. Vertical Roller Mill (VRM) is an important machine for grinding and mixing of various materials especially in the process of producing Raw mix and Portland Cement. This paper discusses various levers for process optimisation of Cement Vertical roller mill to reduce energy consumption and improvement in production.

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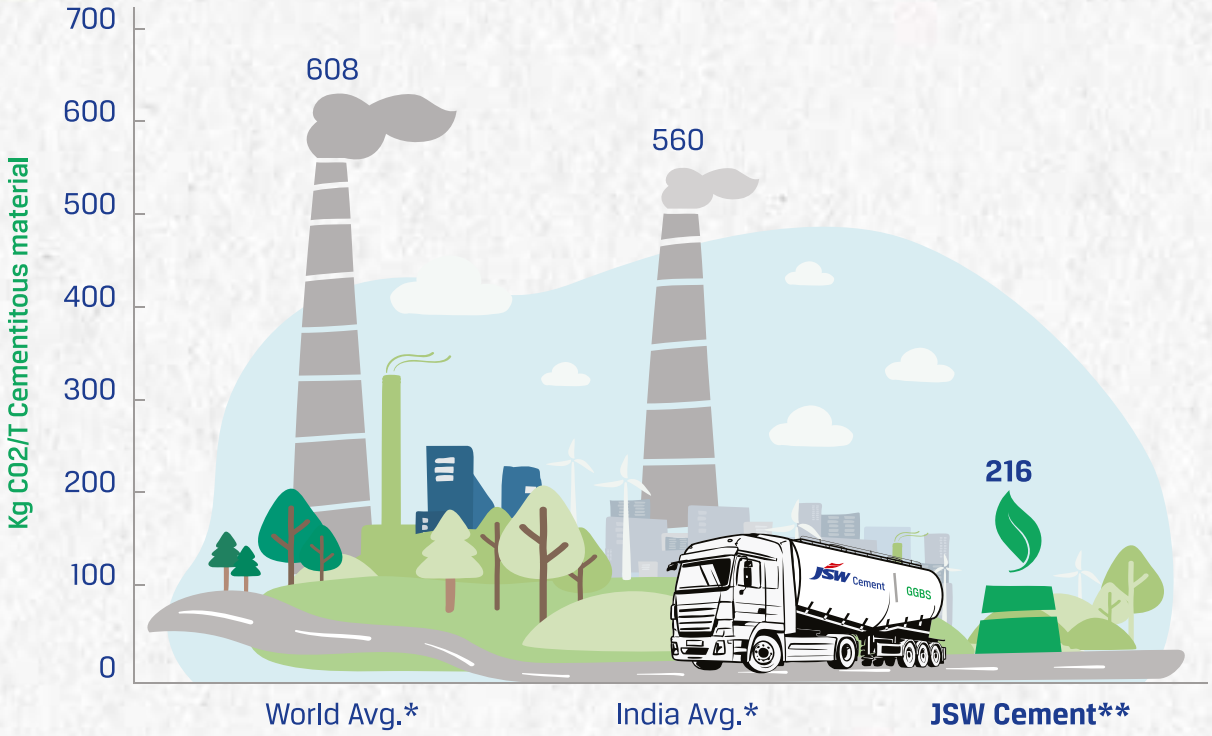
## Net Scope-1 Emissions Intensity Comparison




Source: GCCA GNR Data 2019 - https://gccassociation.org/gnr/
Externally verified GHG statement

*Year 2019
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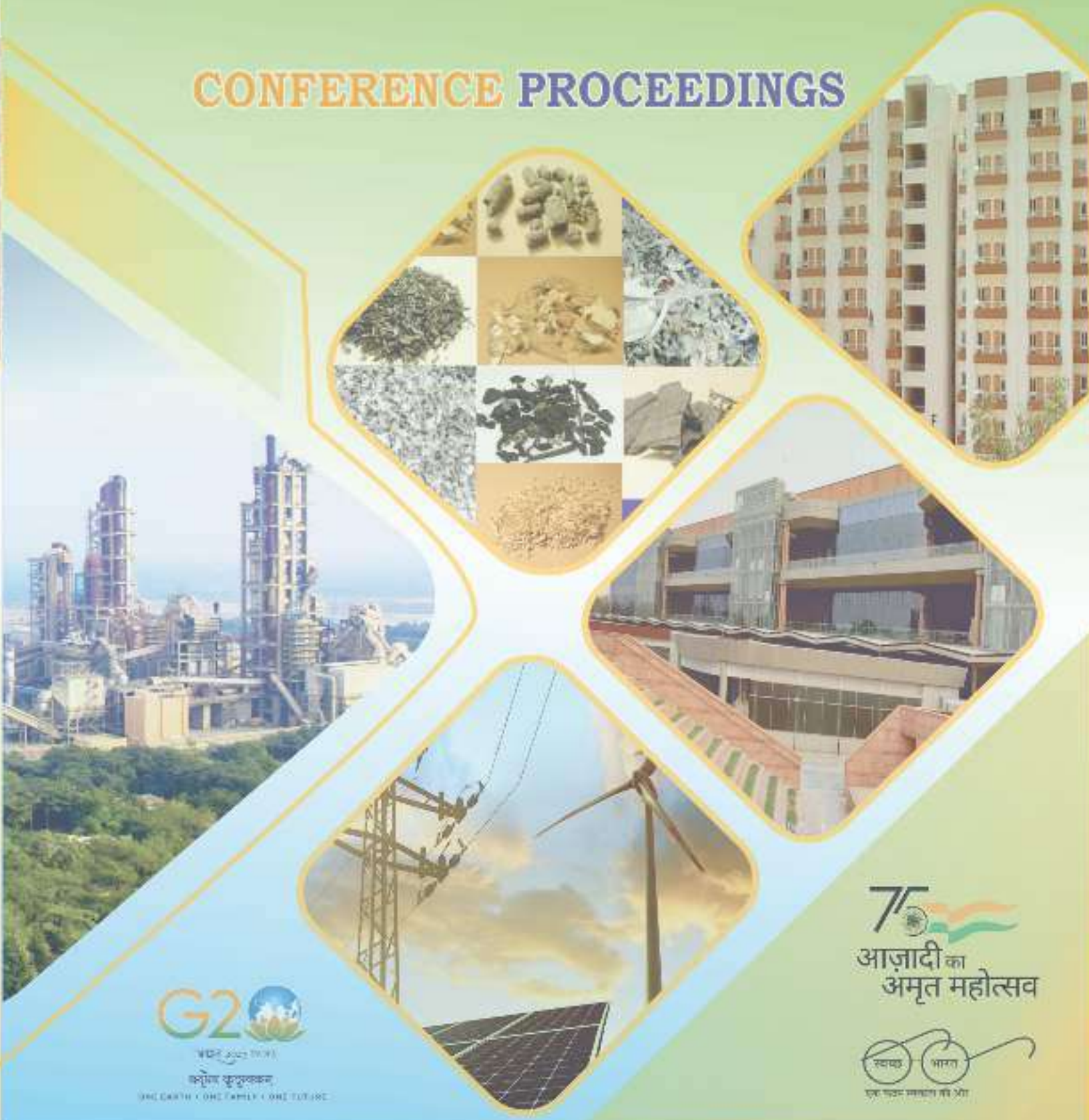
# TECHNICAL SESSION - II B

## ALTERNATE/WASTE FUELS AND RAW MATERIALS - I

# CONFERENCE PROCEEDINGS



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# ALTERNATE SOLID FUEL HANDLING EQUIPMENT CASE STUDY ON THE SOLUTION PROPOSED TO A REPUTED CEMENT MANUFACTURING UNIT IN THE MIDDLE EAST

**Rhea Muthappa & Sunil Kumbhar**

*AltSF Process, Pune*

The alarming rise in waste generation and fall in the availability of fossil fuels have together highlighted the requirement of co-processing of various wastes in the cement plant. Co-processing of these alternative fuels (AF) in the cement plant is an effective option as it leads to energy recovery with no residual waste generation from the material along with effective substitution of fossil fuels. The major challenges in increasing the thermal substitution rates (TSR) is of supply of good quality fuel and process stabilisation after feeding. In order to address these issues a versatile, low budget but effective feeding system is required. For preliminary feeding stages, a phase wise installation can be opted for, where the initial feeding system shall be a cost effective, low capacity system. This shall allow the user to acclimatise the process to the introduction of waste and gradually upgrade to higher capacities.

This paper contains a detailed account of the proposed starter kit at a reputed cement plant in the Middle-East. The system comprises of a container-hoist conveying system, a metallic apron conveyor (MACFEED) and CalFEED, which is a double valve with a safety gate arrangement. The fitment of the proposed solution in the existing plant set-up requires minimum civil and structural modifications and is effective for initiating the AFR utilisation. Eventually, the system can be upgraded up to 15 TPH with minor modifications and installation of an apt conveying set-up along with the reception unit at the ground level. HoppFEED, WeighFEED and RALFEED (Alternate option for calciner feeding) are also elaborated in detail for highlighting the upgrade potential of the system. The technical details of the equipment, operation, working and the upgrade has been discussed in this paper.

# ENHANCEMENT OF LIQUID AFR BY OPTIMIZATION OF NOZZLE SYSTEM

**Girdhar Mishra & Ketan Goel**

*Invotech Industrial Solutions Pvt. Ltd.*

The Indian cement industry is the most energy efficient in the world. At present, the Installed capacity of cement in India is 500 MTPA with a production of 370 MTPA for aggregate clinker along with thermal captive power generating capacity of about 5020 MW and WHRs of over 900 MW. India's cement production capacity is expected to reach 600 MT by 2025. The cement demand in India is estimated to touch 419.92 MT by FY 2027. As the cement industry is a resource-intensive industry that uses enormous quantities of natural resources as raw materials and fuels. While the known fossil fuels, and more importantly coal, which is the primary fuel for the Indian cement industry are fast depleting, it is imperative to look for alternatives. Similarly, increasing demand for cement in the country, exploring alternative resources such as fuels and Raw materials is an important imperative that the cement industry must look for.

Co-Processing in cement kiln is a scientific, proven & established technology for disposing of hazardous & other non-recyclable waste in an environmentally sustainable way. Due to its advantages in terms of combustion of waste & no residual left over, the cement kiln stands apart among the different methods of waste disposal like incineration, waste to energy, and landfilling. Co-processing leads to 100% energy and material recovery and does not leave behind any ash for further disposal (i.e., no liability for waste generators once waste is co-processed in cement kilns). Due to its economic, environmental, and social benefits, it has been recognized as one of the five important levers for large scale reduction of $CO_2$ emissions from Indian cement industry, in the low-carbon technology roadmap. This paper presents a case study of cement plant where liquid AFR is enhanced from 0.5 kL/hr to 4 kl/hr by optimization of nozzle design liquid AF firing.

# INCREASED USAGE OF ALTERNATE FUELS BY UP-GRADATION OF FULL-FLEDGED FEEDING SYSTEM

**T Robert, G Shankarappa & V Saravanan**

*Dalmia Cement (Bharat) Ltd., Ariyalur*

At Dalmia Ariyalur unit, the Alternate Fuel utilization was 6% on TSR basis with temporary feeding arrangement and we are using different kind of waste materials like RDF, Plastic Wastes, Tire threads, Resin waste, Cotton waste, Municipal solid waste, High ash waste mix solid and paint sludge at the feeding rate of 60-80 tons per day. Further we couldn't able to increase more than 80 tons per day due to constraint in the bucket capacity and also we were facing lot of challenges in manual feeding system like more fluctuation in PC outlet temp, feed rate, more manual intervention, no proper mixing which were all leading to increase the more CO formation at kiln inlet and also affecting the clinker production because of more free lime and kiln become dusty condition. To overcome this issue, we have installed full-fledged AFR feeding system.

As committed by Group CEO to achieve Carbon negative by 2040, We had decided to set up a new AFR feeding system with full-fledged manner for Co-processing as well as Pre-processing system with investment of 23 Crores to achieve 18% TSR and Full-fledged feeding system was erected and commissioned successfully on Nov-20.

# ANALYSIS OF ALTERNATIVE FUEL RESOURCE (AFR) BY ENERGY DISPERSIVE X-RAY FLUORESCENCE (EDXRF)

**D Gupta & B N Srivastava**

*Malvern Panalytical, India*

This technical paper presents feasibility of elemental analysis of typical AFR (Alternative Fuel Resource) samples using our latest benchtop EDXRF system. Challenges and solutions for non-destructive sample preparation of AFR has been discussed. Further it has been demonstrated how standard less (Omnian) analysis of AFR samples can help users to scan and quantify an entire range of elements from F-Am. The advantages of EDXRF analysis, relevant to AFR has been discussed along with exemplary results of the analyses, compliance with international norms, and detection limits.

# INNOVATIVE SOLUTIONS FOR MAXIMISING ALTERNATIVE FUEL USAGE

**Sitaram Sharma & Vikram Kancharidasu**

*KHD Humboldt Wedag India Pvt. Ltd., New Delhi*

The use of Alternative Fuels (AF) is seen as one of the major steps in decarbonizing global cement industry apart from its obvious cost competitiveness over fossil fuels to attain better bottom line. As the use of AF is strongly increasing, also in countries without elaborate waste collection and pre-processing infrastructure, cement producers are looking for technologies that can handle any kind and quality of alternative fuels to simplify their procurement process and, at the same time, save costs that result from pre-processing efforts. Also, the use of wet and hard-to ignite biomass as AF calls for combustion technologies with high retention time and robust operation. Key technologies such as KHD's Pyrorotor® allow the use of almost any kind of alternative fuel, while guaranteeing a complete burn-out and the flexibility to handle fluctuating fuel quality levels without any deterioration in the quality of clinker. To reach higher thermal substitution rates, a suitable kiln Bypass is also necessary to eliminate the increased concentrations of Chlorine input through AF to avoid unwanted process disturbances. This paper highlights the working principle and advantages of Pyrorotor® and its operating references along with KHD's Kiln Bypass technology benefits in maximizing AF usage in cement plants.

# CO-PROCESSING SOLUTIONS FOR HANDLING OF ALTERNATE SOLID FUELS

**Luc Rieffel, S K Ambasta & Indrendra Singh**

*ATS Conveyors India Pvt. Ltd.*

Nowadays, Fuel costs have sky-rocketed, leading to maximized use of Alternate Fuels. As a result, majority of Cement production units are exploring ways to substitute coal consumption by maximized use of Alternative Solid Fuels (ASF) to increasing value of their Thermal Substitution Ratio (TSR). This paper presents two case studies for project executed in India by ATS with new technological advancement for co-processing of solid coarse alternative fuels in cement factory.

In first case, user had a firsthand experience of operating low capacity ASF Coprocessing circuit but when they planned to have capacity enhancement of their existing ASF then they made a market survey on various system and found WALTER equipment as the most flexible in handling all range of alternative solid fuels. In second case study, customer was a globally established brand in the field of ASF consumption having successfully running multiple installations of ASF Co-processing circuits within their different Cement plants all over the world. In this project the prime requirement was to have a ASF Co-processing circuit with a fully automated storage and Extraction system. As on date there are over 200 cement plants throughout the globe which are being served by the unique State of Art machines from WALTER Materials Handling division of ATS, with the first installation dating back in 1993 WALTER Material Handling has proved to be a global leader in the field of ASF handling systems.

# USE OF PHARMACEUTICAL LIQUID WASTE AS AN ALTERNATIVE FUEL (INITIATIVE ON TURING WASTE TO WEALTH)

**N S Rao & Pankaj Kumar**

*My Home Industries Private Ltd., Telangana*

AFR (Alternative fuel resource) is one of the important cost driver as well as a major contributor to our green initiatives. Hence, it becomes vital for us to maximize Thermal Substitution Rate (TSR) using whatever wastes are available in the market as alternative fuels–hazardous or non-hazardous. At present, the TSR (Thermal Substitution Rate) of the Indian Cement Industry is 6%, while it is even more than 60% in some developed countries. The Co-Processing Hazardous Substances in Cement Industry is much beneficial option for Alternate Fuel. The conservation of energy and use of waste material as alternate fuel have assumed greater importance for improving productivity and reducing thermal energy consumption.

This case study focus on the reduction of GHG emissions & Incineration of Hazardous Wastes which are very dangerous for environment & society. In an initiative of turning waste to wealth, MCW identified the pharmaceutical waste from nearby industry & started use of this hazardous waste material in Kiln as an alternative fuel. For sustainable use of this waste MCW had installed way backed a start of art liquid alternative fuel feeding system. This initiative also provides a sustainable solution to pharmaceutical industry to use of their hazardous waste material in cement kiln as an alternative fuel. This is also a step towards sustainability for cement industry and set a one of the bench marks to use liquid alternative fuel. In this initiative MCW has utilized pharmaceutical waste of 27050 MT in 2021-22 and consequently contributed to reduce $CO_2$ emission by 10080 MT in 2021-22.

# JOURNEY OF GREEN FUELS UTILIZATION

**G V Ramakrishna, Rajiv Sadavarti, Anand Pratap Singh & Gaurav Patel**
*Dalmia Cements (Bharat) Limited, New Delhi*

Greenhouse gases and global warming due to use of non-renewable fossil fuels are in the forefront of ecological concerns and point of discussion for our society. Cost competitiveness, global competition and profitability are the concerns of business. The major challenge facing today's society is to create balance environmental protection and economic interest. The cement industry consumes a momentous amount of natural resources and energy for the development and modernization of countries. Indian cement industry is continuously trying to improve environmental performance by optimizing the use of natural resources and reducing its overall energy consumption. Replacing fossil fuel and virgin raw material by waste will overall lessen CO2 emissions if the waste material being used would instead been burned or disposed without energy recovery. Dalmia Cement (Bharat) Limited (DCBL) is the first heavy-industry sector company globally to announce *2040 carbon negative commitment* in 2018 and served as a sector influencer

Senior Leadership Team while speaking at the United Nations Climate Ambition Summit 2020 underlined time to act is now as unprecedented climate challenge is being faced by all. He further added that Dalmia Cement has been working towards climate change mitigation to create more sustainable cement and construction sector. He highlighted *"Clean and Green is Profitable and Sustainable"*, the larger purpose business philosophy of Dalmia Cement to create business opportunities in reducing CO2 emissions with a co-benefit approach. Senior Leadership Team emphasised on global collaborations and mentioned Dalmia Cement's collaborations with stakeholders globally towards realisation of the carbon negative roadmap with specific reference to scalable deployment of deep decarbonisation technologies such as 100% renewable electricity, energy efficiency improvements and Carbon Capture and Utilisation (CCU) in a just transition approach. Sustainability has always been a way of life at Dalmia Bharat. The company is globally ranked *No 1 by CDP* on business readiness for a low carbon economy transition. The group is *more than 13 times water positive* and is the first cement company in the world to join both EP100 and RE100. Usages of Alternative fuels and material *is most important lever to achieve Carbon negative commitment.*

# INVESTIGATIONS ON CLINKER MINERALOGY AND MICROSTRUCTURE WITH THE USE OF CHROME SLUDGE AS ALTERNATE RAW MATERIAL IN MANUFACTURE OF CLINKER

**Suresh Vanguri, G Prasad, Suresh Palla, V Ramaswamy, A Sushmitha, V Rama, K V Kalyani & S K Chaturvedi**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Chrome sludge is generated as residual solid waste during the manufacturing process of sodium dichromate.Technical feasibility Studies were conducted to use chrome sludge in clinker manufacturing, with particular focus on to investigate effect of chrome sludge on clinker mineralogy and microstructure. Chrome sludge sample was evaluated for chemical composition, calorific value, ash content and heavy/ toxic elements. Chrome sludge was incinerated and the resultant ash was subjected for chemical composition, to identify the potential area of use of chrome sludge either as alternate raw material or as alternate fuel in clinker manufacturing. Studies on leachability of toxic elements was conducted by Toxicity Characteristic Leaching Procedure (TCLP).Characterization of chrome sludge indicated that the material falls under hazardous category and can be considered as potential alternate raw material as per CPCB Guidelines for Pre-Processing and Co-Processing of Hazardous and Other Wastes in Cement Plant.Raw mixes were prepared using chrome sludge as one of the raw materials for preparation of clinker. Chrome sludge was used up to 5 percent in the raw mix. Burnability studies indicated that increased content of chrome sludge has resulted in decrease in the free lime content at temperatures of 1350, 1400 & 1450 OC. Further, leachability studies for heavy elements were conducted for the raw mix containing 5% chrome sludge and also for the resultant clinker. The changes in the mineralogy and microstructure of the clinker with the increased use of chrome sludge were monitored by X-ray Diffraction studies and optical microscopy studies, respectively. Based on burnability studies, XRD and OM studies, cement sample was prepared using selected clinker and the same has been evaluated for its chemical and mechanical properties. This paper aims to present the detailed study of effect of use of chrome sludge as alternate raw material on clinker mineralogy and microstructure.

# POTENTIAL USE OF HYDROGEN AS FUEL FOR CEMENT INDUSTRY

**Sd. Rayees Ahmed, Prateek Sharma & Anand Bohra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Hydrogen is considered as the key element of energy and transportation systems of the future. Many national and international research groups are developing the hydrogen production methods, delivery, storage and conversion technologies in India and abroad. The final utilization of hydrogen takes place in the fields of industry, energy and transportation.

The hydrogen as a fuel has a great potential to become the fuel of the future, with an ongoing worldwide desire for transition in energy field. The steam cycles using hydrogen can be competitive due to its zero CO2 emissions and high efficiencies. The main concern about hydrogen is the cost of production, safety aspects. On the other hand, the demand for low carbon gas on the market would force the policy makers to focus on alternatives of fuel source.

Cement plants in Europe tried to use hydrogen as fuel to a level of 30%. The level of fuel substitution may increase based on technology, hydrogen availability at low cost, automation, safety practices adopted by plant. This paper explains some of the changes or challenges that hydrogen is going to introduce in the cement manufacturing process.

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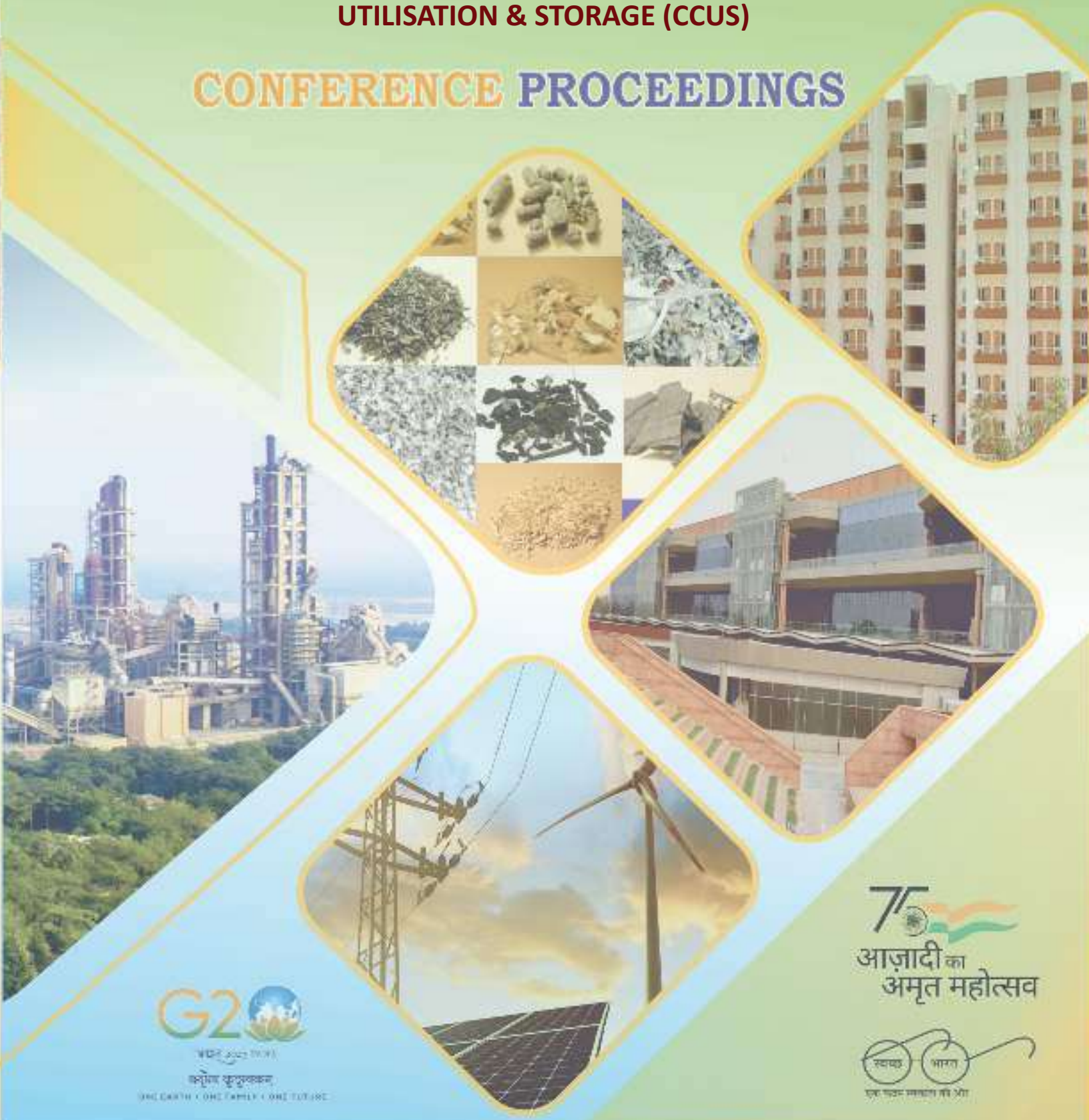
# TECHNICAL SESSION - III A

## NET ZERO EMISSIONS, CARBONS CAPTURE, UTILISATION & STORAGE (CCUS)

# CONFERENCE PROCEEDINGS



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# ROLE OF CARBON CAPTURE AND UTILIZATION (CCU) FOR DECARBONIZATION OF CEMENT INDUSTRY

**B N Mohapatra, S K Chaturvedi, P N Ojha, Brijesh Singh & Anand Bohra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

India's new climate action targets “Panchamrit” by India included a Net Zero target for India by the year 2070, Achieving carbon intensity reduction of 45% over 2005 levels and reducing 1 billion tonnes of projected emissions from now till 2030. Globally, cement sector generates about 7% of the total anthropogenic emissions. In India, the energy consumption and process emissions from cement industry contributes about 4.2% and 2.1% of the total Greenhouse Gas (GHG) emissions of 2531.1 million tonnes $CO_2$ equivalent. Global Cement and Concrete Association (GCCA), CEMBUREAU and Portland Cement Association (PCA) have announced roadmap to achieve Carbon Neutrality across the cement and concrete value chain by 2050 with major contribution from Carbon Capture and Utilization (CCU). Indian Cement Industry have also taken steps on four levers identified in low carbon technology roadmap. However, to achieve the target of Net Zero, cement industry will have to go for implementation of CCU technologies. CCU solutions will play an increasingly important role in addressing climate change by the cement and concrete industry. For implementation of CCU in Indian cement industry, demonstration projects need to be implemented in few plants, which will help in creating expertise in cement industry to run CCU facility and will also encourage other cement companies to move in this direction. For all the novel materials using sequestered CO2 producing carbonated materials and specifically the radically new binders based on carbonates, further fundamental research is needed to create a widespread application. Such research includes not only the carbonation processes but also the comprehensive studies of the novel construction materials in terms of hydration/carbonation mechanisms, concrete mix design, mechanical properties (such as strength, elastic modulus, tensile strength, shrinkage, creep), and durability (i.e. reinforcement corrosion).

# MARCH TOWARDS NET ZERO CARBON EMISSION THROUGH SUSTAINABILITY AUDITS AND PROCESS OPTIMIZATION

**Srinivasan Annamalai & Raveendran Chalil**

*FLSmidth Pvt. Ltd.*

The cement industry contributes about 8% to global anthropogenic $CO_2$ emissions, making the cement industry an important sector for $CO_2$-emission mitigation strategies. $CO_2$ is emitted from the calcination process of limestone, from combustion of fuels in the pyroprocess, as well as from power generation. Carbon dioxide ($CO_2$) is one of the major greenhouse gases, cement production is a highly energy-intensive production process. Energy consumption by the cement industry is estimated at about 2% of the global primary energy consumption, or almost 5% of the total global industrial energy consumption. Because of both direct and indirect emission sources, and because of the emissions from electricity production, the cement industry is a major source of carbon emissions and deserves attention in the assessment of carbon emission-reduction options. In this paper, we review the total $CO_2$ emission reduced through "Productivity Enhancement and Process Optimization" a small step to march towards Net Zero through Sustainability audits cum energy optimization.

# OPPORTUNITIES FOR $CO_2$ REDUCTION & HIGHER EFFICIENCY

**Roger Meier[1] & Tamal K Ghosh[2]**

[1]*FCT ACTech Adelaide, Australia*

[2]*ICON Scientific Systems, Kolkata, India*

The growing importance of being responsible for the environment motivates $CO_2$ producing industries to strive for process improvements. One of the quick wins is the implementation of on-line analysers to monitor the quality of the processed material at a number of locations in the production process. This enables timely control action to be taken to raw mill feeder settings, burning zone firing rates and cement mill proportioning, to ensure optimum production conditions without any compromise of quality.

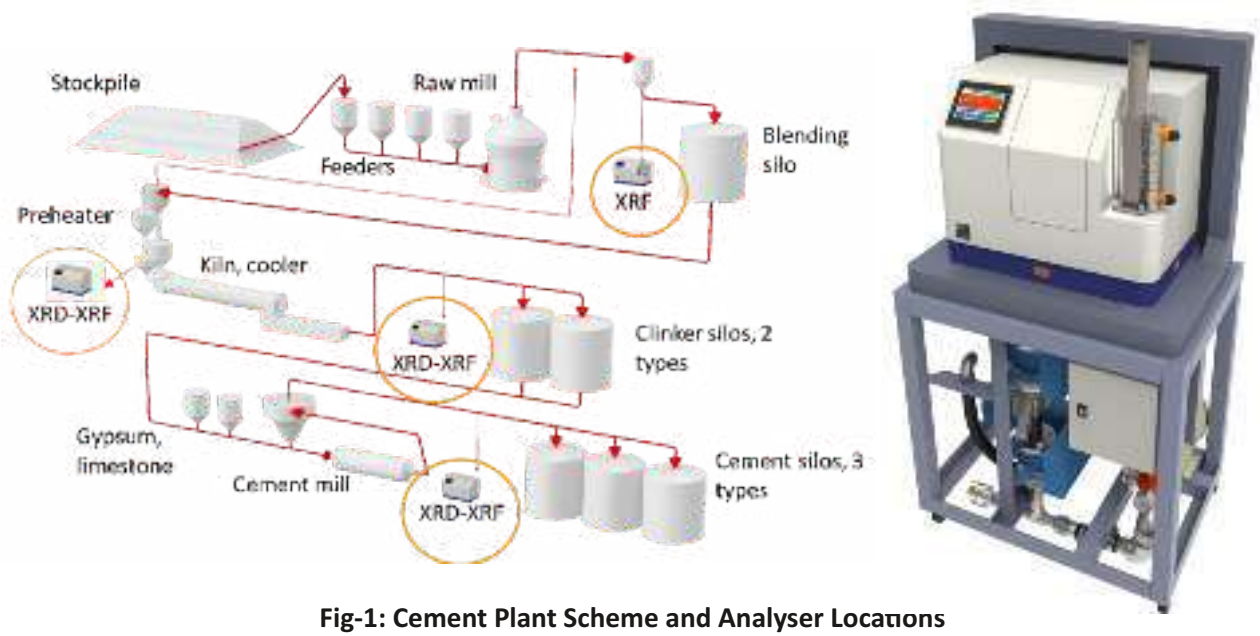



**Fig-1: Cement Plant Scheme and Analyser Locations**

# GREEN CEMENT PLANT TECHNOLOGIES FOR THE SUSTAINABLE USE OF RESOURCES AT LOWEST EMISSIONS

**Uwe Maas**

*ThyssenKrupp Industrial Solutions, BU Polysius, OU cement, Beckum, Germany*

Today's resource consumption is far beyond sustainable limits. In order to preserve and improve global living conditions, the united nations have agreed on sustainable development goals. The cement production is connected to many different goals; i.e. its $CO_2$ emission already contributes about 7 % to the global $CO_2$ footprint. In addition, the cement production process requires large amounts of natural resources, i.e. lime stone, marl and fossil fuels and causes various gaseous emissions. However, sustainable solutions not only require the achievement of environmental standards, they have to comply with societal standards and need to be economically sound as well.

