Sustainability Outlook

Sustainable Materials in the Construction Industry

A $5.5 Billion Dollar Market waiting to be explored

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Sustainability Outlook

The Indian construction industry is expecting to see a growth of 6.6% annually, with reports indicating that 70% of India's buildings are yet to be built.[1] Construction and related manufacturing activities have typically contributed to about 25% of the nation's carbon emissions[2] and this figure is only expected to rise in the future. Figure 1 shows the projected demand for various construction materials in India by 2020 and 2030.[3 4]

While improving energy and resource efficiency of manufacturing processes is the most frequently suggested solution, using alternative Sustainable Materials may prove to have a larger impact on reducing environmental impact of construction activities.

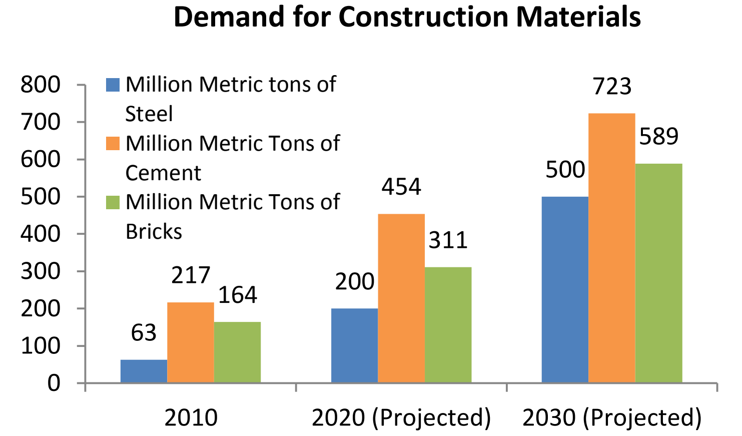

Figure 1: Demand for construction material in India; ***Data from Ministry of Steel[3], UNEP Report on India's Steel Industry[4]; Analysis by Sustainability Outlook***

Sustainability Outlook's research indicates that the use of sustainable materials in the construction industry has a large market, particularly in the case of products like sustainable bricks and recycled aggregates which present a great potential market in India.

Use of Sustainable Materials the Indian Construction Industry

The construction industry is built on the pillars of bricks, steel and concrete - formed by mixing cement, water and aggregates (as shown in Figure 2). The concept of sustainable construction entails moving away from using materials that require large quantities of energy, water and non-renewable natural resources for manufacturing, and using materials which have a lower environmental impact.

While many relatively new-age materials have been found to have a lower environmental impact, studies on their applicability for building and construction purposes are still ongoing. At the same time, there exist questions about the feasibility and cost of manufacturing for large scale production. Hence, for the purpose of this study, only those materials have been considered that have proven to be reliable replacements of conventional materials and are currently being manufactured and sold in India.

Figure 2: Composition of Concrete

Conventional Material	Sustainable Alternative Material
Clay Fired Bricks	Autoclaved Concrete Blocks (AAC)
Aggregates- sand and gravel	Recycled Aggregates
Cement (Ordinary Portland Cement)	Blended cement using recycled fly-ash or slag
Steel	No feasible sustainable alternatives yet

Defining Sustainable Materials

Defining the sustainability of a material involves taking a multitude of factors into account. The total impact of materials on the environment can be accurately measured only by taking the 'cradle-to-grave' approach of Environmental Life Cycle Assessment which factors in the emissions from the mining of natural resources, their extraction, manufacturing and transportation to their end-of-life recycling or disposal.

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[1] Ficci-PWC Construction Industry Overview, June 2014, http://www.thebig5constructindia.com/knowledge-center/construction-industry-overview/

[2] http://www.teriin.org/events/docs/present_japan/sess2/ghosh.pdf

[3] http://www.unep.org/resourceefficiency/Portals/24147/Business-Ressource%20Efficency/Low%20Carbon%20technology%20for%20India's%20Cement%20Industry.pdf

[4] http://steel.gov.in/overview.htm

1. Sustainable Bricks

AAC Blocks have a potential market worth $5.5 Billion (Rs. 330 Billion) by 2030

In conventional construction, clay fired bricks, which are made by mining clay from topsoil, are used. However, these clay-fired bricks are extremely energy and raw material intensive. Today, there exist a number of alternative options for clay-fired bricks like porous clay bricks, calcium silicate bricks and Autoclaved Aerated Concrete blocks.

