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Global Cement and Concrete Association

Azadi Ka Amrit Mahotsav

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Cement and Concrete Industry paving the way for Circular Economy

Circular Economy Symposium 2022

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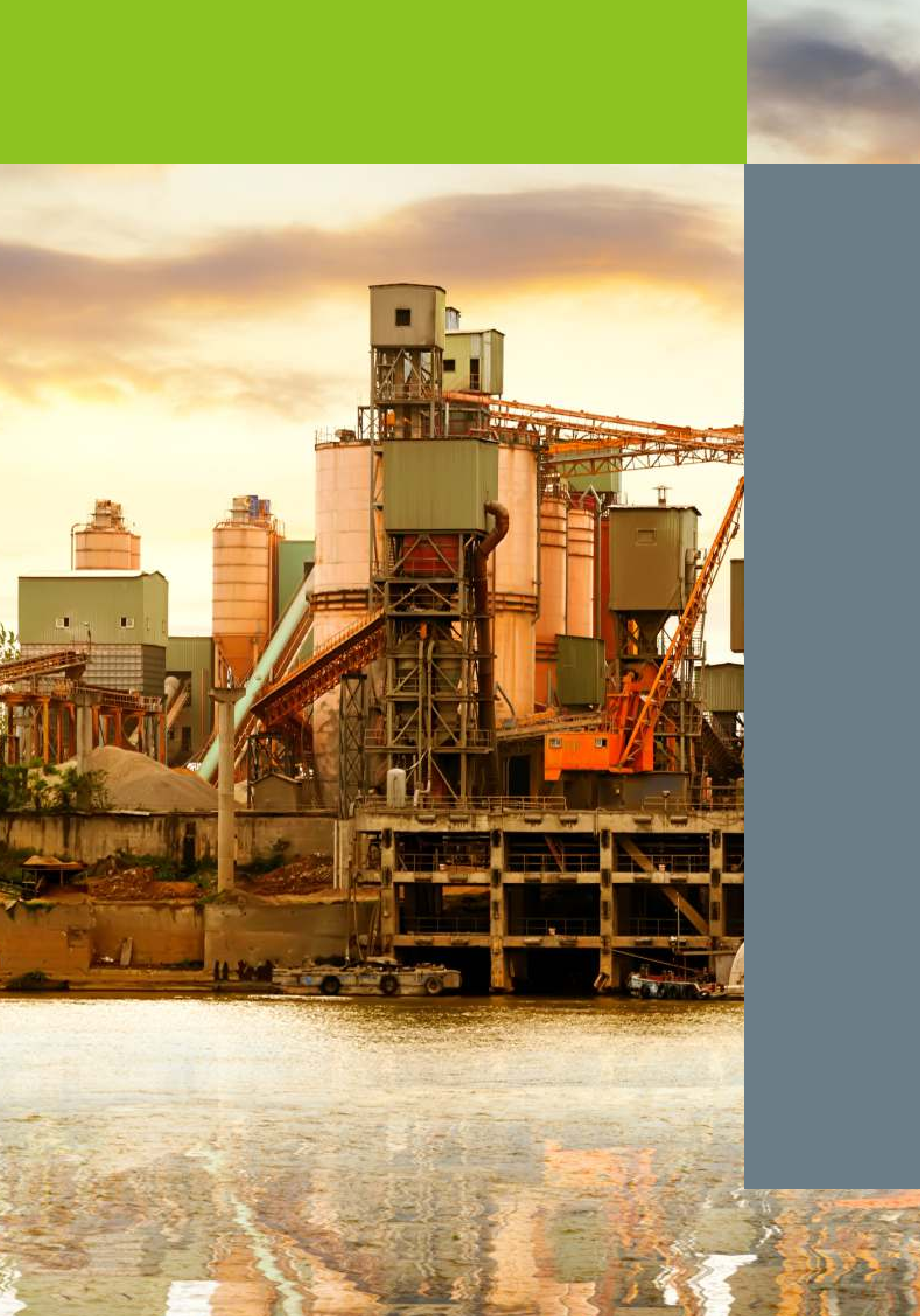

Preface

The concrete and cement industry plays a vital role in the strengthening of a nation's circular economy by effectively utilising recycled and secondary aggregates, cementitious industrial by-products of concrete, and alternative fuels or raw materials in cement kilns.