Thyssenkrupp polysius® is addressing this challenge with the “grey2green” strategy. All sustainable related techniques are bundled under this topic. This paper presents out of this bundle of actions and technologies three aspects:

1. Fossil fuel substitution
2. Calcined clay
3. Carbon capture and utilization


# MITIGATING CLIMATE CHANGE THROUGH LOW CARBON RESEARCH INITIATIVES IN BUILDING MATERIALS

**L P Singh & U Sharma**

*CSIR-Central Building Research Institute, Roorkee*

Demand for low carbon footprint can be a key factor in fostering innovation, while motivating policymakers to encourage sustainable consumption. Buildings are currently the source of about one-third of global greenhouse gas emissions. Together, building and construction are responsible for 40% of all carbon emissions in the world, with operational emissions (from energy used to heat, cool and light buildings) accounting for 28%. The remaining 12% comes from embodied carbon emissions, or 'upfront' carbon that is associated with materials and construction processes throughout the whole building lifecycle. According to the Intergovernmental Panel on Climate Change (IPCC) landmark 2018 report, to stay within 2°C, global CO2 emissions need to decline by about 25% by 2030 from 2010 and reach net zero by 2070. This paper presents the different research initiatives taken by CSIR-Central Building Research Institute (CBRI), Roorkee, to reduce the carbon footprint of buildings materials by sequestering CO2 in waste for the preparation of artificial aggregates, preparation of low-carbon cement and utilization of agro-industrial waste as fuel in brick sector.

# DALMIA RGP CARBON FOOT PRINT ROAD MAP

**Chetan Shrivastav, Arbind Singh, Satish Mishra, Vikas Mangal, Alok Choubey & Aniket Chaki**

*Dalmia Cement (Bharat) Limited, Odisha*

Carbon dioxide ($CO_2$) is a greenhouse gas (GHG) generated predominantly through the burning of fossil fuels. Global $CO_2$ emissions from energy combustion and industrial processes rebounded in 2021 to reach their highest ever annual level. A 6% increase from 2020 pushed emissions to 36.4 gigatons (Gt), an estimate based on the IEA's detailed region-by-region and fuel-by-fuel analysis, drawing on the latest official national data and publicly available energy, economic and weather data. India's current $CO_2$ emissions (2021) are 2.88 Gt. India's generation in a business-as-usual scenario will be 4.48 Gt in 2030. According to this target, India will cut its carbon emission by 1 billion tons (1 Gt) and therefore, our emissions in 2030 will be 3.48 Gt.

The cement industry alone is responsible for about a quarter of all industry $CO_2$ emissions, and it also generates the most $CO_2$ emissions per dollar of revenue. About two-thirds of those total emissions result from calcination. Dalmia Cement has been progressively producing cement with 'greener' alternatives. It has invested in low-carbon technologies that translate into enhanced resources and energy efficiency. It has also increased the proportion of environment-friendly blended cement in its product mix to 80%, reducing its carbon footprint while addressing waste disposal issues of other industries. The company's risk mitigation policies were outlined keeping in mind its long-term vision on the one hand and enhanced sustainability-driven prosperity on the other. It has also increased the proportion of alternative materials, replacing conventional kiln fuels with alternative fuels and bio-fuels. Our future goals are to reduce $CO_2$ Emission and to achieve carbon negativity by 2040. This can be done by achieving 100 % TSR using 100 % alternative (green) fuel for generation of heat to replace fossils fuels by 2035 and switching to 100% blended Cement production by 2026. Our target is to use 100% renewable power under fossils free electricity initiative by 2030 and to double the energy productivity by 2030, base line 2010-11.

# BAT TO AUGMENT GREEN POWER PRODUCTION CASE STUDY OF CHETTINAD CEMENT – DACHEPALLE PLANT

**V Ganesan[1], Ashok Kumar Dembla[2] & Balesh Singh[2]**

[1]*Chettinad Cement Pvt. Ltd.*

[2]*Humboldt Wedag India Pvt. Ltd.*

The Indian Cement Industry has established itself as a global leader in environmental and socially responsible manufacturing. It is largely by virtue of efforts put in place by the core sectors such as cement that India is well on track in meeting its Nationally Determined Contributions (NDCs) targets and staying compliant with the Paris Agreement pledge. The Indian Cement Industry is a frontrunner in the mission for change and has been implementing significant technological measures to ensure a greener future for the Country and the society. It is the only sector to have voluntarily devised a Low Carbon Technology Roadmap aimed at reducing its direct $CO_2$ emission intensity by 45% till 2050 from a 2010 baseline. Course of its growth and expansion has always relied on the Best Available Technology (BAT) and process setups to stay most efficient and sustainable. Several Indian Cement companies have been performing research and development on over-the-horizon green technology/products to stay ahead and achieve techno-economic viability at scale. This paper gives case study about one of the Indian Cement industry plant which has chosen the Best Available Technology to reduce the greenhouse gas emissions, maximize co-generation of power and reduction of environment's pollutants from cement apostrophe plant.

# MOVING TOWARDS NET ZERO CARBON EMISSION

**K Karpaga Jothi, R Raja Mohan, A L Nachiappan & K Vinayagamurthi**

*Dalmia Cement (Bharat) Limited, Dalmiapuram*

In order to alleviate the possible impacts from climate change to the ecology, economy and environment, our organization, M/s Dalmia Cement Bharat Ltd. has been taking various measures and set an aspirational goal of achieving Net zero CO2 emissions by 2040. With this vision of achieving Net zero carbon by 2040, as one of the measures our Unit had started consuming Biomass, along with Coal/Lignite in our AFBC (Atmospheric Fluidized Bed Combustion) fired boiler. And also started generating green power through Solar power plant and Wind power.

M/s DALMIA CEMENT (BHARAT) LTD located in Dalmiapuram near Tiruchirappalli, are operating two numbers of Captive Power Plants with the capacity of 27MW and 18 MW respectively, along with a 5MW Solar power plant and 7 MW WHRS (under erection).In order to reduce the carbon emission in our coal fired AFBC boiler, we have started consuming biomass fuels in both the boilers like Rice husk, Paddy husk, Saw dust, Julie Flora, veneer waste and wood chip. Both our CPP-1&2 boilers are having under bed feeding system. Fine bio mass materials, which are below 10mm size viz., Rice husk, Paddy husk and Saw dust are mixed with coal/Lignite up to 5% of total heat value and fed. By carrying out various feasibility studies, we have modified our CPP-1 furnace to have Over bed Feeding system in our existing boiler in order to have retrograde firing and consuming 25 % of TSR (Thermal Substitution rate) of Bio mass consumption.

This system consists of an exclusive feeding conveyor, screw feeder, main belt conveyor, divider and chain feeder to feed the oversize material, which are above 10 mm (but less than 25mm) like Veneer waste, Julie Flora and wood chip to the boiler through Over Bed Feeding System. The biomass feeding system starts with the biomass feeding conveyor from the ground hopper at the fuel yard. Bio mass fuel is feeding to the hopper with the help of JCB. Feeding conveyor will deliver the biomass to Screw feeder, wherein, the feed rate can be controlled. Screw feeder discharge is connected to main feed belt conveyor (BC-1) . The main biomass fuel conveyor discharges the fuel into the Chain feeder inlet chute. The chain feeder discharges the fuel in to the boiler furnace, through three numbers of fuel feeding chute, which are connected to the chain conveyor and boiler furnace. With the above system, we have started consuming various types of biomass from Sep-2021 onwards and our consumption has gradually increased up to 25% TSR. As one of the steps towards Net Zero carbon emission, thro' Bio-Mass consumption start in our CPP and Solar Power, we had reduced a total CO2 emission of 26713 MT during the period of Sep-21 to July -22. We are planning to increase the Bio mass consumption further from 25 % to 50 % and feasibility study is under progress.

# SUSTAINABLE SOLUTIONS FOR NET ZERO EMISSIONS - COLLABORATIVE APPROACH FOR GREEN CORRIDOR

**Matthias Mersmann**

*KHD Humboldt Wedag International AG, Cologne, Germany*

With climate change being an undisputable reality, the cement industry has committed to reduce its carbon footprint and finally decarbonize completely by mid of this century. The pathways for decarbonization have been set out in various roadmaps already and span from ready-to-apply solutions to technologies which still need to be developed, tested and implemented during the next years. In the course of the next decades the way clinker and cement is being manufactured will see a lot of changes and it is important to navigate through the various options as they become implementable over time. This paper presents favorable technological solutions which can be implemented already today as well as those how are at the verge of being industrially applicable for complete decarbonization of the cement production.

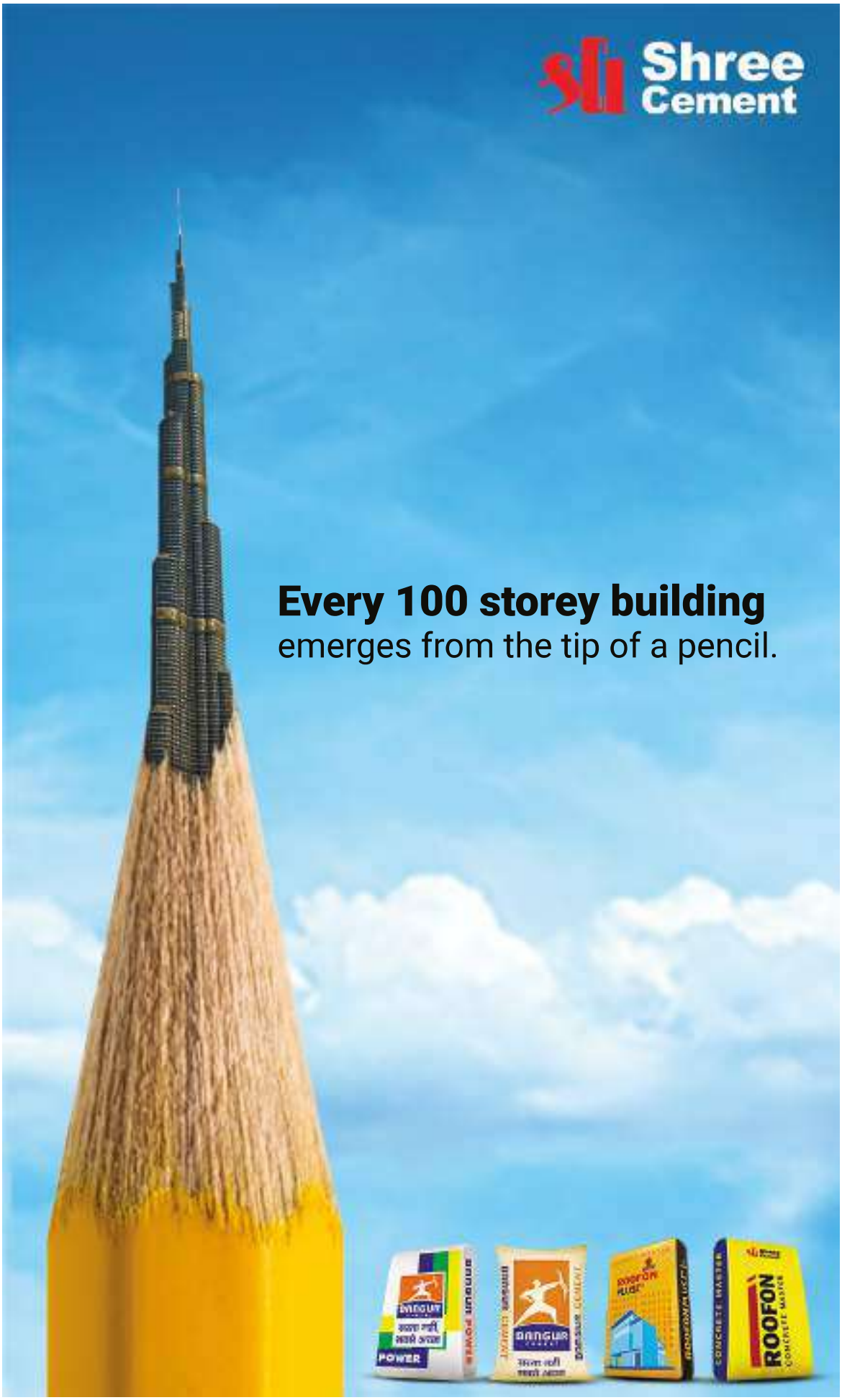
# STUDY ON THE EFFECT OF ACCELERATED CARBONATION ON STEEL SLAG AS A CO2 SEQUESTERING MATERIAL THROUGH DIRECT CARBONATION ROUTE

**Richa Mazumder, Suresh Palla, Giasuddin Ahamed, Sandip Gupta, Kalpana Sharma, S K Chaturvedi & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh,Haryana*

Cement being the most produced commodity in India also associates with it the emissions of environment damaging greenhouse gases (GHG) and the cement industry accounts for almost about 8% of the total national emissions. Of the total emissions carbon dioxide represent the largest contributor and the most dominant greenhouse gas (GHG). This cannot be avoided unless other sources of CaO would be used since calcination of limestone alone results in the two-thirds of those total emissions. Several analyses show that by decarbonizing cement industries, CO2 emissions could be reduced by 75 percent by 2050 by implementing operational advances and technological innovations. From operational advances, only 20 percent of CO2 emissions could be reduced while the remainder will need to come from technological innovation. The emissions-reduction potential from alternative fuels and clinker substitution is limited by the decreasing availability of input materials and operational advances such as energy-efficiency measures, have already been implemented largely. Therefore, to achieve carbon-reduction targets by 2050 more innovative approaches, such as new technologies will be indispensable.

Mineral carbonation is one of the CCU technologies that recover CO2 contained in flue gases coming from kiln to obtain synthetic carbonate from the reaction between CO2 and industrial wastes rich in calcium oxide. These synthetic carbonates can be used either as a final product or as an input to the cement industry. Various researchers have noted the importance of combined economic and environmental aspects to evaluate the performance of CCU technologies applied to the cement sector. It has been reported by several researchers that slags which are generated as a by-product from iron and steel industries dumped in yards as landfills due to their limited utilization form a suitable class of alkaline materials for mineral carbonation reaction. Iron and steel slags are generally rich in calcium oxides and their carbonation results in a capture and permanent sequestration of the atmospheric CO2 into thermodynamically stable carbonate minerals as calcite. The mineral carbonation reaction through which CO2 is sequestered into the material mostly depends upon the mineralogy of the material as well as the ambient environment condition. In this paper attempt were made to sequestrate carbon dioxide into two different types of slag, slag 1 and slag 2 through accelerated carbonation through direct route (dry) of mineral carbonation. For this slag samples, were kept in accelerated carbonation environments in a carbonation chamber, maintained at atmospheric pressure, temperature 27°C, 4 ± 0.5% CO2 concentration and 65% RH for 28 days and 48 days respectively. The XRD analysis shows the formation of calcite as a carbonated product at 28- and 48-days carbonated slag 2 and this is further confirmed by TG/DTA analysis. However, the same has not been observed in the case of slag 1 kept under the same accelerated environment condition which is most probably due to the difference in the mineralogy of the two different types of slag.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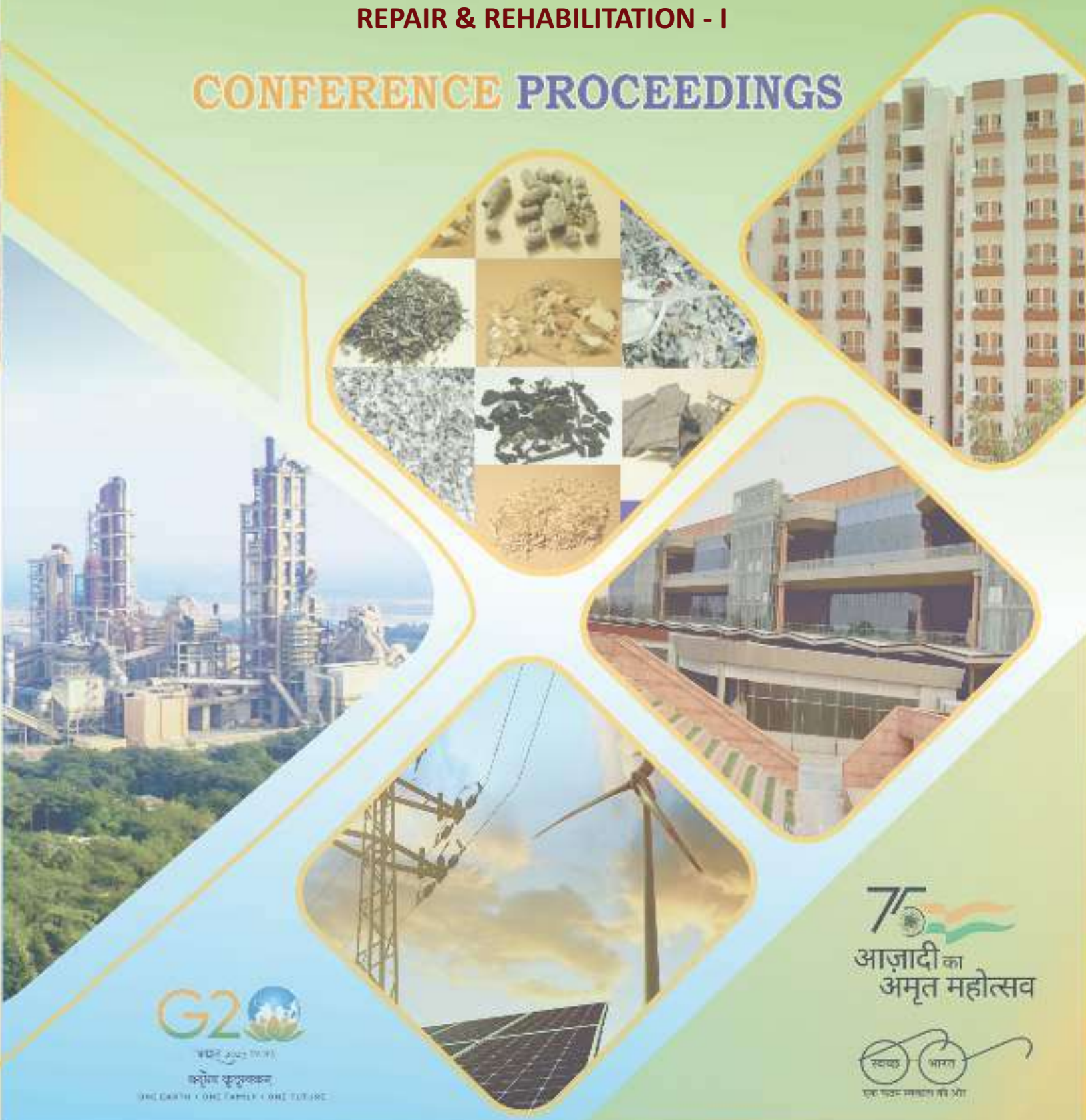
# TECHNICAL SESSION - III B

## CONCRETE DURABILITY, DISTRESS INVESTIGATION, REPAIR & REHABILITATION - I

# CONFERENCE PROCEEDINGS



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# MECHANICAL AND DURABILITY PERFORMANCE OF PORTLAND LIMESTONE CEMENT (PLC) MADE WITH INTERGRINDING HAVING HIGH FINENESS LIMESTONE IN CONCRETE

**Puneet Kaura, P N Ojha & Hardik Jain**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Portland limestone cement (PLC) is a low carbon cement. In the present work, two PLC blends at 10 % and 15 % limestone content were designed and studied. In order to ensure overall fineness of PLC blends as well as limestone more than 425 $m^2$/kg and 600 $m^2$/kg respectively, initially limestone was interground to a fineness in the range of 550- 600 $m^2$/kg. Thereafter fine limestone was intermixed with OPC. The prepared PLC blends were further intergrind to achieve the required fineness. The study has been carried out at two water- cement ratio i.e. 0.40 and 0.60 using two types of PLC blends designed at 10 % and 15 % replacement level of OPC with fine limestone. Performance assessment of concrete made with PLC blends has been evaluated through durability tests like Rapid chloride penetration test (RCPT), non-steady state chloride migration test, Electrical Resistivity, accelerated carbonation test whereas sulphate resistance has been evaluated on mortar samples in accordance to ASTM C 1012. Mechanical behaviour of concrete in terms of compressive strength and flexural strength has been evaluated at various ages and comparison has been drawn with conventional concrete i.e. concrete made with OPC. Based upon the study, it can be observed that addition of fine limestone up to 15 % in PLC blends produces satisfactory performance in terms of compressive strength whereas durability of concrete mixes designed with PLC blends had shown better resisting property against chloride ingress. The phenomenon of carbonation is found to be much more dependent upon w/c ratio rather than limestone content. PLC blends had also shown improved resistance against the attack of sulphate ions in comparison to OPC.

# DURABILITY PERFORMANCE OF CONCRETE PRODUCED USING LIMESTONE CALCINED CLAY CEMENT ($LC^3$)

**Lupesh Dudi, Lav Singh & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

Sustainability needs have been pushing the cement industry towards more and more incorporation of SCMs to bring down carbon footprint. However, present SCMs aren't available in sufficient quantity, whereas $LC^3$ cement provides a solution to this as calcined clay and limestone reserves are widely available. The strength of $LC^3$ lies in the synergetic effect of its components, due to which there is a finer microstructure and improved mechanical and transport properties of concrete. Currently, changing construction dynamics demand the durability of concrete along with strength, to have zero or minimum repair and maintenance of structure during its service life. In the present work, different durability performance tests have been performed on M25 and M50 grades of concrete made with 3 different $LC^3$ blends having different calcined clays. Present work concludes that results from different performance tests fall in either very good or excellent classes as per respective standards used for them. The results indicate that transport properties of concrete made with LC3 are better than other cements.

# EFFECT OF WATERPROOFING COMPOUNDS ON CARBONATION IN LOW CLINKER CEMENT

**Lav Singh, Lupesh & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

The steps taken by the infrastructure industry toward sustainable development reflect a gradual increase in the use of low-clinker cements worldwide. This increase in the demand is accompanied by growth opportunities in chemical admixtures that improve concrete properties like water permeation, porosity and greater resistance to water induced deterioration process like carbonation. One such category of chemicals used for water repellent treatment is the silane-siloxane based hydrophobing agents available in the market. The impact of such chemicals specialized in making concrete water repellent is studied using 2 application processes - integral admixture and surface impregnation. Evaluation of the effects on transport properties - capillary absorption and permeable pore volume is performed on standard mortar specimens prepared with cement having low clinker content, at two different w/c ratios and are compared with other commercially available cement types OPC & PPC. The results of this study indicate that silane-based hydrophobic chemicals dramatically reduce permeable pore volume in the case of impregnation and significantly reduce it in the case of integral application, further reducing capillary sorption. The results indicate the potential of these chemicals to prevent water penetration and thus their usefulness in areas where there is a risk of corrosion of reinforcement and penetration of aggressive substances by water transport.

# PERFORMANCE OF CONCRETE MADE WITH LIMESTONE CALCINED CLAY CEMENT ($LC^3$)

**Prakhar Shrivastava, Gopal Gupta, Nihar Ranjan Tripathy & Pramod Sancheti**

*J K Cement Works, Rajasthan*

This research paper examines the mechanical and durability parameters for the concrete made with limestone calcined clay cement (LC3) and a comparison with ordinary portland and portland pozzolana cement. Characterisation of raw materials used for LC3 mix proportioning was carried out with XRF, XRD and TGA. The cement mixes were used for detail study of mechanical and durability study of M25 and M50 grade of concrete.

The compressive strength results, reveals, at early age LC3 concrete exhibits slightly low strength in comparison to ordinary portland cement. However, at age of 7 and 28 days the rate of strength grain increases and shows almost equivalent strength. Where in M50 grade, LC3 Concrete shows all time equivalent strength with ordinary portland cement. The concrete M25 and M50 made with portland pozzolana cement showing all time low strength than LC3 up to 28-days. In durability aspects (water absorption and chloride ingress), M50 grade have significantly lower capillary sorptivity as compared M25 and LC3 with K-clay giving lowest sorptivity in most case. RCPT results reveals that both M25 and M50 grade of LC3 concrete passes very low charge, hence more resistance to the aggressive environmental conditions

# A STUDY ON THE PARAMETERS AFFECTING THE PROPERTIES OF PORTLAND LIMESTONE CEMENTS

**Prakhar Shrivastava, Nihar Ranjan Tripathy & Arun Shukla**

*J K Cement Works, Rajasthan*

This research paper examines the effects of partial substitution of portland cement clinker with limestone on the physical and chemical properties of portland limestone cement paste and hardened mortar. Chemical analysis was conducted for clinker, limestone and mineral gypsum samples before used for the intended purpose and then checked for conformity with Indian standards.

The compressive strength results, reveals that the portland limestone cement with 12-15% replacement of clinker by limestone and ground up to a finess range of 3600-3800 cm2/gm achieved comparable strength with 100% ordinary portland cement. Furthermore, it was found that 20-25% limestone addition by weight results in slightly lesser compressive strength values in comparison to ordinary portland cement. Observations on the test results further indicated that increasing in fineness of the portland limestone cement results in relative increase of rate of hydration and faster development of the early age strength while decreasing slightly the consistency and the setting time. The loss on ignition (LOI) and insoluble residue (IR) is also observed to increase with the increase in percentage of limestone addition in cement. whereas the percentage by mass of sulphate trioxide and insoluble residue as well as soundness effect of the portland limestone cement remain within the acceptable range.

# ENVIRONMENTAL REMEDIATION FOR DURABLE CEMENTITIOUS SYSTEMS USING SELF-HEALING NANO ADDITIVES

**Mainak Ghosal[1] & Arun Kumar Chakraborty[2]**

*[1]Engineering Colleges affiliated to Makaut, Kalyani*

*[2]Indian Institute of Engineering Science & Technology (IIESTS), Howrah*

Growing environmental concerns and climate change effects have highlighted another major problem with concrete. Concrete's basic ingredients like cement, sand, rocks & water are all sourced from mother earth. With the sand & stone mining ban and with water becoming progressively costly, what should be the new alternatives? For decades, major developments in cement-concrete performance were attained with the application of micro-fine waste particles viz. fly ash, slag, and silica fumes. But recently discovered exotic nano-scale materials, claims of alleviating the problem of natural materials scarcity and reducing all types of wastes including green-house gas (GHG) emissions. Nano titanium made from waste materials has excellent self-cleaning properties and is the most widely used nanomaterial in commercial-environmental applications. The photocatalysis mechanism of this self-healing material has a disinfection mechanism that includes the decomposition of the cell wall and disinfection of novel viruses such as SARS-CoV and COVID-19.

Our paper reports the effect of adding hydrophobic 40 nm dia. nano-sized Titania (NT) particles by functionalizing them to hydrophilic via. surface modification or wrapping by new generation pH neutral polymeric admixtures & added them to cement: sand ratio of 1:3 with a water-cement ratio of 0.4. Mechanical strength results of the cementitious composites were taken at all terms up to 365 Days(D). The optimized quantity of NT as found in cement composites is then added to M-40 Grade concrete composites for compressive strength testing at both shorter & longer terms following Indian standard protocols. Results reveal that the application of NT in cementitious systems has an improved effect when compared with non-NT cementitious systems and also the former is more durable & sustainable. Photocatalytic NT is also time durable and the microstructural investigations disclose the crystallographic nature of NT, which is the main reason for their favorable mechanical impacts. Also, many of the SDG goals especially 3,9,11,12,13,15 & 17 can be related to successful NT applications.

# COMPARATIVE STUDY OF PORTLAND COMPOSITE CEMENTS PREPARED WITH FLY ASH AND DIFFERENT GRADES OF LIMESTONE

**V Liju, S Palla, S Vanguri, P Sharma, S K Chaturvedi & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Environmental Sustainability is the new buzz word in cement sector and the industry is striving hard for it. Production of blended cements with reduced clinker factor has been proved to be a positive step towards sustainability by reducing $CO_2$ emissions, enhancing waste utilization and saving on our natural resources. In India, the share of blended cements has increased from past years and 100% blended cement production is our target. The code for composite cement based on fly ash and granulated blast furnace slag was a crucial step in this direction, however due to non-uniform availability of granulated blast furnace slag its production is less. In the present study, composite cements based on fly ash and limestone is prepared. Three different limestones, cement grade limestone, low grade limestone and dolomitic limestone were used for preparation of composite cements and their effect on performance characteristics of composite cements were studied. It was observed that compared to PCC prepared with cement grade and low grade limestone, the compressive strength was better when dolomitic limestone was used at all the clinker replacement levels

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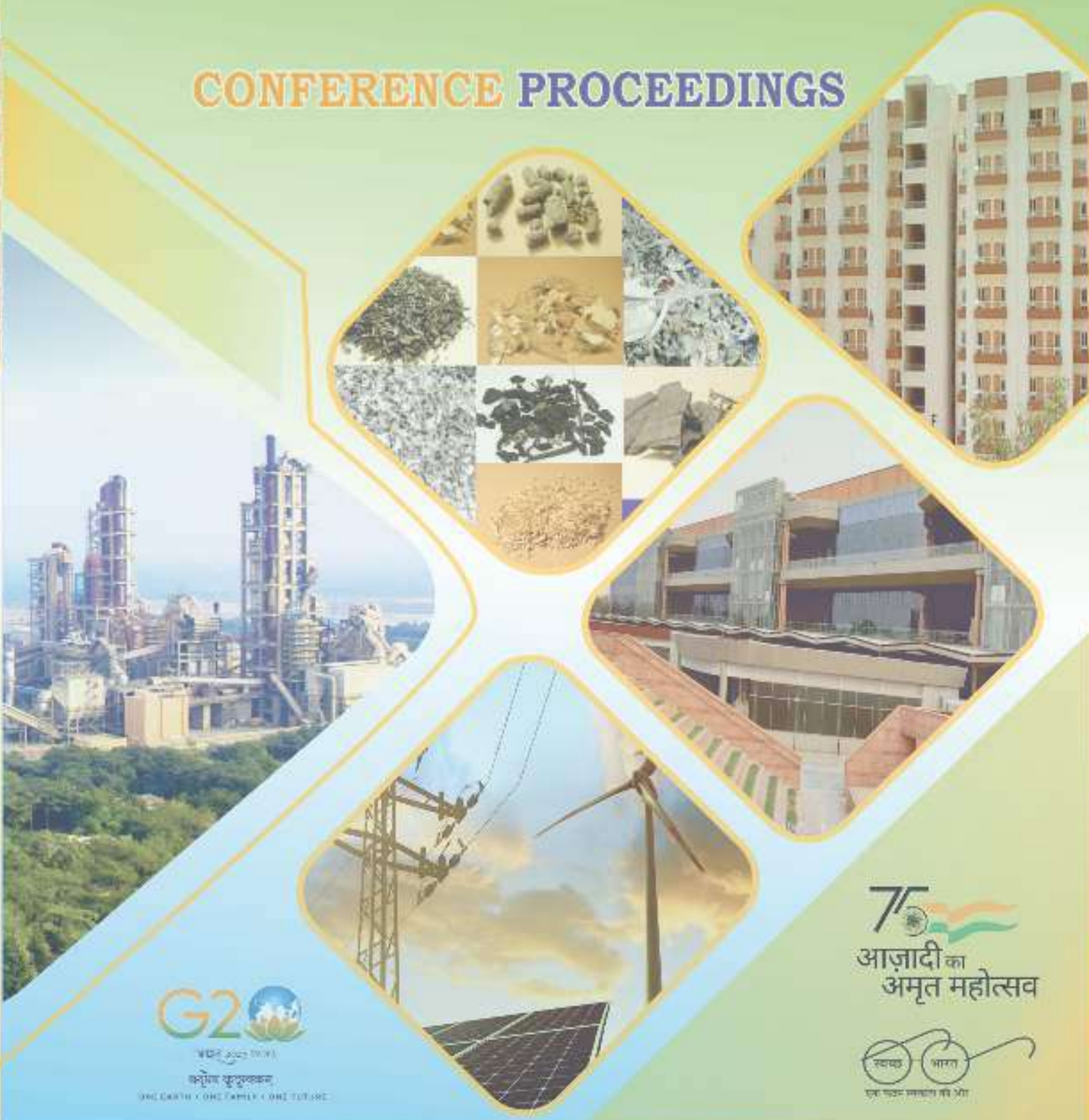
# TECHNICAL SESSION - IV A

## PRODUCTIVITY ENHANCEMENT AND PROCESS OPTIMIZATION - I

# CONFERENCE PROCEEDINGS



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# IMPACT OF ROTARY KILN BURNER DESIGN ON PROCESS PERFORMANCE

**Suresh Thangarasu**

*Fives Combustion Systems, subsidiary of the industrial Fives Group*

Making the right tailor made kiln burner is very important in times where many complex and unique challenges are faced by cement plants. Identifying and understanding the key factors of combustion in pyro process for good clinkerisation namely the right momentum, velocity of axial primary air, pressure of swirl air, factors influencing the thermal profile of your flame, etc. This enables us to understand the key demand and familiarize the process, and by controlling these factors with tailor made solution helps you to achieve stable process, maximum savings and better quality of clinker. The paper provides insights on burner selection considering several key parameters

# USE OF YELLOW SHALE FROM MINES FOR IMPROVED KILN FEED BURNABILITY & IMPROVED CLINKER QUALITY – A CASE STUDY

**U S Choudhary, K S Dangi, Pavan Deshmukh, Venkateshwarlu K & M Nandeshwar**

*J K Cement Works, Karnataka*

A comprehensive understanding of the physico-chemical aspects of limestone and other mining materials, kiln feed and clinker is a necessity for improving the kiln productivity, improving the quality and consistency of the manufactured clinker and achieving reduction in costs. Many a times in cement plants, the compositional parameters and fuel characteristics remaining same, on some days the kiln performance is excellent and the resultant clinker quality is also much improved, while on other days the kiln feed burnability appears to be poor and the kiln conditions are unstable. The plant quality and process teams need to diagnostically assess the properties of the feeding materials (chemistry, fineness, uniformity, and mineralogy) that could lead to improvements in kiln feed burnability and subsequently improve the efficiency of plant operations.

