european cement research academy

European Cement Research Academy

European Cement Research Academy GmbH

Tannenstrasse 2
40476 Duesseldorf, GERMANY

Phone: +49-211-23 98 38-0
Fax: +49-211-23 98 38-500

info@ecra-online.org
www.ecra-online.org

Chairman of the advisory board:
Daniel Gauthier

Managing director: Martin Schneider

Registration office: Duesseldorf
Court of registration: Duesseldorf
Commercial registration no.: 47580

Technical Report

TR-ECRA-120/2012

Technology papers for the Indian cement industry - looking behind the data

Client:	Cement Sustainability Initiative (CSI)
Ordering date:	03.08.2012
Client's order number:	
Our offer number:	0218/2012/V
Project manager:	Dr. Volker Hoenig
Person in charge:	
Despatch date:	12 October 2012
Content:	20 pages

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1 Task and objectives

Under the direction of the Cement Sustainability Initiative India (CSI India) a group of Indian cement experts have developed so-called Technology Papers which describe different technical possibilities to improve the energy efficiency as well as to reduce the CO_2 emissions of the Indian cement industry. The Indian Technology Papers are to some extent based on the global technology papers which were published by CSI and ECRA in 2009. The Indian Technology Papers shall provide a technical database for an Indian cement technology roadmap which is currently being developed by the International Energy Agency (IEA). The expert group consisted of members from the Indian CSI member companies as well as experts from the National Council of Building Materials (NCBM) and the Confederation of Indian Industry (CII).

The final draft of the Indian Technology Papers includes a number of projections for the future development of production as well as efficiency data which are expected to become realistic in the time scale of 2030 and 2050. As these data are much more challenging than the projections in the global CSI / ECRA Technology Papers, CSI has asked ECRA to establish contact with the Indian cement experts and try to identify the specific characteristics of the Indian cement industry from which the Technical Paper baseline data have been developed. Based on this, the specific circumstances of the cement industry in India which underlie the high efficiencies and ambitious forecasts shall be better understood and the differences to other regions shall be identified. The final objective is to understand if the projections in the Indian Technology Papers are realistic, also with respect to materials availability.

This report is based on a meeting which took place with the Indian expert group on 6 and 7 August 2012 in Delhi as well as on publically available information about the Indian cement industry, Indian cement standards etc. In the following, the different characteristics are described only with respect to the objectives mentioned above.

During the meeting the Indian experts compiled a list of typical values for the Indian cement industry which describe the different characteristics. This list is added to this report as Annex 1. The compiled data set is not based on statistical values but shall show typical reference values which can be used as a comparison with data from other regions as well as minimum and maximum values. The data refer to raw materials and fuels which are used in India, the cement types produced and their properties, cement testing methods, burning and grinding technology, power generation and environmental performance values.

2 Specific characteristics of the Indian cement industry

2.1 Raw materials

The major raw material used in India is limestone which is - compared to other world regions - a low-grade limestone with quite a low calcium carbonate content. The silica is finely distributed so that most of the cement plants don't have to use sand as a corrective material. The silica ratio is about 2.1 and the alumina ratio is 1.3 (typical value). Most raw materials are dry (typically 4%) and chlorine and alkali contents are also in the lower range so that only very few cement plants have chlorine bypass systems implemented. As limestone resources are limited in India as a whole and high-grade limestone in particular is rare, the deposits have to be used as completely and efficiently as possible..

In summary, the burnability of the raw materials is very good country-wide, which is also demonstrated by the relatively coarse grinding fineness which is usual (16 to 18% residue on 90µm,, maximum values up to 28%).

Another raw material component is clay and some plants use up to 3% of flyash in the raw mix.

2.2 Fuels

The major fuel used in the Indian cement industry is Indian coal. As in the case of limestone, Indian coal is also limited in quantity and its quality is lower than that of most other coals known from the main coal exporting countries in the world. The typical calorific value of Indian coal is 18.4 MJ/kg (4,400 kcal/kg). This coal is used in the sintering zone, while in the calciner coal of a lower calorific value is also used. The ash content of the Indian coal is quite high - 25 to 40% with a typical value of 35%. The sulphur content is on the same level as that of imported coal.