Members of the Global Cement & Concrete Association (GCCA) India recognise the importance of applying the principles of a circular economy to all stages of the lifecycle of cement and concrete, and have incorporated vital actions to this end in the GCCA Charter and Guidelines. A circular economy is also fundamental to the GCCA Climate Ambition Statement and the forthcoming GCCA 2050 Roadmap for net zero concrete.

Through the utilisation of by-products of other industries and secondary materials, including municipal refuse and concrete demolition waste, the cement and concrete industry has long been a champion of the practical application of the principles of circular economy and industrial ecology.

The cement and concrete sector already contributes significantly towards a circular economy by ensuring that the design of built assets is long-lasting, resilient, low maintenance and reusable. It also contributes through the extensive use of recycled and repurposed raw material and fuel in its manufacturing processes. Furthermore, concrete itself is a fully recyclable material.

In some countries, circularity is already enabled through a supportive policy framework, and the industry has responded with widespread initiative implementation. The circularity can be maximised globally through concrete use, strategic policies, and standards and regulations that have universal application.

GCCA India and FICCI are pleased to share this report highlighting some potential opportunities in circular economy, along with best practices from member companies as well as policy support required by the Indian cement and concrete sector. We look forward to receiving your feedback on the report.

Mr. Parth Jindal
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Foreword

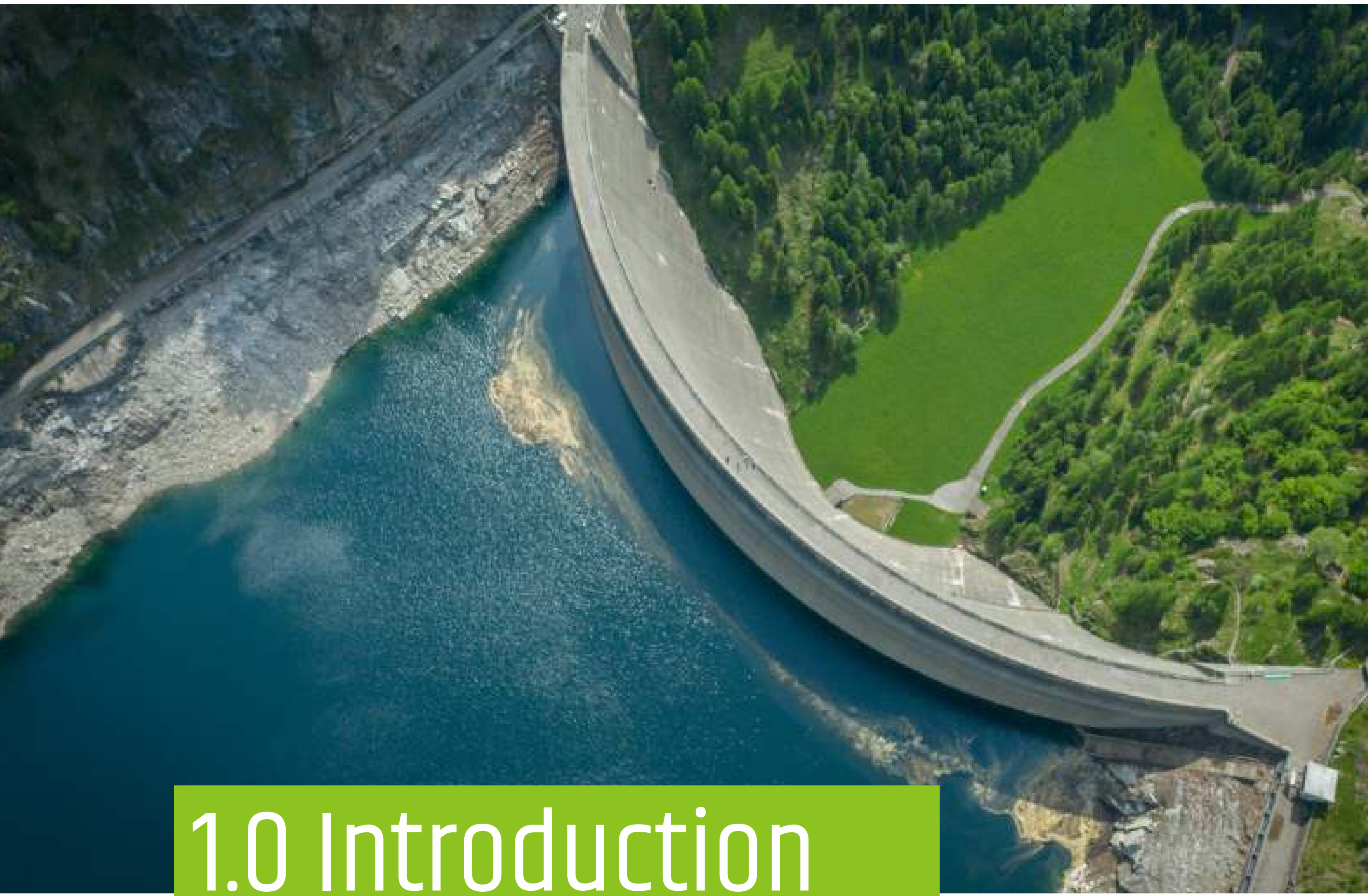
India is the 2nd largest cement manufacturer in the world. As one of the most widely used building materials, cement contributes significantly to CO_2 emissions, providing a huge opportunity for the sector to tackle the challenges posed in global climate change. Concrete is the maximum used human-made material on the planet and uses in everything from roads to metros, tunnels to housing, and hydropower installations to flood control. Cement, a key ingredient in concrete manufacturing, accounts for around 7% of global CO_2 emissions.