Figure 2 below shows resource and energy intensity of various types of bricks and it is quite clear that AAC (Autoclaved Aerated Concrete) Blocks are the most energy and resource efficient among the types of bricks most commonly manufactured in India. [5]

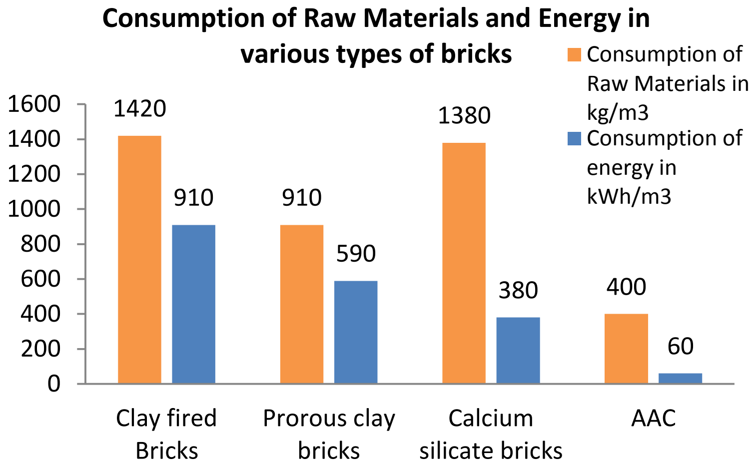

Figure 3: Consumption of Raw Materials and Energy in manufacturing types of bricks; Source: FeBeCel handbook 2000: Le Béton Cellulaire – Matériau d' Avenir

What are AAC Blocks?

AAC blocks are steam-cured mix of sand or pulverized fly ash (PFA), cement, lime, anhydrite (gypsum) and an aeration agent. The high-pressure steam-curing in autoclaves achieves a physically and chemically stable product with an average density being approx. one fifth of normal concrete. AAC comprises myriads of tiny non-connecting air bubbles which give AAC its diverse qualities and make it an excellent insulating material.

AAC vs. Clay-fired bricks

AAC blocks are more favorable than conventional bricks in almost every aspect, as Table 1 below demonstrates.

Table 1: Properties of AAC bricks as compared to Clay fired bricks[7]

Parameter	AAC Blocks	Clay Fired Bricks
Soil Consumption	Zero soil consumption. Primary raw material for AAC blocks is fly ash. This fly ash is industrial waste generated by coal-based thermal power plants.	One sq ft of carpet area with clay brick walling consumes 25.5 kg of top soil.
Fuel Consumption	One sq ft of carpet area with AAC blocks consumes 1 kg of coal.	One sq ft of carpet area with clay bricks consumes 8 kg of coal.
CO_2 Emission	One sq ft of carpet area emits 2.2 kg of CO_2.	One sq ft of carpet area emits 17.6 kg of CO_2.
Cost Benefit	Reduction in dead weight leading to savings in steel and concrete.	None
Energy Saving	Approximately 30% for heating and cooling.	None[6]

AACs are also preferred because of their improved thermal insulation which reduces building heating and cooling needs by up to 30%, thus resulting in continued financial benefit during the life of the building.

AACs have been used in Europe since 1914, and account for 40% of bricks used in the United Kingdom and over 60% in Germany. In contrast, AACs have been introduced to the Indian market less than a decade ago, and according to market sources, they have a low market penetration of less than 5%. There are only a handful of AAC manufacturers (Aercon, Biltech, Magicrete, Siporex, Xtralite) in India today, and most of these companies have seen a meteoric rise in demand for AACs in the last few years.