If needed, imported coal with a higher calorific value (typical value 25.1 MJ/kg) and a lower ash content (12%) is used. On the other hand, imported coal is significantly more expensive than Indian coal.

Petcoke, which is mainly produced in Indian refineries, accounts for up to 10 to 15% of the fuel amount used. Petcoke is high-calorific (typically 34.3 MJ/kg) and very poor in ash. On the other hand it has a typically high sulphur content of 6%, which usually does not cause problems with kiln operation because the sulphur content in raw materials is quite low.

The use of alternative fuels is nearly zero (on average 0.6% country-wide). The situation in India concerning waste policy and waste collection, pretreatment etc. cannot be compared with that in world regions like Europe. The Indian waste policy does not support co-incineration in industrial installations. The acceptance by the public as well as by the government is limited and permitting is difficult. This leads to a situation in which alternative fuels are more or less not available. Materials which are used in Europe as alternative fuels (e.g. waste tyres) would have to be paid for at nearly the same price as coal. Furthermore, logistics are a big problem because most of the waste is generated in the big cities and cement plants are normally are quite far away from these. The future projection of the Indian cement experts is therefore also very cautious, but they see a certain potential in the use of biogenic materials as fuels.

2.3 Clinker

With respect to the raw materials used and the high-ash coal, the representative clinker shows a relatively low LSF (typical value 0.92), but clinkers with LSF down to 0.85 are also produced. This means that the C_3S content is low compared to that in other world regions (typical value of 50% according to Bogue's potential and a range of 45 to 60%). This means that the Indian clinkers are comparatively high in belite content and low in alite content. With C_3S being the most important mineral component of clinker to create early strength, this should result in a lower reactivity of the clinker which creates some challenges for the production of blended cements. Based on the good burnability of the raw materials, the typical free lime contents are at a normal level.

2.4 Cement

Principally the Indian cement standard BIS - Bureau of Indian Standards - covers three general cement types: Ordinary Portland Cement (OPC) with three grades (33/43/53 MPa), Portland Pozzolana Cement (PPC, equivalent to OPC 33 grade) and Portland Slag Cement (PSC, also equivalent to OPC 33 grade). During recent years the Indian cement industry has significantly increased the ratio of blended cements, which today extends to a market share of about two thirds. The Indian cement standard differs in several aspects and partly significantly from other standards like the European EN standard or the American ASTM standard. BIS includes standard values for 3-, 7- and 28-day strength; on the market the one-day strength is usually agreed between suppliers and customers and is the most important strength value in daily life. The minimum strength values for 7 and 28 days correspond more or less to the European values in EN. No maximum strength values are defined in BIS. On the other hand, BIS defines minimum fineness values, given in cm^2/kg according to Blaine.

The most common cements on the market are the PPC (equivalent to OPC 33 grade), OPC 43 and 53 grade and to a lesser extent PSC (equivalent to OPC 33 grade). OPC 33 grade is hardly produced. The typical fly ash addition in PPC is about 27%, slag addition in PSC is typically about 40%. No limestone cements are included in BIS. On the other hand, BIS allows intergrinding up to 5% of "performance improvers" in OPC (not in PSC and PPC). Usually limestone, fly ash or slag are used as "performance improvers", typically at a 3% level. The addition of performance improvers to OPC has to be stated on the cement bag and is therefore a market issue. Some companies therefore steer clear of this option.

Table 1 shows the comparison of typical fineness values of the four cement types mainly produced in India and corresponding cements according to the EN standard. From this table it can be seen that the Indian cements are ground significantly coarser than the European ones. OPC / CEM I in particular show a huge difference between 3,000 Blaine in India versus > 3,600 Blaine for 32.5 and nearly 5,000 Blaine for 52.5 grade.

