Confederation of Indian Industry

Discussion Paper on
Composite Cement

May 2016

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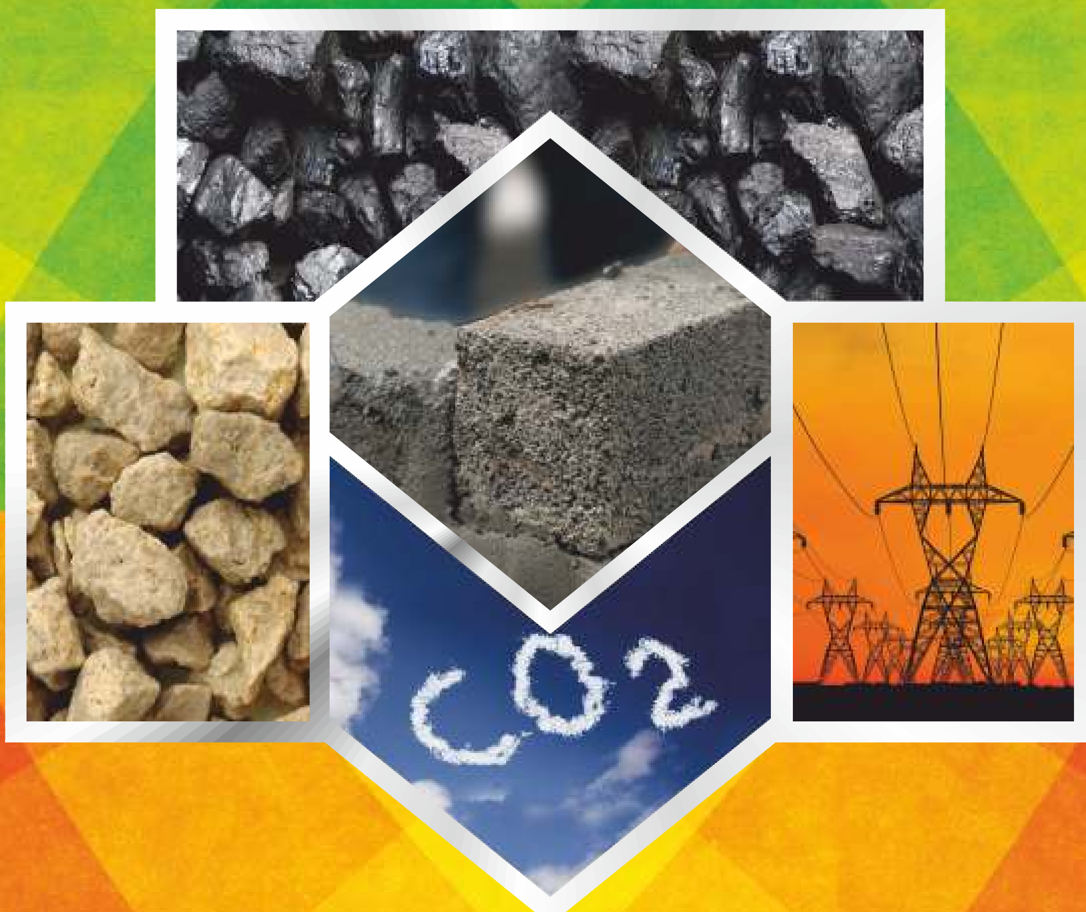

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CII - Sohrabji Godrej Green Business Centre
Survey # 64, Kothaguda Post,
R R District, Hyderabad - 500 084, India

Foreword

Promoting sustainable business practices is one of the top priorities of CII. We strongly believe economic development & environment should go hand -in - hand.

Building on this imperative, CII-Godrej GBC in partnership with Cement Manufacturing Association (CMA) and other stakeholders has launched a unique initiative titled- World Class Energy Efficiency in Cement sector.

As part of this initiative, CII has been regularly releasing various publications to facilitate sharing of best practices/success stories/ case studies to stakeholders of Indian cement industry. One such publication is "*Discussion paper on Composite Cement*".

Composite cement is produced by adding fly ash and slag together in Portland cement. Manufacture and use of composite cement is desirable for maximizing the utilization of waste materials, reduction in clinker factor, reducing carbon footprint and conservation of natural resources.

We hope this publication will equip companies to opt for composite cement production and in the process play a catalytic role in facilitating a Greener India.

We warmly invite you to share your feedback to us at encon@cii.in. Your feedback will encourage us to take similar such initiatives in the future.

G Jayaraman

Chairman, Green Cementech 2016

Acknowledgment

CII-Sohrabji Godrej Green Business Centre would like to express its sincere gratitude to all the stakeholders of Indian cement industry for their continuous support to this initiative. Our special thanks to National Council for Cement and Building Materials (NCB) for sharing the data required for this manual.

We would also like to thank all our technical experts and associations for sparing their valuable time in offering inputs and suggestions in bringing out this publication.

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Executive Summary

Cement production and consumption is directly linked to economic development. The availability of cement is vital for infrastructure expansion, modern housing and urbanization.

India has a low per-capita cement consumption at about 190 kg[1] as of 2015 against the world average of 350 kg. The cement demand is projected to grow 2.5 to 2.7 times the current volume, reaching 500-650 million tonnes per annum (mtpa) by 2025[2], mainly on account of rising infrastructure and housing needs propelled by rapid urbanisation.

Meeting the rising demand for cement will require considerable capacity addition along with a sharp rise in available resources, which could present many challenges.

Cement production is also an energy intensive process and one of the major sources of CO_2 emissions. The manufacture of cements with additives has been pursued as an alternative to reduce CO_2 emissions. The environment-friendly blended cement is more cost-effective to produce, as it requires lesser input of clinker and energy. The availability of fly-ash (from thermal power plants), blast furnace slag (from steel plants) and use of advance technology has increased the production of blended cement in the recent years.

The Bureau of Indian Standards (BIS) previously had, approved only blends of either fly-ash based cement (Portland Pozzolana Cement-PPC) or slag-based cement (Portland Slag Cement-PSC). BIS has recently released the standards for composite cement which is a blend of both fly ash and slag together with clinker. As per the standards, in Composite cement clinker can be substituted up to 65% by additives. The Composite cement has considerably lower cost of production as well as lower CO_2 intensity.