At J K Cement Muddapur plant, the kiln feed burnability is moderate to poor, however on some days with some Limestone stack piles, the kiln performance is excellent and the resultant clinker quality is very good. Judicious diagnostics of the available process and quality data of in-process materials, indicated that as and when, in the formation of limestone stack pile to achieve the pile quality targets of LSF and MgO contents, there is often use of yellow Shale. It was observed that the limestone piles made with use of around 1 to 3 % yellow Shale exhibited good kiln performance and good consistent improved clinker quality. Detailed studies were carried in quality labs to understand the improvements observed with use of different percentages of yellow Shale.

This paper discusses the data generated in the comparative studies carried out with Raw Mixes made with and without the yellow Shale, which includes chemical-mineralogical characteristics, thermal behavior of the yellow Shale, comparative burnability studies of the Raw Mixes, comparison of quality of clinker produced at the lab scale clinkering. The present paper deals with the influence of yellow Shale on burning of raw mix at temperature below the eutectic temperature assessed by the reduction in free lime content by 1% resultant that improvement in clinker C3S, uniformity in clinker C3S, improvement in kiln performance &throughput, burnability factor & improved hydraulic potential of the resultant clinker. Additionally, able to use overburden of mines which contributes towards conservation of natural resources.

# PROBLEM SOLVING - QUALITY IMPROVEMENT TOOLS

**B A Agate & Mani Pangen**

*Cement Sector Expert*

It is well understood and also established in every industry whether it is manufacturing oriented or providing services to the customers, there are number of Business Processes in vogue which are being practiced since ages. These may be termed as “Legacy Systems”. The Cement Industry is not an exception to this. However, with the passage of time and technological development it becomes essential to give a re-look to these processes and understand whether these age old processes are really effective or redundant in the present economic scenario which is undergoing through a rapid change with the recent Covid-19 pandemic era. These processes are now getting replaced with “New generation computer based Systems” when Artificial Intelligence (AI) & Machine Learning (ML) are at the threshold of Cement Industry. With globalization and pandemic trying period, country's economy is showing swings; the market place has shown a fierce competitiveness. Now it is a matter of “Survival of Fittest” for all the Cement Plants. To combat with this kind of changing scenario, it has become extremely necessary to look for an innovative organized approach where real quality improvement in business processes get focused in the Cement Industry. The concepts like Total Productive Management (TPM), Total Quality Management (TQM), Business Process Re-engineering (BPR), Bench Marking (BM), and Save Energy Reduce waste Action Committee (SERWAC), Enterprise Resource Planning (ERP), Small Group Activities (SGA), Quality Circles (QC), Quality Improvement (QI), Environment Management Systems (EMS), Bureau of Energy Efficiency (BEE) Perform Achieve and Trade PAT Audit – E- certificates and many others have already taken birth in the Cement Plants. In the list of these concepts, one more innovative dimension gets reinvented that may be captioned as “Problem Solving - Quality Improvement Tools (QIT)”.

# CASE STUDY FOR MITIGATION OF YELLOW CORE APPEARANCE IN CLINKER

**Narendra Diwakar, Pravesh Kumar Sharma, Dinesh Agrawal & Manish Kumar Singh**

*Prism Johnson Limited, Satna*

Alite (C3S) & Belite (C2S) are the major forms of oxides of Calcium & Silicon which constitute about 75% – 85% in the clinker compared to others oxides such as Calcium Aluminates (C3A) & Calcium Alumino ferrite (C4AF). Alite contributes to "Early" strength & Belite contributes to "later" strength in the cement. Alite is more reactive because of its higher (Ca) content, and the presence of an oxide ion in the lattice.

Due to variation in raw material quality & process conditions affects the formation of Alite & Beilte gets affected. A phenomenon of yellow core in clinker was observed at Unit II Kiln of *PRISM JOHNSON LTD,* Satna. This has impact on appearance & color of the clinker. Although strength of the product was not affected due phenomena of yellow core clinker, but it was a serious issue related to customer satisfaction. The objective of this paper is to present the case study for mitigation of the appearance of yellow core in clinker through various improvements jobs, studying the impact of improvements jobs on quality parameters of the clinker, production etc.

# FLASH ACTIVATION OF CLAY: HIGH PRODUCT QUALITY AND ENERGY EFFICIENT PROCESS

**Steven W Miller[1] & Rasmus Franklin Momme[2]**

[1]*FLSmidth Inc., Allentown, PA, USA*

[2]*FLSmidth A/S, Valby, Denmark*

The cement industry is estimated to emit 8% of global $CO_2$ emissions. With more than 60% of this coming from the calcination of limestone as part of the process required to make clinker, replacing clinker with a low-carbon (i.e., low limestone) supplementary cementitious material (SCM) such as activated clay presents a viable solution to the industry's environmental impact. In line with its MissionZero objective to enable zero-carbon cement production by 2030, FLSmidth has developed a low-energy, low-emissions clay Gas Suspension Calciner process. As a result, high clinker substitution within the cement standards can achieve 40% reduction in power consumption, a >30% reduction in fuel use and a >40% reduction in $CO_2$ emissions compared to the same cement quality/properties as a standard OPC and about 20% reduction in power consumption and $CO_2$ emissions compared to a standard PPC. It is also projected that there will be a significant decline in flyash and slag availability in future, hence the usage of alternate such as activated clay is imperative.

# REDUCING THE MANUFACTURING COST OF CEMENT & INCREASING THE PROFITABILITY OF CEMENT MILL BY USING POND-ASH INSTEAD OF FLY ASH

**Rajni Kant Manawat**

*Process Expert Services*

Setting up the most advanced cement manufacturing facility does not, on its own, guarantees profitable operations. In order to ensure its profitability and make it maximum cost efficient, cement manufacturing facility constantly requires sound operational practices besides advanced technological design. All the stakeholders are striving hard to ensure best operational practices but this approach is a continuous exercise. Undoubtedly, Cement Industries are facing couple of challenges. But other than saving costs, we have to be mindful about being energy efficient and using a robust and reliable solution to ensure best operational practices in the cement plants. To offset the challenges in the area of energy management and ensure energy efficiency in the cement industry, the Companies are employing cutting edge technology solutions and also emphasizing on, what's wrong or what kind of improvement can be done with production/operations to increase profitability.

Concrete is the second most consumed substance on Earth after water. Cement production is expected to rise to 3.7- 4.4 billion tons by 2050. The production of cement releases greenhouse gas emissions both directly and indirectly and another major problem is dumping of fly ash and pond ash. Coal ash represents a major environmental problem. In India, every year 100 tons of fly is produced. The prevalent practice is to dump fly ash and pond ash on wastelands, and this has lain to waste thousands of hectares all over the country. These sites are not lined and it leads to seepage, contaminating groundwater and soil. It lowers soil fertility and contaminates surface and ground water as it can leach into the subsoil. When fly ash gets into the natural draining system, it results in siltation and clogs the system. It also reduces the pH balance and portability of water.

# ENHANCEMENT OF KILN OUTPUT BY 1200 TPD THROUGH TECHNOLOGICAL UPGRADATION

**Lokesh Bahety, Rajesh Shrivastava, Shishir Choudhury & Anshul Mishra**

*Dalmia Cement (Bharat) Ltd., Banjari*

RCW'Banjari was designed for 1600 TPD clinker with single string separate line calciner. It was running at an average of 1450 TPD & the DOC of 5th stage cyclone was 75% to 80%. SHC & SPC were very high due to poor efficiency of cooler, PH system & fans. Kiln volumetric Loading was only 3.5 TPD/$m^3$. Raw Mill SPC (30 kwh/MT) was also high due to crusher drier in circuit, poor efficiency of fan & heavy false air in the circuit, along with this output was only 110 TPH. Coal mill SPC was approx. 80 kwh/t & production 11 TPH only with Saudi pet coke and without water spray. The paper highlights the modification carried out in grading circuit and pyro-processing system to enhance the output to 2650 TPD clinker. Some of them are highlighted below:

Pre-calciner changed from single string separate line claciner to Single string in line calciner, retention time increased from 2.8 sec to 7 sec. Top cyclone changed from 4.2 m diameter to 4.8 m diameter with enhanced efficiency from 92% to 96%. Installation of higher capacity PH Fan of 475000 $m^3$/Hr, Pressure: 1000 mmwg, from earlier PH Fan of: 3,60,000 $m^3$/Hr, Pr: 900 mmwg. with VFD. Baghouse Fan replaced with higher capacity fan of 420000 $m^3$/hr. One additional module added in baghouse. Increase of Kiln rpm from 3.0 to 5.5 by replacement of Gearbox & motor. Cooler static grate changed to IKN with 1st & 2nd grate Pyro step from conventional grate cooler. All cooler fans changed & VFD installed. Raw mill capacity enhanced from 120 TPH to 200 TPH. Reduction of False air in the Circuit from 14% to 8%. Shredder of 25 tph also being installed for effective utilization of green fuel from 5% to 25% TSR.

# PLANT OPTIMISATIONS & MODERNISATIONS – SUCCESSFUL CASE STUDIES

**Sitaram Sharma, Vikram Kancharidasu & Prakash Patil**

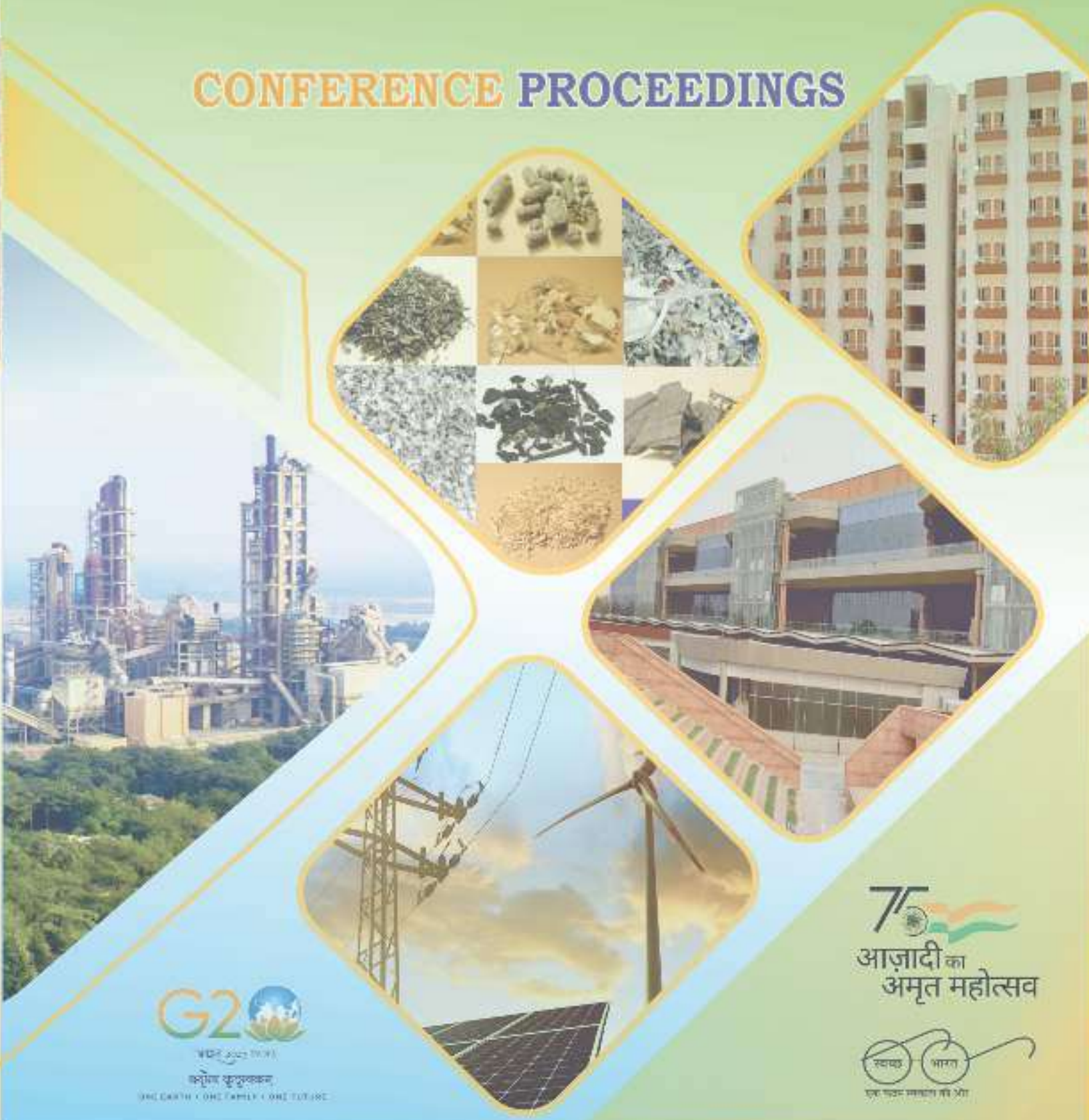
*KHD Humboldt Wedag India Pvt. Ltd., New Delhi*

The manufacturing process of clinker is typically energy-intensive and it requires large amount of resources. The variable cost of clinker manufacturing process is predominantly defined by the required amount of thermal and electrical energy demand. Further, the GHG emissions associated with energy consumption apart from calcination process is also an important factor. Therefore, improving technology to optimize operations on continuous basis not only reduces the manufacturing cost but also aids the sustainability initiative. One of the strategies to be embraced is to improve production units by replacing or modifying inefficient equipment with new solutions that results in improved energy efficiency and availability. In this paper, we have shared few successful plant modernization case studies highlighting the benefits achieved after implementation of KHD's latest state-of-art technologies.

# TECHNICAL SESSION - IV B

## PERFORMANCE-BASED DESIGN OF CONCRETE STRUCTURES

# CONFERENCE PROCEEDINGS



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# SHEAR BEHAVIOUR OF REINFORCED ALKALI ACTIVATED SLAG AND FLY ASH CONCRETE UNDER AMBIENT CURING: COMPARISON WITH OPC BASED CONCRETE

**Amit Trivedi, Brijesh Singh, Abhishek Singh, P N Ojha, Pranay Singh & Dinesh Kumar**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Alkali activated concrete popularly known as geopolymer concrete is seen as alternative to the conventional OPC based concrete. Production of OPC releases tremendous amount of $CO_2$ and is considered one of the major source of greenhouse gas emission. The geopolymer concrete uses industrial mineral waste like fly ash and Ground Granulated Blast Furnace (GGBS) as a binder material in concrete. Past studies have shown that although geopolymer concrete and conventional OPC concrete have different microstructural arrangements and gel systems, both depicts comparable mechanical properties. While a substantial amount of researches has focused on the flexural behavior of geopolymer concrete beams, there exists a relatively limited amount of studies concerning the shear behavior of geopolymer concrete beams with stirrup. The present study evaluated the shear behavior of reinforced geopolymer concrete and reinforced conventional concrete of M40 and M60 grade. The experimental program consisted of eight beams: Four Conventional Concrete (CC) beam and Four Geopolymer Concrete (GC) beams wherein two beams were tested for each grade of concrete for both types. The study concludes that both the reinforced geopolymer concrete and reinforced conventional concrete shows similar behavior in terms of shear strength, maximum deflection, crack pattern and crack width. The findings suggest that existing codal provisions for Reinforced conventional concrete can suitably applied for shear design of reinforced geopolymer concrete.

# ANALYTICAL MODELLING OF CREEP IN BLENDED CEMENT PASTE: A LITERATURE REVIEW

**Amit Kumar & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

Creep, being a long-term deterioration phenomenon in structures, is difficult to be measured experimentally by conducting multi-year long creep tests. The predictions of creep, even through the most famous empirical formulae, are not suitable for use in environmental and test conditions different than those in which these formulae were developed. Therefore, analytical methods based on physics are promising alternatives for estimating the same. With developments in the field of cement technology, various blended cements are being developed, whose viscoelastic properties are still not well-understood. The underlying mechanism of creep is not yet understood completely, and various postulated creep theories are debatable. Therefore, understanding the basic creep phenomenon occurring at the micro-level of concrete, along with the factors affecting it, are a significant area of research at the current time. This paper reviews the literary work in the field of analytical models of creep in blended cement pastes.

# SHEAR BEHAVIOR AND CAPACITY EVALUATION OF NORMAL AND SELF CONSOLIDATING CONCRETE

**Sahith Gali[1] & Kolluru V L Subramaniam[2]**

[1] *Iowa State University, U.S.A*

[2] *Indian institute of Technology Hyderabad, Hyderabad*

A comparison between the shear responses of normal (NC) and self-consolidating Concrete (SCC) is reported. The SCC and the NC are proportioned for nominally comparable compressive strength. The tensile strengths of the NC and SCC from the fracture tests are also comparable. The crack propagation during the shear test response of reinforced concrete beams made with NC and SCC are studied using Digital Image Correlation (DIC). There is a significant decrease in the shear capacity of reinforced SCC compared to NC beams. In both NC and SCC, the shear capacity is determined by the failure of stress transfer across the shear crack. Failure in SCC occurs at a small crack opening, less than 0.1 mm whereas in NC it occurs at an opening of 1.0 mm. The lower shear capacity of SCC compared to NC is attributed to a smoother crack and lower frictional shear stress transfer.

# FRACTURE AND SHEAR IN HIGH-STRENGTH RECYCLED AGGREGATE CONCRETE

**Sourav Chakraborty & Kolluru V L Subramaniam**

*Indian Institute of Technology Hyderabad, Hyderabad*

The fracture and shear response of the concrete with natural coarse aggregate (NCA) and recycled coarse aggregate (RCA) is evaluated. Replacing NAC with RAC results in a 25 % reduction in compressive strength of concrete proportioned for 50 MPa characteristic strength with NCA. The tensile strength is less sensitive with a 17% decrease on replacing NCA with RCA. The fracture surface area created in concrete with NCA and RCA are, however, comparable. The shear capacity of reinforced concrete beams made with NCA and RCA is nominally identical. While there is a higher level of cracking in the reinforced RCA beams, the peak load capacities of the NCA and the RCA beams are nominally equal. The failure in shear is produced by the loss of stress transfer across the flexure shear crack leading to the splitting along the crack. Due to the similar fracture surface area, concrete with RCA is able to sustain comparable shear stress transfer as the NCA, and therefore it has nominally similar shear capacity as concrete with NCA.

# IMPACT OF LONGITUDINAL SPACING BETWEEN SPRING ISOLATORS ON THE FATIGUE STRENGTH OF FLOATING SLAB TRACK

**S Bashir[1,2], A R Chowdhary[1,2] & N Akhtar[1,2]**

[1]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad

[2] CSIR-Central Road Research Institute, New Delhi

The fatigue strength of the steel-spring floating slab track (FST) was studied under the influence of longitudinal spacing between the spring isolators. These isolators are routinely employed to support the concrete slabs (floating slab/second stage concrete) on the first stage concrete laid over the tunnel invert and thus decrease the effects of dynamic loads generated inside tunnels, thereby attenuating the vibration levels transmitted into the surroundings. The spring isolator consists of two springs, i.e., an outer/external spring and an inner/internal spring. When trains travel on the slab tracks, these spring isolators are subjected to repeated fluctuations in dynamic stresses, which may fail the entire slab track system. The fatigue potential increases when the isolators are not correctly placed or when the gap between the isolators is inappropriate. However, the spacing between the isolators also affects the construction cost of the slab track structure.

This study used an analytical investigation of a typical steel-spring FST system to show the stresses developed in the isolators at different spacings. The fatigue characteristics of the FST were validated using Goodman's diagram according to DIN-13906-1-2013. The study was conducted for two train speeds, i.e., 110 kmph and 200 kmph. The longitudinal spacing between the isolators was varied while the other parameters of the tunnel-FST system remained constant, and the permissible stresses in the external and internal springs on the outside and inside of the track were determined. The calculated results show that increasing the spacing between the spring isolators causes additional stresses in the spring unit. However, as the spacing between the isolators is decreased, the stress levels show a reduction. Spacings of 1.35 m and 1.3 m were determined to be adequate for speeds of 110 kmph and 200 kmph, respectively. The study will be very useful in finding an optimum design for the steel-spring FST.

# STUDY ON SHRINKAGE OF ALKALI-ACTIVATED FLY ASH - SLAG BLENDS

**Mude Hanumananaik & Kolluru V L Subramaniam**

*Indian Institute of Technology Hyderabad, Hyderabad*

This study investigates the influence of added silica on the shrinkage behaviour of the alkali activated fly ash slag blends (AAFSB). The fly ash to slag ratio is kept as 50:50, while the added silica content is varied from 0 to 3%. The solution molarity of NaOH is fixed at 3M and the solution to binder ratio (s/b) is taken as 0.40, to ensure the workability of the concrete. An increase in silica content in the activating solution resulted in an increase in strength and also produced an increase in drying shrinkage. The drying shrinkage of the AAFSB with low silica content is comparable to OPC. The shrinkage increases disproportionally with silica content in activating solution. Unlike cement paste, shrinkage in AAFSB is not proportional to the mass loss due to drying. The increase in drying shrinkage is correlated with porosity and pore size distribution of the AAFSB. The critical pore size and porosity of the AAFSB decreased with an increase in silica content in the activating solution, which resulted in increase in drying shrinkage.

# PERFORMANCE EVALUATION OF ULTRAFINE MINERALS ON THE STRENGTH OF CONCRETE

**Ajay Pathik[1], Avijit Chaubey[2], Rajat Tyagi[2] & Pawan Sen[2]**

*[1]Ultrafine Minerals & Admixtures Pvt. Ltd.*

*[2]RDC Concrete India Pvt. Ltd.*

The document reports on the study conducted on ultrafine slag for its effect on the strength of concrete and a mathematical model is presented. The paper also tries to find the applicability of Ultrafine slag material to reduce Ordinary Portland cement (OPC) content and reduction in its associated carbon footprint to achieve same strength and workability compared to control concrete.

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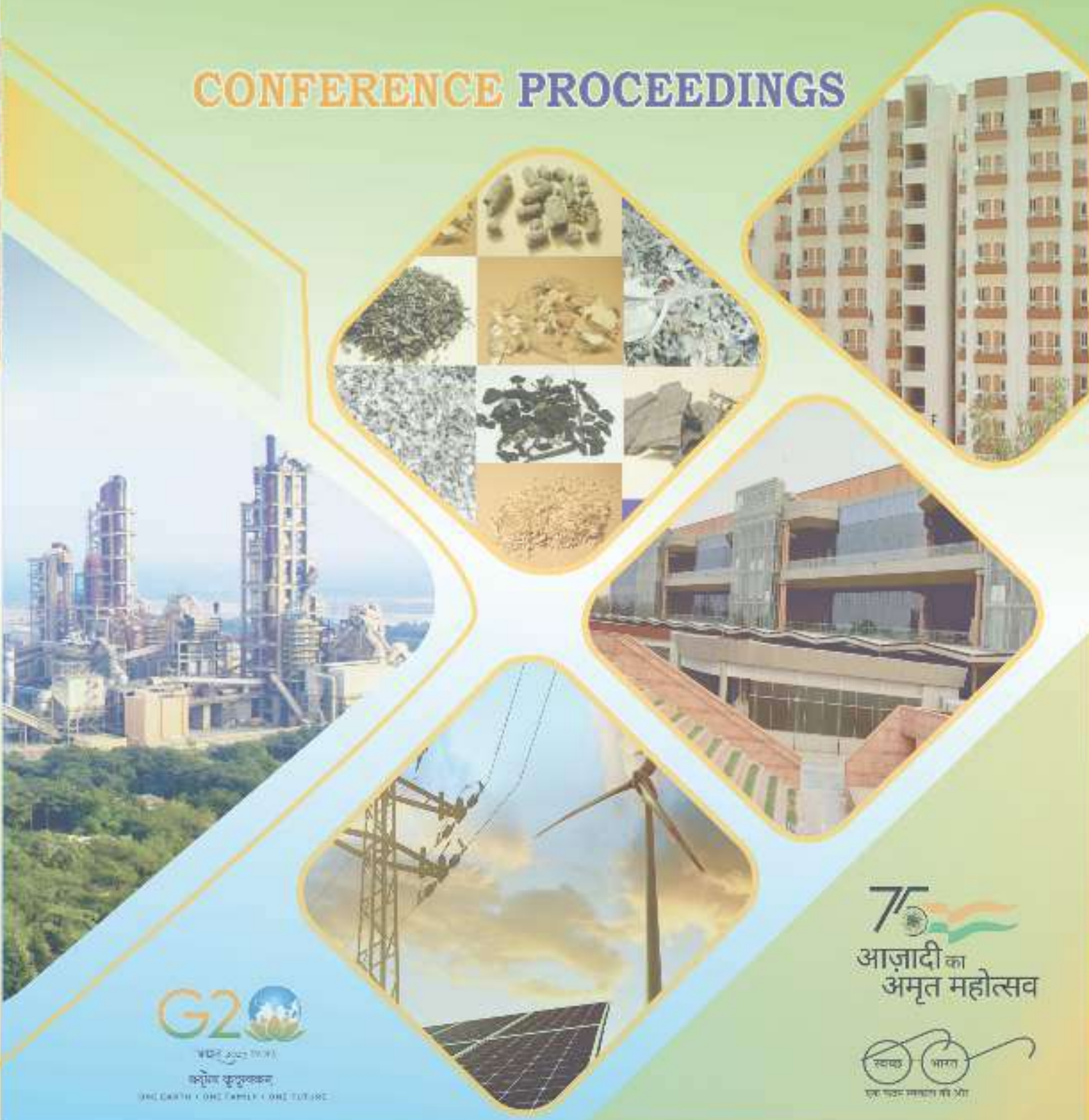
# TECHNICAL SESSION - V A

## ADVANCES IN GRINDING SYSTEMS - I

# CONFERENCE PROCEEDINGS



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# EMPOWER YOUR CEMENT MILL EQUIPMENT EFFICIENCY WITH DIGITAL TOOLS DATA-LED DECISIONS SUSTAINABLE PRODUCTIVITY

**Nuser Bilal**

*Automation Technologies, FLSmidth*

Economic growth, urbanization and industrialization are driving the need for new infrastructure and improved living standards. This in turn is fueling global demand for cement. However, greater scarcity of resources such as energy, water and raw materials is leading to more complex and costly operations, which challenges the performance of cement companies. Your challenges drive us to find solutions that can increase your production output, decrease operating costs and reduce environmental impact even under these conditions. As a full-service provider covering your entire flowsheet, we are well positioned to identify areas where our digital solutions using AI/ML can enable you to discover full productivity potential.

Recently, the cement industries have seen a change in what shapes growth. The spotlight has shifted from increasing capacity to enhancing productivity. Digitalisation has considerable advantages to make this shift possible. To support our customers, we are building a growing portfolio of digital solutions that connect, monitor, and optimise performance, in response to the demands of this changing business landscape. We call it ENABLR. Because it enables you to simplify your operations and improve productivity.

# MULTIPLE MATERIALS, ONE SOLUTION – ROLLER PRESS COMMINUTION, SUSTAINABLE & PROFICIENT SYSTEMS

**Niko Hachenberg**

*Humboldt Wedag GmbH, Germany*

Up to two-thirds of the electrical energy in a cement works is consumed by grinding plants. Even more, when producing high fineness. By consuming the lowest specific energy per ton of any kind of target product, the combination of a roller press and modern separator technology, known as KHD Comflex® & GrindC® Grinding Systems, has proven to be the most favorable grinding solution in the market.

KHD Humboldt Wedag can rely on the experience of more than 300 successful roller press grinding projects. Tailor-made grinding concepts are offered for the use of high portions of clinker substitutes, like slag and fly ash. But also, difficult to grind raw materials with varying moisture content, that are either very hard or soft, easily or hardly crushable, or even plastic, and especially highly abrasive materials like sand, are best suited to be ground most efficiently with a roller press.

In view of the above this paper presents an overview of the initiatives and efforts to match the increasing demand from cement and construction industries to contribute to a sustainable future by decreasing their CO2 footprint while also reducing capital and operational expenditure to a minimum.

# SUCCESS OF GRINDING SYSTEMS RAW MATERIAL GRINDING AND CLINKER GRINDING A CASE STUDY

**Stefan Diedenhofen[1], Vinod Wadile[2], Nitin Jain[2] & Anirudh Dani[3]**

[1]Thyssenkrupp Industrial Solutions AG, Beckum, Germany

[2]Thyssenkrupp Industries India Pvt. Ltd., Pune

[3]Wonder Cement Ltd. & J K Cement Ltd.

The construction industry all over the world is growing rapidly and is always looking for better, stronger and sustainable concrete. While meeting the huge market demands the cement manufactures have to keep a close watch on reduction of the energy consumption, carbon footprint and maximise the use of industrial wastes in the cement manufacturing process. Use of latest technology makes the manufacturing process highly energy-efficient and optimising the clinker factor by use of industrial wastes like fly ash, slag and low quality gypsum helps in the reduction of $CO_2$ emissions. This is an eco-friendly way, which makes the process cost effective by use of industrial by-products (fly ash, slag and gypsum) as partial substitute for clinker, lowers the energy consumption in production. Additionally, it also helps to solve a major problem of industrial waste disposal, which is a significant contributor to land pollution.

In 2018, Wonder Cement for their 8000 tpd line 3, opted for 2 high pressure grinding roll (HPGR) size 20/13-9 operating in finish mode as against a single VRM. The circuit was commissioned in 2019 and it quickly surpassed the warranted performance. The circuit produces 2 x 360 tph at 2 % R on 212 micron with a specific power consumption for core equipment as ~11.10 kWh/t at meters. It not only achieved savings in the specific power consumption to the tune of min. 3.0 kWh/t raw meal, but also provided additional benefits such as zero process water requirement, higher WHRS potential, no reduction in output due to worn out liners, better availability and significantly increased wear life. JK Cement Ltd. commissioned the clinker grinding unit supplied by thyssenkrupp in 2014, which has a production capacity of 1.5 MTPA. At Jhajjar, HPGR size 20/13-9 is working in combi-mode with ball mill size Dia. 4.4 m x 11 m EGL and sepol PC 32/27-410. The circuit produces PPC at ~300 tph at 3350 Blaine with a specific power consumption for core equipment as ~16.5 kWh/t at meters and for complete grinding circuit as ~18.9 kWh/t at meters which is one of the lowest. The system operates with zero hot gas even at lower clinker temperature and zero process water for grinding bed formation. It also facilitates reduction of clinker factor by achieving similar cement strength with flatter particle size distribution and thus puts a step forward towards green cement.