The cement and concrete industry have beautifully addressed the key challenges and prioritised environmental sustainability within their business. The industry has taken lead in spearheading transition towards a circular economy & pioneering to accelerate the sustainability goal of lowering carbon emissions as well as optimise the overall logistics cost. The Indian Cement industry thus has been rated as one of the best performers of circular economy across various industrial sectors in terms of energy efficiency, quality control, resource recovery and technology advancement.

The Indian cement industry heading to play a pivotal role in nation building by creating the infrastructure that drives growth, employment, tax revenues and sustainable growth in the country. However, there are still some fundamental challenges at the policy level, which needs to be addressed to accelerate its adoption and transition at full throttle.

FICCI is glad to commission this joint report with Global Cement & Concrete Association - GCCA - India highlighting challenges & issues faced by the cement industry at the ground level & their contribution of the cement industry towards 'cementing' cause of circular economy.

Arun Chawla
Director General
FICCI



1.0 Introduction

The Indian cement industry is 2nd largest in the world and highly developed in terms of technological advancements. It has the best thermal and energy efficiencies in the world. The production of cement in India in 2021 was 294 million tons.[i] and the clinker factor was around 71%. [ii] This means that the clinker required to produce almost 85 million MT of cement was not necessary to be manufactured, thereby conserving more than 120 Million Mt of fossil resources.

The Indian cement industry, therefore, is already aligned towards the cause of circular economy and is marching ahead at a reasonably accelerated pace compared to the global cement industry. The Indian cement industry is destined to play a unique role in building the new India due to its essential role in creating the infrastructure that drives growth, employment, tax revenues and sustainable growth in the country. Considering the projected population of India in 2030 to be about 1.5 billion[iii] and assuming reasonable GDP growth of 6.5% to cater to this population, the cement demand in India by 2030 would be atleast 500 million tons. Based on the current environmental considerations, the construction industry is moving towards concrete as the marketed material. It is causing accelerated growth of the concrete industry as well. The Ready - Mix Concrete (RMC) production in India in 2020 was about 60 Million Cu. M.[iv] Considering a conservative growth rate of 6% - 7% in the RMC market, the RMC Industry size would be about 120 Million Cu M in 2030. To sustain the projected growth of India's cement and concrete sector, these industries must adopt the relevant circular economy measures in their operations. UNEP has proposed a "9Rs" based approach to transform the currently dominant Linear Economy into Circular Economy[v] which is depicted in Fig. 1.