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[5] http://shaktifoundation.in/wp-content/uploads/2014/02/strategies%20for%20cleaner%20walling%20materials%20in%20india.pdf
[6] http://www.aac-india.com/aac-blocks-vs-clay-bricks/
[7] http://www.aac-india.com/aac-blocks-vs-clay-bricks/

The cost of conventional bricks has gone up in the last few years due to increase in labour prices and are currently around Rs. 3000-3500 per ton. AAC blocks cost only marginally higher at Rs. 3500-3800/ton. Conventional brick manufacturing processes include manual molding and firing thus, making the process labor intensive. AAC manufacturing process, on the other hand, is largely automated. Thus, while the AAC blocks are slightly more expensive than clay-fired bricks, they are insulated from labor issues that have come to pose a big challenge to clay-fired brick manufacturers. Due to increased market uptake, the cost of AACs has come down recently and for construction companies as well as brick manufacturers, there is a real business benefit seen in moving towards AAC, since they lead to consistent energy savings over the life of the building.

"Walling is a Rs 500 billion industry and even a 10% conversion over next 5 years would amount to a significant size for AAC. We are currently catering to Western and Northern Indian markets from our 3 plants. Market for AAC has grown from Rs 500 million five years ago to Rs 5 billion presently," says PVS Srikant, one of the co-founders of Magicrete Building Solutions, a firm which caters to the AAC market in India. Magicrete has seen orders from large construction companies like Larsen & Toubro and Shapoorji Pallonji in the last few years and has a turnover of over Rs. 1 billion within 5 years of starting operations. The business case for AACs has already been proven and large infrastructure development companies are already moving towards AACs. Energy efficiency in buildings is already a major area of concern for India, and as green buildings become a norm, AAC blocks are likely to see increased uptake due to their insulation properties.

Currently, the only stumbling block associated with AACs is logistics. Bricks in India are largely locally manufactured by small decentralized units. They are characterized by a distance-to-market of less than 200 kms. However, most AAC manufacturing units are currently located mostly in Gujarat and Maharashtra.

AACs use fly-ash as raw material, which is available from thermal power plants, and with thermal plants located all across the country, there is no real hindrance to setting up AAC manufacturing units in different regions of India. As the market becomes more aware of the benefits of using AAC, even without policy incentives, market sources suggest that AAC blocks are likely to see upwards of 40% uptake by 2030.

Matured markets for AAC blocks like Germany and some Scandanavian countries have a market penetration of around 60-80%.