> This study indicates that production of Composite Cement in a 1 MTPA cement plant, requires 57% less raw material, 52% less thermal energy and 34% less electrical energy in comparison to Ordinary Portland Cement (OPC) production. The CO_2 emission intensity of Composite cement is 0.36 tCO_2/ton of cement which is 56% lower than OPC.

1 Report on Cement by IBEF, January 2016

2 Low carbon technology roadmap for Indian Cement Industry, developed by IEA and WBCSD CSI members, technically supported by National Council for Cement and Building Materials (NCB) and Confederation of Indian Industry (CII) and financially supported by International Finance Corporation (IFC)

The production of composite cement needs additional fly ash and slag. The availability of fly ash and slag indicates that indigenous slag availability is a bottleneck and can support only upto 20% replacement of OPC with composite cement.

The manufacturing of composite cement is the most attractive in the states of Chhattisgarh, Odisha, Jharkhand, Karnataka, West Bengal and Andhra Pradesh as both the fly ash and slag are available in these states. The cement plants located in the coastal areas can also manufacture composite cement by importing slag.

This manual focuses on composite cement manufacturing standards, benefits (monitory and environmental) and possible locations where it can be produced.

1. Introduction

Cement industry plays a major role in the economic development of a nation, provides the vital raw material for the basic building blocks of nation's infrastructure and housing development. India is the world's second largest cement producer with an installed capacity of 390 million tonnes per annum[3]. By 2025, the total cement production could reach 500-650 million tonnes.

Cement manufacturing is an energy intensive process with high fuel (710 kcal/kg clinker on average) and electricity consumption (78 kWh/ton of cement on average). Energy costs account for 40-45% of the production costs of cement, so efforts are always being made to reduce the demand for fuels and electrical energy. The cement manufacturing process also releases carbon dioxide (CO_2), which makes the cement industry as one of the highest CO_2 emitter in the world.

Indian cement industry is most efficient in the world in terms of thermal and electrical energy. The sector's efforts to reduce its carbon footprint by adopting the best available technologies and environmental practices are reflected in the achievement of reducing total CO_2 emissions to an industrial average of 0.719 tCO_2/t cement in 2010 from a substantially higher level of 1.12 tCO_2/t cement in 1996[4].

Given the recent trends in the industry and those foreseen, following are the challenges faced by the Indian cement industry:

High Grade Limestone availability: Indian Bureau of Mines (IBM) estimates total cement grade limestone reserves is 89,862 million tonnes could last only for another 35 - 41 years, based on expected growth and consumption pattern.

Fuel availability: Coal is one of the major raw materials required by the industry both in the manufacturing of cement and for generating power. In the recent years, there has been a steep drop in the supply of linked coal to the cement industry due to diversion of coal to the power sector. Cement companies, therefore, have to resort to either open market purchase or import coal which is nearly 2 to 2.5 times higher than the domestic coal price. The shortage of coal, with no assurance of its availability in future, may actually hamper the required capacity additions for the future build up. With the increasing cost of coal and other input materials the production cost of cement has gone up significantly.

Challenges in fly ash handling: The total fly ash generated in the year 2012-13 was 184.14 Million Tonnes, out of which 102.54 million tonnes was put to productive use. Cement industry utilized only 43.33 million tonnes of fly ash in 2012-13 for manufacture of PPC. A large portion of fly ash therefore is available for use by the cement industry. The increase of fly ash percentage in PPC and manufacture of newer types of cement with higher

3 Report on Cement by IBEF, January 2016
4 Low Carbon Technology Roadmap for Indian Cement Industry

percentage of fly ash are some of the alternatives available. There is a need for awareness creation and capacity building to transform the market and make the blended cement acceptable.

Challenges in Alternative Fuel & Raw Material (AFR) usage: The present national average Thermal Substitution Rate (TSR) value is about 4% and has potential to reach 25% by the year 2025 given the right enabling environment. The major challenge faced by the Indian cement industry with regards to using waste for co-processing was the government policies which has been now addressed to a large extent with the recent amendments issued in hazardous waste and other Municipal Solid Waste (MSW) rules.

Future trends:

India intends to reduce the carbon emission intensity of its GDP by 33-35% by 2030 from 2005 level. Cement industry being one of the major contributors of CO_2 emission (around 7% of the country's total energy and process CO_2 emissions) has to play a crucial role to support India's INDC of reducing the carbon emission intensity.

Indian cement industry being the most efficient in the world in terms of thermal and electrical energy has already adopted many of the best available technologies and environmental practices. The second cycle of PAT (Perform, Achieve and Trade) program by Bureau of Energy Efficiency has laid down a specific energy reduction target of 8% of Gate to Gate energy consumption by 2018-19 for cement industry. Cement industry can achieve the energy reduction target and can reduce the carbon emission intensity by employing the following five levers:

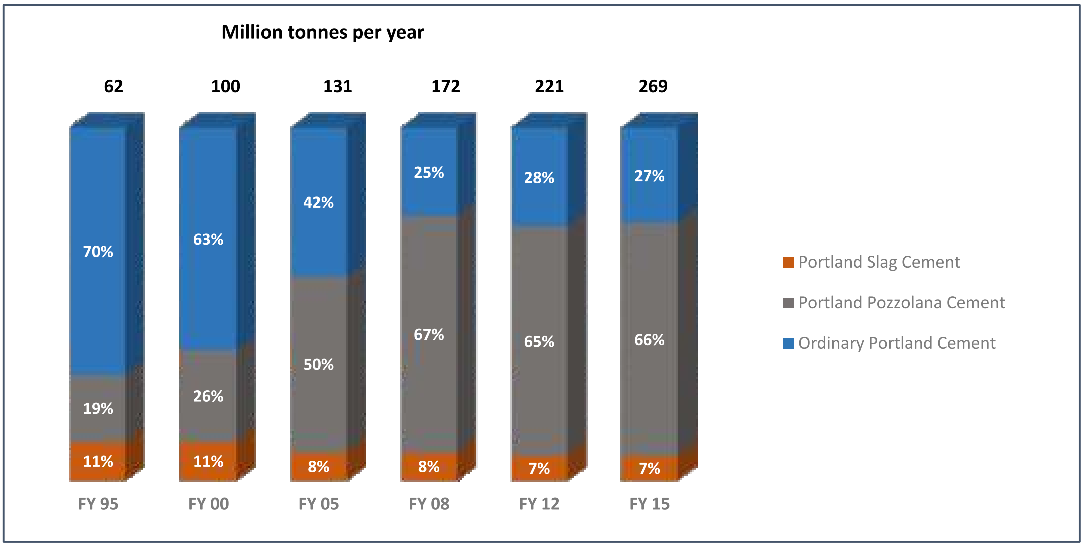
1. Improvement of electrical and thermal energy efficiency
2. Increased use of alternate fuel & raw materials
3. Reducing clinker factor
4. Waste heat recovery
5. Adopting state of the art newer technologies

Improving the clinker factor will result in reduction in specific thermal and electrical energy per tonne of actual cement produced. In PAT Cycle-I, one of the major factor that helped several cement plants achieve the energy reduction target was improvement in clinker factor and increase in the blended cement production.