# REDUCTION IN VRM FAN POWER CONSUMPTION BY INSTALLATION OF AERO FOIL DESIGN LOUVER RING IN VRM

**Rajpal Singh Shekhawat & Pankaj Tiwari**

*J K Lakshmi Cement Ltd, Rajasthan*

Cement industry in India is enjoying success and capacity enhancement due to the rapidly growing demand in various sectors but at the same time a threat is approaching to cement industry that its input cost is increasing day by day like power cost, fuel cost, raw material cost. Cement industry is a highly energy consuming industry. Hence to survive and sustain in the market its profitability needs to be enhanced by increasing productivity and reducing energy consumption. This paper unveils the deliberation of reduction in pressure drop across the mill to reduce power consumption of raw mill section. We have installed an aero-foil design louver ring resulted into a saving of 0.54 kw/t and reduction of 1035 t $CO_2$/annum.

# WEAR PROTECTION OF VERTICAL ROLLING MILL COMPONENTS IN CEMENT INDUSTRY

**Harisha Kumar AP**

*Henkel Adhesives Technologies India Pvt. Ltd., Pune*

In cement manufacturing industry, Vertical Rolling Mill (VRM) is one of the major equipment which is used for cement manufacturing process. VRM components undergo lot of wear due to fine particle movements with high velocity. Maintaining VRM and its components are the key challenges for maintenance engineers and the same needs to be addressed for better performance of VRM. The major components of the VRM which are exposed to wear are tie rod, cage rotor, inlet & outlet chutes, classifier static vanes, reject cone, classifier shaft, roller guard, pipe spool & bends, etc. Currently, there are many traditional practices to protect VRM components against wear and tear like wear-plates, hard facing, ceramic tiles, cast basalt liners, etc. These traditional practices have their own limitations like metallurgy change due to welding, time consuming, additional requirement of bonding agents for ceramic tiles, inventory of components, difficulty to do localized repair, etc.

Ceramic bead and silicon carbide-based wear protective coating was developed to combat against wear in VRM of the cement industry. This wear protective coating consists of epoxy matrix and ceramic or silicon carbide reinforcement, together to form a very hard protective coating, which can be used for wear protection of critical components of VRM. The benefits include cold application, mold to any shape and size, sacrificial coating, strong adhesion to metal surfaces, etc.

# ENHANCEMENT OF FLY ASH ABSORPTION BY CONTROLLING PARTICLE SIZE DISTRIBUTION OF CEMENT

**Shyamal Roy, Sanjeev Srivastava, A K Singh & Raju Goyal**

*UltraTech Cement, Mumbai*

Particle size distribution (PSD) of cement is very important parameter for the performance of cement which depends on many factors including grinding technology. PSD greatly impacts on water demand, setting time, strength development, permeability, hydration temperature and microstructures development. Maximization of fly ash absorption in Portland Pozzolana Cement is also associated with the particle size distribution. The present study showed improvement in strength of cement with the proper adjustment of grinding media charging pattern, mill separator adjustment leading the improvement in circulation factors which pave the way for additional fly ash absorption of 2.8% with specific power reduction of 1.4 unit & mill output increase by 5%.

# TECHNICAL SESSION - V B

## LATEST INNOVATIONS & TRENDS

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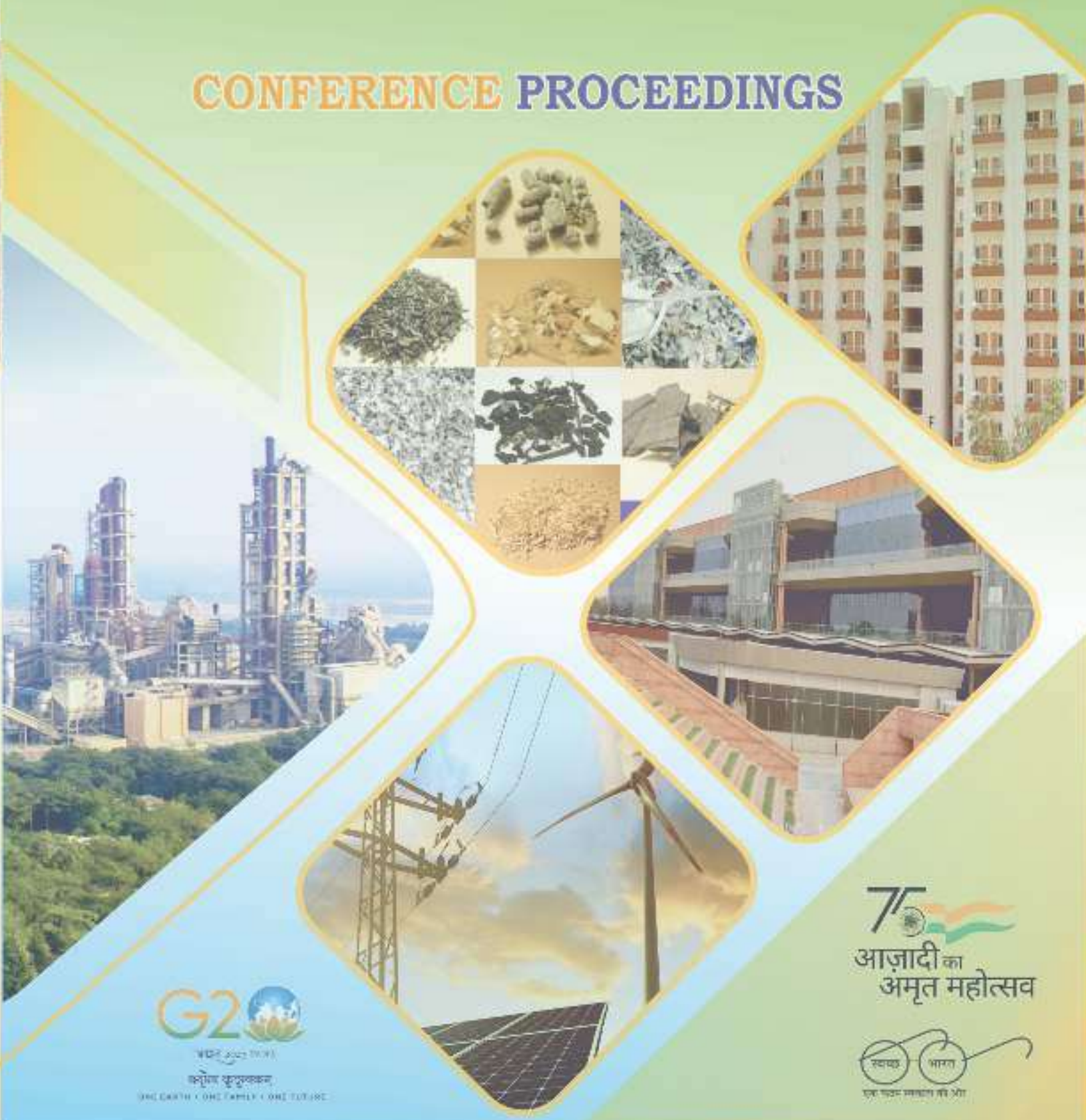

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# RHEOLOGY CONTROL AND 3D CONCRETE PRINTING WITH ALKALI-ACTIVATED BINDERS

**Tippabhotla A Kamakshi & Kolluru V L Subramaniam**

*Indian Institute of Technology Hyderabad, Hyderabad*

Alkali-activated fly ash and slag blends that are optimized for strength are not suitable for 3D printing. Rheology modification is necessary to achieve printability with these mixes. Rheology modifiers provide specific improvements in yield stress and thixotropy that enable shape retention and buildability required for printing applications. A pumpable, extrudable, and buildable material requires a yield-type behavior and an adequate thixotropy. The rheology modifiers used in the present study are Bentonite clay and Carboxymethyl Cellulose (CMC). Specific changes in rheology caused due to the rheology modifiers are evaluated and are related to the performance in printing. A synergy between bentonite clay and CMC is established to achieve printability.

# COMPREHENSIVE DIGITAL TWIN SUITE FOR CEMENT PLANTS - VALUE CREATING TECHNOLOGY FOR THE CEMENT INDUSTRY

**Matthias Mersmann**

*KHD Humboldt Wedag International AG, Cologne, Germany*

Experiencing the potential of digitization technologies like IOT (internet of things) and ML (machine learning) in many industries and other aspects of life, the cement industry is on its way to utilize these methods and systems for its own purpose as well. Having a long track record of automation already, still the sustainable and effective utilization of data for the optimization of the production and maintenance of cement factories has seen some disappointment in many cases. With the advent of huge advancements in data processing, cloud technologies and machine learning, a new generation of digitized solutions is being implemented in the cement industry. This paper showcases the latest development of KHD Humboldt Wedag's automation department: a comprehensive digital twin suite for a cement factory. The digital twin system creates real value for the cement producers by integrating digital functionalities for remote monitoring and the optimization of the production and maintenance of the plant.

# ROOM-TEMPERATURE CURED FLY ASH-BASED GEOPOLYMERS USING LOW MOLARITY ACTIVATORS

**Kruthi Kiran Ramagiri & Kolluru V L Subramaniam**

*Indian Institute of Technology Hyderabad, Hyderabad*

The development of high compressive strength fly ash-based geopolymer binders cured at ambient temperatures without the use of highly alkaline activators is explored. Alkaline activators proportioned based on reactive components in fly ash are used. With the addition of 5% slag in the binder, high strength is achieved at room temperature curing using 3M sodium hydroxide. The main reaction product is characterized as sodium aluminosilicate hydrate (NASH) gel. The compressive strength is related to the formation of sodium aluminosilicate (NASH) gel. The addition of 5% slag enhances early reactivity and results in an increased formation of NASH gel.

# CALCIUM SULPHOALUMINATE CEMENT: ACID RESISTANCE AND EARLY-AGE STRENGTH DEVELOPMENT

**Tom Damion & Piyush Chaunsali**

*Indian Institute of Technology Madras, Chennai*

Calcium sulpholauminate (CSA)-based binders have been promoted as shrinkage-compensating cement due to its expansive characteristics. CSA-based binders offer a promising way to enhance the sustainability of concrete. Lower kiln temperature (i.e., 1250°C) requirement and lesser limestone demand for CSA binder's manufacturing contribute to a significant reduction in its carbon footprint compared to Portland cement. Furthermore, the porous nature of the CSA cement clinker results in lesser grinding energy requirement than that for Portland cement (PC) clinker. For applications such as concrete pipes carrying domestic and industrial wastes, it becomes pertinent to evaluate the performance of CSA-based binders in acidic environment. Such type of structures are mostly prefabricated and early strength attainment is important. This study focuses on assessing the relative acid resistance of a high ye'elimite CSA-based binder with respect to PC. The study also focuses on strength evolution in CSA system. The acid attack was simulated by exposing the CSA-based binders to citric acid. The study consists of detailed characterization of untreated and treated CSA-based binders using x-ray diffraction, mass loss, and area loss measurements. It shows that CSA-based binders have good citric acid resistance in terms of mass loss and area loss measurements. Enhanced acid resistance can be attributed to the phase assemblage of CSA-based binders. The ultimate strength of CSA-based binder could be attained by around seven days.

# PREPARATION OF CGA-BASED LOW-DENSITY AERATED CONCRETE UTILISING SINGLE-USE POLYETHYLENE BAG-CUTS WASTE

**Madhumita Biswas, Ashok N Bhaskarwar & Narendra K Tiwary**

*Indian Institute of Technology Delhi, New Delhi*

Today's global-level concerns about the shortage of energy and environmental protection lead among others to a search for green building materials. Autoclaved aerated concrete (AAC) is a certified green building material that possesses low thermal conductivity and low self-weight. Currently, the most-widely practised aeration technique for the manufacture of the AAC is aluminum-powder based. Our Research Group proposed, in the last decade, a novel eco-friendly and a much less energy-intensive method of preparation of the aerated concrete. In this new method, micron-sized colloidal gas aphrons (CGAs) are introduced as an aerating medium into the wet cement matrix to prepare an aerated slurry. This ultra-light-weight slurry not only helps in preparing aerated concrete with a low-density (400-800 kg/$m^3$), but also solves another major problem of littering happening with lightweight solid-plastic waste. The initiatives like banning and phasing-out to beat the plastic-waste problem are not very effective. Polyethylene bags are one of the major plastic wastes produced. Every year, about 500 trillion tons of plastic bags are used (Shreyas et al., 2018). In the CGA-based aerated slurry, we have successfully utilized single-use polyethylene bag-cuts. It was possible to use up to 1.5% w/w of polyethylene bag-cuts with respect to the total solids in the matrix. From these experiments, it was established that polyethylene bag-cuts have a good impact on enhancing the tensile strength and also on reducing the water absorption of the CGA-based aerated concrete blocks.

# DEVELOPMENT OF ARTIFICIAL LIMESTONE AGGREGATES USING FLY ASH THROUGH MINERAL CARBONATION

**Mohd Hanifa[1,2], L P Singh[1,2], P C Thapyal[1,2] & U Sharma[1]**

*[1]CSIR- Central Building Research Institute, Roorkee*

*[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad*

$CO_2$ emission is a primary driver of global climate change. It is widely recognized that the world needs to urgently reduce emissions to avoid the worst impact of climate change. Reduction of $CO_2$ emission is the most important factor in fighting against climate change to meet the target of reducing the global temperature by 1.5°C at the end of the century. The increase in the $CO_2$ emission from the construction industry emitted an average of 9.95 Gt $CO_2$ and is the highest contributor up to 2019. $CO_2$ emission from the construction sector reduced by 16% up to 2030 to achieve net-zero emission by 2050. Mineral carbonation is one of the best methods for the permanent sequestration of $CO_2$ than geological storage. This paper presents a detail study on the preparation of limestone aggregates through carbon sequestration in a waste and their mineralogical and morphological study using X-Ray diffractometer (XRD) and Field Emission Scanning Electron Microscopy (FESEM), respectively. For the preparation of pellets, fly ash (class F) and lime were mix in a 3:1 weight ratio using water to solid ratio 0.16. The prepared pellets were cured in 100% $CO_2$ environment for 4hrs. XRD results show that after 4hrs of $CO_2$ curing almost all the $Ca(OH)_2$ get converted to $CaCO_3$, which is responsible for the compact microstructure as observed in FESEM results.

# EFFECT OF PHYSICAL, CHEMICAL AND MINERALOGICAL PROPERTIES OF CEMENT ON THE PERFORMANCE OF CONCRETE

**B N Mohapatra, S K Chaturvedi, Richa Mazumder & Sandeep Gupta**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

It is known that the type and quality of cement play a significant role in determining the strength development of concrete. The performance of concrete is influenced by many factors mainly due to the mix proportion of cement, sand, aggregates, and water. In this paper effects of cement properties on the performance of concrete have been discussed. The reaction of water with the cement that takes place in concrete is extremely important to its performance and these reactions may continue for many years. The strength of concrete is very much dependent upon this hydration reaction and depends upon chemical, physical and mineralogical properties of cement, presence of SCMs in blended cement, chemical admixtures, presence of calcium sulphate, temperature, the water content of the system, cement fineness and availability of “anhydrous” phases for the reaction which directly influences the kinetics of hydration.

# ESTIMATION OF FREE SILICA & PYRITIC SULPHUR IN LIMESTONE BY XRD

**Gaurav Bhatnagar, Suresh Palla, Mamta Pawar, Suresh Vanguri, G B Prasad & S K Chaturvedi**

[1]*National Council for Cement and Building Materials Ballabgarh, Haryana*

Determining the content of free silica is especially important to understand burnabilty of raw mix and clinker quality. The burnability of raw mix depends on several factors, chemistry of raw mix, homogeneity and fineness along with process parameters. Estimation of free silica and pyretic sulphur takes substantioal time and it is tedious job to estimate the same continuously for all the samples as well as involves manual, method and standard deviation errors. In addition to all these, both the methods are indirect methods for estimation of free silica and pyretic sulphur. A reliable, precise, and reproducible method to quantify the free silica and pyretic sulphur of limestone is to use X-ray diffraction (XRD) in combination with the Rietveld method. In the present study, a methodology was proposed to estimate the free silica and pyretic sulphur of limestone using XRD. Different limestone samples were identified from different locations of India. Quartz (Free silica) and pyretic sulphur of all the collected samples were estimated by conventional method as well as XRD method. It is found that quantification of free silica and pyretic sulphur by XRD shows comparable results with conventional methods.

# A STEP TOWARDS SYNTHESIS OF ZEOLITE PHASES USING INDIAN CEMENTITIOUS RAW MATERIALS: FLY ASH AND GRANULATED BLAST FURNACE SLAG

**A K Dikshit, G Ahamed, Meenu Verma & S K Chaturvedi**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

This paper summarizes the investigation results on the main parameters affecting the synthesis of zeolites mixed phases using Indian cheaper cementitious fly ash (FA) and granulated blast furnace slag (GBFS) as raw material. Both cementitious raw materials were grounded through a laboratory ball mill maintaining. The Blaine fineness of the grounded FA and GBFS were 246 and 261 m2/kg, respectively. The synthesis was performed by dissolution of raw materials 2 to 5 wt% into sodio alkali solution of 2(M) followed by thermal treatment and structural modifying agent sodium silicate was added into the alkaline hot solutions. This alkaline solution was heat treated by maintaining a predefined temperature at 900C for alkali-activation at autogenous atmospheric pressure for a time period of 4-5hrs for chemical reaction until viscous brownish color developed. This viscous solution was cool down at room temperature for gelation and kept the solution for air dried condition in the hot oven at 600C for nucleation and crystals growth for 4 to 5 days. The obtained various phases and morphological investigation were carried out using X-ray diffraction (XRD) and scanning electron microscopy (SEM), respectively. The XRD profile revealed that various kind of sodium aluminosilicate of mixed zeolitic phases were produced. The mineralogical investigation by XRD showed that the original crystalline phases of fly ash such as quartz and mullite were mostly converted into the zeolitic phases after the alkali activated thermal reaction. But the amorphous chemical constituents for the GBFS samples were also found to be converted to zeolitic phases after the alkali activated through sol-gel process treatment. The experiment of zeolite mixed phases were only developed only when ratio of Si /Al is greater than 1.3 or more, acid treatment at specific temperature and time period, salinity of solution have a significant effect on of newly formed zeolites phases and NaOH /Al is more than 2.7. The developed zeolite phases have wide range of porosity in the scale of sub-micron with high % of porosity.

# FORMULATION OF LIGNOSULFONATE BY-PRODUCT FOR CONSTRUCTION INDUSTRY: IN FAVOUR OF SUSTAINABILITY AND CIRCULAR ECONOMY

**A K Dikshit, Brijesh B Sahoo, S K Gupta & S K Chaturvedi**

*National Council for Cement and Building Materials Ballabgarh, Haryana*

This study compares the differences and similarities of two types of superplasticizer lignosulfonate (LS) and PCE (Polycarboxylate ether) in cement mortar systems, in terms of normal consistency (NC), setting time, soundness from LC and compressive strength. Results show that with either lignosulfonate or PCE addition's the more superplasticizer is added, the more it is adsorbed and the more it remains in the interstitial pore solution. The setting time and compressive strength also decrease with increasing addition the amount of either superplasticizer. It was observed that PCE is less efficient in decreasing the compressive strength than lignosulfonate. More importantly, the setting time patterns and compressive strength trends are different with lignosulfonate and PCE additions; this is tied to the adsorption and dispersing mechanisms of these two types of superplasticizers individually. But for their formulation in the ratio of 1:1, 1:2 and 2:1 of both admixtures showed different setting time and compressive strength. The results for LS: PCE 1:2 result is encouraging in terms of delay setting time without affecting compressive strength. The utilization of lignosulfonate waste from paper and pulp industry with PCE admixture for 1:2 composition to adjust comparable properties with PCE in favour of circular economy.

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## ADVANCES IN GRINDING SYSTEMS - II

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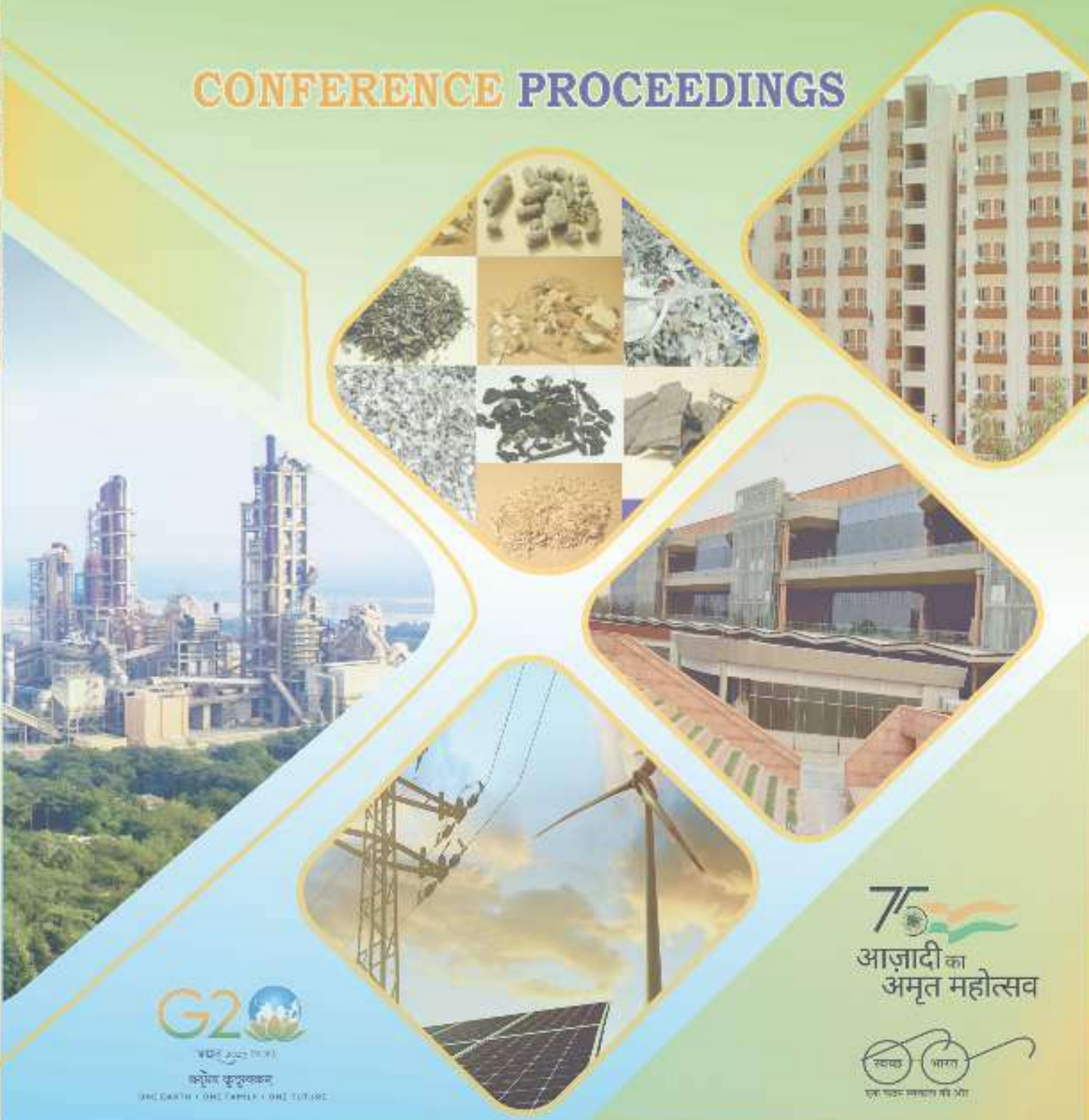

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# OPTIMIZATION OF VRM PROCESS WITH FOCUS ON ENERGY EFFICIENCY

**Caroline Woywadt[1] & Vikram Sharma[2]**

*[1]Gebr. Pfeiffer SE, Kaiserslautern, Germany*

*[2]Gebr. Pfeiffer Private Ltd., Noida, India*

For grinding of raw materials, solid fuels and cements the VRM system is one of the most energy efficient systems available. The combination of three process steps in one system – drying, grinding, separating – makes it very versatile in regard of handling dry and moist feed materials, grinding to very high fineness, creating the product properties required by the different market areas. Cements low in clinker content have been produced and developed since decades, but well known supplementary cementitious materials becoming less available e.g. fly ash and blastfurnace slag. Therefore, other SCMs such as natural pozzolana, calcined clays are used. All SCMs influence the grindability and operational behavior plus the need for adequate reactivity.

The modular vertical MVR mill is since the first prototype installation in 2006 a well-known and proven system, the series of vertical modular roller mills covers a wide range for small to large capacities, very fast time to the market with the ready2grind system and a versatile system for many feed material applications. The continuous product improvement in regard to sustainability, efficiency and digitization is oriented towards the clients needs. The Industry 4.0 trend gives an exciting approach to determine ideal conditions and settings for all applications in combination with artificial intelligence, where a huge potential is identified and the first results with an industrial mill have been very promising.

In this paper a case study of commissioning and subsequent optimization steps to achieve the most energy efficient performance of an vertical modular roller mill will be introduced. Features for energy efficiency already applied and potential / new features will be described in detail. Features are e.g. optimization of nozzle ring covers, dynamic water injection, feed material fineness detection, and application of AI.

# CM-3 VRM PRODUCTIVITY IMPROVEMENT BY SEPARATOR MODIFICATION

**U S Choudhary, Anwar Ajaj & Deepak Narti**

*J K Cement Works, Karnataka*

The most advanced cement manufacturing technology defined by its specific and assure profitable operations. The cement manufacturing operation for maximum cost efficiency not only requires the advanced technological design but also sound operational practices. Plant Process audit is the major tool to optimize any system to reach its desirable output level in terms of Less Specific Power consumption and more productivity. This paper elaborates the process audit and modification of Vertical Roller Mill separator and also shares the best optimization techniques adopted in our plant to achieve the Benchmark figures in the industry. Cement Industry is the high energy intensive industry in which Cement Grinding section is consuming more power while compared to all the other sections in the cement plant. Every industry should adopt energy saving measures by process optimization and technology up gradation to ensure profitability in the business. Vertical Roller Mill modification includes separator area reduction and to optimize this we have stabilized grinding bed, Air balance across the system, Pressure drop reduction, Nozzle ring velocity, study of process fan curve optimization and false air reduction. Specific Power Consumption before separator modification was 23.5 Kwh/t Cement in VRM.

In Cement Mill - VRM we were facing high mill power consumption. The grinding time is shorter in a VRM; excessive powder flow ability can lead to insufficient or inefficient grinding because the material flows too fast through the mill. In contrast to ball mills, VRMs have a very high internal circulation, a short mill retention time and a huge number of classifying steps that carry the well dispersed fines out of the mill system. Hence we have carried out velocity profile in mill. Though we found that the mill body is lesser (5m/sec) than the standard (8 to 10 m/sec) So, Our Mechanical team in concurrence with Process team has modified the mill cross-sectional area to increase the velocity across the Mill. Cross sectional area was reduced 29% by putting skirting inside the mill casing. The Concept behind this idea was to increase the mill separator loading by directing the more material towards the same and to avoid the fines returning to the mill table resulting in the less internal material circulation load. After separator modification specific power consumption is 21.5 Kwh/t Cement VRM. In this paper, we will elaborately share the plant separator modification, process audit guidelines, optimization techniques adopted to achieve the lowest power consumption equivalent to the national benchmark figures. After this project, we have tremendously decreased the specific power consumption and also increased the productivity which supports enormously in cement cost reduction

# FIVE GOLDEN RULES TO IMPROVE BALL MILL PERFORMANCE

**Amit Kumar Kanojia**

*Ambuja Cement Ltd (Adani group Company), India*

Grinding elements in ball mills travel at different velocities. Therefore, collision force, direction and kinetic energy between two or more elements vary greatly within the ball charge. Frictional wear or rubbing forces act on the particles, as well as collision energy. These forces are derived from the rotational motion of the balls and movement of particles within the mill and contact zones of colliding balls. Only 5% energy is used for grinding, so it makes very important to understand the golden rules of cement mill operation (Mill Design, Production management, Quality management, Media charging). These rules are broadly covering all the major aspects of the mill performance like mill loading, reducing the leakage or wastage at all the points, extracting quality margins by strict control over fineness, Optimum use of gypsum etc. After applying these golden rules we have achieved the results as increase in mill productivity by 17%, reduction in specific power consumption by 12% and improvement/ consistency in product quality.

# LATEST DEVELOPMENT FOR SUSTAINABLE AND ENERGY EFFICIENT OPERATION OF GRINDING PLANTS WITH MVR MILLS AND TRT DRYING PLANTS

**Bernd Henrich[1] & Rahul Sharda[2]**

*[1]Gebr. Pfeiffer SE, Kaiserslautern, Germany*

*[2]Gebr. Pfeiffer (India) Pvt. Ltd., India*

Sustainability, efficiency, and digitization are intrinsically linked with the supply and services of Gebr. Pfeiffer. Sustainability has come to the forefront because clients strive to improve their environmental performance and energy use. Efficiency is important for sustainability, as well as for the reduction of production cost. Digitisation feeds into the ease of use of the mill and machines in a cement plant, as well as its process efficiency and, hence sustainability.

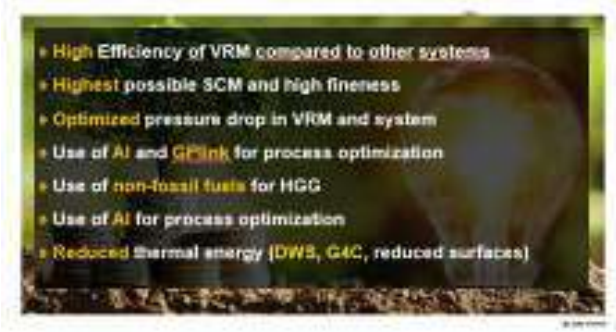


**Figure 1: Pfeiffer´s efforts on greener cement**

**Figure 2: MVR mill**


# OEE, SUSTAINABILITY KPI MONITORING & BENCHMARKING FOR CEMENT MILL THROUGH IOT DATA

**R Manikandan[1] & Kiranmai Sanagavarapu[2]**

*[1]Smart Products - Group Digital, FLSmidth A/S, Denmark*

*[2]Grinding Systems, FLSmidth Pvt Ltd, India*

Overall Equipment Effectiveness (OEE) is a critically important measure for Cement plant equipment, but measuring OEE accurately, consistently and at any given moment can be incredibly difficult for plant managers. OEE provides Plant managers & equipment operators with an overall measure of equipment utilization and enables them to identify where major issues are, enabling them to focus improvement activities to improve the bottom-line. This chapter describes how the FLSmidth Industrial Internet of Things (IIoT) platform and suite of applications – insights and machine learning models (***ENABLR***) provide users Live / History access to "Operational & OEE data" of Vertical Raw / Cement Mill from anywhere any time. Then empower users to perform self-serving analytics & reporting to perform root cause analysis (RCA), baseline and benchmark the operation to discover the sustainable opportunities to improve performance & availability.


# UNLOCKING UPGRADE POTENTIAL IN GRINDING SYSTEMS

**Janardhanan Ananthakrishnan & Shankar Kannan**

*Grinding Cement Industry, FLSmidth*

FLSmidth has taken up the challenge to unlock the upgrade potential in grinding system with the vast product-process know-how built on all grinding products in portfolio. Pyro processing upgrades are well established in the market and many lines are being upgraded with our latest technology namely FLSmidth Cross-Bar® Cooler, JETFLEX® burner, ABC™ inlet etc. But when it comes to raw grinding application where predominantly VRM grinding system has been widely installed, becomes a bottleneck in upgrading and enhancing the capacity.


# QUALITY CONTROL IN GRINDING STATIONS: HOW REACTIVITY DATA MINIMIZES EFFECTS OF CLINKER SOURCE CHANGES

**M A Enders[1], Siddharth Gajjala[1] & L Wadsö[2]**

[1]*Tyssenkrupp Industrial Solutions, Germany*

[2]*Calmetrix Inc & Lund University, Sweden*

This paper focuses on a new method to assess clinker and cement reactivity in cement plants during ongoing production. Automated isothermal heat flow calorimetry in process control overcomes two deficiencies of conventional compressive strength testing: a 24-48 h delay relative to the production of clinker and cement and a critical human error during the preparation of mortars for compressive strength testing. The benefits of this new analytical approach can be easily discussed in the case of grinding stations where the interference to the process is often limited to optimized separator settings and clinker factor. However, more evolved control concepts are available for clinkering plants by controlling raw feed (slow) and fuels (fast) and or process parameters (fast). This paper focuses on the integration of automated calorimeters in lab automation systems and the impact of calorimetry to process control. In future, when new emission targets lead to decreased $CO_2$ emissions (less calcination, more composite materials) reactivity will be a main property to maintain cement performance targets during production.