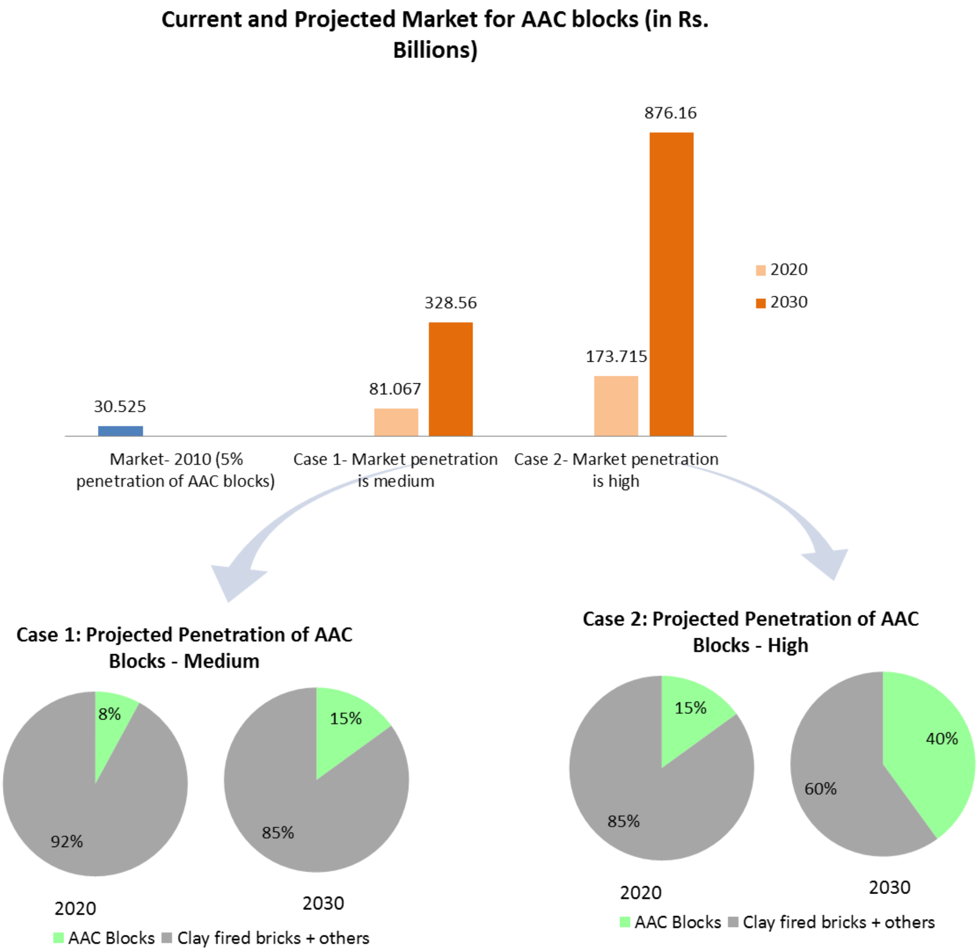

Figure 4: Projected Market Size for AAC Blocks in India by 2020 and 2030; Source: Market research and analysis by Sustainability Outlook

GRIHA studies suggest that in the next 10 years, the market penetration for AAC blocks would increase to at least 10%[8]. Market sources say that taking into account the growing labour concerns in the brick industry, as well as a drive towards green buildings, the market penetration of AAC blocks is likely to be closer to 40% by 2030.

[8] http://www.grihaindia.org/events/ncgd2013/files/ppt/Atul_Kapur_ppt.pdf

2. Sustainable Aggregates

A significant policy overhaul is needed for use of recycled aggregates in construction

Aggregates account for 66% of material in concrete and the production of aggregates in India was estimated to be 2.2 billion tonnes in 2010, the second largest in the world.[9] Currently, all the sand and stones used as aggregates for making concrete are freshly mined material. In 2012, the Union Ministry of Housing and Urban poverty alleviation alerted the Rajya Sabha about the shortage of building material especially aggregates. At the same time, there is a huge pile of construction and demolition (C&D) waste that is generated annually in India, which ends up in landfills. A possible replacement for aggregates is using recycled aggregated from construction and demolition waste.

This urban waste management sector is so unregulated that the official estimates of the total amount of C & D waste generated have remained constant between 2000 and 2010 at 10-12 MT per annum. However, field studies suggest that the actual figure for 2013 was closer to 530 MT. [10] Even if part of the 2.2 billion tonnes of aggregates can be replaced by the 530 MT of C&D waste generated, two critical issues can be solved at the same time: (a) that of waste disposal and (b) fresh mining of aggregate material. The generation of C&D waste is largely concentrated in urban areas where a majority of the new construction would be taking place, and this would also reduce the transport costs and emissions involved in mining and transporting sand and stones.

However, the recycled aggregate market in India does not exist because the Indian Standards for Concrete aggregates IS: 323-1970, states that these should be 'naturally sourced'. Thus, only virgin materials (sand, aggregate) mined directly from nature can be used.

At present, a pilot project operated by IL&FS in collaboration with the Delhi Municipal Corporation is currently recycling C&D waste from government infrastructure projects. However, due to the regulation mentioned above, their plant at Burari only recycles C&D waste into pavement bricks and kerbstones and not aggregates.

There is an urgent need to look into standards and policies for promoting the use of recycled material as aggregates. The concern is that some of the recycled materials may not be structurally viable for re-use, but with proper channels for processing and grading of waste, these hurdles can be overcome. Some of the guidelines and standards that need to be developed for better practices in 'Urban Mining' should deal with:

Policy Interventions needed for use of Recycled Aggregates

- Rules for segregation and grading of C&D Waste
- Guidelines for re-use of C&D waste
- Checks on landfilling and disposal of only the portion which cannot be re-used
- Promotion of 'Deconstruction' rather than 'Demolition'. Deconstruction is planned breaking of structures with the aim that majority of the components can be reused.
- Developing a market for recycled aggregates by giving tax breaks

Today, even if 10% of the C&D waste generated (10 M.Tonnes according to MOEF estimates) was recycled into aggregates, it would represent a market of Rs. 500 million[11].