Growth of blended cement in India

The production of blended cements in the country has increased from 19% in FY-95 to 66% in FY-15[5] and consuming about 42 per cent of the total fly ash generated and the entire quantity of ground blast furnace slag.

5 CII- Cement Vision 2025: Scaling New Heights



There is need to increase the utilization of industrial wastes to the fullest extent. In 2014-15 the total fly ash generation from the coal based power plant was 184.14 million tons[6] and out of which around 102.54 Million Tons was utilized for various applications such as blending material in PPC, fly ash bricks manufacturing, mine filling, concrete, roads and flyover etc. Cement industry has utilized 43.33 million tonnes (42%) of fly ash.

India is having slag generation capacity of 10 million tonnes[7] per annum at existing steel plants. Indian cement industry is consuming almost the entire granulated slag produced.

The Bureau of Indian Standards previously had approved only blends of either fly-ash based cement (Portland Pozzolana Cement-PPC) or slag-based cement (Portland Slag Cement-PSC). Composite cement is a blend of both fly ash and slag together with clinker. BIS has recently released the standards for composite cement also. Production of composite cement would be helpful in enhancing the sustainability of cement industry. Various lab trails conducted for composite cement in the country shows fruitful result for composite cement.

Composite cement production in India will help in utilizing waste materials such as fly ash and slag together in one cement when both are available in sufficient quantity at the same place.

6 Report on fly ash generation at coal/lignite based thermal power station & its utilization in the country for the year 2014-15 by central electricity authority

7 Indian Minerals Yearbook 2014

2. Composite Cement, Benefit, Application and its Indian Standards

2.1 Composite Cement

By definition, the blended cements, which are produced by using more than one mineral addition, are known as composite cement. Composite cement is mixture of clinker and certain amount of gypsum, fly ash & slag. It can be produced either by intimately inter-grinding Portland cement clinker, granulated slag & fly ash or intimately and uniformly blending Ordinary portland cement, finely ground granulated slag & fine fly ash with required addition of gypsum.

2.2 Benefit of Composite Cement [8]

Production of composite cement offers various benefits over OPC and other blended cement which has been listed below:

2.2.1 Conservation of Raw material

For 1 million tonne cement plant producing OPC, PPC, and PSC requires nearly 1.5-1.6, 1.0-1.1 and 0.8-0.9 million tonnes of lime stone respectively, whereas production of same quantity of composite cement requires 0.6-0.7 million tonnes thus resulting in reduction of limestone consumption.

2.2.2 Reduction in Thermal Energy

The thermal energy cost for production of 1 MTPA of Composite cement reduces by 52% as compare to OPC production. Thermal energy cost for production of PPC and PSC reduces by 27% and 35% respectively as compare to OPC production.

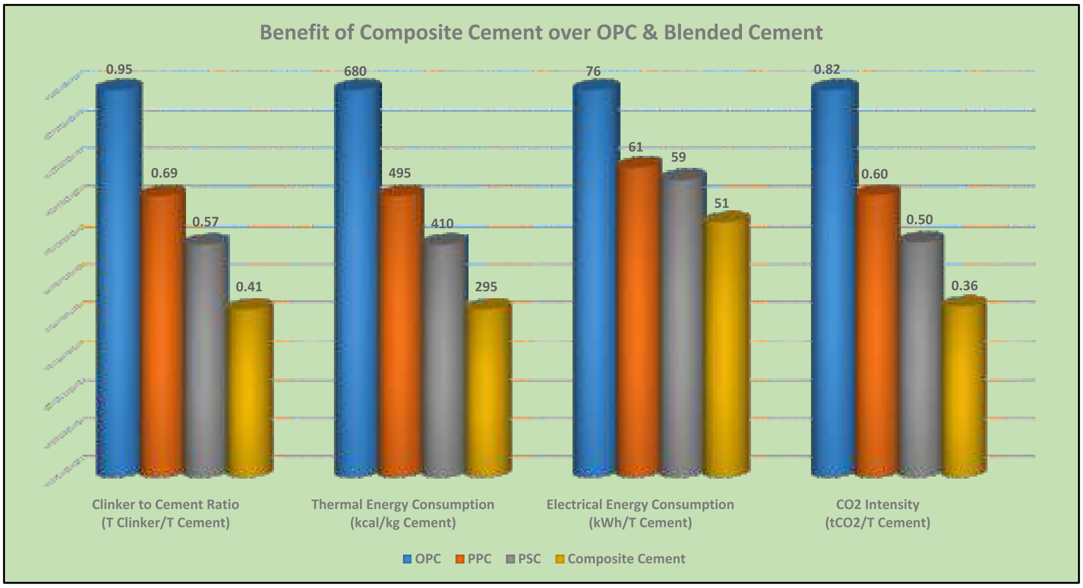
2.2.3 Reduction in Electrical Energy

Production of composite cement requires 34% less power as compare to OPC and production of PPC and PSC requires 20% and 23% less power respectively as compare to OPC.

2.2.4 Reduction in CO_2 Emission Intensity

CO_2 emission intensity reduces by 56% for Composite cement production as compare to OPC, and for PPC and PSC cement it reduces by 27% and 39% respectively.

8 Refer Annexure for basis of calculation



2.3 Application & Performance of Composite Cement

Composite cement has several advantages over OPC cement as it can be used in many application where rate of heat generation and high sulphate & chloride resistent environment plays a vital role.

List of composite cement application are given below.