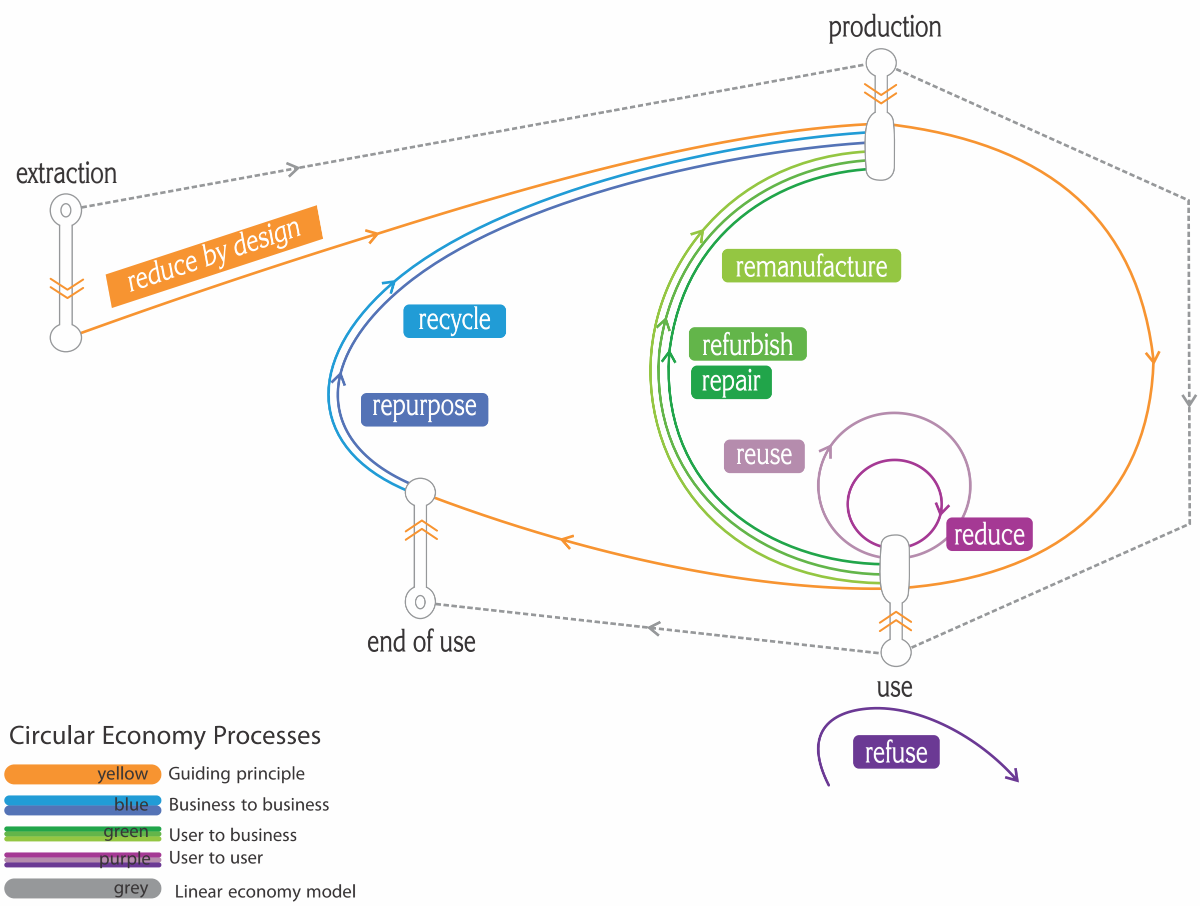


Fig 1: "9Rs" Based Approach to Building Circular Economy

The Indian cement and concrete industry have to transform from a linear economy to a circular economy. It needs to define its strategies based on the 9R's approach proposed by UNEP. Currently, the Indian cement & concrete industry is evaluating different technological options to implement the feasible "R" approaches to contribute to the cause of a circular economy. It is poised to achieve a higher level of success through the readily available options and those still in the development stage.

2.0 Potential opportunities to implement circular economy:

There are several levers through which the Indian cement and concrete industry can contribute to the cause of the circular economy. Some are already in practice, and others have the potential to be tapped in future.

2.1 Existing Levers:

The Indian cement industry is implementing excellent best practices in respect of the levers that are in practice currently, and the same are described in brief below.

a) Reduction in Thermal Energy

Cement plants are implementing various measures to reduce thermal energy consumption using criteria such as improved cooler design, reduction in false air ingress, reduction in thermal energy losses, optimisation of the air requirement, waste heat recovery from the exhaust gases, etc.

Case Study: Orient Cement Ltd. Modifications in cooler design

Orient Cement Ltd. has implemented measures such as replacing a conventional burner with a Low NOx burner, introducing horseshoe in Cooler, implementing outlet duct modification of cooler fans, installing TAD damper, carried out cooler bell mouth modification, introducing digitisation of operational parameters, etc. It has reduced specific heat consumption from 718 Kcal/Kg of clinker during FY18 to 697 Kcal/Kg of clinker in FY22. Fig 2 displays the modifications carried out by the company on the cooler.