Table 1 Cement fineness (Examples)

Cement / Standard	Grade in MPa	Typical fineness in cm^2/g (acc. Blaine) [1]	
		India	Europe
OPC / Cem I	43 / 42.5 53 / 52.5	} 3,000	3,600 4,880
PSC / Cem III / AS	33 / 32.5 43 / 42.5	3,600 n. a. [2]	3,920 4,440
PPC / Cem II B V (W)	33 / 32.5	3,400	4,470

1) acc. VDZ database
2) not included in BIS

When comparing strength levels of cements according to the different standards, it must be stressed that also the testing procedures laid down in the respective standards lead to significantly different results:

- Firstly, the strength test is performed at a temperature of 27°C (BIS) instead of 20 °C (EN).
- Secondly, the strength test according to BIS is performed at a standard consistency instead of a standard water/cement ratio (EN).

Both issues lead to the fact that the same cement tested according to BIS would show a higher compressive strength than if it were tested according to EN standard. As a rule of thumb, and supported by some published Indian articles, it can be stated that e.g. a BIS 43 grade OPC may be comparable to a 32.5 class CEM I cement according to EN 197-1. A good quality 53 grade OPC (according to BIS) may satisfy a 42.5 class (N) of EN 197-1.. Furthermore it should be mentioned that the Indian standard does not include 43 or 53 grade PSC and PPC. The higher graded slag cements in particular are quite common in Europe and require an even higher grinding fineness.

Obviously, the Indian cement standard is adapted to Indian conditions with respect to market, available materials and ambient conditions. On the other hand, this allows the Indian cement producers to grind their cements much more coarsely compared to other world regions and in so doing to minimise their electrical power consumption in cement grinding.

2.5 Concrete

The context described in the previous chapters lead to the assumption that for a similar performance of the final product concrete, more cement is needed per cubic metre of concrete. A comparison of the Indian concrete standard IS 456: 2000 and the European EN 206-1 and its natural application role in Germany (DIN 1045-2) show that this really is the case. Although the different values cannot be directly compared, Table 2 shows an exemplary comparison for two different types of construction elements and different exposure classes of the two standards. The direct comparison of the minimum cement content per cubic metre of concrete already shows higher values for the Indian standard. Furthermore, the maximum water/cement ratio in the Indian standard is significantly lower compared to the European values.

Assuming a constant water/cement ratio, there is more or less a linear relationship between the compressive strength of concrete and cement. At a water/cement ratio of 0.5 the relation between the relative compressive strength of concrete and cement is 1. At lower water/cement ratios the value becomes higher than 1 and at higher water/cement ratios it becomes lower than 1.

As the Indian standard defines significantly lower water/cement ratios, the same cement used in concrete at the same content would lead to significantly higher strength values if the Indian standard is applied. Reducing the water/cement ratio from 0.75 to 0.55, as mentioned in **Table 2** for the inside construction elements, a higher strength development by ca. 50% would be achieved in concrete based on the same compressive strength of cement. It should be mentioned that differences to regulations in other EU countries also exist, but can be smaller than to Germany.

Table 2 Concrete requirements (Examples)

Class of exposition	EN 206-1 (DIN 1045-2)			IS 458 2000		
	min. cement content in kg/m³	max. w/c ratio	exposure class	min. cement content in kg/m³	max. w/c ratio	exposure class
Inside construction element	240	0.75	XC1	300	0.55	mild
Outside construction element	280	0.6	XC4/ XF1	300 320	0.5 0.45	moderate severe

In summary, the Indian concrete standard ensures that the differences in the cement standards are compensated to a certain extent and the performance of the concrete is secured.

According to the information derived from the Indian experts, in practice mainly three types of concrete exist, containing 330, 400 and 500 kg/m³. These values are even higher than the cement contents in concrete mentioned in the standard.

2.6 Burning technology

The Indian cement industry has one of the most modern cement technologies available. 99% of the installed capacity uses the dry process technology and about 50% of the capacity has been built within the last ten years. Most kilns are modern pre-calciner kilns with 5 or 6-stage pre-heaters. The average capacity today is 4,500 tons/day. Only very few small kilns remain and the biggest kiln reaches a capacity of 13,500 tons/day. About 20% of the kilns are equipped with waste heat recovery systems and power generation. Most plants have captive power plants onsite and produce their own power.