- Mass concrete application such as dams, retaining walls
- Precast concrete, such as pipe and block
- Building construction & civil engineering where early strength is not important
- Concrete exposed to harsh environment, such as waste water treatment & marine application

Effect of addition of fly ash & grounded granulated blast furnace slag on the properties of concrete is shown below in table[9]:

<table>
<tr><td rowspan="5">Fresh Concrete</td><td></td><td>Grounded Granulated Blast Furnace Slag addition in concrete</td><td>Fly ash addition in concrete</td></tr>
<tr><td>Bleeding</td><td></td><td></td></tr>
<tr><td>Setting Time</td><td colspan="2">Slight retardation</td></tr>
<tr><td>Cohesiveness</td><td></td><td>Ultra-fine FA increases cohesiveness</td></tr>
<tr><td>Workability</td><td>Slight improvement with some aggregates</td><td>Improves: lower water requirement for given slump</td></tr>
<tr><td rowspan="10">Hardened Concrete</td><td>Rate of early-age strength</td><td>Reduces especially at lower temperature</td><td>Slight reduction, especially at lower temperature</td></tr>
<tr><td>Response to steam curing</td><td colspan="2">Improves</td></tr>
<tr><td>Strength gain after 28 days</td><td colspan="2">Increases</td></tr>
<tr><td>Rate of heat generation</td><td colspan="2">Reduces</td></tr>
<tr><td>Pore structure</td><td colspan="2">Improves</td></tr>
<tr><td>Density of aggregate paste interfacial zones</td><td>Improvement</td><td>Improvement, especially with ultra-fine FA</td></tr>
<tr><td>Impermeability of concrete</td><td colspan="2">Improves</td></tr>
<tr><td>Sulphate resistance</td><td>-</td><td>Improves</td></tr>
<tr><td>Rate of chloride diffusion</td><td colspan="2">Reduces: improves protection of embedded steel against corrosion</td></tr>
<tr><td>Alkali aggregate reaction</td><td colspan="2">Prevents or retard if content is sufficient</td></tr>
</table>

9 Cement and Concrete Institute, Midrand

In India, numerous trials has been carried out on composite cement wherein different combination of flyash & granulated blast furnace slag was used. The study of these trials indicates the physical properties of composite cement prepared using 40-60% clinker and 20-30% each of fly ash and granulated blast furnace slag (GBFS) were in the range specified for Composite cement by Bureau of Indian standard (IS 16415:2015) provided lower early days strength development. The results of the trial taken by National Council for Cement and Building Materials (NCB) is attached in **Annexure - 2**.

2.4 Indian Standards (IS 16415:2015) for Composite Cement

Bureau of Indian Standards (BIS) has released standards pertaining to composite cement. It covers the required information about manufacture, chemical & physical requirements, packing and marking. Some of the silent features of the standards are listed below

2.4.1 Material proportion to be used in Composite Cement as per Indian Standards (IS 16415:2015)

Material proportion for production of composite cement along with the required proportion of gypsum to control the setting time as necessary is given in below table:

SL. No.	Material	Proportion (percentage by weight)
1	Portland cement clinker / Ordinary portland cement	35 - 65
2	Fly ash	15 - 35
3	Granulated slag	20 - 50

2.4.2 Physical requirement as per Indian Standards (IS 16415:2015)

Composite cement shall comply with the physical requirements given in below table:

SL No.	Characteristic	Requirement for composite cement	Method of Test Ref to
1	Fineness, m^2/kg, Min	300	IS 4031 (Part 2)
2	Soundness		IS 4031 (Part 3)
	a) By Le Chatelier method, mm, Max	10	
	b) By autoclave test method, percent, Max	0.8	
3	Setting time		IS 4031 (Part 5)
	a) Initial, min, Min	30	
	b) Final, min, Min	600	
4	Compressive strength, MPa		IS 4031 (Part 6)
	a) 72 +/- 1 h, Min	16	
	b) 168 +/- 2 h, Min	22	
	c) 672 +/- 4 h, Min	33	

2.4.3 Chemical Requirement as per Indian Standards (IS 16415:2015)

When tested in accordance with the methods given in IS 4032, composite cement, shall comply with the chemical requirements given in below table:

SL No.	Characteristic	Requirement
1	Insoluble residue, percentage by mass	
	a) Max	$X + \frac{4.0\,(100-X)}{100}$
	b) Min	0.6 X Where X is the declared percentage of pozzolana in the given composite cement.
2	Magnesia, percentage by mass, Max	8.0
3	Total sulphur content calculated as sulphuric anhydride SO_3), percent by mass, Max	3.5
4	Sulphide sulphur (S), Max	0.75
5	Loss on ignition, percent by mass, Max	5.0
6	Chloride content, percent by mass, Max	0.1 0.05 (for prestressed structure)

2.5 Comparison of Indian Standards and European Standards for Composite Cement

Internationally European Cement Standard EN-197 is available for composite cement (CEM-V/A & CEM-V/B). Below table shows comparison between Indian Standard (IS 16415:2015) & European Standard (EN-197 CEM-V):

SL No.	Characteristic	Indian Standards	European Standards	
		IS 16415:2015	EN-197-1	EN-197-1
			CEM V/A	CEM V/B
1	Portland cement clinker / Ordinary Portland cement (%)	35-65	40-64	20-38
2	Fly ash (%)	15-35	18-30	31-50
3	Granulated Slag (%)	20-50	18-30	31-50
4	Compressive strength, MPa			
	a) 3 days	16	> 10 to 30	
	b) 7 days	22		
	c) 28 days	33	> 32.5 to 52.5	
5	Setting time Initial Min Final, Min	30 600	> 45 to 75	
6	Soundness, mm	10 Max by Le Chatelier method 0.8 Max Percentage by Autoclave test method	< 10	
7	Loss on ignition, percent by mass,	5.0	-	-
8	Insoluble residue, percentage by mass		-	-
	a) Max	$X + \frac{4.0\,(100-X)}{100}$		
	b) Min	0.6 X Where X is the declared percentage in the given composite cement.		
9	Total sulphur content (as SO_3), percentage by mass	3.5 max	< 3.5 to 4	< 3.5 to 4
10	Chloride Content, percentage by mass	0.1 max 0.05 (for prestressed structure)	< 0.10	< 0.10

3. Composite Cement Outlook for the year 2025

In 2014, cement production in India was 269.24 million tonnes. Share of OPC, PPC and PSC was 27%, 66% and 7% respectively of total cement production. Fly ash consumption was around 44 million tonnes which contributes to 25% of total PPC cement production & 42% of total fly ash generation. Slag generated during year 2014 was nearly 10 million tonnes out of which almost 100% has been utilized by cement industry.