Fig 2: Cooler modification

Challenges encountered and proposed remedial actions:

As the percentage of AFR co-processing increases in plants, the specific fuel consumption of the kiln increases due to higher moisture content, low calorific values, and inconsistency in quality and availability of the AFRs, it is desired that the AFRs are processed beforehand to the desired level and made available to the cement industry to reduce the impacts on the thermal heat consumption of the cement industry.

b) Reduction in Electrical Energy

The reduction in electrical energy is achieved by implementing design changes to reduce the system pressure drop, using high-efficiency motors, energy-saving devices such as VFDs, replacing reciprocating compressors with centrifugal compressors and centrifugal ones with screw compressors, using energy-efficient fans, pumps, grinding equipment, BF & ESPs, etc.

Case Study: Shree Cement Ltd.
Centrifugal Compressor in place of Reciprocating Compressor

Reciprocating compressors have been used in the cement industries due to their robustness and easy maintenance. However, this has high specific power consumption and leads to power loss during the unloading condition. As a part of internal energy audits, Shree Cement identified replacing the reciprocating compressor with a centrifugal compressor that reduces the specific energy consumption. They replaced all the reciprocating compressors with centrifugal compressors for plant air (Pyro, raw mills, coal mills and other areas) with a target to reduce the specific energy consumption of compressed air power by 30-35%.

Fig 3: Centrifugal Compressor in place of Reciprocating Compressor modification

Case Study: Orient Cement:
Reducing Specific Power Consumption

Orient Cement has reduced its specific power consumption by 13% from 2018 (73.8 KWH / ton of cement) to 2022 (63.9 KWH / ton of cement). Achieved it by installing VFDs in Fans, optimising energy consumption, arresting air leakages, and optimising process control closed loop in Lime Stone Crusher. Used digital technologies for optimising control systems and process control closed loops in Pyro, Coal mills & Cement Mills. It was optimising Compressors operations and replacing inefficient compressors with efficient ones.

c) Use of Renewable Energy

To reduce fossil fuel consumption & therefore, the GHGs, industry is rapidly switching to Renewable Energy such as Wind, Hydel and Solar Power with an aspiration to reach the entire electrical energy requirement through renewable sources.

Case Study : Shree Cement Ltd.

Fig 4: Solar Power Plant at Shree Cement

Total installed capacity of green power sources (WHR, Solar and Wind) for (2021-22) 263 MW; Share of green power in total power consumption (2021-22) is 48.2%

Case Study : Nuvoco Vistas Corporation Limited

Fig 4a: Solar Plant at Nuvoco Vistas Corporation Limited

Total Installed capacity of green power sources which include WHR & Solar is 46.2 MW in FY 21-22. This contributes to share ~ 20% of green power in total power consumption during FY 21-22.

Case Study : UltraTech Cement Ltd.

Fig 5: Solar Power Plant at UltraTech

The total green energy capacity of UltraTech Cement Limited is 492MW which includes 325 MW of renewable energy capacity and 167 MW of Waste Heat Recovery System (WHRS).

Case Study : J K Cement Ltd.

Fig 6: Solar Power Plant at J K Cement Ltd.

In the clean power portfolio, JK Cement Ltd. have 17.2 MW of Renewable Energy (Solar and Wind) and 42.3 MW of WHRS system. The total Green Power Mix of J K Cement Ltd. is 42.95% (YTD FY23) of the total electrical energy required in its manufacture. JK Cement Ltd is aggressively working to fulfil its commitment towards the UN energy compact to increase Green Power Mix from 19% (FY20) to 75% (FY30).

Case study: JSW Cement

JSW Cement has consumed 15.2 million units of Renewable Energy (RE) units at its Salboni and Nandyal plant, which has helped them increase its RE portfolio to 3.6% in 2021-22 compared to 3.2% in 2020-21.

Case study: Shree Digvijay Cement Ltd.

Fig 7: WHR, Central Control Room at Shree Digvijay Cement Company Limited

Shri Digvijay Cement Company Ltd. meets 65% of its energy requirements from renewable sources, including Waste Heat Recovery systems and wind energy.