Alternative Fuel Processing

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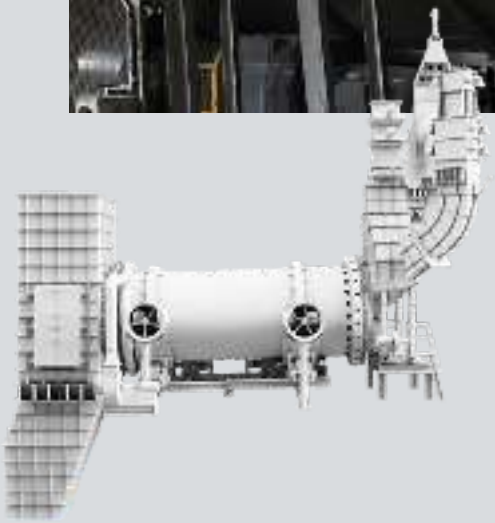

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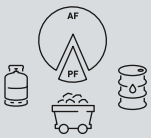


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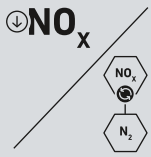


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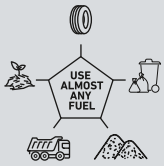


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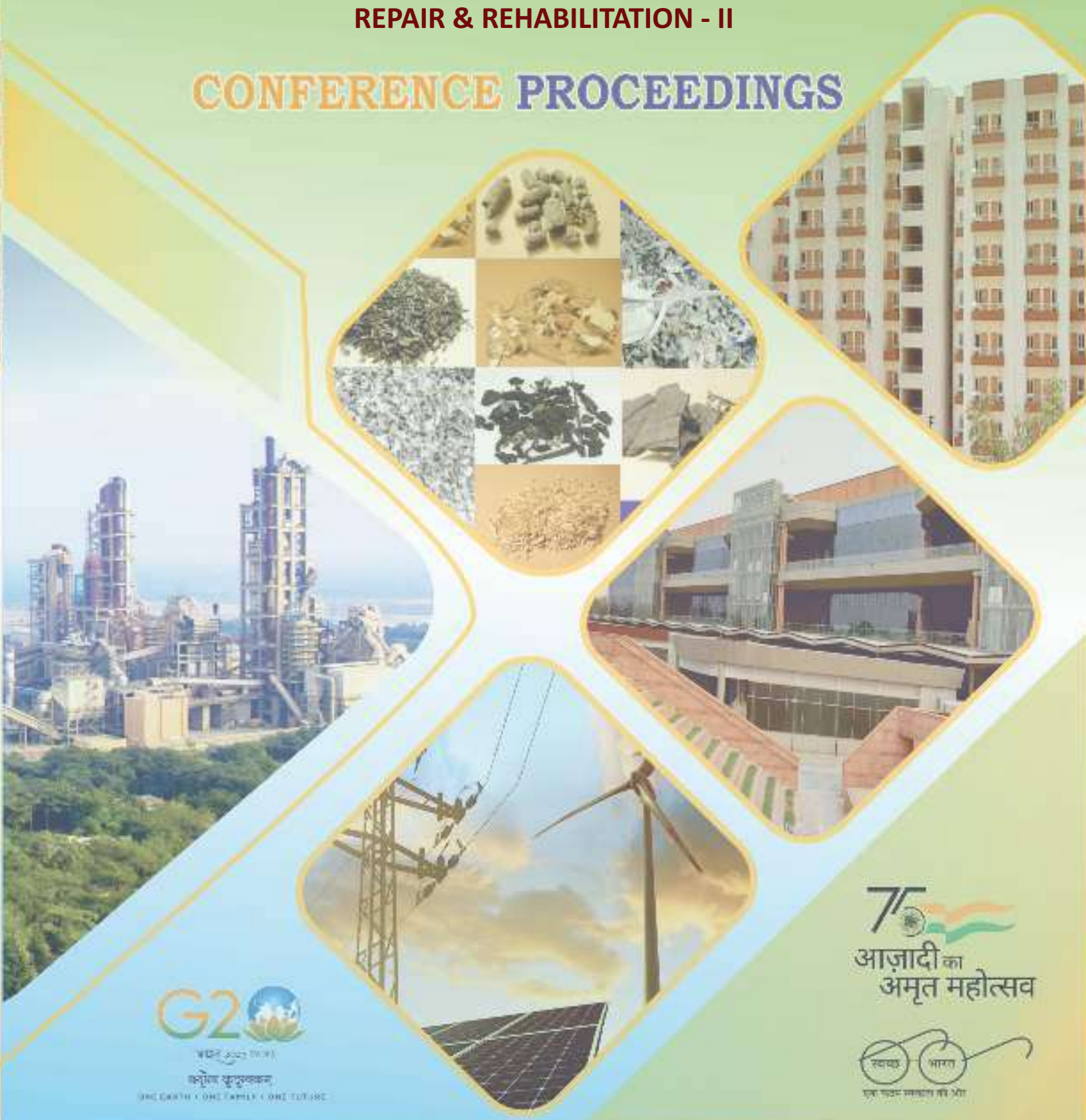
# TECHNICAL SESSION - VI B

## CONCRETE DURABILITY, DISTRESS INVESTIGATION, REPAIR & REHABILITATION - II

# CONFERENCE PROCEEDINGS



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# CONDITION ASSESSMENT OF REINFORCED CONCRETE MEMBERS OF A FIRE DAMAGED STRUCTURE – A CASE STUDY

**Rizwan Anwar, P N Ojha, Nitin Chowdhary, Brijesh Singh & Adarsh Kumar NS**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Fire is the one of the severe environmental exposure conditions to which a structure may be subjected in its life time. A detailed post fire exposure investigation to assess the integrity of the affected structural members should be conducted. A proper condition assessment of reinforced concrete structure after a fire event involves field and laboratory investigations to determine the extent of fire in order to design an appropriate and cost effective repair scheme. The present paper presents a case study where an attempt has been made to carry out a condition assessment of a fire damaged building in a systematic manner. Concrete has superior fire resistance properties than steel and therefore even in severe fires it may offer effective in-situ repair options or partial removal and replacement options compared to the alternative of complete demolition and reconstruction in case of structural steel members. This paper evaluates the extent of damage and residual strength of affected reinforced concrete members of a newly constructed Coal Crusher House Structure of Thermal Power Plant, based on various field and laboratory investigations. To determine the extent of fire damage occurred in affected RCC members of the Coal Crusher House Structure, field assessment to investigate the damage to concrete covering Quality assessment using UPV testing, Rebound Hammer testing, measurement of concrete cover, carbonation and concrete core testing, followed by laboratory scale assessment of residual strength of concrete cores, Optical Microscopy (OM), X-Ray Diffraction (XRD) and Differential Thermal Analysis (DTA) studies are reported in this paper. Highlights on suitable materials & techniques to carryout repair and strengthening of the affected reinforced concrete members are also briefly described in this paper.

# USE OF LOW CLINKER CEMENT AS A REPAIR MATERIAL

**Bharati, Lupesh Dudi & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

World is moving towards reducing carbon footprints. Cement industry is also making its contribution towards this by reducing the use of clinkers and substituting it with materials that entail far less energy consumption as compared to clinker production. One such material is a ternary blend called limestone calcined clay cement ($LC^3$). $LC^3$ has exhibited promising results in terms of mechanical properties and durability. In this study another aspect of suitability of $LC^3$ as repair material has been explored especially for the structures that have embedded rebars and are under risk of corrosion. $LC^3$ can aid in slowing down the ongoing corrosion due to its high resistivity and ability to hamper the ingress of moisture from external environment. $LC^3$ exhibits excellent resistivity and great resistance to transport of moisture and ions hence, showing a potential for mitigating ongoing corrosion in reinforcement. This study uses $LC^3$ for patch repair of concrete with admixed chlorides and monitoring the corrosion rate in rebar over time.

# ENHANCING THE SERVICE LIFE OF CONCRETE STRUCTURES THROUGH SCMS & CORROSION INHIBITORS

**Samidha Pathak & Pranav Desai**

*Nuvoco Vistas Corp. Ltd.*

The study is focused on the evaluation of durability and corrosion resistance of concrete structures. The fresh, hardened & durability properties of concrete are analyzed and compared at varying proportions and combinations of supplementary cementitious materials – Pure Ordinary Portland Cement and blend of cement, fly ash, microsilica. The durability factors like chloride ion penetration, water permeability, chloride diffusion and water absorption are calculated. The effect of chloride ion penetration by admixing corrosion inhibitor was studied. Two case studies are presented – Concrete for basement slab in the coastal exposure region of Bhubaneshwar and another case study of concrete with service life requirement of 125 years for construction of Underground Metro's tunnel segments is also presented using Life 365 – Service Life Prediction Software.

# LOW GRADE LIMESTONE SUITABILITY FOR LIMESTONE CALCINED CLAY CEMENT ($LC^3$) PRODUCTION

**Lupesh Dudi, Ashirbad Satapathy & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

Increase in cement production over the last decades is resulting in faster depletion of limestone reserves and an increasing contribution of cement industry to carbon dioxide emissions. For sustainable development, we need to reduce carbon emissions and use our natural resources more judiciously. In the present work limestone calcined clay cement ($LC^3$) which effectively brings down the carbon footprint, production suitability with low-grade limestone is evaluated to reduce dependence on high-grade limestone. Suitability has been evaluated based on the hydration curve and compressive strength development for $LC^3$ made with different limestone (calcium carbonate content varying from 55 to 80%). Present work concludes that a change in limestone purity within this range does not have a significant effect on hydration and compressive strength development as similar results can be obtained with low-grade limestone as well. Hence, it is more efficient, economical and eco-friendly to use low-grade limestone for $LC^3$ production.

# DEVELOPMENT OF SUSTAINABLE AND DURABLE CONSTRUCTION THROUGH SUITABLE SUSTAINABLE CEMENTITIOUS MATERIAL

**Lopamudra Sengupta**

*JSW Cement Ltd., Mumbai*

"To make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable design strategies provide tangible ways, for integrating sustainability into early phase product design work. Examples include design for re manufacturing, reduce, reuse, recycle and design for the base of the pyramid, which are tailored to business priorities. Various fields in sustainability were reviewed to aid engineers & architects to choose strategies, based on relevance to their project, in terms of both business, sustainability, durability & performance perspective. Various building materials used in construction were studied to check their performances viz a viz durability & sustainability parameters.

Sustainable development can be achieved by creating sound economy, taking climate change mitigation measures and developing sustainable infrastructure like smart Cities or smart infrastructure. A sound local economy attracts people, industry, investment, and increases tax base, creates employment opportunities for residents, and generates public revenues. An economic strategy should balance the need for development goals along with objectives like social, cultural, and environmental ones, to create a truly livable environment that continues to grow and thrive sustainably.

Part of the answer to making development 'sustainable' is an all-embracing coordinated management of resources and infrastructure, a collaborative approach to a cleaner and greener environment.

These objectives includes but are not limited to: Increasing revenue of the various public departments, improving operational efficiencies and reducing consumption of natural resources, reducing costs of services, improving citizen satisfaction and quality of life, staying ahead of the consumption cycle, identifying new service opportunities for businesses, improving economic investment which results in maximum public revenues and minimum public service costs, employment generation and poverty elimination, effective utilization of industry by products and conservation of natural resources, reduction of greenhouse gas emission and carbon footprint, use of renewal energy and alternate materials and taking inspiration from nature.

# REVIEW OF DESIGN CONSIDERATIONS FOR CATHODIC PROTECTION & CASE STUDY OF DESIGN OF CP WITH GALVANIC ANODES FOR REINFORCED CONCRETE

**Arup Ghatak, P N Ojha, Sanjay Mundra, Rizwan Anwar & Nitesh Kumar**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Conventional patch repairs using fresh mortar or concrete exhibit the problem of the formation of incipient anodes along the periphery of the executed patch repairs due to which such conventional patch repairs have reduced durability and provide limited service life enhancement. In order to avoid this, use of cathodic protection (CP) systems involving sacrificial anodes in conventional patch repairs has been picking up pace in some parts of the world. While the design procedures of CP for conventional steel structures are well documented, this is not the case for reinforced concrete structures. Considering the future prospects of this repair and rehabilitation technique, use of intelligent and judicious design based on sound principles is the need of the hour to ensure economical and optimum use of anodes. This paper reviews and discusses in length the design considerations that should be accounted for in an intelligent design of a CP system and presents a case study where the results of published research on the exponential nature of decay of current output of galvanic anodes along with Faraday's First Law of electrolysis and the concept of CP zones has been made use of in the design of a CP system based on galvanic anodes.

# INFLUENCE ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF CLAY UPON CALCINATION

**Mehnaz Dhar & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

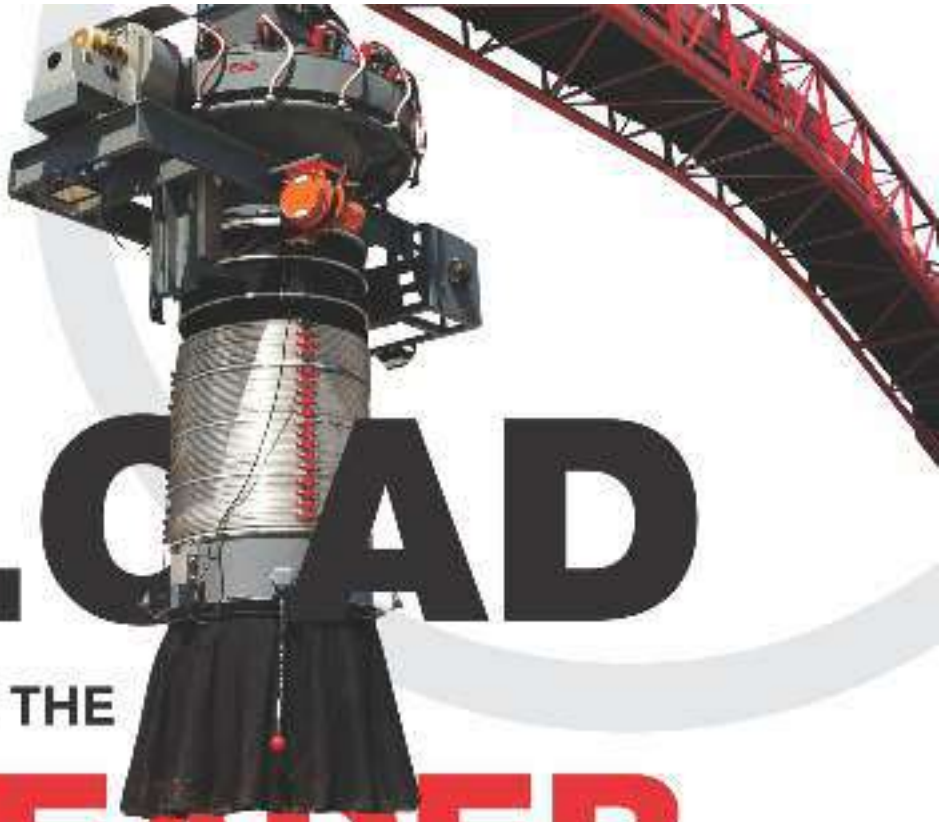
The utilization of clays as supplementary cementitious material is becoming interesting as it has the potential to compensate for the decrease in quantities of fly ash and slag. Clays are heated to high temperatures so that the dehydroxylation reaction occurs and forms amorphous phase with excellent pozzolanic reactivity. The performance of a binder containing calcined clay is governed by the physico-chemical characteristics of calcined clay that is imparted during the calcination process. In this paper, the effect of calcination temperature on physical and chemical properties of clays is reviewed. Changes in specific surface area, specific gravity, particle size distribution and morphology upto calcination temperature of 1000 °C are presented and discussed in detail. The structural changes due to dehydroxylation were also studied using Fourier transformation spectroscopy technique. The results show that structure modifications that occur in clay do not influence the physical properties as they lie in same range during dehydroxylation process. However, increasing the calcination temperature to 950 °C or higher, results in the formation of crystalline phase like spinel that exhibits different physical characteristics than the disordered metakaolin.

# CONDITION ASSESSMENT OF RESIDENTIAL BUILDING AFFECTED BY EARLY CORROSION OF EMBEDDED STEEL REINFORCEMENT DUE TO ADMIXED TYPE CHLORIDE- A CASE STUDY

**Rizwan Anwar, Arup Ghatak, P N Ojha, Nitin Chowdhary & Nitesh Kumar**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

The steel reinforced concrete has been widely used as popular method for civil construction across the globe over the last century or so. Although the structures have been designed for life of 50 to 100 years, it is evident that if the structure have severe exposure or negligence during construction, the concrete can be damaged or the steel can corrode in a dramatically shorter period than specified design life. It has been observed that structures get affected due to corrosion of steel reinforcement at an early age if chlorides (more than threshold value) get admixed in concrete during construction stage itself due to negligence/poor quality control on input materials. The paper discusses a case study on reinforced concrete residential buildings affected by corrosion of embeded steel reinforcement at early age than the design life. The condition assessment of structure was done by using various Non-Destructive Evaluation techniques, core extraction & chemical analysis of concrete. Onset of corrosion has been observed in RCC members which were exposed to moisture, therefore members of the buildings were categorised depending up on their exposure condition/location viz. external/peripheral RCC members, internal members in moisture prone areas & internal members in relatively dry areas. The remedial measures covering treatment of corroded reinforcement and installation of discrete type sacrificial anode cathodic protection system has been discussed in the paper.



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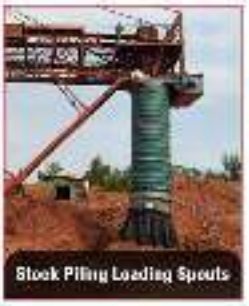
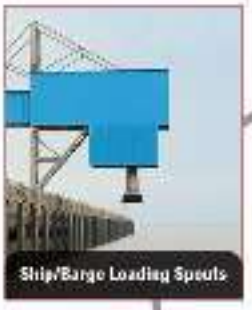
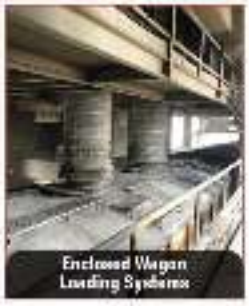

Stock Piling Loading Spouts


Ship/Barge Loading Spouts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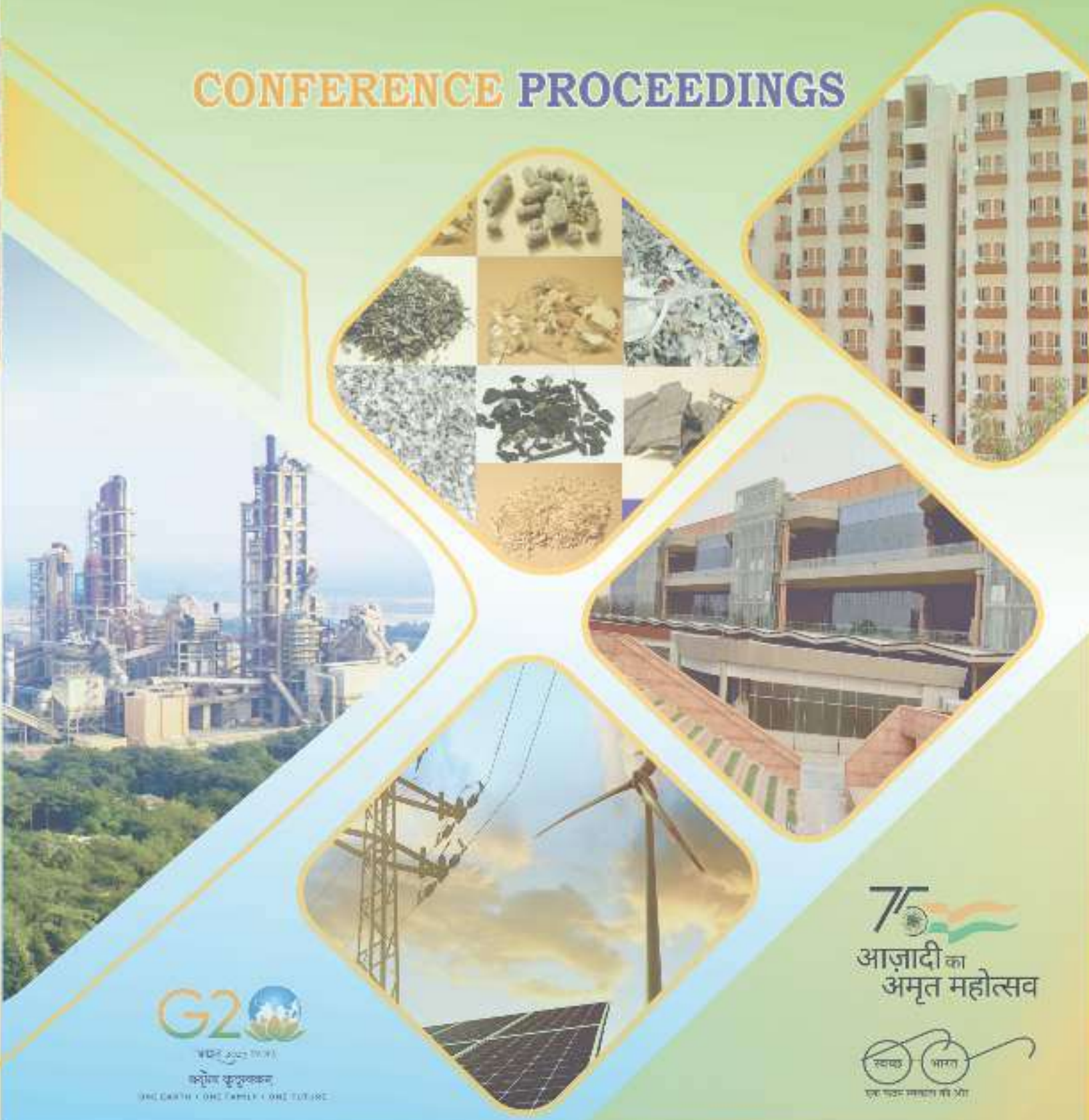
# TECHNICAL SESSION - VII A

## LOGISTIC, CSR INITIATIVES & TOTAL QUALITY MANAGEMENT

# CONFERENCE PROCEEDINGS



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# IMPACT OF CSR INITIATIVES ON WATER FOOT PRINT OF CEMENT PLANT

**V Rama Raju**

Dalmia Cement (Bharat) Limited – Kadapa

Water is the precious source for life of all living things on earth, even for industries like Cement manufacturing companies. With 97% total water available on earth being in oceans and another 2% in glaciers, we left with only 1% fresh water for usage. It is therefore, a challenge and necessity to conserve fresh water. This paper discusses about so far situation on the context water availability and efforts made to achieve water positivity index at cement manufacturing unit of Dalmia Bharat Group at Kadapa District of Andhra Pradesh.


# IMPLEMENTATION OF TOTAL QUALITY MANAGEMENT IN NCB

**B N Mohapatra, Amit Trivedi, Suresh K Shaw, P Srikanth, Anand Bohra, K R P Nath**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Total Quality Management (TQM) is an integrated organizational approach in delighting customers (both external and internal) that strives for quality in all aspects of the operation of a company or business. Under TQM approach, the management and employees of company or business gets involved in the continual improvement of the production of goods and services. The important elements of TQM are customer focus, employee involvement, continual improvement, process centered, effective communication, decision making based on facts, integrated system, leadership commitment, and strategic & systematic approach. The effect of implementation of TQM in any organization will result in improved customer feedbacks from the customers, increase in revenue, customer retainment and increase in brand value of the organization.

Under the dynamic leadership of Director General-NCB, direction and support for performance improvement, through: planning; coordination, setting action plans and reviewing the outcomes, use of various TQM tools leading to continual improvement. The paper discusses the various aspects of total quality management and actual implementation of various TQM tools in NCB and resulting in improvement in performance parameters.

# REDUCING CARBON FOOTPRINT IN CEMENT INDUSTRY: ENERGY SAVING BY COMPRESSED AIR LEAK ELIMINATION

**Asha Kumari & Jigar Shah**

*Henkel Adhesives Technologies India Pvt. Ltd.*

Compressed air is an inevitably essential utility of the cement plant and since energy is needed to convert electricity into compressed air, it can be one of the most expensive sources of energy in a plant. Very often, the actual cost of generation is unknown. Only 10% to 20% of the energy required to generate compressed air ever reaches the point of use.[7] Unfortunately, in majority of the plants compressed air is taken as not that important utility until plant starts to suffer due to drop in pressure or supply inadequacy, moreover in most of the plants an easy go solution for this problem is considered only to increase pressure set for compressor or simply addition of one more compressor. While many inefficiencies of system can be eliminated with proper maintenance, it is important to monitor them in use. That includes detection and repair of expensive air leaks which may cost businesses thousands of rupees per year. Compressed air leak audits carry significant high-cost savings and are best opportunity to save energy in compressed air system.


# USAGE OF BAMBOO AS ALTERNATE FUEL TO REDUCE THE $CO_2$ EMISSION ALONG WITH SOCIO ECONOMY DEVELOPMENT IN NEARBY VILLAGES COMMUNITY

**Amitava Roy, Pallab Kalita & Rohini Baishya**

*Calcom Cement India Ltd. (A subsidiary of Dalmia Cement Bharat Ltd.), Assam*

Indian cement industry is the second largest in the world with a total installed cement capacity of > 500 MTPA (Million Tons per Annum), including around 15 MTPA in northeastern states, with a forecast to reach 600 MTPA by 2025, which will increase the energy demand. There is only one earth for us & global warming is really a major concern for everyone's survival & ecological balance.

Reduction of $CO_2$ emission in the Indian cement industry is now need of the hours and in present scenario usages of alternate fuels in place of fossil fuels is the only possible way. Indian cement industry is also taking various initiatives for reduction of $CO_2$ emission like usages of blended cement, higher usages of additive, reduction of OPC cement, Alternate fuel usages, enhancement on plantation etc. Usage of Bamboo as an Alternate fuel is one of the best option in North East India due to its soil as well as weather condition. The present study describes the bamboo usage as one of the alternate fuel in north eastern cement plant.

# INVESTIGATIONS OF BURNABILITY USING MICROSCOPY WITH RESPECT TO THE COARSE AND FINE RAW MIX RESIDUE

**Venkateshwarlu B C, Asis Kumar K, Reetam Chaudhury & Sujit Ghosh**

*Dalmia Cement (Bharat) Limited, New Delhi*

Clinker microscopy is a powerful tool for the evaluation of clinker and cement properties. Although, fully automated analytical devices like XRF or XRD are prevalent nowadays, yet, we cannot get a visual representation of clinker minerals using these tools. Optical Microscopy gives us the ability to actually look at and observe the mineral phases, their distribution and, their crystal size and shape[1]. Optical microscopy of clinker microstructures helps us solve innumerable problems of clinker quality by optimising pyro-processing parameters [1] through brain storming, Root-Cause Analysis, confirming the probable causes, Why-Why Analysis & Actions. Both positive & negative aspects are identified using optical microscopy. These lead to homogeneity of raw meal, reduction in burning conditions[1] inside the kiln, slow cooling conditions[2] etc. which eventually results in improving the production process and hence, clinker quality. In the current paper, chemical and mineralogical properties of raw meal residues and formation of clinker phases have been assessed for their role in cement mortar strength. Results give insight towards burning and residence and depicts a slow cooling rate. Raw material residues suggest inhomogeneous heat distribution typical of pyro processing.

# CASE STUDY: A PATENTED INNOVATIVE ANTI-STICK HYRBID COATING TO REDUCE THE DOWNTIME OF EQUIPMENTS IN CEMENT MANUFACTURING PLANT

**Jigar Shah**

*Henkel Adhesives Technologies India Pvt. Ltd.*

In cement industries, equipment like Induced draft fan (ID fan) impeller, hoppers, bucket elevator get abraded and corroded because of processing of a highly abrasive, wet and/or dry material. During the operation, high velocity particles abrade the surface and sticks on equipment resulting into equipment misalignment, subsequently which leads to down time. Various high-performance coatings are being used in the market to address this challenge. However, the main limitation of these coatings is required to cure at higher temperatures, doesn't provide wear protection and anti-stick property at the same time and needed to be apply frequently which not only imparts process complexity but also extra cost. To overcome the above-mentioned problems and ease the application, a novel room temperature curable hybrid coating has been developed. This article illustrates the development, physio-chemical and mechanical properties of a two-part antistick hybrid coating using various ASTM methods and compared with traditional two-part abrasion resistant coating. This article also describes the how the anti-stick hybrid coatings provide benefits in terms of reducing the down time and increase the durability of the cement plant equipment's.

# DEVELOPMENT OF CRM– TARGETING QUALITY PRODUCT AND EXCELLENCY IN COMPETENCY

**S K Shaw, V Naga Kumar, A Agnihotri & Amit Trivedi**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

In the present scenario of globalization of economy, globally acceptable measurements are required where the availability of Reference Materials becomes crucial for universal acceptance of products and test reports. Reference material is characterized by a metrologically valid procedure for one or more specified properties, accompanied by a reference material certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability. These materials are traceable to SI units through National Metrology Institute (NMI). Certified Reference Materials (CRMs) are being used for calibration of instruments, validation of test methods, establishing purity of materials, evaluating proficiency of analysts etc.

# SIGNIFICANCE OF PROFICIENCY TESTING (PT) IN THE FIELD OF CEMENT AND BUILDING MATERIALS

**V Naga Kumar, Suresh Kumar Shaw, Abhishek Agnihotri & Amit Trivedi**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Laboratory Proficiency Testing (PT) is defined in ISO/IEC17043: 2010 [1] as "the evaluation of participant performance against pre-established criteria by means of inter laboratory comparison." Proficiency testing is a key element in the laboratory accreditation process and also enabling labs to monitor the quality of their analytical results. Proficiency testing determines the performance of individual laboratories for specific tests or measurements and is used to evaluate laboratories continuing performance.

Laboratories [3] need to monitor their performance by comparison of results with other laboratories by participating in proficiency testing as per 7.7.2 (a) of ISO/IEC 17025:2017(E). For labs that are going for accreditation for the first time, it is particularly important as an initial step in that process. Even if there are no plans for accreditation, successful participation in PT programmes assist laboratories in variety of ways by demonstrating accurate laboratory performance in sales promotion and also helps to measure individual employee performance and training.

The benefit of the Proficiency Testing is that it enables the management of participant laboratories to benchmark their own performance against other laboratories using defined sample. If performance is below standard, laboratory management can review and revised their methods to ensure that quality and safety criteria for products to be meet the objective to compete in competitive market.

# SIGNIFICANCE OF INTERMEDIATE CHECKS OF EQUIPMENT AND EXPLORATION OF VARIOUS INTERMEDIATE TECHNIQUES

**P Srikanth, V Naga Kumar, Bharat Ram, Rishi Raj & Amit Trivedi,**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

The Calibration and Testing laboratories which have got accredited themselves as per ISO/IEC 17025:2017-General requirements for the competence of testing and calibration laboratories, are familiar with the term: "Intermediate Checks". The laboratories have to implement Intermediate Checks as part of maintaining confidence in the performance of equipment (Clause 6.4.10 of ISO/IEC 17025:2017) and ensuring validity of results (Clause 7.7.1(e) of ISO/IEC 17025:2017). Intermediate Checks can be defined as measurements of instrument in smaller increments of time than calibration cycle, to verify that the instrument is still within the bounds of acceptable performance.

In this paper, the authors have explored, analyzed and made efforts to list out intermediate check methods, which are practical, implementable and acceptable. The authors have arrived on these methods through literature survey, data generated in laboratories and available relevant standards.