[9] http://www.aggbusiness.com/sections/market-reports/features/booming-indian-aggregates-market/
[10] http://www.cseindia.org/userfiles/Construction-and%20-demolition-waste.pdf
[11] Cost of aggregates taken as Rs. 500 per tonne
http://www.kpkqs.com/download/annual/unit_rates/material_labour_prices80_86.pdf

3. Sustainable Steel

There is a need for technology and process up-gradation in the Indian Steel Industry

Even though extraction of iron ore and manufacturing of steel itself is a resource intensive process, research suggests there are hardly any viable alternatives to steel for the construction industry. This is in part, due to the fact that steel has an unmatched tensile and compressive strength, and does not deteriorate with time. In fact, steel from end-of-life buildings can be 100% recycled into steel again. Today, all steel manufacturing uses recycled steel as a raw material.

It is due to these properties that steel can often replace more energy and resource-intensive materials used in construction. For example, building structures made with steel are longer lasting than those made of concrete, and use much less material for construction, which in turn reduces emissions related to extraction, manufacturing and transportation of those materials. In fact, the LEED Green Building Ratings give maximum credits for using structural steel in construction due to high recycled content in steel.[12]

The environmental impact of steel largely depends on how polluting and energy intensive the mining and extraction of iron-ore and steel are. In light of that, there are a number of measures that the Indian steel industry should take in order to move towards the best available practices. They can be summed up as:

Modernisation & Technological upgradation	Blast Furnace Improvements	Smelting Reduction Process Improvements
•Harnessing of Waste Heat at every step of the production process. •Numerous commercially established energy conservation technologies: •Sinter Cooler Waste Heat Recovery, •Coke Dry Quenching (CDQ), •Coal Moisture Control (CMC) in Coke Ovens, •BF Top Pressure Recovery Turbine (TRT), •Waste heat recovery from BF stove waste gases, •OG boiler in BOF, •Regenerative Burners, Near Net Shape casting etc.:	•Process improvements viz. revamping/conveyorization of stock house and increasing screening efficiency of ore, sinter and coke, strengthening stoves capacity, increasing blast volume and flow rate, increasing oxygen enrichment of blast, higher hot blast temperatures of at-least 11000 C etc. •High level of alternate fuels injection to drastically reduce coke rate: incorporation of technologies for injecting pulverized/ granulated coal (+ 200 kg/thm), oil (100 kg/thm), Natural gas (100 kg/thm) and waste plastics granules. •Adoption of energy efficiency measures in existing and new blast furnaces e.g. Top pressure Recovery Turbine, use of waste heat stove gas for preheating of gas, high efficiency stoves etc.	•Primary objective is to produce liquid iron directly from iron ore (fines & concentrates) and non coking coal, by-passing agglomeration and coke making requirements (reduced investment cost : 10-15%). •Plant emissions contain only insignificant amounts of NOx, SO2, dust, phenols, sulfides and, ammonium besides far lower waste-water emissions. •The promising alternative technologies which have been commercialized/ are in the process of commercialization and appear to be relevant are COREX, FINEX, HISMELT, HISARNA, TECHNORED etc.

Table 2: Sustainable Techniques available for the Iron & Steel Industry; Source: Best Avaiable Techniques for the Indian Iron & Steel Industry, CSE[13]

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[12] http://in.usgbc.org/leed

[13] http://www.cseindia.org/userfiles/GRP%20BAT%20guidelines%20steel%20sector%20pdf.pdf

4. Sustainable Cement

75% of the cement manufactured in India has low environmental impact

The Indian cement industry is one of the most efficient in the world. Its 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 t of CO_2/t of cement in 2010 from a substantially higher level of 1.12 tCO_2/t cement in 1996. However, because the manufacturing process relies on the burning of limestone, it still produced 137 MtCO_2 in 2010 – approximately 7% of India's total man-made CO_2 emissions. [14]