Based on this, as well as on the information given in the previous chapters, there are different reasons why Indian cement kilns show a lower thermal energy consumption than many other kilns worldwide. The good burnability of the raw materials in combination with the low raw material moisture allows the construction of pre-calciner kilns with at least 5 or even 6 cyclone stages. One kiln has recently been equipped with the seventh stage. Due to the relatively low chlorine and alkali contents in the raw materials no bypass systems are needed, which always lead to a certain energy loss. Furthermore these kinds of raw materials enable a smooth kiln operation with few kiln stops, a good availability, low operational fluctuations etc. The more or less exclusive use of ground coal or petcoke as fuel also allows an easy kiln operation. All this, combined with relatively big kiln capacities, make the relatively low reported thermal energy consumption appear comprehensible.

The future projections will be discussed below.

2.7 Grinding technology

The grinding equipment is also predominantly quite new and modern. The raw materials are mainly ground in vertical roller mills (65%), ball mills (30%) and roller presses (5%). In most Indian cement plants no sand is used and the limestone is a low-grade marly limestone which is easy to grind. As it is also easily burnable, the raw material fineness is comparatively low which all in all leads to very low electric power consumption for the raw material grinding.

Cement is ground by 35% in roller presses with finish grinding, in ball mills (45%), finish grinding in vertical roller mills (10%), and vertical roller mills with ball mill finish grinding (10% of the cement plants). The cement properties, in particular the fineness, have already been discussed and lead to very low electric power consumption compared to that of other regions in the world.

Slag is mainly ground separately in vertical roller mills or in roller presses in the finish mode (drying in V-separators).

Flyash has to be ground in India because it is delivered quite coarse from the power plants and is mainly interground directly with the clinker.

Coal is ground in vertical roller mills (75%) and ball mills (25%).

The use of grinding aids is not very common in India (and probably not necessary), and only 10% of the mills use grinding aids for certain cements.

In summary, the properties of the ground materials as well as the properties of the materials themselves (e.g. fineness) lead in combination with the modern technology installed to the very low consumption values which have been reported.

2.8 Environmental aspects

The main filters behind the raw mills are 50% baghouse filters and 50% ESPs. Clinker coolers are more or less completely equipped with ESPs. The cement mills are mainly operating with baghouses (75%) and only about one quarter with ESPs.

The dust emission limit is between 50 and 150 mg/Nm³ and is therefore significantly higher than e.g. in Europe. New limits have been proposed (50 mg/Nm³). Limits for NO_x and SO_x are not in place; proposed limits are such that no abatement measures have to be installed.

In summary, the power demand for emission abatement in India is quite small compared to e.g. Europe and supports the reported low consumption values.

3 Expected developments

It is generally expected that the consumption and production of cement will increase significantly in the future. Different scenarios have been discussed during the experts' meeting in Delhi. The proposed scenarios use the 2010 production value of 217 million tons as a basis. In the so-called 2DS/Low Demand scenario from IEA it is expected that the production will increase to 767 million tons per year in 2050 (corresponding to a per capita consumption of 453 compared to 196 in 2010). In the high demand scenario the production will increase to 1,356 million tons (801 kg/per capita). It is expected that the added capacity will be a completely new, modern and very efficient technology. Furthermore it is expected that there will be a strong growth in waste heat recovery application, although there might be a certain limitation by low power prices if surplus power is sold to the public grid. Waste heat recovery does not contribute to a reduction of thermal or electric energy consumption. The expected use of alternative fuels is limited, but an increase in the use of biomass as fuels, based on new plantations, is projected. In summary, this might amount to 15 to 20% substitution ratio in 2050.

Furthermore, the additionally installed grinding technology is expected to be highly efficient and new. It is also expected that the availability of fly ash and slag will not be a limiting factor in producing cements with low clinker/cement ratio. The strong increase in power demand will lead to a strong extension of coal-based power generation. Fly ash of sufficiently good quality should therefore be available for cement production. With respect to the production of slag cement it is expected that the steel industry will grow on a similar level as the cement industry and that the degree of granulation (today 50%) will provide an additional potential to increase the availability of slag.