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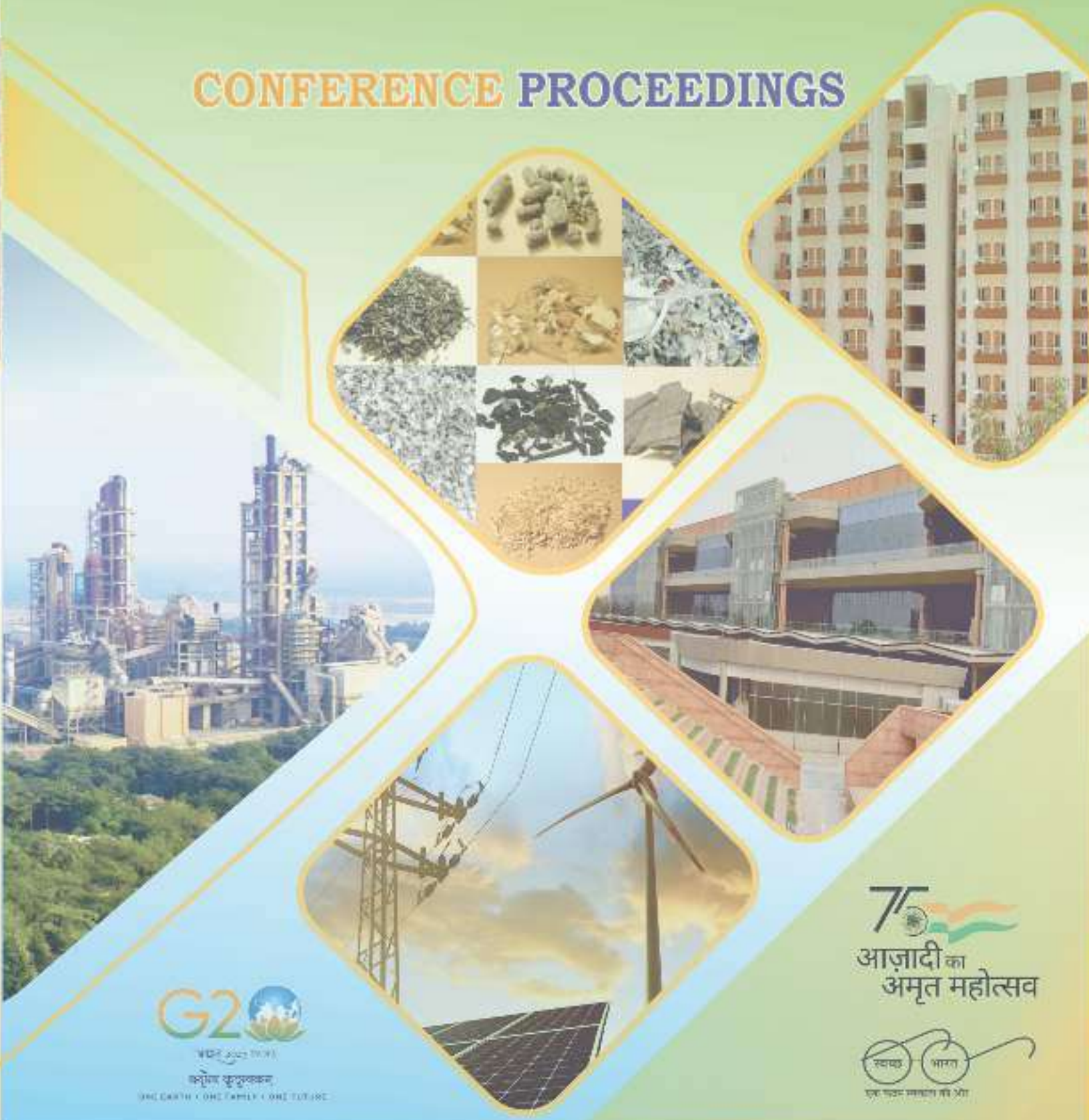
# TECHNICAL SESSION - VII B

## CEMENT PLANT MACHINERY & PROJECT ENGINEERING - II

# CONFERENCE PROCEEDINGS



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# ADVANCED REFRACTORIES SOLUTION FOR MODERN CEMENT PLANTS

**Sourav Duttagupta[1], Sayan Ray[1], Parthasarathi Mukhopadhyay[2], Purushottam Bedare[2], Premanshu Jana[1], Abhinav Srivastava[1] & Mithun Nath[1]**

*[1]Global R&D Center for Advanced Refractories, Vesuvius, Visakhapatnam*
*[2]Vesuvius India Limited, Visakhapatnam*

This paper summarizes the advanced refractory materials solutions for modern cement plants that use alternative fuel & raw materials (AFR). The wide range of AFR contains many inconsistent and variable impurities responsible for numerous complex low-melting reactions upon interaction with refractories. Therefore, the performance of the usual refractory can be severely affected due to such derogatory reactions. So, the development of AFR-resistant materials solutions to inhibit the propagation of such low-melting reaction-kinetics. Apart from materials fabrication techniques, physical and thermo-mechanical properties evaluation, meticulous and sophisticated investigation techniques are introduced to analyse the developed materials. As a result, the study ensures the applicability of our AFR-resistant product in the harsh & complex environment of modern cement plants that uses AFR.

# DEVELOPMENT OF HIGH CORROSION RESISTANT MAGNESIA SPINEL BRICK FOR CEMENT ROTARY KILN

**Avishek Mitra & S K Hazra**

*Dalmia Cement (Bharat) Limited, India*

Cement is one of the leading industries in the world with a capacity of 502 million tonnes per year only in India. Previously, Magnesia Chrome bricks were being used in the Upper and lower transition zones as well as in the burning zones of cement rotary kiln. Recently chrome free bricks like Magnesia-spinel have attracted interest due to eco-friendlyness and probably better properties. Magnesium aluminate spinel brick is known to offer a desirable combination of mechanical, chemical and thermal properties both at ambient and elevated temperatures. In Plant A, we were supplying magnesia spinel bricks with an average life of 9-10 months and the main reason for shut down was corrosion of bricks mostly in lower transition zone.

The objective of the present work is to investigate the causes of damage and low life of Magnesia Spinel bricks in Lower Transition Zone of cement rotary kiln and ultimately to improve the life. This paper highlights the different steps we have taken like Micro-structural analysis of the used brick, study the diffusion behaviour of clinker into the brick matrix, chemical analysis and XRD of different parts of used brick. This paper also speaks about the formulation of a new recipe with special additive to counter faster corrosion of these bricks thus resulting in higher life. The physico-chemical properties of the developed brick along with its improved corrosion are also discussed.

# FREQUENT FAILURE OF ALUMINA BRICK IN SAFETY AND CALCINATION ZONE – REASON & REMEDY

**Shyamal Roy, Sanjeev Srivastava, Amit Shah & Raju Goyal**

*UltraTech Cement, Mumbai*

One refractory failure in kiln will have the stoppage of plant for at least 4-5 days including patch up, cooling / heating schedule, which incurs huge loss of production, particularly when the kiln is demanding. For one million ton plant, the loss of one refractory failure in kiln will be around Rs. 1.5 - 2 Cr including production loss, refractory cost, installation cost & additional fuel cost. Safety concern for any additional job is another concern. So the impact of even one additional stoppage of kiln due to refractory failure is really a concern in today's demanding kiln. Refractory failure is observed in many areas of kiln like outlet area, transition zone, burning zone, safety zone & calcination zone. Alumina bricks is being used in safety & calcination zone of kiln. Now a day's refractory life is very much vulnerable in safety & calcination zone due to many factors like, kiln mechanical condition, quality of brick, installation practices, fuel usage, etc. In this article analysis against each reason has been discussed in detail with relevant pictures. Remedial measure against each probable reason also mentioned. This will definitely help to improve the refractory life of alumina brick used in calcination & safety zone.

# ONLINE WEAR MONITORING & ADVANCED METAL DETECTION SYSTEM FOR HPGRs OPERATION IN CEMENT PLANTS

**Prashant Garg & Manoj Srivastava**

*Diffusion Engineers Limited*

An online wear monitoring system and efficient metal detection for HPGRs is developed with predictive artificial intelligence arrangement to offer the cement plant mill user a unique opportunity to get ahead of roller press roller breakdown using with precise online information on how, when, and where it's going to happen.

This way, the user can schedule maintenance activities only when they are strictly necessary avoiding productivity downtimes and saving money in unexpected repair costs. This paper focuses on the advantages of the sensor based technology employable in HPGR mills to overcome the premature failure of roller press rolls. This system helps the user in three critical aspects of HPGRs operation – real time visualization of wear on the roller surface, cheek plate orientation and effective metal separation.

# INNOVATIVE STEP FOR THE IMPROVEMENT OF EQUIPMENT EFFICIENCY AND BEST MAINTENANCE PRACTICE A CASE STUDY

**N Diwakar, Narendra Pal Singhai, Praveen Shrivastava, Dinesh Agrawal, Sanjay Singh & Manish Kumar Singh**

*Prism Johnson Limited, Satna*

In the current scenario of a competitive industrial environment, it's important to reduce manufacturing costs by enhancing productivity and reducing energy consumption, which have now become the top priority of all the cement plants. The present paper discusses the reduction in electrical power consumption with retrofitting of high-efficiency impellers in the existing process fans in the Raw Mills & Cement Mills of Unit I plant. They were operating at lower efficiency consequently higher power affecting consumption the performance of plant and having a bad impact on the environment due to emission of greenhouse gases. On an average, 0.82 kg of $CO_2$ is released to the atmosphere per 1 kWh power generation.

Process fans majority contribute approximately 35% of power consumption in raw grinding, 70% of power consumption in Pyro-Processing, 35% of power consumption in coal mill & about 10% of power consumption in the Cement Mills section at Prism Johnson Limited. In order to reduce power consumption various optimization techniques such as false air reduction, cooling air, optimization of raw mill nozzle area, dam ring height & water spray etc. are in process along with preventive maintenance practices. All these efforts could improve the performance up to system efficiencies. In case of changes in process parameters due to changes in operation methodology or any system modifications, the performance of the equipment also gets changed.

In an effort to improve performances of the major process fans, retrofitting helps to reduce power consumption. Details of the concept to implementation is described in the sections of the paper. Present paper discusses improving the energy efficiency of process fans to a reduction in electrical power consumption by retrofitting the existing process fans in the raw mills & Cement mills of our Unit I operating at lower efficiency.

# TRAVELLING CRUSHERS UNDER WAGON TIPPLERS AND TRACK HOPPERS

**K S Nalwaya & Jogesh Narula**

*KSN Tech Ventures Pvt. Ltd.*

This paper is focused on installing of travelling crushers on the grizzly of the wagon tippler hopper, so that oversize coal blocking the grizzly is mechanically crushed in place and smooth and fast rake evacuation ensured and wagon turnaround time and demurrage minimized

# USAGE OF BIODIESEL IN THE HEAVY EARTH MOVING MACHINERIES

**T Robert, G Shankarappa, B R Prasannakumar & C S Balakrishnan**

*Dalmia Cement (Bharat) Limited, Ariyalur*

Biodiesel use as an automotive fuel is expanding around the world and this calls for better characterization of its impact on diesel combustion, and emissions. This article presents a review on usage of Biodiesel in Heavy Earth Moving Machineries (HEMM) and its constrains faced along with our journey towards 100% utilization.

As per our commitment to become carbon negative by 2040 and based on the National Biodiesel Board, in Bioenergy (Second Edition), 2020, we committed to use biodiesel as a replacement of diesel in HEMM by taking a calculative risk. For 100% conversion to Biodiesel usage, specialized 5 stage filtration unit with filter size of 2 microns is used to remove dust contamination. Also, the Empty filters are cleaned on daily basis to ensure that Cotton & Paper filters are not getting clogged during long run.

Biodiesel is the most promising fuel in the near future as an alternative to fossil diesel. Despite of its advantages, it still has some disadvantages which needs to sorted out before biodiesel is applied into diesel engines in a large scale. Therefore, in-depth studies on the application of biodiesel into diesel engines are necessary.

# STATE OF THE ART PERFORMANCE IMPROVEMENT WITH NEAR INFRA-RED ONLINE ANALYSIS

**Petra Mühlen**

*Spectra Flow Analytics AG, Switzerland*

The paper will present a non-radioactive technology for Online Chemical Analyzers installed as Crossbelt Analyzer (CBA) or Airslide Analyzer in the cement production process. The measurement technology is based on near infra-red (NIR) analysis of the raw or process material. The main advantages are:

1. No radioactivity
2. No special permits required
3. No expensive sources
4. Lowest cost of ownership
5. Proven system with the best accuracy
6. Applied for

    a. Raw material stockpile optimization (closed loop)
    b. Raw Meal or kiln feed control (closed loop)
    c. Coal or alternative fuels analysis (organic and minerals)
    d. Finish cement control (close loop mineral phase analysis)

7. Can measure the standard oxides CaO, $SiO_2$, $Fe_2O_3$, $Al_2O_3$ but moreover

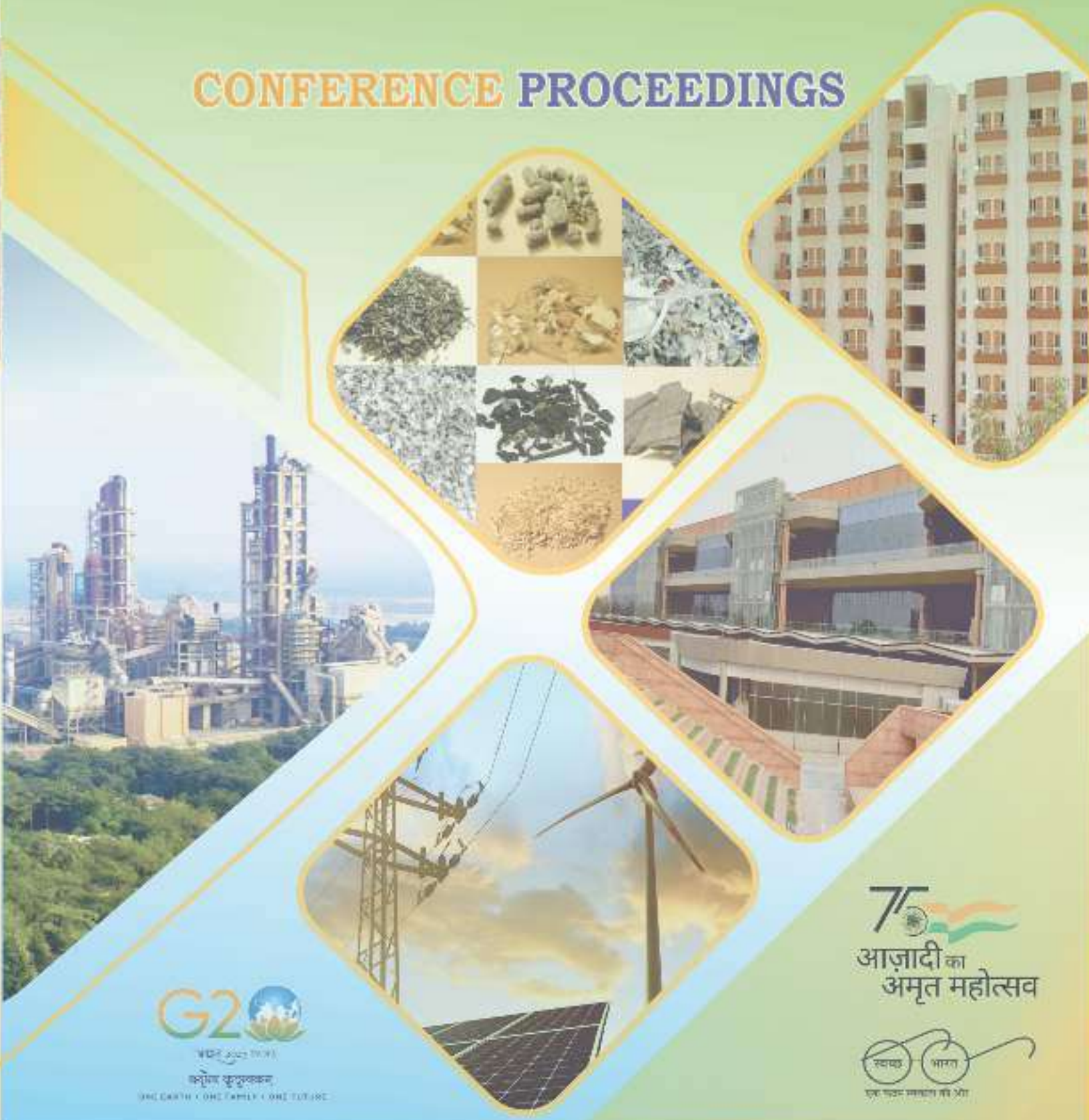
    a. elements and mineral structures (clinker phases)
    b. down to ppm concentrations in
    c. raw material, raw meal and finished cement,

    like: moisture (H2O), MgO, $SO_3$, $TiO_2$, $Na_2O$, $K_2O$, Cl, $P_2O_5$, Hg, carbohydrates, $C_3S$, $C_2S$, $C_3A$, $C_4AF$, etc.

# TECHNICAL SESSION - VIII A

## ALTERNATE/WASTE FUELS & RAW MATERIALS - II

# CONFERENCE PROCEEDINGS



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# SUSTAINABLE SOULTION FOR CO-PROCESSING OF SPL MIXED FINES IN CEMENT PLANTS

**Alka Mishra, Anand Pratap Singh, Rajiv Sadavarti, G V Ramakrishna & Arbind Singh**

*Dalmia Cement (Bharat) Limited , New Delhi*

One of the major challenges in the Aluminium Industry today is to utilize hazardous waste that is generated during production of Primary Aluminium from the Alumina Smelting Industries, by segregation of fines from lumps of carbon and refractory portion of Spent Pot Lining (SPL). These fines are referred as SPL Mixed Fines (SPL-MF) that is categorized as Hazardous waste (S. No. 11.2 of Schedule-I of HOWM Rules 2016) and is required to be disposed in authorized disposal facility in accordance with authorization condition, when not utilized as energy/ resource recovery. It has no energy value, but contains few very valuable components and can be used for specific purpose.

Dalmia Cement Bharat Limited Odisha Unit is the first Cement Plant in India to conduct a trial run to co-process SPL-MF, as per the guidelines of CPCB and SPCB-Odisha (Ref. No. 10943/IND-IV-HW-1361; dtd. 24-06-2022). The trial run has been conducted successfully and has resulted in, up to 1.0% absorption of SPL-MF in clinker production. However, proper pre-processing of SPL-MF is must prior to co-process in cement kiln. Co-processing needs a separate controlled feeding system to feed into kiln inlet while maintaining clinker quality and rated production was the challenging task.

# QUEST OF GREEN FUEL AT KADAPA CEMENT WORKS

**Mukesh Sinha, M Nemani & Netaji Rao**

*Dalmia Cement (Bharat) Limited, Kadapa*

Kadapa Cement Works (A unit of Dalmia Cement) is the cement clinkerisation unit in the Andhra Pradesh. It is our responsibility to conserve the precious natural resource & to preserve environment most importantly the fossil fuel (Coal). The journey of kadapa Cement works towards AFR is shown in Fig


The Dalmia Cement kadapa works has been promoting the recycling of waste as alternative fuels or raw materials. At high thermal substitution rates (TSR), we may introduce more chlorine into the kiln system than we can incorporate in the cement while complying with the respective cement standard (0.1% of chlorine in all types of cement). Consequently, as the amount of waste recycled has increased above 13-15% of TSR, the amount of volatile components, in particular, chlorine will also increase. Therefore, a new Gas bypass system have been installed to remove chlorine effectively from our kiln-preheater system. Purpose of a Gas bypass system is to reduce incrustations by removing chlorides from the kiln system. This “Gas-bypass” is located in a position where a maximum concentration of chlorides is absorbed on the fine kiln feed particles and relatively small amount needs to be taken out from the inlet section of kiln system in order to reduce “chlorine recirculation” significantly and to stabilize kiln operation with TSR 40% & beyond.

# AN EXPERIENCE IN CO-PROCESSING OF HAZARDOUS LIQUID WASTE IN CEMENT KILNS AT JK LAKSHMI CEMENT LTD, JAYKAYPURAM

**Rajpal Singh & Manish Vijay**

*J K Lakshmi Cement Ltd, Jaykaypuram*

The large volume of industrial by-products and wastes from the chemical, pharma, and polymer industries has become a serious challenge worldwide. Co-processing these industrial wastes as functional materials in the cement industry is an efficient approach to sustainable development. This paper presents an approach for demolition waste through cement kilns and its impact on pyro-processing. The combined plant enabled the cost-effective disposal of various industrial wastes in a single process unit. The results show that the economic and environmental impact of the chosen techniques, in terms of their energy consumption, is highly efficient in the disposal method in the waste hierarchy. These industrial wastes can be used as sustainable materials to produce clinker, contributing to sustainability in the cement industry.

# RIGHT APPROACH FOR CHUTE DESIGN-HANDLING ALTERNATIVE FUELS

**Kapil Kukreja[1,2], Manoj Kumar Soni[2], B N Mohapatra[1] & Soubhagya Ranjan[1]**

[1]*National Council for Cement and Building Materials, Ballabgarh Haryana*

[2]*Birla Institute of Technology & Science, Pilani*

Indian cement industry, being the second-largest cement producer globally, is always sensible towards sustainable & cleaner production. The industry has been accepting many challenges for reducing its carbon footprint and supporting India's vision of carbon neutrality by 2070 shared during COP26. The industry is targeting to replace 25% of coal by utilizing Alternative Fuels (AFs) by 2030. However, available AFs in India have different characteristics & properties, and handling multiple types of AFs with a single system is a challenge. Although the technical know-how for AFs material handling equipment is well established now, the transfer of material from one equipment to another through a transfer chute may lead to jamming issues if the chute is not designed as per AFs properties and equipment kinetic parameters. Transfer chute design is often overlooked, leading to build-up, blockage, and wear in chutes. This paper covers right approach to design the transfer chute while handling various types of alternative fuels.

# TECHNO ECONOMIC ANALYSIS FOR CO-PROCESSING OF PADDY STUBBLE AS AN ALTERNATIVE FUEL IN INDIAN CEMENT INDUSTRY

**Kapil Kukreja, Prateek Sharma, S K Chaturvedi, D K Panda & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

The disposal of stubble generated during paddy harvesting is a growing concern in India leading to serious health hazard. The total stubble quantity burnt by the farmers is 11.3 million tonnes out of which Punjab state has a major share of 88%. This has caused the worst air quality in the National Capital Region Delhi and vicinity and a loss of over USD 30 billion annually considering health and economic costs. One of the promising substitutes to stubble burning can be the co-processing of stubble as an alternative fuel in cement kilns which is not fully explored, and the issue needs in-depth analysis. The characterization of paddy stubble suggests that it can be used in the cement plant for coprocessing with conventional fuel however high content of chloride and alkali is the major challenge. The objective of this research article is to propose a concept model for the utilization of 50 % of stubble burnt in Punjab in the cement industry. The model considers the preprocessing of the stubble to pellets which are to be transported to the cement plant clusters across the country through rapid wagon loading system. The investment for establishing facilities is estimated at around 1300 to 1400 crores (excluding land cost) which is almost negligible considering health and economic costs. The landed cost of stubble pellets shall vary from Rs.6,000-7,450/tonne.

# MODELLING AND EXPERIMENTAL STUDIES FOR PROCESS INTEGRATION OF RDF GASIFICATION IN CEMENT MANUFACTURING PROCESS

**Prateek Sharma[1], Pratik N Sheth[2] & B N Mohapatra[1]**

*[1]National Council for Cement and Building Materials*

*[2]Birla Institute of Technology and Science – Pilani*

Alternative fuels are one of the important cost drivers as well as a major contributor to green initiatives of Indian cement industry. Cement plants are putting strenuous efforts to maximize TSR. RDF is one of the prominent alternative fuels in the current scenario and cement plants are able to achieve high TSR through RDF. However, there are operational challenges such as high CO and incomplete combustion, increased specific heat consumption, reduced production, jamming and build-ups. Thus, RDF gasification has been thought as a novel approach to further enhance TSR in Indian cement plants and minimising the adverse impacts. In this regard, National Council for Cement and Building Materials (NCCBM) has taken up a R&D project titled" Process design and integration of refuse derived fuel (RDF) gasification in the cement manufacturing process" in collaboration with BITS Pilani-Pilani campus, Rajasthan. The project includes detailed RDF characterisation, experimental studies at different operating conditions in a lab scale downdraft gasifier along with process design. This paper highlights the key findings of modelling and experimental studies of RDF and RDF-biomass mix gasification.

# REFUSE DERIVED FUEL (RDF) CO-PROCESSING IN KILN MAIN BURNER IN A CEMENT PLANT: A CASE STUDY

**Prateek Sharma, Kapil Kukreja, K P K Reddy, Ankur Mittal, D K Panda & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

High Thermal Substitution Rate (TSR) through co-processing of alternative fuels is a key lever to reduce Greenhouse Gas (GHG) emissions in cement industry. Cement plants in India are utilizing alternative fuels mainly in calciner. Firing of alternative fuels through main burner can help to achieve nationwide target of 25 % TSR by 2025. This paper presents a case study of an Indian cement plant for achieving 25 % TSR through Refused Derived Fuel (RDF) firing in kiln main burner of a suspension preheater cement plant. Conventional mono-channel burner, semi direct coal firing system, leakages at kiln outlet, low kiln inlet riser capacity, inefficient coal mill bag filter, coal dosing system, cooler with entire moving grate and high specific heat consumption are some of the identified challenges in achieving high TSR. Thus, a comprehensive system design starting with RDF received in cement plant to the firing in kiln main burner for 3 tonnes per hour (tph). RDF handling and storage along with impact assessment and investment is worked out in the study. The major impact envisaged is the loss of clinker production to tune 22 tonnes per day (tpd) along with increase in the specific heat consumption of 28 kcal/kg clinker when achieving 25 % TSR. At 25 % of TSR through RDF, it is estimated that there shall be savings of approx. 0.135 t $CO_2$/t clinker which corresponds to 30% of the existing $CO_2$ emissions.

# $LC^3$ CLAY MAPPING AND THEIR SELECTION CRITERIA IN INDIAN SCENARIO

**Aastha Singh & Shashank Bishnoi**

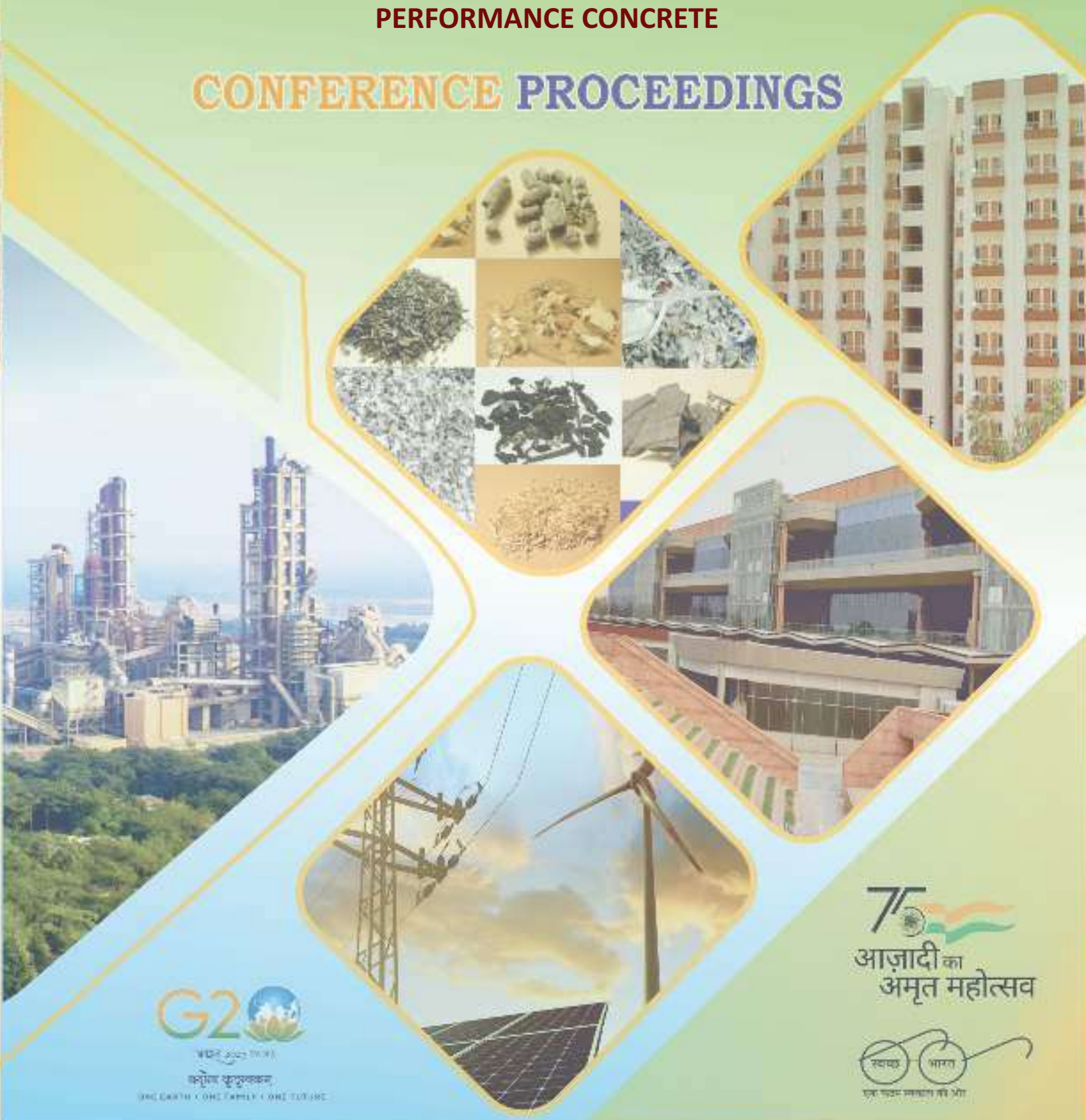
*Indian Institute of Technology Delhi, New Delhi*

Amidst all potential supplementary cementitious materials, calcined clay is the most abundant in the earth's crust and can replace clinker in cement. In this paper, it is highlighted that the global distribution of kaolin clay does not include the clays with low kaolinite content whose reserves are undiscovered, it also includes the clay samples collected from different parts of India, their selection criteria and suitability for $LC^3$. A map of the clays tested in India and the cement plants throughout India was prepared. Based on the data collected by characterizing the clays in terms of their mineralogical and oxide composition, selection criteria are proposed for the clays with kaolinite content between 40% and 60% suitable for $LC^3$.

# TECHNICAL SESSION - VIII B

## SMART CONCRETE, 3D PRINTING & ULTRA HIGH PERFORMANCE CONCRETE

# CONFERENCE PROCEEDINGS



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# MIX OPTIMIZATION FOR DEVELOPMENT OF 3D PRINTED CONCRETE

**Manish Mandre, Brijesh Singh, Amit Trivedi, P N Ojha & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

3D concrete printing is an emerging technology which has wide application and potential in the construction industry. This technology requires specific requirement to print a 3D printable object, especially on its rheological properties in the fresh state. The current codes and standards for conventional concrete construction are not applicable for guiding the 3D printable mix design. Hence a specific approach is required for design a 3D printable concrete, considering 3D printer parameters. The present study is about optimisation of material quantity to obtain a 3D printable mix with 3D printer. Cement, fly ash, silica fume, fine aggregate, water and chemical admixture are used for develop a 3D printable mix and optimum dose of chemical admixture is used to optimise the 3D printable mix. The study indicated that the dosage of superplasticizer needed to achieve the similar flow value increases as a/b increases. The plastic viscosity increased by about 35% when a/b increased from 0.75 to 0.9. The flow was ranging from 160 to 225 mm which indicates dependency on the material type and packing density. Study also highlighted that yield stress of mix is important to achieve buildability and low yield stress value can lead to collapse of layers and will also prevent layer wise buildability. The optimum dose of polypropylene fibre was found to be 0.1% to achieve 3D printable mix without clogging or shrinkage crack. The open time is found to be about 12-15 minutes for the materials. Studies reported in this paper highlights that both mix optimisation with different combination of cementitious binders and selection of optimum dosage of superplasticizer and VMA are very critical in achieving a 3D printable concrete.


# PROPERTIES OF THIXOTROPIC RAPID HARDENING MORTAR AND CONCRETE FOR 3D PRINTING

**K Suresh, Manish Kuchya & Raju Goyal**

*Central R & D, UltraTech Cement Limited, Mumbai*

Automated additive techniques are becoming increasingly important in the construction and building industry. With the potential to replace about 75 % of the building materials in housing, 3D printable materials are gaining importance. Apart from the high speed and low cost of construction, 3D printing of concrete offers flexibility in designing and building various shapes. Ideally, the mortar or concrete needed for 3D printing should be thixotropic in nature and have specific setting and hardening properties. Also, the bonding with the subsequent layers printed is another problem to be addressed. In this study, the effect of the material properties on extrudability, open time, and buildability for 3D printing is investigated. The strength and durability of the printable concrete and mortar were compared against normal concrete properties. It was found that the material developed showed excellent 3D printability.