Indian cement industry production is expected to reach 500-650 million tonnes per annum by the year 2025.

Assuming the percentage share of blended cement in year 2025 same as it is currently (66% PPC, 27% OPC & 7% PSC), requirement of fly ash would be 80-110 million tonnes & slag would be 13-17 million tonnes by the year 2025.

It is assumed that at least 20% OPC can be replaced by composite cement. Replacement of 20% OPC by composite cement can reduces CO_2 emission intensity by 14% (to 0.56 t CO_2/T of cement) as compared to business as usual scenario, conservation of high grade lime stone by 15-20%, reduction in electrical energy cost by 9% and reduction in thermal energy cost by 14%.

Replacement of 20% OPC with composite cement requires fly ash in the range of 110-140 million tonnes & granulated slag around 45-65 million tonnes. To find out possible availability of fly ash & slag in year 2025 projection study has been carried out.

3.1 Fly Ash – Thermal Power Plant

Installed power generation capacity in India is about 298.06 GW[10] as on March 2016, out of which State, Central & Private sector contributes 34%, 26% & 40% respectively. The fast growing power sector with target to add 1,00,000 MW every five year plan, would have higher and higher demand for coal, resulting in generation of large volumes of flyash. In India currently more than 70,000 acres of land are occupied by ash pond. Such a huge quantity does pose challenging problem, in the form of land uses, health hazards and environmental dangers. Both in disposal, as well as in the utilization, utmost care has to be taken, to safeguard the interest of human life, wild life and environment.

To reduce the requirement of land for disposal of fly ash in ash ponds and to address the problem of pollution caused by fly ash, Ministry of Environment, Forests and Climate Change (MoEFCC) has issued various notifications on fly ash utilization. The first notification was issued on 14th September, 1999 which was subsequently amended in 2003 and 2009 vide notifications dated 27th August, 2003 and 3rd November, 2009 respectively.

10 Growth of Electricity Sector in India from 1947 - 2015, Ministry of Power

All coal and, or lignite based thermal power stations and, or expansion units in operation before/after issue of MoEFCC's notification i.e. 03.11.2009 were to achieve 100% target of fly ash utilization by five years from the date of issue of notification

Sl. No	Target of Fly Ash Utilization (In percentage of fly ash generation)		Target Date
	Thermal Power Stations Before notification	Thermal Power Stations After notification	
1	At least 50%	At least 50%	One year from the date of issue of notification
2	At least 60%	At least 70%	Two years from the date of issue of notification
3	At least 75%	-	Three years from the date of issue of notification
4	At least 90%	At least 90%	Four years from the date of issue of notification
5	100%	100%	Five years from the date of issue of notification

3.1.1 Fly ash Generation & its Utilization for the year 2014-15

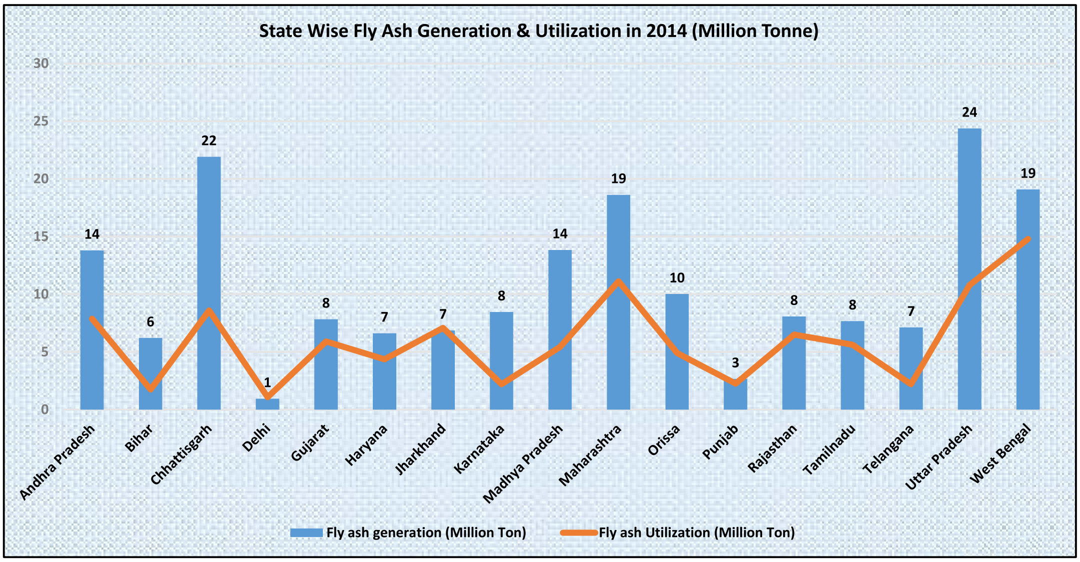
During the year 2014, total fly ash generation was 184.14 million tonnes out of which 102.54 million tonnes (55.68%) of flyash was utilized for different applications such as blending material in PPC, fly ash bricks manufacturing, mine filling, concrete, roads and flyover etc.

A brief summary of fly ash generation & utilization for year 2014 is given below

Installed Capacity	MW	138915.8
Coal Consumed	Million Ton	549.72
Fly Ash Generation	Million Ton	184.14
Fly Ash Utilization	Million Ton	102.54
Percent Utilization	%	55.68
Percent Avg. Ash Content	%	33.49

Out of 102.54 million tonnes flyash utilization 43.33 million tonnes of flyash utilized in cement industry which contributes to 42% of total fly ash utilization.

State Wise Flyash Generation & Its Utilization during year 2014 -15



3.1.2 Projected Fly Ash Generation for the year 2025

In India, it is expected that 2/3rd of power generation in the country would continue to depend on coal. The annual generation of flyash is expected to be around 200-220 million tonnes by 2020 & 220-250 million tonnes by 2025[11].