Challenges encountered and proposed remedial actions:

There are several challenges encountered in implementing renewable energy options - the major one being the differences in the policy frameworks of the respective state governments. It causes project cost escalation and the cost of generation and wheeling of the power. The policy must be uniform across the country regarding permitted project structure and the levies in respect of the generation & wheeling of electricity. Also, it is desired that a single window clearances system is implemented in respect of the renewable energy sector.

d) Co-processing of AFRs in cement manufacture

Co-processing is an excellent lever to recycle the wastes generated from the Municipal, Industrial and Agricultural sectors. Co-processing such wastes in cement kilns as Alternative Fuels & Raw Materials (AFRs) is an ecologically sustainable and environmentally sound option for their gainful utilisation. Co-processing helps industries to reduce the consumption of fossil fuels and raw materials, thereby contributing to the cause of conserving the natural capital of the country.

Indian Cement industries achieved a TSR of 3% in 2017. It works out to be about 2 Million tons of Alternative Fuels. Considering the push the Indian cement industry has given to the co-processing of AFRs, the current TSR of the Indian Cement Industry is expected to have crossed 4%.

Although the average TSR% of the Indian cement industry is low at about 4%, many plants are able to operate at >15% TSR and some at >25% TSR. Almost all cement plants are currently setting up required facilities for converting waste into AFRs using pre-processing technologies, for utilising large quantum of AFRs through co-processing facilities and a Chlorine by-pass system to control Chlorine in the kiln system.

Case study: J K Cement

Fig 8: Pre-processing Facility at J K Cement

J K Cement established facilities for pre-processing and co-processing of liquid and solid AFRs and has achieved a TSR% of 11.2% and is aspiring to achieve a TSR of 35% by 2030.

Case study: JSW Cement

At its Nandyal plant, JSW Cement has been co-processing several types of wastes, including liquid hazardous waste, plastic waste, biomass waste like rice husk etc., for the past few years. Last year, they co-processed almost 35000 tons, including nearly 9000 tons of Biomass waste, which has helped them reach a Thermal Substitution Rate (TSR) of 7.1% compared to 4.2% in 2020-21, representing an increase of almost 70%. It led to not only a reduction of its net CO_2 emissions by close to 40,000 tons but also helped save more than 15000 tons of coal.

Fig 9: Biomass Co-processing at JSW Cement

Case Study: Orient Cement Ltd.

Orient Cement has installed the liquid and Solid AFR co-processing facilities and achieved an AFR of 15.1% in FY22 compared to 10.6% during FY21.

Fig 10: AFR Storage facility at Orient

Case Study: Dalmia Bharat Cement Ltd.

Fig 11: AFR Pre-processing facility at Dalmia Bharat Cement Ltd.

Dalmia Bharat Cement Ltd. achieved a TSR of 13% in FY 22, utilising about 0.4 Million MT of Alternative Fuels. To improve the utilisation of Alternative Fuels, it has recently implemented a Chlorine by-pass system in two of its plants which are the first Chlorine by-pass installations in the country to use AFRs.

Challenges encountered and proposed remedial actions:

The major challenge the industry faces is the availability of processed AFRs having uniform quality in the required proportions. The other is permitting co-processing and material movement across the states. For this, it is vital to promote the establishment of pre-processing facilities in different parts of the country to convert the wastes from the Industrial, Municipal and Agricultural sectors into quality AFRs. Further, the permitting process needs to be streamlined for smooth operations – particularly interstate movement.

e) Use of Fly ash & GGBS as Pozzolana in cement manufacture

The Indian cement industry is at the forefront of utilising waste materials like fly ash from thermal power plants and Ground Granulated Blast-Furnace Slag (GGBS) from Steel plants as cementitious materials because of their pozzolana characteristics. As per BIS, the permitted levels of fly ash addition in cement is 35%, and that of GBFS is 60%. Most cement plants are operating very close to these permitted addition levels.