Last but not least, the main potential from the decreasing energy demand is expected to come from the increased production of blended cements.

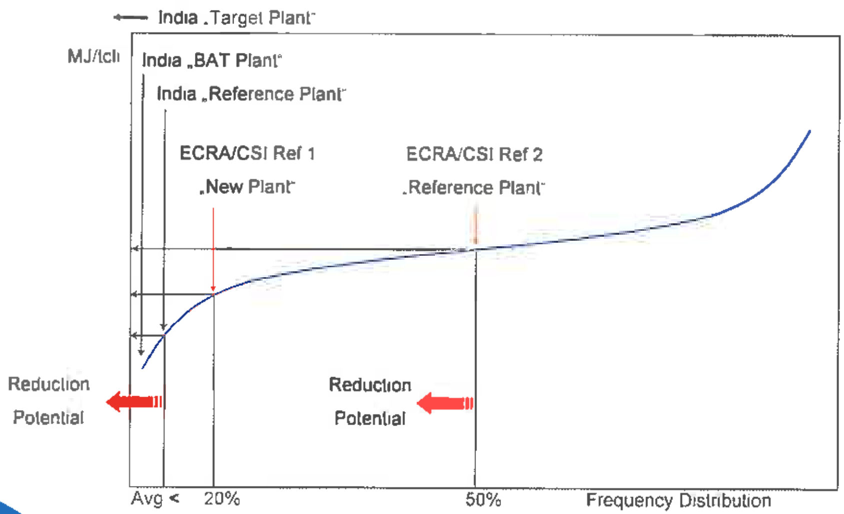
Carbon capture and storage is not expected to play a significant role in India because the Indian government has refrained from the storage of CO_2 in India.

4 Future projections

4.1 Methodology

Different methodologies for the definition of „Reference", "New" or "BAT" plants have been used in the global CSI/ECRA Technology Papers and the Indian Technology Papers. Figure 1 shows the principles which have been used in both projects. In the global roadmap, the "Reference Plant" was chosen based on the global GNR data. The "Reference Plant" has been defined as the 50% percentile of these data. It was assumed that this represents an average plant for the global cement industry. The reduction potentials described in the Technology Papers were based on this „Reference Plant", meaning that the reductions based on the technologies described can be deducted from the performance values of this "Reference Plant". Of course, an addition of reductions coming from different technical options is not possible. If "Reference Plants" are replaced by "New Plants", in the global Roadmap the "New Plant" has a performance of the 20% percentile of the global GNR frequency distribution. The 20% percentile was chosen because globally there are differences in many aspects of cement production (like raw materials, fuels etc.). This is why it was assumed that not everywhere in the world can a new plant have the performance of the best plant in the world.

Fig. 1: Comparison ECRA-India Reference Kilns (Principle)



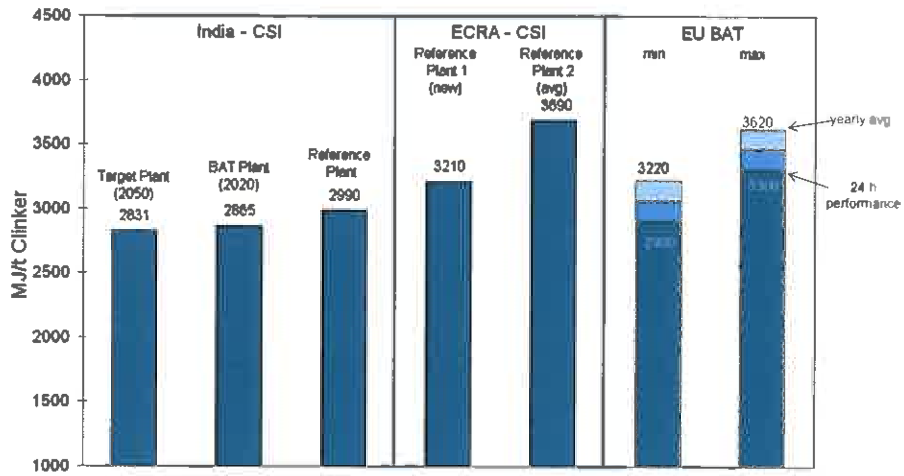
The India "Reference Plant" is based on the average of the 20% best plants in India because almost 60 % of India's cement capacity was added in last 10 years and to a large extent with state of art equipment and with high levels of energy efficiency practices incorporated. This reference plant has been considered for emission reduction estimates in the Indian Technology Papers. During the meeting on 6/7 august new numbers for key indicators for Indian cement industry were arrived at. These data have been included in the next figure.