11 India Energy Outlook 2015

3.2 Slag - Iron & Steel

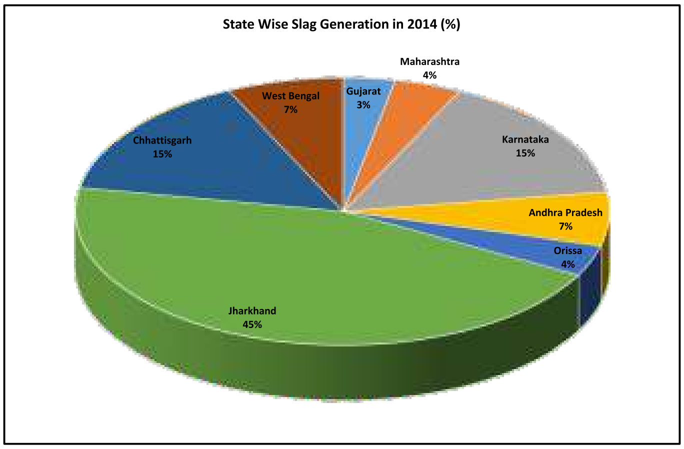
Slag is a by-product generated during manufacturing of pig iron and steel. The slag produced at blast furnace during pig iron manufacturing is called blast furnace slag and slag produced at steel melting shop is known as steel slag. Slag output obtained during pig iron and steel production is variable and depends mainly on composition of raw materials and type of furnace.

One of the major challenges faced by industry is generation of waste. Among all the solid/liquid wastes, slag generated at iron making and steel making units are created in the largest quantities. As India is likely to grow in the range of 9% to 9.5% of GDP growth[12], disposal of large quantities of slag becomes a big environmental concern and a critical issue for steel makers. At present, most of the generated slag is disposed by means of open dumping, which creates environment problem such as soil leaching, breeding of insect, lack of aesthetics.

3.2.1 Slag Generation for the year 2014-15

Typically, for ore feed containing 60 to 65% iron, blast furnace (BF) slag production ranges from 300 to 540 kg per tonnes of pig or crude iron produced. Lower grade ores yield much higher slag fractions, sometimes as high as one tonne of slag per tonne of pig iron produced. Steel slag output is approximately 20% by mass of the crude steel output.

In India nearly 10-12 million tonnes of slag was generated in the year 2014[13]. State wise generation of granulated blast furnace slag is given below



12 Report of working group on steel industry for 12th five year plan
13 Indian Minerals Yearbook 2014, Ministry of Mines.
Basis:- 400 kg / Tonne of Crude steel Plant capacity utilization 60%

3.3.2 Projected Slag Generation for the year 2025

India is one of the largest producers of steel in the world, in spite of that it has been lagging behind other major steel producing countries in terms of intensity of steel usage in overall economic activities (i.e., per unit of GDP) or per capita consumption of steel. In 2010, per capita consumption of steel was only 51.7 Kg as against the world average of 202.7 kg[14]. So, there exists enormous potential in the economy for higher growth of domestic steel demand in medium and long term

To cater to the domestic demand, Indian steel industry will likely to produce 170 to 220 million tons of crude steel in 2025 and 200 to 250 million tonnes[15] of crude steel in 2030. With 170 to 220 million tonnes of crude steel production, slag generation will be in the range of 45-65 million tonnes considering 400 kg slag generation/ tonnes of pig iron.

Description	In Million Ton		
	2020	2025	2030
Crude Steel Production	150-200	170-220	200-250
Blast Furnace Pig Iron Generation	100-150	110-160	120-180
Slag Generation	40-60	45-65	50-70

3.3 Possibility of Composite Cement Production

Above analysis indicates that the fly ash generation by year 2025 is expected to be in the range of 200-220 million tonnes and slag generation is expected to be in the range of 45-65 million tonnes. Different scenario has been assumed to estimate the fly ash and slag requirement for production of composite cement considering replacement of either OPC and/or PPC or both with 10% and/or 20% composite cement by 2025. (PSC production proportion is assumed same as current proportion).

For production of 20% composite cement by replacing OPC, requirement of fly ash would be 110-140 million tonnes and requirement of slag would be 45-65 million tonnes. The analysis indicates that it is possible to replace 20% of OPC with composite cement by year 2025.

The analysis indicates that the fly ash will be sufficiently available but the slag availability will be a limitation for increasing the composite cement production above 20% of the overall cement production by the year 2025.

14 Report of working group on steel industry for 12th five year plan
15 Energy Transition For Industry - India & Global Context by IEA

	Business As Usual	OPC Replacement by Composite Cement		PPC Replacement by Composite Cement		OPC & PPC both Replacement by Composite Cement
	Scenario -1	Scenario – 2 10% OPC replacement	Scenario – 3 20% OPC replacement	Scenario – 4 10% PPC replacement	Scenario – 5 20% PPC replacement	Scenario – 6 10% OPC & 10% PPC replacement
Cement Production	500-650	500-650	500-650	500-650	500-650	500-650
Clinker Production	380-490	350-460	320-420	360-470	350-460	340-440
OPC Production	140-180	90-120	40-50	140-180	140-180	90-120
PPC Production	320-420	320-420	320-420	270-360	220-300	270-360
PSC Production	35-45	35-45	35-45	35-45	35-45	35-45
Composite Production	0	50-65	100-130	50-65	100-130	100-130
Lime Stone Requirement	600-800	570-740	520-690	590-780	570-750	550-720
Fly Ash Requirement	80-110	90-130	110-140	80-110	80-110	100-130
Slag Requirement	13-17	30-40	45-65	30-40	45-65	45-65
CO_2 Emission	320-420	300-400	280-360	310-410	300-390	290-380

Fig. Effect on Clinker to Cement Ratio & CO_2 Intensity by replacement of OPC with Composite cement

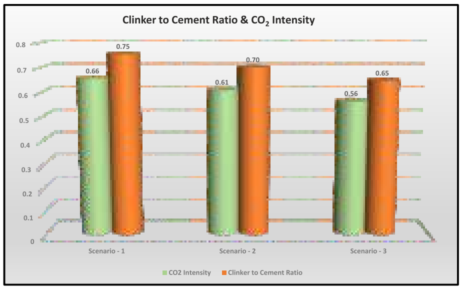
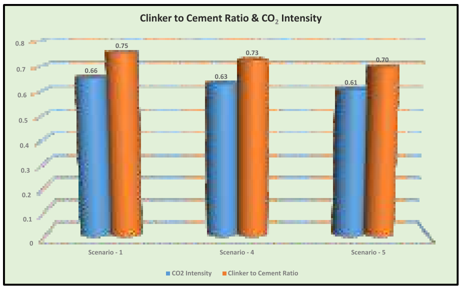


Fig. Effect on Clinker to Cement Ratio & CO_2 Intensity by replacement of PPC with Composite cement



Note : All figures in above table are in million ton.