# EFFECT OF CURING REGIME ON COMPRESSIVE STRENGTH OF ULTRA HIGH STRENGTH CONCRETE

**Brijesh Singh, P N Ojha, Amit Sagar, Abhishek Singh, Pranay Singh & Ravi Yadav**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Ultra-high-strength concrete (UHSC) is an engineered material used in new construction and conjunction with conventional concrete. However, some issues still exists which limit the wider application of UHSC, such as high autogenous shrinkage, low workability for mass concrete production, high cost, and variable strength depending upon curing method. In UHSC production, it is well known that curing process plays a major role to obtain its desired performances. Curing phase has a vital role on strength development of UHSC. There is no standard curing condition for UHSC as of now. Generally, UHSC is cured in three types of curing regimes (i) ambient curing (ii) elevated temperature curing (iii) autoclave curing. This detailed study aims to investigate the different effects of curing regimes on the strength development of UHSC. The total cementitious content used for developing concrete mix has been kept as 1000 kg/m$^3$ and w/b ration as 0.17. In the present study, three different curing regimes used were (a) Standard water curing till the age of testing (28 days) (b) Steam curing at 90ºC and 100% RH for 24 hours followed by Standard curing till the age of testing (up to 10 days) (c) Autoclave curing at 2.1 MPa and 215ºC for 6 hours followed by Standard curing till the age of testing (up to 10 days). The mixing methodology adopted in study and preparation of concrete mix using planetary mixer developed for this study ensured homogeneous mixing without any lump formation. The results of compressive strength determined on 100 mm diameter and 200 mm height cylindrical specimens indicated average strength of 101.10 N/mm$^2$, 114.74 N/mm$^2$ and 153.84 N/mm$^2$ for 30 specimens each cured under water curing, steam curing and autoclave curing respectively. Higher values of compressive strength in the tune of about 1.51 times compared to the water curing and 1.34 times compared to the steam curing has been obtained in autoclaving for the mix under study. Elevated temperature curing is advantageous to the pozzolanic reactions between CH from the hydration of cement and supplementary binder materials such as silica fume, which improves the microstructure. The specimens under autoclave curing indicated dissolution processes around quartz grains, which lead to a better cohesion between fillers and fine crystalline cement paste.

# DEVELOPMENT OF GREEN MINERAL ADMIXTURES FOR HIGH PERFORMANCE CONCRETE

**Mukesh Kumar & Sunil Kumar Saxena**

*J K Lakshmi Cement Ltd , Rajasthan*

New innovative additive for low carbon Mortar and concrete produced from widely available mines waste materials and overburden of clay mines as a step towards sustainable infrastructure development. Being a versatile product, it can be used as a additive during concrete production. New additives as PP+ improve properties of concrete by several simultaneous processes. The aluminosilicate of new additives contributes in the pozzolanic reaction; smaller particle size of new green additives imparts filler effect providing extra sites for nucleation and growth of hydration products, the reaction of carbonates helps in improving efficiency.

# COMPARISON OF CREEP COEFFICIENT OF NORMAL, HIGH AND ULTRA HIGH PERFORMANCE CONCRETE

**P N Ojha, Brijesh Singh, Abhishek Singh, Amit Sagar, Amit Prakash & Ravi Yadav**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Recently, the use of Ultra-High Performance Concrete (UHPC) has become popular due to the availability and significant variety of the mineral and chemical admixtures. Ultra high performance concrete leads to increase in the load carrying capacity of the columns or piers thereby reducing size of members in building and bridges. In prestressed concrete bridges and multi-storeyed buildings, creep becomes critical. A concrete structure when subjected to sustained load causes progressive strain over time, which is associated with the creep phenomenon. The papers presents determination of creep coefficient on concrete cylinder of 100 mm diameter and 200 mm height for UHPC and 150 mm diameter and 300 mm height for normal & high strength concrete. An experimental study was conducted to determine the time induced creep strain using creep rig of capacity 2000 kN. The strength level for UHPC, high strength and normal strength concrete were 153.79 MPa, 100.21 MPa and 45.66 MPa respectively. The experimentally obtained creep coefficients were compared with B-3 Model, FIB model code 2010 and B4 model for the test done upto 180 Days and age at loading was 28 days. The creep coefficients determined using B3 and B4 model are over estimating the values in case of high strength concrete and Ultra High Performance Concrete. The primary reason for over estimation of creep in high strength concrete and Ultra High Performance Concrete using B3 and B4 model can be attributed to chemical volume reduction and self-desiccation along with decrease in pore humidity. The complications noticed in creep prediction while using B3 and B4 model due to attenuating effects of diverse admixtures and reactive additives present in high and ultra-strength concrete. In FIB model code 2010, basic creep concept has been considered. Wherein, basic creep has been modelled using a logarithm function, which is infinite ongoing deformation while drying creep approaches a finite value.

# ESTABLISHING STRENGTH CO-RELATION FACTOR FOR CUBE VS CYLINDER STRENGTH IN HIGH GRADES

**Aswathy Rajendran, Samidha Pathak & Pranav Desai**

*CDIC, Nuvoco Vistas Corp. Ltd.*

Compressive strength is commonly acknowledged to be the most important factor considered while selling any concrete. The IS Code allows for the use of cube moulds and cylinders to cast concrete and for further compressive strength testing. A specific strength ratio has also been established by the code to convert cube strength to equivalent cylinder strength and vice-versa. This is because shape of concrete specimen influences the strength of concrete owing to various factors. However, these values were generated at a time when the Indian construction did not employ grades higher than M50. Conversely, given the current situation of our construction sector, which is moving towards high-rise buildings, M80 and M90 mixes will become conventional grades in 2-3 years. Higher grades are likely to have a different Interfacial Transition Zone (ITZ) since they have more binder content and use smaller average aggregate sizes. Hence, it becomes important to revisit the co-relation factor for higher grades to understand if shape of specimen is still an important factor influencing the strength of such concrete. This study examines the varied conversion factors for M70 grade concrete evaluated using 150mm cubes and 150 x 300mm cylinders at various ages, and provides insights on what alters the margin. The findings of this study are expected to provide some reference to practical engineering, such as to prevent under or overdesigning concrete to pass the target criteria when evaluated with any form of concrete specimen.

# APPLICATION OF INDUSTRIALLY PRODUCED $LC^3$ TO PAVEMENTS AND AAC BLOCKS

**Mukesh Kumar & Sunil Kumar Saxena**

*J K Lakshmi Cement Ltd, Rajasthan*

$LC^3$ produced were used in the manufacturing of AAC blocks and High performance concrete ( M 50). It was found that in most applications, OPC could be easily replaced by the same weight of LC3 without a negative impact on performance. Plain, reinforced and fibre-reinforced pavements were cast using the cement and the construction could be carried out using usual construction procedures.

$LC^3$ could also be used in the production of autoclaved aerated concrete (AAC) blocks, without a significant change to the technology or performance. It was found that a better cohesion and flow could be obtained by the use of LC3 in place of OPC in manufacturing of AAC block and High Performance concrete. It was found that a direct replacement of OPC by LC3 was possible without negatively influencing the performance of the product.

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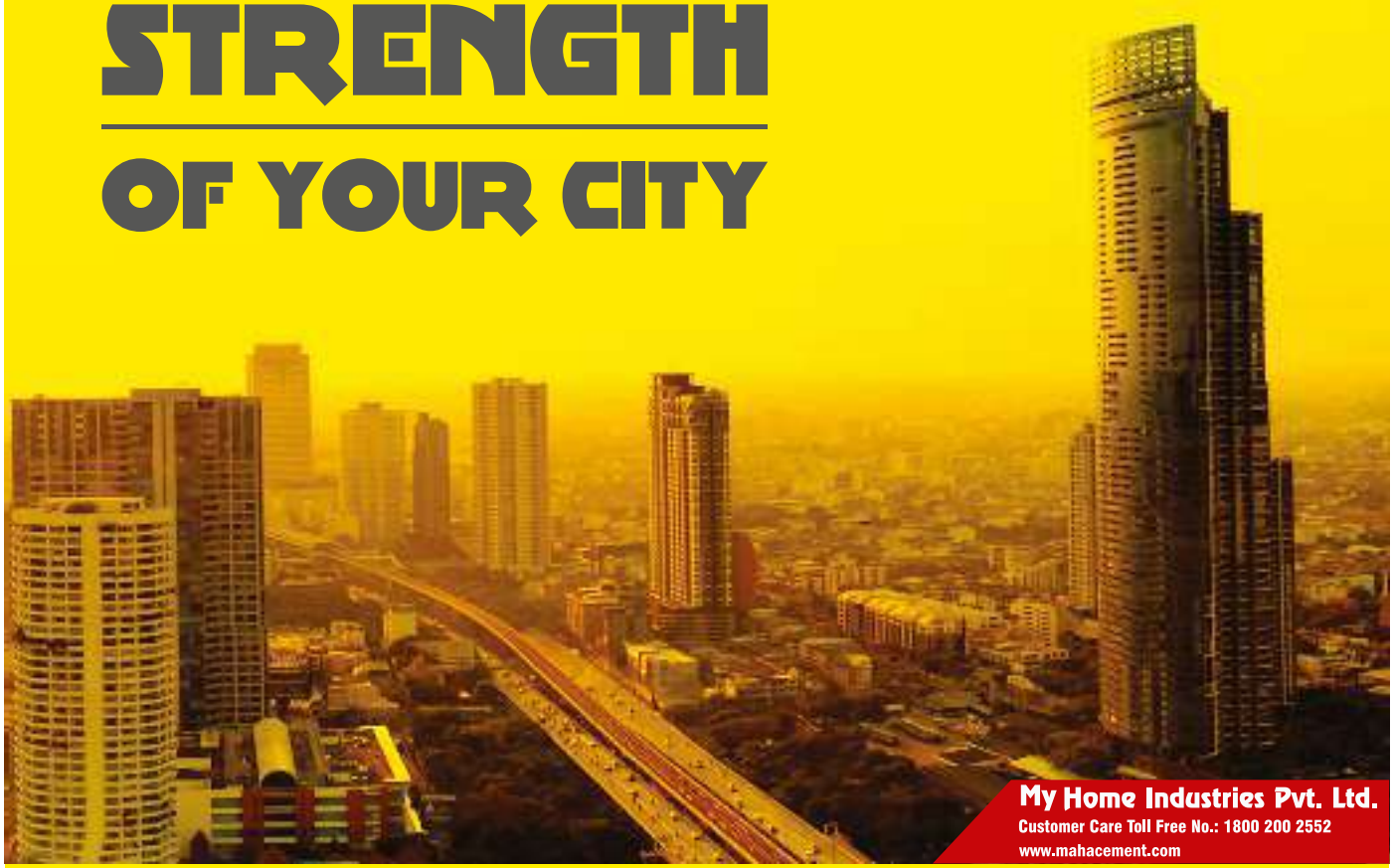

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# TECHNICAL SESSION - IX A

## ENERGY CONSERVATION SYSTEMS

# CONFERENCE PROCEEDINGS

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# ELECTRICAL POWER OPTIMIZATION FOR FREE OF COST EXPORT

**U S Choudhary, R Durgaram & Kherajram Chowdhary**

*J K Cement Works, Karnataka*

Captive power plants (CPP) are generally used by power-intensive industries where continuity and quality of energy supply are crucial, such as aluminum smelters, cement plants, steel plants, chemical plants, paper products and pharmacy plants etc. Our CPP provides the required energy for our cement manufacturing process. CPP can be operated like off-grid (Island mode) or connected to the grid (Synchronous mode). A comprehensive understanding of the losses in the power plants during unscheduled power injection to the grid due to cement plant load fluctuations. In order to control the free export power, two stage approach was incorporated namely Island mode operation and Implementation of In-house developed export power control logic. During the synch mode operation there is a possibility of export power pumping into the grid from the CPP due to load fluctuations. When the study was carried to control the export power, it was found that around 150 MWH per month of power was exported to the grid as free. Indirectly, the loss of around Rs. 1.26 Cr. To reduce this export power maximum possible island operation was proposed and implemented. Also, to ensure safe and smooth functioning of CPP several steps were taken. By doing this we were able to reduce the free cost export power to 78 MWH per month.

Now, Our CPP operates majorly under island condition to generate and supply the required power for our internal cement manufacturing process. During synch mode operation with power Grid, good amount of CPP power is injected in the Grid due to load fluctuations as free cost export power. The total amount of free cost export was around 78 MWH per month in FY 2019-20 which is equivalent to about 65 Lac Rupees. This power accounts to roughly 1% of total power plant generation in a month. Additional amount of coal is consumed to generate the same amount of export power. This was a huge loss to the company. To reduce the free cost export power to the grid many consultations and studies were done. After many such brainstorming sessions, the emergency tripping facilities and the in-house export power control logic was developed and implemented. This control logic gradually decreases free cost export power depends upon the set point which is entered by CPP operator without affecting the key parameters of CPP.

This paper elaborates the impact of the free cost export power to the grid and also shares the result of the applied methodologies, Implemented steps and Control logic to reduce and control the same. The free cost export power which was around 150 MWH per month was brought down to 3 MWH per month, we can say around 98% reduction in the free cost export power injection to the grid.

# PROCESS STABLIZATION & ENERGY CONSERVATION AT PH FAN SPRS (BREAKING THE LOSS ICEBERG BY TECHNOLOGICAL EXPLORATION)

**N S Rao & K P Srivastava**

*My Home Industries Private Ltd., Telangana*

Energy is very significant in entire process of evolution, growth and survival of the world. The increasing energy demand has an adverse effect on environment also. The demand in our country is rising exponentially. Its conservation can be the best solution for bridging demand and supply gap in energy supply chain. Cement manufacturing needs high energy consumption. Electrical energy is an important component of total requirement in Cement Manufacturing process. Its conservation without compromising uses is a great task. Wider range of fan speed control with SPRS is achieved for process stabilization and energy conservation.

This has reduced losses and resulted tangible benefits of Rs. 65.7 lakh per annum. Process stabilization has improved by smoother control on PH Fan speed which is major intangible benefit. The technological exploration is successfully achieved a year back after sensing need to break the loss iceberg. The wider range of speed control through SPRS is in operation consistently after modifications. Its advantages are delivered & delighted by the end customer (plant maintenance & operation team) on continuous basis.

# ADVANTAGES AND DEVELOPMENTS OF WASTE HEAT RECOVERY SYSTEM IN CEMENT PLANTS

**Abhay Patil**

*Thyssenkrupp Industries India Pvt. Ltd., Pune*

Waste Heat Recovery (WHR) system as a technology has gained momentum in Cement Sector in India during the last decade. Cement production has been one of the energy-intensive processes and has been contributing to carbon footprint. In order to implement pollution control measures and efficient energy management scheme, energy & environment audit is generally carried out in a cement plant. Reduction in emissions and in the production cost of cement is very important because of which waste heat recovery is implemented in the cement industry.

The waste heat recovery reduces the Greenhouse gas emissions and enhances the overall energy performance. The aim is to lower the emissions and generate green power by utilizing the waste exit gases from the Pre-heater and cooler. This also leads to saving in fossil fuel combustion, which would have been necessary for power generation. Also by producing green power from cement waste heat, auxiliary consumption of cement plant also comes down. Power produced by WHR system is quite reliable as well as dependable. thyssenkrupp has vast experience in Waste heat recovery system for cement plants and self-motivating for developments with new concepts based on site feedback and challenges faced.


# ENERGY EFFICIENT TECHNOLOGIES AND OPERATIONS IN MELLACHERUVU CEMENT WORKS (MCW)

**N S Rao & R V Krishna Kumar**

*Myhome Industries Private Ltd., Telangana*

In this growing economy, Cement is one of the most widely used substances on earth. Making cement is an energy and resource intensive process with environmental, health and safety impacts. In today's world, we can't run our business with conventional methods. India is the second largest producer of cement in the world, accounting for more than 7% of the global capacity with its installed capacity of over 600 million tons per annum. Indian cement industry will add further 80-100 million tons of capacity by FY25.

The Cement Industry is highly energy intensive with energy cost as high as 50-70% comprising of both thermal and electrical energy of total cost of production. This paper covers a case study related to findings for reduction in energy consumption and optimization of Specific heat consumption of Unit 1 Kiln at MCW by modifying the cyclone 1 feed box on cyclone 3-2 riser. By this modification unit gain in sp. energy by 0.36 KWh/MT Clinker and 5 kcal/kg clinker gain in specific heat consumption resulting in overall saving of Rs.57 Lakh / Year on energy conservation.

# AN INNOVATIVE VORTEX REDUCER TO REDUCE PRESSURE DROP BY 20% IN PREHEATER TOP CYCLONES

**Mohammad Fazil, Jayateerth V Joshi, Sanjeev Srivastava & Raju Goyal**

*UltraTech Cement Limited, Mumbai*

In this work an innovative vortex reduce has been designed to reduce pressure drop by 20% in cement preheater top cyclones. This work is an extensive research on the scientific work on laboratory cyclones of 0.3 meter in diameter by *D. Noriler et al., 2004*. New dimensional correlation for industrial cyclone has been designed and discussed in this study. Impact on the separation efficiency of the preheater top has been also investigated and findings confirmed that there is no adverse impact on the cyclone separation efficiency. The pressure drop reduction occurs due to the effects of the introducing swirling breakdown phenomenon at the inlet of the vortex finder. This vortex reduce works by sudden reduction and shifting tangential velocity peak, which is responsible for 80% of the pressure drop in cyclones. As resultant this peak reduction in tangential velocity causes a decrease in pressure drop by a breakdown of the swirls, and because of this phenomenon the overall performance of the cyclones is improved.

Numerical simulations were conducted with a 3D, transient, asymmetric, and high Reynolds number turbulence model. CFD simulations showed a 25% reduction in pressure drop in industrial cyclones of 5 meters in diameter and a shift of the transient velocity peak towards the wall. The Lagrangian-Eulerian method was used for cyclone separation efficiency simulations of dispersed multiphase flows by solving the continuous phase in the Eulerian framework while treating the dispersed phase as point particles in a Lagrangian framework. ANSYS CFX commercial solver was used to carry out all design experiments, demonstrating good numerical stability and convergence rate when used with high-order computational schemes. The discussed work has been implemented and the benefits have been monitored at an integrated cement manufacturing unit of Ultratech cement Ltd. For 750 TPH Kiln feed, reduction in pressure drop across the top cyclones was established by 20 mmwg, which is equivalent to equivalent to reduction in fan power (KWh/MT-CL) by 5% at clinker production of 11250 TPD.

# UPCOMING TECHNOLOGIES FOR RENEWABLE SOURCES OF ENERGY

**Sunil Shah, Pawan Mathur & Raju Goyal**

*UltraTech Cement, Mumbai*

The cement business is one of the most energy-intensive sectors, and energy expenses make up a considerable portion of overall manufacturing costs (about 30-40%). To combat growing power prices and supply unpredictability, the cement industry currently sources its power requirements from Captive Thermal Power Plants, WHRS, Grid, and Renewable Energy.

# DEVELOPMENT OF GREEN BATTERY BY INDUSTRIAL WASTE USING GEOPOLYMER TECHNOLOGY

**Mukesh Kumar & Sunil Kumar Saxena**

*J K Lakshmi Cement Ltd., Rajasthan*

Geopolymer cement or concrete are proved to have high strength, lesser shrinkage, resistance against reinforcement corrosion, acid and sulphate resistance, freeze-thaw resistance, fire resistance and resistance to alkali-aggregate reaction. There has been growing in development of sustainability structure such as buildings, roadways, and bridges etc. This paper focuses on the use of geopolymer technology for development of Green Battery by using industrial waste, we have used Potassium based geopolymer composite, which can store energy in the concrete. The geopolymer Mixes maximum power is about 0.28 kW/M2 with the discharge life of one hours.

# ENERGY REDUCTION THROUGH INNOVATIVE APPROACH & ADOPTING ENERGY EFFICIENT TECHNOLOGIES

**Suman Nath, Chandan Singh & C Anil Kumar**

*Calcom Cement India Ltd. (A subsidiary of Dalmia Cement (Bharat) Ltd.), Assam*

The cost of energy as part of the total production costs in the cement industry is significant, ranging from 30-40%, warranting attention for energy efficiency to improve the bottom line. Opportunities exist at cement plants to improve energy efficiency while maintaining or enhancing productivity. This paper presents the journey of Calcom Cement India limited from high to one of the lowest specific energy consuming plants in India.

# COMMITTING GREEN CEMENT MANUFACTURING PROCESS

**Om Prakash Verma, Jabir Khan & Manish Kumar Singh**

*Prism Johnson Limited, Satna*

India is the second largest manufacturer of cement and consuming substantial amount of thermal & electrical energy during the process of making cement. It contributes large emission of greenhouse gases (GHG), especially by calcination of limestone and burning of fuels. To has overcome from the present situation, cement industries are mainly focusing on energy saving, reducing clinker factor and CO2 footprint. Over the past many years cement manufacturing changed its manufacturing process and moving towards blended cement products such as Portland Pozzolana cement (PPC), Portland Slag Cement (PSC), & Composite cements. Production of blended cements results in reduction of GHG emissions, conservation of natural re-sources and utilization of industrial wastes.

In addition to above initiative, we focused to reduce further CHG emission by moving towards the renewable sources of electrical energy and alternate fuel for thermal energy. The ratio of energy consumption in the cement manufacturing is approximate thermal (75-77%) and electrical (25-23%). It's a well-known fact that to generate one unit of electrical power (Thermal power plant) there is emission of about 1 kg CO2, it means there is scope for the reduction of CHG emission by replacing the electrical power into renewable (green) electrical power such as WHRs, Wind Energy & Solar Power etc. As a first step in a phased manner, Prism Johnson Limited (Cement Division), Bathia, Dist-Satna have replaced the conventional energy sources with green energy in terms of thermal as well electrical energy.

The objective of this paper is to reduce the CO2 emission and contribution for the green cement manufacturing. To achieve this objective our focus is on clean energy adoption, energy efficient solution, Installation of waste heat recovery system, and solar PV cells (In MW Range) to generate the electricity for our plant. Prism Johnson Limited (Cement Division), Bathia, Dist-Satnaare one of leading group in terms of solar power plant capacity with respect to cement production at one location.

# NOVEL CONFIGURATIONS FOR WHRS IN CEMENT INDUSTRY

**Prateek Sharma, Ankur Mittal, K P K Reddy & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, India*

Waste heat is generated in a process by way of fuel combustion or chemical reaction, and then dumped into the environment even though it could still be reused for some useful and economic purpose. Indian cement industry has come a long way in implementing Waste heat recovery systems which resulted in numerous benefits, such as mitigating GHG emissions and achieving PAT cycle targets. WHRS capacity in India increased by 212% in 2017 compared to 2010. The present total installed capacity is more than 900 MW. This may ultimately help contribute to long-term energy security in India. Further, there is lot of scope for WHRS for thermal applications in cement plants apart from power generation. This paper discusses several new innovative concepts to utilize waste heat for thermal applications in cement industry where efficiency is much higher as compared to power geenration.

# SIGNIFICANCE OF POWER QUALITY ANALYSIS UNDER ENERGY AUDIT OF PLANT- A CASE STUDY

**Ankur Mittal[1], Devinder Singh[2] & Vaddy Venkatesh[1]**

[1]*National Council for Cement and Building Materials*
[2]*Indona Innovative Solutions, Zirakpur (Punjab)-140603*

Managing harmonics in power system is joint responsibility of both plant and utility and therefore harmonics limits are recommended for both voltages and currents. Voltage distortion can be kept below objectionable levels by limiting harmonic current injection by consumer or user. Hence, limits are imposed on both voltage and current. These recommended limits are applied only at the Power Control Centre (PCC).

The IEEE 519 summarized the allowable harmonic limit for both voltage and current. The current distortion limits are applied to users connected to systems for systems normally rated 120 V to 69 kV, 69 kV to 161 kV, and above 161 kV. The allowable current distortion (again defined in terms of THD) is a function of the stiffness of the system at the PCC, where the stiffness of the system at the PCC is defined by the ratio of the maximum short-circuit current at the PCC to the maximum demand load current (at fundamental frequency) at the PCC. The term “power quality” refers to the purity of the voltage and current waveform, and a power quality disturbance is a deviation from the pure sinusoidal form. Harmonics superimposed on the fundamental are one cause of such deviations, and the chapter describes the nature, generation, and effects of harmonics on power supply systems, together with the limitation of such effects and harmonic studies.

This paper provides a summary of the main standard regulations on power system harmonics. It explains the nature of harmonics in power systems followed by a review of the sources of such harmonics. It provides the major effects of harmonics in the power supply followed by a discussion of current methods of limitation. It concludes with an explanation of the nature of harmonic studies and their importance in modern system design.

# TECHNICAL SESSION - IX B

## ENVIRONMENTAL MANAGEMENT, SUSTAINABLE DEVELOPMENT & SAFETY

# CONFERENCE PROCEEDINGS

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# HOW PREDICTIVE MAINTENANCE CAN HELP ACHIEVE NET-ZERO EMISSION GOALS FOR CEMENT MANUFACTURERS

**Sunil Vedula, Suraj Pisharody & Prashant Verma**

*Nanoprecise Sci Corporation*

Cement manufacturing is an energy-intensive process. The energy consumption is around 3% of the global greenhouse gas emissions and 58% of the total industrial non-energy related greenhouse gas emissions. Cement industries need raw materials, chemical additives, and fuel which also contribute to GHG (Green House Gas) emissions which negatively affect the atmosphere. In attempts to save the environment from these GHG emissions, many developed countries have imposed strict environmental regulations forcing cement manufacturing industries to shift their plants to other countries which are not so strict with environmental regulations. An alternative approach is to achieve net-zero emissions, for which cement manufacturing industries must adopt new operational methods and practices. Predictive maintenance using AI and machine performance monitoring can be a powerful tool in their arsenal that will help reduce emissions and improve or maintain production process efficiency and other critical business KPIs. Besides improving the reliability of the equipment sets, predictive maintenance solutions can also effectively maintain their performance levels thereby reducing GHG emissions as throughput & other KPIs are optimized.

# ENERGY SAVINGS MEASURES IN CEMENT INDUSTRY

**P K Choudhary, Jayant Kandpal, Amit Dixit & Harsh Mishra**

*Birla Corporation Limited,* Kundanganj

The cement industry is one of energy-intensive industries. The industry needs energy (thermal and electricity) including coal and electricity. In particular, the increase in consumption of fossil- based energy may increase the amount of pollutants besides its availability is increasingly limited. Energy consumption is one important indicator in sustainable manufacturing of the cement industry. This paper reviews the preceding studies concentration on the provision of energy saving, carbon dioxide emission reductions correlated with implementation of a number of technologies applicable to improve the energy efficiency.

Covered areas include compressor optimization, augmenting classifier efficiency & process fan optimization to increase the energy efficiency.

# XRD: AN EFFECTIVE AND ECONOMIC SOLUTION TO PROBE ADDITION OF SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCMS)

**Mangesh Mahajan**

*Malvern Panalytical India*

Today, many industries are looking for ways to reduce $CO_2$ emissions as well as energy consumption and increase their reuse of waste materials. In the cement industry, this trend is leading to a higher use of alternative fuels, a continuous optimization of burning conditions and the replacement of clinker by cementitious additives. One of the key elements of reducing $CO_2$ emissions during cement production is to reduce the clinker-to-cement ratio by replacing clinker with supplementary cementitious materials (SCMs). The amount of SCMs in cement can go up to several tens of percent. This drastically reduces the carbon footprint per kilogram and also reduces fuel consumption. As SCMs have many elements in common with the clinker, direct mineralogical probing by X-ray diffraction (XRD) is an effective way to obtain the necessary information in both the scenario. This article will shocase few examples where a benchtop XRD provides effective information in cement process control which will help to monitor the environmental/economical benefits.

# AN INCREDIBLE JOURNEY OF HIGHEST GREEN FUEL CO-PROCESSING IN CEMENT KILN - A COMMITMENT TOWARDS SUSTAINABLE FUTURE

**Raj Kumar Singh, Chandra Kanta Nayak, Ajay Kumar Singh & Prabhat Kumar Singh**

*Dalmia Cement (Bharat) Limited, Belgaum*

Dalmia Cement (Bharat) Limited (DCBL), Belgaum has step forwarded for significant initiation to co-process the nearby solid & liquid waste material in cement kiln which can reduce the use of non-renewable fossil fuel and reducing greenhouse gas emissions and also helps to address the increasing need for safe and ecologically sensitive municipal wastes and hazardous waste generated by chemical and other allied industries. In order to minimize dependency on fossil fuels like Coal, the Green Fuel makes path for remarkable replacement.

A study has been carried out in order to optimize the use of thermal energy and to minimize the $CO_2$ emission by using various green fuels which are generating wastes from various sources/industries. Cement kilns have a number of characteristics which makes them ideal installations for disposal of above wastes through co processing route in an ecofriendly manner. The huge variation in physico-chemical properties of these materials have huge impact on operational as well as clinker quality parameters. In outset, alternative fuels contain high percentages of chlorides, sulfur, moisture etc, thus impact had been observed in terms of process disturbance, breakdowns, raw mix alteration, disturbance in clinker quality. The paper presents a case study of phase wise achieving 35% TSR on sustainable basis in Dalmia Cement (Bharat) Limited, Belgaum, Karnataka

# IMPACT OF LOW CARBON CEMENTS ON CARBON FOOTPRINT OF INDIAN CEMENT INDUSTRY

**B N Mohapatra, S K Chaturvedi, Anand Bohra & Varsha Liju**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Globally, cement sector generates about 7% of the total anthropogenic emissions. Accordingly, decarbonization of the Indian Cement Industry has assumed importance as it is considered as Hard-to-Abate sector, as about 50 - 60% of GHG emissions result from calcination of limestone which is an integral part of cement manufacture. India is blessed to have supplementary cementitious materials like fly ash and blast furnace slag. In 2021-22, 270.8 million tonnes of fly ash and about 12 million tonnes of blast furnace slag were generated in our country. Apart from annual generation, 1700 million tonnes of legacy fly ash lying at various thermal power plants in our country. NCB has undertaken extensive research for development of low carbon cements like Portland Composite Cement based on fly ash and Limestone, Portland Limestone Cement etc. The impact of low carbon cements on carbon footprint of Indian Cement Industry is discussed in the paper. The availability of fly ash will gradually reduce due to the focus of Government of India on renewable energy generation and utilization of alternative fuels in thermal power plants. In this scenario, PCC will emerge as a viable alternate option to PPC, with utilization of lower grade of limestone replacing portion of fly ash. As compared to specific $CO_2$ emissions of OPC, the specific $CO_2$ emissions associated with PLC and PCC are about 17% and 36% lower respectively. Thus, the replacement of OPC by low carbon cements like PCC or PLC will result in lower carbon footprint of Indian cement industry.

# INVESTIGATION FOR THE USE OF THERMAL POWER INDUSTRIAL WASTE FLUE GAS DESULPHURIZATION GYPSUM IN CEMENT AS MINERAL GYPSUM REPLACEMENT

**G J Naidu, T M Rajan, Richa Mazumder, G Bhatnagar, O P Sharma, S K Chaturvedi & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Achieving circular economy and enhanced waste utilization are the goals of nations around the world. In India, Ministry of Commerce, and Industry, under its department for promotion of industry and internal trade (a.k.a DPIIT) has classified self-reliance for the availability of gypsum, a key constituent for the manufacturing of cement. India is set to see a continuous increase in its cement production capacity along with consumption for the coming decades, with a year-on-year growth rate of 7 to 8 % percent. The increasing demand of cement requires increase in gypsum import which essentially affect the forex reserve. In 2020, Indian agency constituted, a special task force team to find an alternative solution to address the challenge of replacing imported mineral gypsum with any other similar material. Gypsum (CaSO4.2H2O) a natural material is an integral component of all the cements and its production. Gypsum essential act as a cement setting time retarder and is added up to 5% during the manufacturing of cement. Being a product from nature, the availability of gypsum falls short as per the quality requirements for the cement production in India. India imports gypsum from countries like Oman, UAE, Iran, Bhutan etc. to fulfill its cement manufacturing demand. In this paper, use of FGD gypsum, a by-product derived from Flue Gas desulfurization (FGD) systems, generated at a coal-based thermal power plant as a setting time retarder was investigated so as to replace or reduce the demand of conventional mineral gypsum. The study investigates FDG gypsum quality compared to conventional gypsum, as like the properties given in the Indian Standards. The study reports that FGD gypsum shows comparable properties as like convectional mineral gypsum, hence can be an effective alternative to existing mineral as a replacement for Indian cement manufacturing industries.