For the so-called "BAT plant" (new plant) the best performing plant in India was chosen. It is assumed that industry as a whole may achieve these average numbers by the year 2020. Of course, the minimum values for thermal and electric energy demand do not come from the same plant. The so-called "Target Plant" in the Indian Roadmap is even better than the best plant in India today. Target plant incorporates all wish list ideas and practices and could depict the average performance of the Indian cement industry by the year 2050.

Of course, the situation in India differs from that in other regions like Europe or North America. In India significant growth has taken place in the past decade and is expected in the future as well, therefore new plants will most often show the best performance. Based on information coming from the Indian experts, there are no significant differences in the different areas of India with respect to the main influencing parameters. Therefore, this assumption would be acceptable. Whether it is possible to achieve even lower values than the India "Target Plant" it is difficult to assess, because this technology is not available today.

Figure 2 shows the comparison of the different performance levels for thermal energy demand in the India Technology Papers, the global CSI/ECRA Technology papers and the BAT values described in the European BREF document for state-of-the-art technologies in the cement industry. The EU BAT values are defined as short-term performance values. Therefore (and this is described in the European BAT Reference Document) for the yearly average an add-on of 160 to 320 MJ per ton of clinker has to be added. The comparison shows that the "Reference Plants" performance in the global Technology Papers is more or less in line with the EU BAT values. The average value is at the upper end of the BAT spread and the second plant (new plant) is close to the lower end of this spread. The Indian values are all significantly lower than the global and the European values.

Fig. 2: Comparison ECRA-India Reference Kilns with EU BAT



When assessing these data, also in the IEA Roadmap for India, the different methodologies of defining Reference and BAT Plant performance values should be considered.

4.2 Proposed CSI-data for IEA modelling

During the meeting in Delhi the assumed performance data were re-discussed and values were slightly modified. The methodology used was the following: for the year 2010 the average values for the existing capacity was used. Depending on the different scenarios from the IEA (2DS, 6DS and low versus high demand), different production values have been assumed for the years 2030 and 2050. For the additional capacity performance values have been assumed which are slightly higher than the best value achieved today. **Table 3** shows an overview of the calculation methodology and basic assumptions for the 2DS scenarios. **Table 4** shows the result for the 2DS scenarios (low and high demand) which have been finally decided on for use in the IEA modelling.

Table 3 Methodology for the determination of projected data

2 DS/Low demand					
		2010	**2050**	**Delta 2010/2050**	**Remarks**
Production	Mio. t	217	767	550	
power today	kWh/t cem	80			best plant today: 67
power 2050	kWh/t cem	72	**69,8**	69	2010: old capacity 80 -> 72
fuel today	kcal/t cli	725			best plant today: 667
fuel 2050	kcal/t cli	689	**679**	675	2010: old capacity 725 -> 689
2DS/High demand					
		2010	**2050**	**Delta 2010/2050**	**Remarks**
Production	Mio. t	217	1357	1140	
power today	kWh/t cem	80			best plant today: 67
power 2050	kWh/t cem	72	**69,5**	69	2010: old capacity 80 -> 72
fuel today	kcal/t cli	725			best plant today: 667
fuel 2050	kcal/t cli	689	**677**	675	2010: old capacity 725 -> 689

For the existing capacity a certain improvement was also assumed by 2030 and 2050. By mixed calculation, the values for 2050 were calculated.