Fig. Flyash Availability & it's Requirement for the year 2025

Fig. Slag Availability & it's Requirement for the year 2025

4. Initiatives/support needed for promoting production of composite cement in India

Manufacture and use of composite cement is desirable for maximizing the utilization of waste materials and for better control over cement properties.

There is need for market transformation for use of composite cement which depends on how accepted composite cements are with construction companies and other customers. With a view to promote use of composite cement in order to conserve non-renewable resources and efficient resource utilization, the following needs to be done

1. Government through Departments like MoEFCC, Central Public Works Department (CPWD), Department Of Industrial Policy & Promotion (DIPP) should promote composite cement, generate public awareness considering its positive impact on the environment

2. Handy and accurate data availability on fly ash and slag generation across the country will enable the cement industry to plan the production of composite cement.

3. States where both fly ash and slag are available composite cement could be promoted, production and usage of OPC to be banned for general applications where blended cements can be used, state government should consider using composite cement in applicable areas like concrete roads, general construction application and coastal area application

4. Incentives could be offered for manufacturing of composite cement using both fly ash and slag

5. Ratings systems & scientific tools like Life Cycle Assessment (LCA) study should be used to demonstrate, quantify the benefits associated with composite cement

6. Industrial symbiosis can be promoted. Forum consisting of steel plants, cement plants, thermal power plants along with policy makers, Building Associations to

5. Conclusion & Way forward

Conclusion

Composite cement production in India will help in utilizing waste materials such as fly ash and slag together in one cement when both are available in sufficient quantity at the same place.

Preliminary study suggest that cement plants situated in the states of Chhattisgarh, Odisha, Jharkhand, Karnataka, West Bengal & Andhra Pradesh have most possibility of composite cement production as fly ash and slag both are available in these states. Cement plants located in the coastal areas and where thermal power plant are already available can import slag for composite cement production.

The report analysis shows that as compare to OPC production, production of composite cement can reduce the raw material consumption by 57%, the thermal energy cost reduces by 52% and electrical energy requirement reduces by 34% for 1 MTPA cement production. Composite cement production will have CO_2 emission intensity of 0.36 tCO_2/ton of cement.

The report also analyses the status of fly ash and slag availability by the year 2025 for composite cement production. The availability of fly ash and slag is estimated for production of composite cement considering replacement of either OPC and/or PPC or both with 10% and/or 20% composite cement in 2025. The estimate shows that fly ash is sufficiently available but slag availability is only for maximum 20% of composite cement production considering the projected cement growth.

Way forward

Concerns over the depleting raw material reserves present a particular challenge for Indian Cement industry. In view of the rapidly depleting raw material resources, it is an imperative to reduce the clinker factor of cement by promoting the new blended cement types like composite cements and Portland limestone cements which are already in use in European countries and need to be adopted, standardised and produced in India. The production and use of cements with several main constituents and reduced levels of clinker make a substantial contribution to climate protection. Cements with several main constituents also prove to be viable alternatives to Portland cements from the technical point of view.

There is a need to increase the utilization of industrial wastes to the fullest extent. Development of norms for composite cement will allow combination of various supplementary cementitious materials such as slag and fly ash in cement. This provides avenue for better utilization of various kinds of wastes and utilizing materials such as fly ash and slag together in one cement when both are available in sufficient quantity at the same place.

Support and incentives from the Government would promote the production of composite cement. Production of composite cement will result in Resource conservation, greater sustainability and lower CO_2 emission. Composite cements present a variety of environmental benefits and it is anticipated that their production will also move forward.

Considering the growth potential of thermal power plants and steel plants in the country along with the cement production, promoting composite cement can be the best possible options to achieve resource conservation and effective environmental sustainability.

Concerted efforts by all the three sectors can facilitate in producing higher share of composite cement and in the process encourage other countries to tread this path.

Annexure

Annexure - 1:

Basis for calculation

1.	Cement Production	:	1 Million Tonne
2.	Thermal Energy Cost	:	Rs. 1000/Million Kcal
3.	Electrical energy cost	:	Rs. 4.0/kWh
4.	Emission factor		
	a. For Coal	:	4.36 tCO2/toe
	b. Process emission	:	0.525 tCO2/t clinker
5.	Raw mill to clinker factor	:	1.5
6.	Clinker to cement factor	:	0.95 for OPC
		:	0.69 for PPC
		:	0.57 for PSC &
		:	0.41 for Composite cement
7.	Specific thermal energy consumption	:	715 kcal/kg clinker
8.	Specific power consumption		
	a. Upto clinkerisation	:	50 kWh/MT clinker
	b.Cement grinding	:	27 kWh/MT for OPC
		:	25 kWh/MT for PPC
	c. Slag grinding	:	35 kWh/MT slag

Thermal energy required for slag drying has been consider for calculation.

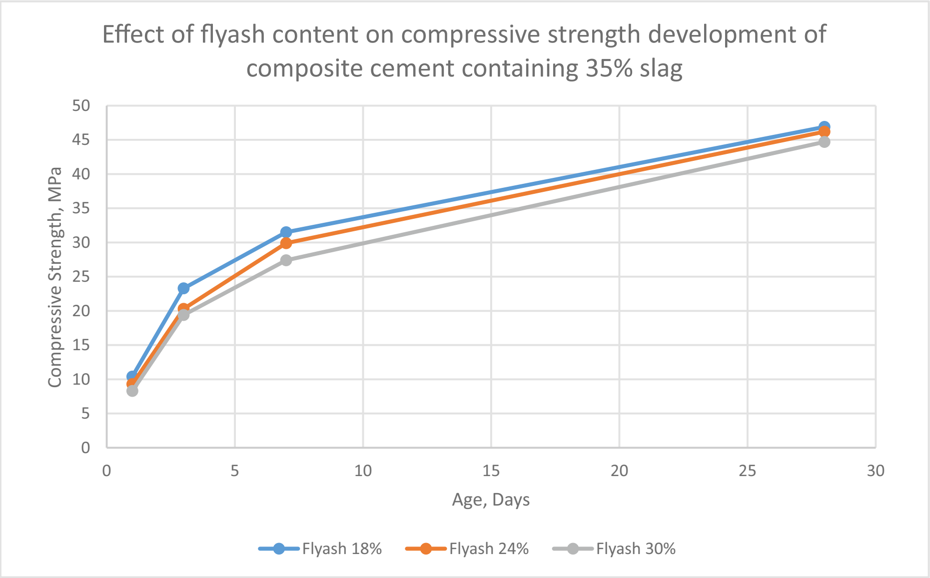
Annexure - 2:

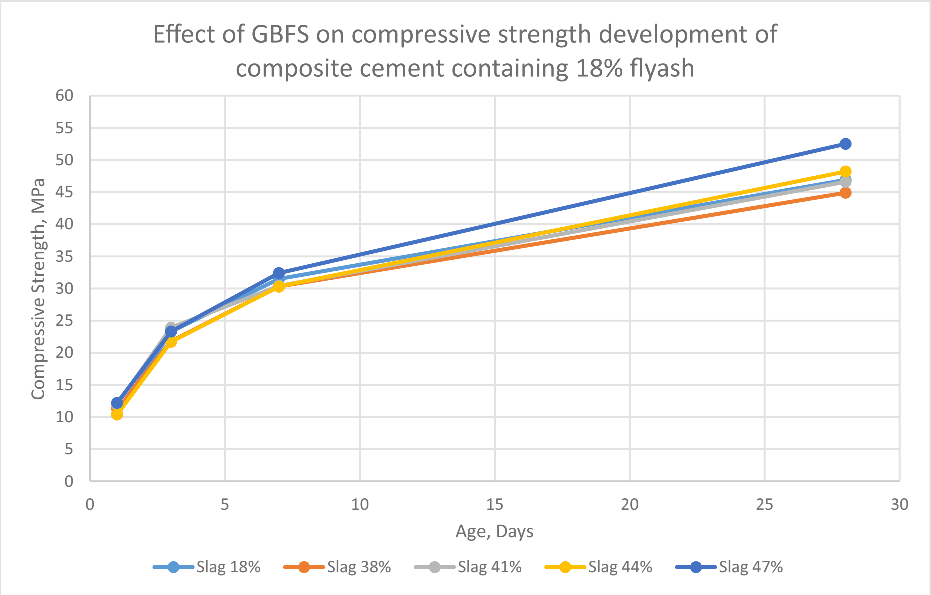
Lab trials on Composite Cement by NCB

In India National Council for Cement and Building Materials (NCB) has carried out numerious trials on composite cement wherein different combinations of flyash & granulated blast furnace slag was used for preparing composite cement blends. The results indicated that slag & flyash could be added simultaneously as the mineral admixture in preparation of composite cement.

The clinker, flyash, granulated slag & gypsum samples collected from industries and were characterised. Physical performance evaluation of the cement blend was carried out upto 360 days as per relevant Indian standards. Performance characteristics of composite cement prepared using GBFS & flyash is shown below table

SL No.	Clinker %	Slag %	Flyash %	Imp. Gypsum %	S.S m^2/kg	R-90%	R-45%	NC	IST min	FST min	CCS-1D	CCS-3D	CCS-7D	CCS-28D
1	42	35	18	5	420.9	3.9	20	30.5	130	190	10.4	23.3	31.5	46.9
2	39	35	21	5	410.8	4.6	17	31.5	120	170	10.3	21.1	30.0	46.1
3	36	35	24	5	423.4	4.4	21.8	32.3	140	225	9.3	20.3	29.9	46.2
4	33.5	35	27	4.5	426.5	5	21.7	33.1	110	170	9.1	20.9	29.3	44.7
5	30.5	35	30	4.5	421.4	4	23.1	34	120	170	8.3	19.4	27.4	44.7
6	42	35	18	5	423	3	20.6	34.5	120	180	12.5	23.7	31.8	38.4
7	39	35	21	5	420.4	4	19.8	33.5	130	190	10.5	20.1	28.4	40.3
8	36	35	24	5	413.3	4	19.6	32.5	120	170	11.5	25.3	32.4	45.6
9	33	35	27	5	426.8	2	16.6	33	110	160	12.3	24.2	35.0	48.6
10	30	35	30	4.5	420.3	4	18.6	33	135	205	10.2	20.3	31.3	45.5
11	39	38	18	5	413.7	3	16.6	32	145	250	11.3	21.8	30.3	44.9
12	36	41	18	5	423.4	4	12	32.5	120	170	11.9	23.9	30.4	46.6
13	33	44	18	4.5	426.8	2.6	11.9	32	135	205	10.4	21.7	30.3	48.2
14	30	47	18	4.5	426.8	3.1	12.2	32	140	200	12.2	23.3	32.4	52.5





The results of the experiments conducted at the plant on composite cement samples containing clinker 30.5%, GBFS 47%, flyash 18% and gypsum 4.5% were found to show improvement in compressive strength as compared to Portland slag cement (PSC) containing GBFS 57%, clinker 38% and gypsum 5%.

The other properties such as consistency and setting time were more or less comparable to PSC. Adopting the manufacture of composite cement using above combination can results in

- Reduction in clinker utilization by 7.5% (compared to PSC)
- Thermal saving ~51 kcal/kg cement
- CO_2 reduction (direct) ~7.5 kg CO_2 / tonne cement

Confederation of Indian Industry

ABOUT US

Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India´s development process. Founded in 1895, India's premier business association has over 7900 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 200,000 enterprises from around 240 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

CII – Sohrabji Godrej Green Business Centre (CII – Godrej GBC), a division of Confederation of Indian Industry (CII) is India's premier developmental institution, offering advisory services to the industry on environmental aspects and works in the areas of Green Buildings, Energy Efficiency, Water Management, Renewable Energy, Green Business Incubation and Climate Change activities. CII-Godrej GBC works closely with the stakeholders in facilitating India emerge as one of the global leaders in Green Business by the year 2022.

For further information, kindly contact :

P V Kiran Ananth

Senior Counsellor

CII - Sohrabji Godrej Green Business Centre

Survey No. 64, Kothaguda Post,

Near Hitec City, Hyderabad.

TEL: +91 40 4418 5152

E-mail : kiran.ananth@cii.in