# ENHANCING FLY ASH UTILIZATION IN PORTLAND POZZOLANA CEMENT (PPC) BEYOND BIS LIMIT OF 35% USING MECHANICAL ACTIVATION METHODOLOGY

**Varsha Liju[1], Suresh Palla[1], S K Chaturvedi[1], B N Mohapatra[1], N K Soni[2], Rajiv Satyakam Pranay[2] & A K Das[2]**

[1]*National Council for Cement and Building Materials Ballabgarh, Haryana*

[2]*NTPC Energy Technology Research Alliance (NTPC-NETRA), Greater Noida*

Reduction in green house gas emissions is one of the focal points in the present world scenario. The use of various kinds of industrial wastes, by products such as fly ash from thermal power plants, granulated blast furnace slag from steel plants, low grade limestone from mineral processing industries and cement plants etc., reduces the emission of green house gases besides conservation of natural resources. The increased use of blending materials has direct impact on reduction in clinker content in cement thereby reducing the $CO_2$ emission by reduced fuel combustion and reduced limestone calcinations at the same time reduced usage of natural limestone. Fly ash, produced from thermal power plants, is widely used in the preparation of Portland Pozzolana cement (PPC), its utilization level in India in the sector of building materials accounts for only 30% of total production of fly ash. With the increasing power demand in India, the fly ash generation is likely to increase. It is estimated that fly ash generation will reach to 400 MTPA by the year 2030 from present generation level of about 200 MTPA. Therefore, investigations on the enhanced utilization of fly ash, especially in the manufacture of cement become inevitable.

In this study high volume fly ash blends are prepared and investigated using mechanical activation routes.

# A WORLD WITHOUT WASTE DUMP

**Chetan Shrivastav, Arbind Singh, Kishore Rathore, Ravi Sharma, Vikas Mangal, Aniket Chaki & Md. Nawaz**

*Dalmia Cement (Bharat) Ltd., Odisha*

Usage of Alternative fuel is one of the most important levers to achieve carbon negative commitment. Dalmia Cement Bharat Ltd, Rajgangpur has advanced marching towards 2040 goal and made capital expenditure of more than 200 crores towards required infrastructure for co-processing and alternative fuels.

In FY 20-21, Dalmia cement kilns co-processed more than 2.2 lakh tons of hazardous and non- hazardous waste. Major contributing material as AF were RDF (70,000 tons) along with Multi layered plastic and plastic generated in paper mills (around 50,000 tons). In FY 21-22, average YTD TSR% for cement Kiln in DCBL, RGP is 12.45% and Quantity of AFR used in place of conventional fuels was 126.9 KT resulted into decrease in convention of Conventional fuels up to 51 KT in FY 21-22. Dalmia also pledged that 100% of plastic generated equal quantity will be consumed from urban local bodies in the coming years.

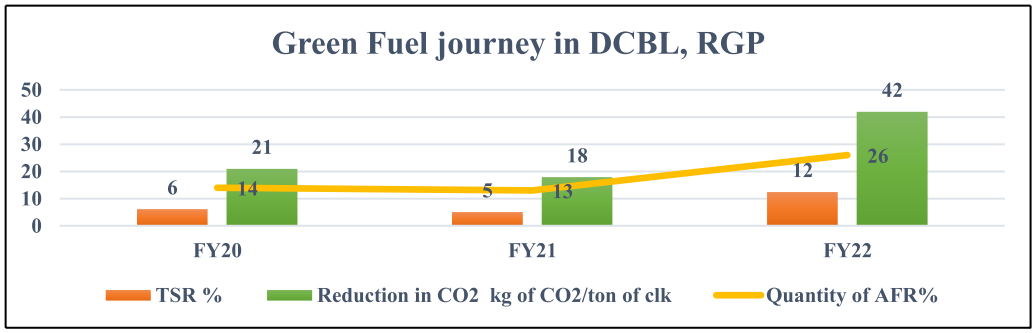



**Fig-1: Global waste composition (percent)**

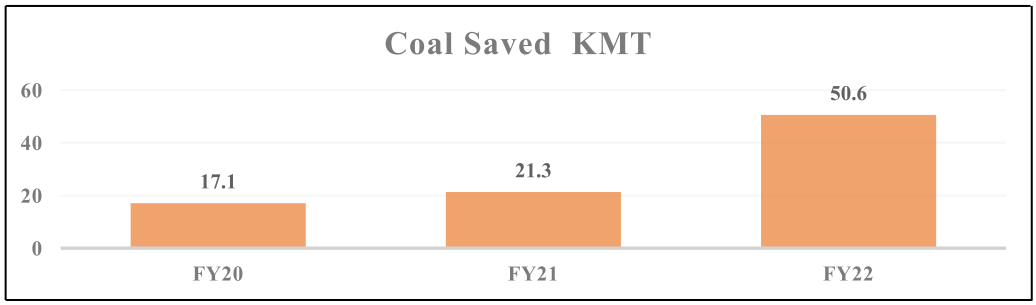
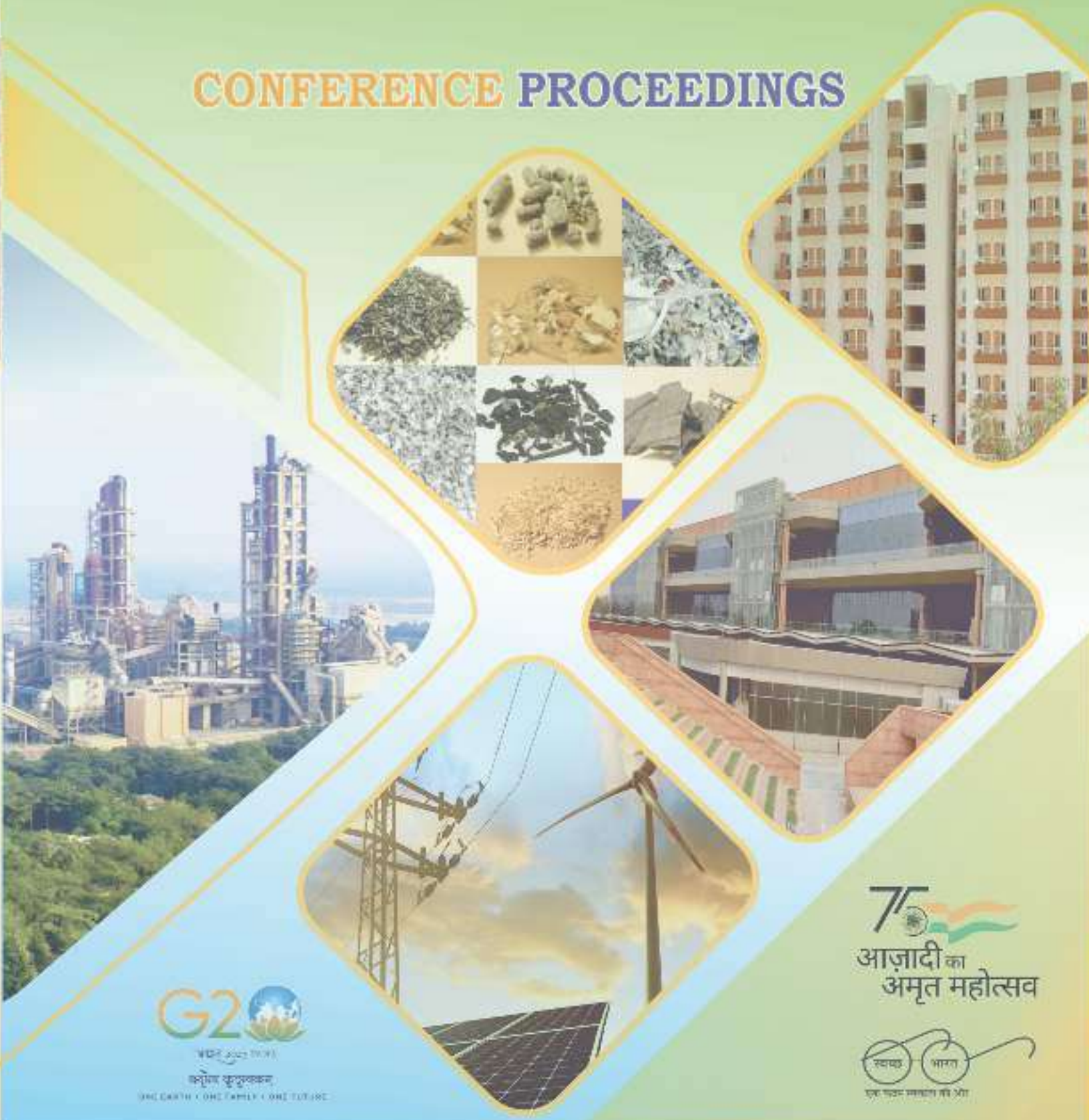



**Fig-2: Coal Saved MT**

# TECHNICAL SESSION - X A

## PRODUCTIVITY ENHANCEMENT & PROCESS OPTIMISATION - II

# CONFERENCE PROCEEDINGS



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# INNOVATIVE APPROACH TO INCREASE CVRM- PPC PRODUCTIVITY AND REDUCTION OF SPECIFIC POWER

**T Robert, G Shankarappa & V Saravanan**

*Dalmia Cement (Bharat) Limited, Ariyalur*

At Dalmia Ariyalur unit, the Cement Mill was operated at 370 TPH with SPC of 23 kWH/MT against the OEM design of 300 TPH with SPC of 28 kW/MT. Further mill output could not able to increase above 370 TPH due to higher mill DP. We have taken challenging target to increase the mill output and reduce the SPC. The detailed study has been conducted throughout mill by taking velocity & pressure profile and While analyzing we found that classifier annular velocity is operating 5m/sec which is leads to increase the mill DP and fan efficiency is operated with 78% which is less and there is a possibility and scope for improvement by increasing classifier velocity and mill fan efficiency by changing the high efficiency impeller. After our brain-storming session, our technical team was decided to reduce the classifier annular gap to increase the velocity as well as improve the productivity and reduce the SPC of Fan by replacing the mill fan with efficiency impeller. The entire modifications carried out by in-house design.

# PROCESS OPTIMIZATION BY IMPLEMENTATION OF INDUSTRIAL

**T Robert, G Shankarappa, N Nagaraj & V Rajendran**

*Dalmia Cement (Bharat) Limited, Ariyalur*

At Dalmia cement Ariyalur unit, the Kiln is operating from 4500 to 6200 TPD based on market demand. We have started to use many alternative fuel (green fuels) like municipality solid waste, plastic, and rubber etc. While using green fuels, we were facing issues in quality, increasing of specific fuel and power consumption due to more variations in pre-calciner temp, high CO, inconsistence green fuel feeding. Hence we have implemented the new technologies to resolve the issues and improve the performance of the plant operation. Most of the cement plant following manual sample collection for monitoring and control the quality parameters. The sample collection and preparation will play vital role in the accuracy level of the samples. In manual method, there is a possibility for error while sample collection and preparation due to persons and inconsistent interval time. But automated Robotic sample collection and preparation systems will be more accurate and reliable without any manual intervention.

The data is available in different system and operating platforms takes more time to collect and do analysis. All the system data were integrated to common platform and IT & OT system were integrated for easy monitoring and do analysis. The equipment healthy status is being monitored by CCR executive only and abnormalities communicated to concern after reaching threshold limits or tripped as CCR operator can't monitor all equipment continuously. Its leads to breakdowns and reducing the equipment reliability. Hence, we have implemented real time equipment alert and monitoring system by using mobile APP and PIMS (Plant information management system) for continuous monitoring and take immediate action before reaching threshold limits and equipment breakdown. As travel is restricted due to pandemic situation, Service engineers and experts couldn't able to availed during breakdowns and service assistance. It will lead to increase the breakdown hours of the plant. Hence we have implemented Augment reality tool for get remote support from external and internal experts whenever support required.

# IMPROVISING KILN MAINTENANCE BY VIRTUE OF STRENGTHENING INSPECTION CHECKS

**Kedar Godbole, Neeraj Dalal & Raju Goyal**

*UltraTech Cement, Mumbai*

Kiln is considered as the heart of the cement plant. As any heart related issue affects the complete functioning of the body, so comes true for the kiln in a cement plant. Hence, in view of the significant criticality of the kiln for a cement plant, the maintenance of the kiln along with its upstream & downstream equipment is pivotal for cement plant's performance.

This paper discusses mainly about the detailed maintenance and inspections checks that shall be done for improvising the maintenance of Kiln.

# AVOIDING BELL MOUTH ISSUE IN KILN SHELL AT OUTLET END

**Kedar Godbole, Neeraj Dalal & Raju Goyal**

*UltraTech Cement, Mumbai*

Bell mouthing (or flaring of kiln shell) at outlet end is one of the critical issues being faced in many of the kilns which is causing premature failure of refractory in outlet area as well as premature failure of tip casting components. This results in poor availability of kiln, heavy production loss on account of unplanned kiln stoppages and requires early replacement of outlet end shell.

This paper discusses about this issue in detail and suggest measures to avoid bell mouthing at outlet end of kiln shell.


# INCREASE IN CEMENT MILL-2 PRODUCTIVITY WITH THE USE OF ONLINE PARTICLE SIZE DISTRIBUTION ANALYZER

**Rajpal Singh Shekhawat & Pankaj Tiwari**

*J K Lakshmi Cement Ltd, Rajasthan*

It is creditably documented that cement performance is cognate to its composition and its fineness. Cement particle size directly influences the setting and hardening process and a series of physical processes, such as its strength and flow characteristics. Our team pin down a unique idea of increasing the output of Cement Mill-2 with the help of getting online data of Particle size distribution, as it fosters tuning the mill parameters which further fosters optimizing the mill throughput.

Online Particle Size Analyzer in the Cement Grinding section, to dwindle the large power demand of finish milling, which will improve the efficiency of grinding. In the Cement plant, due to escalating cost of electrical energy, advanced technology that will help to reduce electrical energy consumption is entailed. We have installed an online Particle Size Distribution analyzer in our Cement Mill - 2 which helped us to increase throughput by 2.5 %. The Total investment of this project is 46 lacks and the total saving is 82.40 lacks. The simple payback period of this project is 6.6 months.

# INSTRUMENTAL ROLE OF ENERGY AUDIT FOR ACCELERATING PLANT ENERGY EFFICIENCY- A CASE STUDY

**Ankur Mittal, Prateek Sharma, K P K Reddy & B N Mohapatra**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

Indian cement industry is performing exemplary well and showcasing example in terms of production, sustainability, curving emission, energy efficiency etc. Cement is counted among one of the essential commodities under robust infrastructure construction. The first cement plant in India was setup in year 1914 in Porbandar, Gujarat with a capacity of 1000 tonnes per year. The cement industry now is one of the pioneer industries which is at the base of countries development and progress. In terms of particular energy use, the Indian cement industry is one of the most productive and energy-efficient in the world.

Energy audit plays a vital role in accelerating plant energy efficiency measures. The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. The objectives of an energy audit can vary from one plant to another. However, an energy audit is usually conducted to understand how energy is used within the plant and to find opportunities for improvement and energy saving.

This paper makes an effort to present a case study for a cement plant in southern India. Adequate coverage is provided for some of the energy saving recommendations in this paper. A competent team of energy auditors from NCCBM visited the plant in year 2021and detailed analysis as well as measurements were performed towards execution of the energy audit project.

# ESTIMATION OF OPC, FLY ASH AND SLAG CONTENTS IN BLENDED AND COMPOSITE CEMENTS BY SELECTIVE DISSOLUTION METHOD

**Suresh Palla, Suresh Vanguri, Rashmi Gupta, S K Chaturvedi & B N Mohapatra**

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This research paper presents the results of the study on the estimation of fly ash, slag and cement contents in blended and composite cements by novel selective dissolution method. Types of cement samples investigated include OPC with fly ash as performance improver, OPC with slag as performance improver, PPC, PSC and Composite cement confirming to respective Indian Standards. Slag and OPC contents in PSC were estimated by selectively dissolving OPC in stage 1 and selectively dissolving slag in stage 2. In the case of composite cement sample, the percentage of cement, slag and fly ash were estimated systematically by selective dissolution of cement, slag and fly ash in three stages. In the first stage, cement dissolved and separated by leaving the residue of slag and fly ash, designated as R1. The second stage involves gravimetric estimation of fractions of OPC, residue and selective dissolution of fly ash and slag contents. Fly ash content, R2 was estimated through gravimetric analysis. Thereafter, the difference between the R1 and R2 is considered as slag content. The obtained results of cement, fly ash and slag using selective dissolution method showed 10% of standard deviation with the corresponding percentage of respective constituents. The results suggest that this novel selective dissolution method can be successfully used for estimation of OPC and SCMs contents in different types of cements.

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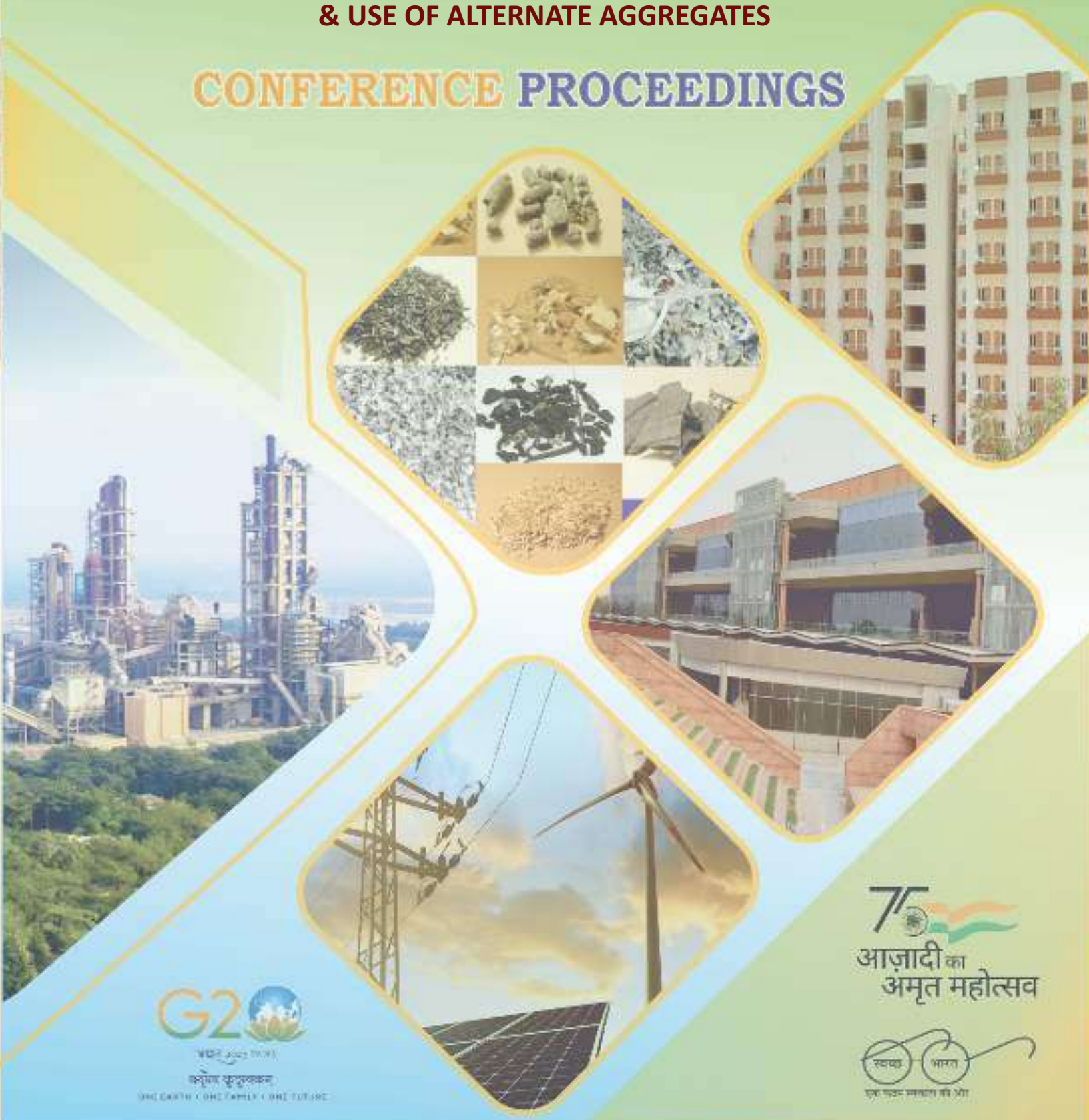

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# RECENT RESEARCH ON IRON, STEEL, COPPER AND FERROCHROME SLAG FOR UTILIZATION IN CONSTRUCTION INDUSTRY

**P N Ojha, Abhishek Singh, Brijesh Singh, Amit Trivedi & Puneet Kaura**

*National Council for Cement and Building Materials, Ballabgarh, Haryana*

A linear economy traditionally follows the "take-make-dispose" step-by-step plan. This means that raw materials are collected, then transformed into products and the bi products generated during production as well as the product (after its use) are finally discarded as waste. In a circular economy, waste does not get discarded and products, bi products as well as raw materials are reused as long as possible. In circular economy, waste is the new raw material. Slag is a by-product of smelting (pyro metallurgical) ores and used metals. Broadly, it can be classified as ferrous (by-products of processing iron and steel), ferroalloy (by-product of ferroalloy production) or non-ferrous/base metals (by-products of recovering non-ferrous materials like copper, nickel, zinc and phosphorus). Apart from Iron slag, significant portion of slag produced in India remains unutilised. Owing to steep decline in availability of reserves for natural resources to be used as cementitious materials and aggregates, construction industry has emerged as an excellent avenue for utilisation of various types of slags in different forms based on the physical, chemical and mineralogical characteristics of individual slag. At NCCBM, research studies have been carried out to study the utilisation of different types of slags as component of cementitious binder as well as fine and coarse aggregates for production of concrete. Studies were conducted to enhance the prevailing provisions of Indian Standard IS 383: 2016 on maximum permissible substitution of natural sand in concrete with copper slag and blast furnace slag fine aggregates. Investigations were carried out to explore the possibility of utilisation of ferrochrome slag as replacement of conventional fine and coarse aggregates in concrete. Attempts were made to investigate the feasibility of utilisation of LD slag as partial replacement of granulated BF slag for preparing composite slag which will be subsequently used for manufacturing of Portland Slag Cement. Along with that, research studies were also carried out to develop normal and high strength geopolymer (alkali activated) concrete by using GGBS and fly ash as cementitious binders in different proportions.

# APPLICATION OF LC$^3$ IN NON - STRUCTURAL PAVER BLOCKS

**Narendra Kumar, Lav Singh & Shashank Bishnoi**

*Indian Institute of Technology Delhi, New Delhi*

With ease of laying, wide variability in design, and durability, paver blocks have become ideal materials for the application in footpaths, low traffic load areas and roads, etc. A considerable amount of cement is consumed in these paver blocks fabrication, which should be further brought down considering their non-structural applicability and pressure on construction industry to meet sustainability needs. In the present study, limestone calcined clay cement (LC$^3$) with a clinker factor varying from 0.3 to 0.5 has been used to make paver blocks of both interlocking and non-interlocking types. Compressive strength and tensile strength development of these blocks has been compared with blocks made of OPC and guidelines of strength requirement given in Indian standards. Finally based on the strength development results, limit of clinker factor of LC$^3$ for different traffic categories has been discussed.

# PROPERTIES OF PAVEMENT QUALITY CONCRETE WITH BOF STEEL SLAG COARSE AGGREGATES

**Binod Kumar**

*Former Senior Principal Scientist, CSIR-CRRI, New Delhi*

Basic Oxygen Furnace (BOF) Slag is generated when pig iron received from Blast Furnace is further refined to produce steel in a Basic Oxygen Furnace. Lot of flux in the form of calcium oxide and coke is added into the furnace and pressurized oxygen is blown into the molten metal to remove carbon and to produce steel. The slag removed from basic oxygen furnace is called BOF steel slag. The slag is dumped into yards for gradual cooling and afterwards it is converted into aggregates of different sizes using aggregate crushers. The aggregates prepared from BOF steel slag are very hard and possess mechanical properties better than conventional aggregates used in road construction. But, BOF steel aggregates contain free lime (CaO) which makes the aggregates to expand upon hydration of free lime. The expansive potential of steel aggregates may lead to cracking and deterioration of concrete if such aggregates are used for the preparation of cement concrete mixes. Un-weathered BOF slag coarse aggregates were used in pavement quality concrete (PQC) mixes to evaluate their influence on various properties of green and hardened concrete. The compressive and flexural strength of concrete decreased slightly when prepared with BOF steel slag coarse aggregates in comparison to conventional concrete. The drying shrinkage of concrete reduced with the use of slag aggregates. The abrasion resistance of BOF slag concrete was observed to be better than the concrete with conventional aggregates.

# CHALLENGES MET DURING CONSTRUCTION OF EXTRUDER & PURGE- BIN BUILDINGS OF LLDPE/HDPE SWING UNIT OF PETROCHEMICAL COMPLEX - A CASE STUDY

**C R Rajasekar**

*Engineers India Limited*

A Mega Petrochemical Project is being set up at an existing Refinery in Northern India having a project cost of USD 3 Billion. It is executed with integration to the existing Refinery area, with hybrid mode of contracts. The Petrochemical complex consist of many process units. This paper highlights real-time data, execution challenges, logistics issues of landlocked location and practical solutions implemented to achieve the challenging targets as per schedule for successful completion of the project. Detailed case study was done about various challenges faced during construction of 2 no. of Extruder & Purge bin buildings (Twin Tower) with a height of 60M from the ground level and 11 no of slabs in each building. Extruder & Purge building is state of the art building with compliance of all the norms and codes of OSID & NBC. HSE & Quality were of prime importance given the nature of job. 5.5 MILLLION LTA free Safe Man-hours was achieved in this swing unit. Pre-job discussion, zero tolerance & finish strong practices were adopted among the workforces to compete without any single incident.

This paper also shares the latest construction techniques implemented during the execution stage such as concurrent engineering, Self-Compaction Concrete (More than 20,000 cum), reinforcement TMT bars of 2800MT, replacement of red brick with Autoclaved Aerated Concrete blocks (AAC-1600 cum) for industrial buildings, deployment of apt construction machineries & equipment's to counter the execution challenges. These studies share the tangible experiences, projects data captured, hurdles encountered while lifting of materials during construction in the extreme weather conditions & the practical solutions executed by the construction to complete the project on schedule.

# UTILIZATION OF DOLOMITIC LIMESTONE WASTE AS AN AGGREGATE

**Arunachala Sadangi, Aswathy Rajendran & Pranav Desai**

*Nuvoco Vistas Corporation Ltd., Mumbai*

The quantities of waste rocks and tailings generated from the limestone mines have been increased in the last decades. The accumulation and the surface storage of these mine wastes represents a real challenge in terms of environmental and sustainability point of view for the cement industry. Thus, the recycling and valorization of these mine wastes is one of the most effective ways of reducing their volume and mitigating their negative environmental impact. In India most of the cement plants are operating on heterogeneous intricate limestone deposits with the result that mine reject generation is high. Besides low grade its variability is extremely high due to intercalation of dolomite, clay, pegmatite, schist etc.

Recently, Indian Bureau of Mines issued a notification for implementation for thresh hold value of minerals. “Threshold Value of Minerals” means limit prescribed by Indian Bureau of Mines based on the chemical composition of Limestone. The limestone having CaO 34% (Min.) and MgO 5% (Max ) are incorporated as beneficiable/marketable, below which a mineral/material obtained after mining can be discarded as waste. As per IBM policy, around 7000 Million tons of waste material generated throughout the cement industry. The aim and objective of this paper is to study the suitability of mining waste i.e. dolomitic - limestone as an aggregate for the ready mixed concrete and road construction by focusing mainly on the mechanical and chemical performance of each types of waste.

# PRECAST CONCRETE PAVEMENT CONSTRUCTION: A TECHNOLOGY PERSPECTIVE

**Aishwarya Badkul, Rakesh Paswan & S K Singh**

*CSIR-Central Building Research Institute, Roorkee*

Prolonged traffic delays and restrictions on highways due to construction and maintenance of concrete pavement are main drawback of conventional cast-in-place concrete pavement. This causes traffic congestion, fuel consumption and emission of greenhouse gases in the environment. As a consequence, an efficient and feasible alternative technology should be implemented to ensure high quality performance of pavement with least possible time delay. The present paper focuses on precast concrete pavement (PCP) technologies which enable construction of pavements in short duration and ensures better quality performances. The core purpose of this review is to acquire better knowledge and perceptive of PCP technology with background, scope, characteristics, advantages, mechanism, detailing (dowel bar and tie bars) and installation. The PCP systems are generally used for repair, rehabilitation and reconstruction of pavement. The accumulated information in the review serves for the expansion and development of a new PCP system for highways depending upon various conditions.

# PERFORMANCE OF EAF STEEL SLAG AS AGGREGATES IN CONCRETE- A REVIEW

**Sheetal & S K Singh**

*CSIR-Central Building Research Institute, Roorkee*

Slags obtained from steelmaking plants are posing environmental problems. The electric arc furnace (EAF) slag is mostly produced by recycling of steel scraps. Its generation takes place by the action of various fluxes upon materials within steel melting process. Therefore, its gainful utilization is need of the hour. This review presents suitability assessment of EAF slag as coarse aggregates in order to make sustainable concrete. This review confines the process of EAF slag generation, research findings including physico-chemical characteristics of slag coarse aggregates, fresh and hardened properties to appraise its efficacy in concrete. These aggregates were found much denser than natural due to iron infused within its composition resulting in a heavier and denser. Physico-mechanical properties of concrete with incorporating EAF slag was found enhanced than that of reference concretes. As the proportion of the slag aggregates increases the mechanical properties were found increased. The fundamental reason reported behind this was the high density and presence of surface pores and rough texture of slag aggregates which makes better bonding between aggregates and binder matrix. The main problem associated with this slag was observed that the produced concrete was suffered for its volume stability in the extreme conditions. The main reason behind this is the variation in the chemical composition and the presence of free CaO and free MgO, which causes dimensional instability due to the hydration of these free oxides. As a measure of prevention from this phenomenon, researchers suggested various methods of treatment before using into the concrete. These methods includes outdoor weathering, hot water treatment, steam aging, autoclave aging, heat treatment and the accelerated carbonation treatment. The aim of this paper to disseminate the knowledge and information about sustainable utilization of EAF slag as coarse aggregates in construction.

# DEVELOPMENT OF ECO-FRIENDLY WHITE CEMENT BASED WALL PUTTY PRODUCT FOR SUSTAINBLE GROWTH OF WHITE CEMENT BUSINESS

**Rajesh Singh, Arvind Gupta, Vinit Purohit, Rakesh Kumar & Kareena Kumari**

*Aditya R&D Center-Birla White, UltraTech Cement Ltd. Jodhpur*

As a part of clean & green Initiatives for long-term sustainable growth & development of white cement business, Birla White has taken a new initiative towards geo-polymer arena. Now-a-days Birla White is facing two major problems i.e. the rapid depletion of natural High Grade limestone (HGLS) deposits and increase in price and scarcity of imported polymers. There is an immediate necessity of conserving this HG-Limestone (<0.10% $Fe_2O_3$) as its existence is very limited in pan India. Birla White has annual production of approx. 60% of cement and 40% putty & value added product (VAP). For putty production, we need 100k-105k MT of white cement. The above data reflects that putty production consumes a significant amount of white cement. The use of SCM/Pozzolanic materials are gaining acceptance in building material Industry to reduce the consumption of natural resources like limestone so aligning our research in the same direction, we came across this Geo-polymer which has unique dual characteristic which has potential to replace both cement as well as polymer. Polymer is imported material while GP-65 (coded) is indigenous material which promotes the vocal for local campaign by Indian government.

In this paper, there is implementation of replacement of white cement and polymer from the current level in putty by 1st of its kind cementitious material named as Geo-Polymer (GP-65) in putty. Thereafter, prepared different formulations by partially replacing cement & polymer contents and finally achieved a putty formulation which meets desired technical quality specification of IS: 17545. This formulation has been successfully implemented in putty plant production from 2021 & saved 2744MT of white cement (conserved-HGLS by 3645MT, $CO_2$ emission reduction by 2401MT & water saving by 933KL) annually. By introducing GP-65 in production, Birla White is heading towards greener building solutions and on the road of sustainability which is need of the hour.

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