Table 4 Modelling assumption figures proposed by CSI India

		2DS			
		Low demand		High demand	
	2010	2030	2050	2030	2050
Production (Mt) low demand case	217	589	767	850	1356
Clinker-to-cement ratio	0.74	0.64	0.58	0.64	0.58
Electric intensity of cement production (kWh/t cement)	80		69.9		69.5
Thermal intensity of clinker production (kcal/t clinker)	725		679		677
Alternative fuel use (%)	0.6%	19.2%	25.3%	19.2%	25.3%

It is important to stress that the add-on for the increase of the substitution rate with alternative fuels - which are described in the Indian Technology Papers - has not been taken into account in these figures. As this amounts to up to 40 kcal per ton of clinker (up to 170 MJ per ton of clinker), this would have to be added in the proposed performance data for the thermal energy demand. It is also essential that this topic is mentioned in the discussions with the IEA, because the performance data do not reflect this issue.

5 Conclusions

In summary, the discussion with the Indian experts showed that the Indian CSI companies have put a lot of expertise, experience and high-level assumptions into their database and future projections. The technical level of the Indian cement industry is already very high today due to the huge share of new capacity which has been built in the last decade as well as the boundary conditions described in the previous chapters.

The Indian BIS cement standard differs in several aspects and partly significantly from other standards like the European EN standard or the American ASTM standard. The testing rules laid down in these standards lead to the fact that the same cement tested according to BIS would show a higher compressive strength than if it were tested according to EN standard. As a rule of thumb it can be stated that e.g. a BIS 43 grade OPC may be comparable to a 32.5 class CEM I cement according to EN 197-1. A good quality 53 grade OPC (according to BIS) may satisfy a 42.5 class (N) of EN 197-1.

Obviously, the Indian cement standard is adapted to Indian conditions with respect to market, available materials and ambient conditions. On the other hand, this allows the Indian cement producers to grind their cements much more coarsely compared to other world regions and in so doing to minimise their electrical power consumption in cement grinding.

The Indian concrete standard ensures that the differences in the cement standards are compensated to a certain extent and the performance of the concrete is secured. The comparison of the minimum cement content per cubic metre of concrete in BIS and EN standards shows higher values for the Indian standard. Furthermore, the maximum water/cement ratio in the Indian standard is significantly lower compared to the European values. According to the information derived from the Indian experts, in practice even higher cement/concrete ratios than the values mentioned in the BIS standard are applied.

On the other hand, this very good performance level makes it very challenging to further reduce the thermal as well as the electric energy demand in the future. The methodology which has been used to develop the future projections is comprehensible, but the data are really challenging.

For the discussions between CSI and the IEA, the following points have to be stressed:

- It has to be clarified that the special situation in the Indian cement industry (which has been described in this report) cannot be transferred to other regions of the world or to the global level.
- If the IEA includes the increase of the substitution rate by alternative fuels (as mentioned in the modelling assumptions of the Delhi meeting) it has to be clarified that the increase of thermal energy demand caused by the increased use of alternative fuels has to be included.

- The topic of CCS was not discussed in detail during the Delhi meeting because the Indian government does not allow for the storage of carbon dioxide. Therefore, it should be discussed how to deal with this topic, because the IEA usually compensates high reduction targets arising from policies and technical limitations by carbon capture and storage.

European Cement Research Academy GmbH

Dr. Volker Hoenig

6 Annex 1

ANNEX 1: Typical values for Indian cement industry

	Minimum Values	Maximum Values	Typical Reference Value
Raw mix			
Silica Ratio	1.8	2.5	2.1
Alumina Ratio	0.8	1.7	1.30
LSF (%)	94	110	96
Raw Material Moisture (%)	0.5	12	4
TOC Content (%)	0	0.5	0
Cl Content	0.015	0.04	0.02
Alkali Content	0.5	1.0	0.7
Grinding Fineness (% residue on 90 micron)	10	18 (28)	16-18
Fuels			
GCV (As Received)			
1. Indian Coal (kcal/kg)	4000	5000	4400
2. Imported Coal (kcal/kg)	3800	6500	6000
3. Pet Coke (kcal / kg)	7700	8800	8200
Ash content			
1. Indian Coal Ash %	25	40	35
2. Imported Coal Ash %	5	25	12
3. Pet Coke Ash %	0.2	2.0	0.8
Fuel Sulphur %			
Indian Coal	0.2	3.5	1.0
Imported coal	0.5	3.0	0.8
Pet coke	4.5	7.0	6.0
Petcoke utilization (%)	0	100	15 (country average)
Alternate Fuel utilization (TSR %)	0 %	6 %	0.6 %
Clinker			
LSF (%)	0.85	1.0 (0.97)	0.92
Free lime content (%)	1	3	1.5
C_3S content (%) Bogue's potential	45	60	50