Challenges encountered and proposed remedial actions:

The incorporation of fly ash & GGBS in cement is limited to 35% and 70%, respectively. On many occasions, based on the feasible performance parameters, the same can be incorporated at higher levels also. It is expected that the levels of incorporation of fly ash and GGBS be defined based on the performance parameters rather than the specifications of the limits .

f) Use of Fly ash & GGBS in concrete manufacture

The Indian concrete industry size currently is more than 625 million Cu. M per annum. It is utilising Fly ash & slag to an average extent of about 25% in the Ready Mix Concrete (RMC) as against the permitted quantum of 35% & 70% fly ash and slag, respectively. It helps in improving the durability & microstructure characteristics of the RMC. Incorporating this level of Fly ash in RMC on an average basis helps replace 25% of the cement that otherwise would have been utilised in RMC.

Case Study: UltraTech Cement Ltd.

UltraTech Cement Limited has 180+ concrete production sites (Ready Mix Concrete - RMC plants) located across the country. It utilises about 0.25 Million tons of Fly Ash and 0.1 Million tons of GGBS in concrete production.

Fig 12: RMC Plant of UltraTech Cement Ltd.

Challenges faced and proposed remedial measures:

1. Prescriptive specifications by the customers restrict the replacement of cement by fly ash and slag in many projects – Promotion of performance-based specification and propagation of increased use of these materials by BIS and other government bodies.

2. Reduction in early strength gain may be addressed by research on activating admixtures which will enhance the early strength gain.

2.2 Potential Levers:

The opportunities available to implement projects in some potential levers are described in more detail below.

a) Gainful utilisation of Emissions (CO_2, SOx, NOx) by making products from them:

The primary emissions from the cement industry are CO_2, NOx and SOx, apart from the dust. There is much focus currently on Carbon Capture Utilization & Storage (CCU&S) to reduce GHG emissions. Various technologies are in the process of development and demonstration.

The major potential applications of captured CO_2 are.

1. Curing of concrete.
2. Utilisation in Soda Ash, Urea and other industries
3. Conversion to methanol and other chemicals that can be utilised as building blocks to produce derived chemicals.
4. Production of Algae and utilising the same as a fuel and a resource in the manufacture of different oil and chemical-based products.

SOx and NOx present in the emissions from cement kilns have the potential to be converted into Ammonium Nitrate and Ammonium Sulphate mix fertiliser. The Electron Beam Application (EBA) a process developed in Japan and demonstrated on exhaust gases of some of the commercial plants has shown promising results. In this process, an electronic beam generated through high voltage has impinged onto exhaust gas after particulate removal. Ammonia gas is injected where the reaction between SOx and NOx gases takes place to produce the Ammonium Nitrate /Sulphate mix fertiliser in powder form is produced. It is trapped in a dust collection system. Conversion of SOx & NOx gases to fertiliser opens the opportunity to market it as a product.

Recommendations:

It is desired that the relevant technology assimilation/development to convert SOx and NOx into Ammonium Sulphate and Ammonium Nitrate fertiliser is implemented through a collaborative effort of Research Institutes and the Cement industry with the support of the Indian Government. Subsequently, it is implemented at commercial scales.

b) Use of new types of pozzolana materials

Apart from Fly Ash and GGBS, which are generated in large quantum from the manufacturing processes and utilised as Pozzolana materials in cement manufacture, Bauxite Residue also has similar potential. Research has demonstrated that Bauxite residue also can be converted into a Pozzolanic material.[viii] And cement industry can take advantage of the same.

Recommendations:

It is desired that the technology development to convert Bauxite Residue into a Pozzolanic material is implemented through a collaborative effort of Research Institutes and the Cement industry with the support of the Indian Government. Subsequently, it is implemented at commercial scales.

c) Use of recycled aggregates and sand in concrete:

Indian Government has notified its policy on Construction and Demolition waste in which it has mandated to convert the C&D waste into construction substitute materials such as aggregates & sand. Several demonstration plants are already established in the country, and more are expected. It is desired that the Concrete industry switches to using these substitute aggregate and sand products to contribute to the circular economy.

Fig 13: Aggregates and Sand from Construction & Demolition

Case Study: Nuvoco Vistas Corporation Limited (RMX Business)

Nuvoco RMX plants wherein the C&D waste is available, have replaced 8% - 10% CR sand with C&D recycled aggregates materials.