Cement

Indian Cement Standards

	OPC	PPC	PSC
Standard	IS 12269 (1987) / IS 8112 (1989)	IS 1489 (1991)	455 (1989)
	Strength (MPa)		
3 Day	27/23	16	16
7 Day	37/33	22	22
28 Day	53/43	33	33
Blaine (kg/m^2)	225	300	225

Typical values (Current addition levels)	Minimum	Maximum	Avg
1. Flyash addition (%)	15	33	27
2. Slag addition (%)	35	60	40
3. PI Addition (%) (Only in OPC as Performance improver)	0	5	
Typical Fineness (Blaine gm/cm^2)	2700	4600	OPC – 3000 PPC – 3400 PSC – 3600

Testing Methods

1. Sieve Analysis
2. Specific Surface area monitoring (Blaine)
3. Particle size distribution
4. Compressive Test

Concrete	M25	M 30	M 40
Concrete Standard	IS 10262, IS 456	IS 10262, IS 456	IS 10262, IS 456
kg cement/m^3 concrete	330	390	440

Burning Technology

Dry Process: 99 % of total Installed Capacity
Semi Wet process: 1 % of total Installed Capacity
Wet process: 0 % of total Installed Capacity

Capacities (TPD)	1200	13500	4500
Bypass Systems Five Plants are operating with bypass system			
Preheater (stages)	4	7	5
Kiln operation (Running hours/annum)	7000	8280	8000

Grinding Technology

Raw mill grinding technology
1. Vertical Roller Mills: 65 % of the cement plants
2. Ball mills: 30 % of the cement plants
3. Roller press in finish grinding mode and others: 5 % of the cement plants

Cement grinding technology
1. Roller press with ball mill: 35 % of the cement plants
2. Ball Mills: 45 % of the cement plants
3. Vertical Roller Mills: 10 % of the cement plant
4. Vertical Roller Mill with Ball Mill: 10 % of the cement plant

Slag grinding technology
1. Ball Mills
2. Roller press with ball mill
3. Vertical Roller Mill
4. Roller press in Finish mode

(25 Million Tons of slag cement is produced in the above mentioned grinding technology)

Fly ash grinding technology
100 % inter grinding with clinker. Some plants are attempting separate fly ash grinding and blending

Coal grinding technology
1. Ball Mills: 25 % of the cement plants
2. Vertical Roller Mill: 75 % of the cement plants

Grindability

Raw Meal – Bond Index	4	14	8
Coal / Pet Coke - HGI	45 / 35	60 / 50	55 / 45
Clinker – Bond index	12	16	14

Use of grinding aid
1. No usage for raw meal grinding
2. 10 % of the mills use grinding aid for cement grinding (Amine based and ethylene glycol based)

Power Generation

Captive Power Plants
62.86 % of cement was produced by using captive power during 2009-10.
(Reference: CMA Cement statistics 2010)

Waste heat recovery
110 MW of installed capacity as on 2012

Environmental Performance		
Installation of dust filters in cement industry Raw Mills: Bag House / ESP (50 % of the plants) Clinker Coolers: 100 % operating with ESP Cement Mills: 75 % are operating with Bag house 25 % are operating with ESP		
	Current values mg/Nm^3	**Proposed Limits** mg/Nm^3
SPM	50 – 150	50
SO_X	< 100 generally 1000 for plants with pyritic sulphur	100 1000 for plants with pyritic sulphur
NO_X	< 1000 generally 1000 - 2000 (for pet coke fired kilns / SLC)	600 (upcoming) / 1000 (existing)