Fig 14: Sand produced from C&D Waste is utilised in the RMC Plant of Nuvoco Vistas Corp. Limited

Recommendations:

1. Properly processed C&D waste into aggregates and sand should be made available for utilisation in the production of RMC. The price of the same should be economically workable for the concrete industry.
2. Processes should be established to segregate concrete-based waste and other waste during demolition.
3. Dumping of demolition waste should be fined to promote recycling.
4. BIS has currently restricted the replacement of C&D-based recycled aggregate to a maximum of 20%. This limit should be revised and aligned to a performance-based approach.

d) Use of recycled cement as Alternative Raw material in cement

The construction and Demotion waste is a mix of used aggregates, sand and set cement. While the concrete industry can utilise the processed and segregated aggregates and sand, the leftover (set cement) can be utilised as raw material mix in the cement manufacture as this set cement is a mix of oxides in a specific crystalline phase. It will react again with the other raw materials in the kiln to produce cement. This way, not only can the aggregates and sand content of the C&D waste be gainfully utilised, but even the set cement will also provide a useful application to get recycled.

Recommendations:

It is desired that a process to segregate the set cement from the C&D waste is developed and made available to the C&D processing plant to integrate it into the existing set-up.

Further, the technology development to establish the use of set cement segregated from the C&D waste is implemented through a collaborative effort of Research Institutes and the Cement industry with the support of the Indian Government. And subsequently, it is implemented at commercial scales. Bauxite Residue into a Pozzolanic material is implemented through

e) Designed structures for reuse.

By designing modular precast concrete structures that can be dismantled easily, it would be feasible to reutilise them in other construction applications. This concept is already in practice in implementing moving walls to make space to accommodate varying material storage requirements in storage sheds.

Recommendations:

Architects / Consultants / Designers of buildings/structures should be encouraged to develop this concept into a commercial reality.

Encourage the establishment of a few pilot projects based on this concept for demonstration and commercial exploitation.

Establish relevant BIS standards for such modular design structures.

3.0 Summary and Recommendations

As discussed above, with the levers already being implemented as best practices, the Indian Cement and Concrete industry can substantially contribute to a circular economy by utilising different 'R's as defined in the UNEP strategy. Large amounts of different waste materials are getting gainfully used as resources in the cement and concrete industry, helping conserve a large quantum of natural capital. There are more opportunities to build a circular economy in these industries with the identified potential levers. The cement and concrete industry needs to bring them into focus and act suitably to harness the same. With more emphasis on implementing practices aligned to the existing and potential levers, the cement and concrete industry is likely to make a much more impact in promoting the cause of recycling.

Following stakeholder support is desired to be provided to the cement and concrete industry to achieve success in scaling the circular economy journey using the levers defined above.

1. Clear policies for implementing Circular Economy (CE) related initiatives with a Single window clearance approach
2. Providing RE equivalent status to the Waste Heat Recovery Systems
3. Abolition of the currently operating State wise policies and notification of single uniform national-level policy with facilitating fiscal incentives in respect of RE and CE initiatives.
4. The maximum limit of installing and operating with renewable energy should be increased up to 100% on a national basis. Ease of interstate power transfer with reduction of charges and continuous availability of RE from the grid as per the requirement on competitive price should be facilitated.
5. Fiscal incentives towards the development & implementation of new technologies promoting CE.
6. Policy support for the collection, transportation, pre-processing & co-processing of wastes derived from Industrial, Municipal and Agricultural sources
7. Replacement of content-based standards with performance-based standards
8. Promoting implementation of processing plants for conversion of C&D waste into desired quality aggregates, sand and set cement for recycling.
9. Establishment of relevant BIS standards for modular design concrete structures for buildings construction to facilitate their reuse after dismantling

Acknowledgement

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India

About GCCA India

Global Cement & Concrete Association (GCCA) India works with the Indian cement & concrete sector on Climate Change, Circular Economy, Health & Safety, SDGs, and Advocacy. It currently has 13 member companies, aggregating more than 65% of

India's cement production capacity. The GCCA exists to drive advances in sustainable construction to demonstrate industrial-sustainable leadership in cement and concrete manufacturing. It is working hard to enhance the cement and concrete industry's contribution to many significant global, social and developmental challenges.

The cement & concrete industry's sustainable development is at the core of the GCCA's work. It has five pillars: health & safety, climate change & energy, social responsibility, environment & nature, and circular economy. The GCCA gathers and publishes data on the industry's sustainability commitments and guidelines and initiates research. The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete is the collective commitment of the world's leading cement and concrete companies to fully contribute to building the sustainable world of tomorrow. More information about 2050 roadmap and GCCA is available at https://gccassociation.org/

About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

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