The two sustainable alternatives to Ordinary Portland Cement (OPC) are Portland Pozzolona Cement (PPC) and PSC (Portland Slag Cement). These two types of cement contribute to around 75% of cement that is manufactured in India at present.[15]

Definition	Ordinary Portland Cement -OPC	Portland Pozzolona Cement - PPC	Portland Slag Concrete- PSC
Manufacturing	OPC is obtained by adding raw materials like calcareous materials and argillaceous materials. OPC (Ordinary Portland Cement) is the basic form of cement with 95% of it being the clinker and 5% being gypsum which is added as an additive to enhance the setting time of the cement to a workable 30 minutes odd or so. This cement is the standard norm being manufactured and sold by cement manufacturers around the world.	PPC is obtained by adding pozzolonic materials like flyash, pumicites, volcanic ashes, shales, tuffs, etc., addition of up to 35% of fly ash in making the type of cement, commonly known as the Pozzolanic Portland Cement (PPC). This way, the waste product which could have become a serious environmental hazard, has now become a sought-after raw material for manufacture of modern day large-scale produced cement known as the Pozzolanic Portland Cement (PPC).	Portland Slag cement is made by replacing a part of the clinker with steel slag, which is a byproduct of steel manufacturing. Currently, the laws in India allow up to 65% replacement of the clinker with steel slag.
Energy Intensity		18% reduction in energy intensity for 35% fly-ash replacement	30% reduction in energy intensity for 50% slag replacement
Water Intensity		Reduces water demand by 8-9% for 35% fly-ash replacement	Reduces water demand by 12-14% for 50% slag replacement
Carbon Emissions	850-900 kg/ ton	560 kg/ton	400 kg/ton
Cost per kg	Rs. 55	Rs. 55	Rs. 55

[14] http://www.iea.org/publications/freepublications/publication/low-carbon-for-the-indian-cement-industry.html
[15] http://newsletters.cii.in/newsletters/mailer/trade_talk/pdf/Cement%20Industry%20in%20India-%20Trade%20Perspectives.pdf

PPC replaces a part of the cement mixture with fly-ash, a by-product of thermal power plants, and PSC replaces a part of the cement mixture with Slag, which is a by-product of metal smelting and extraction processes. In India, PPC already commands a 67% share of the cement market in India, while PSC accounts for 8%. Comparatively, PPC forms a much lower share of total cement manufactured even in developed nations (PPC forms less than 20% of cement manufactured in Japan).

While PSC is much less energy and water intensive than OPC as well as PPC, PSC manufacturing in India is limited by the slag production capacity. India's current slag production capacity is about 10 million tonnes per annum at existing steel plants and the Indian cement industry consumes almost the entire granulated slag produced and can consume up to 70% of the blast furnace slag generated.[16]

Major steel plants in India are located in the eastern parts of the country like Bihar, Jharkhand, Orissa, while India's major limestone deposit (the most important raw material for cement) are located in the western and southern parts of the country like Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu.

The geographical variation of raw material availability coupled by Policy has played a significant role in encouraging production and uptake of PPC in India. One of the most significant drivers was that thermal power plants were asked to give away their fly ash for free to industries that could use it for 10 years of their operations.

Since this policy was introduced in 2006, the percentage of blended cement manufacturing in the country has gone up from 35% to 75% in a span of 8 years.

Possible Policy Intervention for the Cement sector

Current PPC policy allows only 35% mixture of flyash in cement, whereas the global limit is 65%.

Currently the government has plans to introduce a fourth type of cement in the market, called Pozzolona Slag Cement, which will contain both steel slag and fly-ash. This cement will have a higher percentage of blended material than PPC and thus, a lower environmental impact. This policy is meant to encourage the majority of the cement manufacturing industry in the country to move from PPC towards Pozzolona Slag Cement.

Thus, the opportunity zones for the use of sustainable materials in construction lie in using sustainable alternatives to clay-fired bricks and aggregates. Both of these present a large opportunity zone for investment and growth. AAC blocks do not need much of a policy push, since a business case already exists for use of AAC blocks over conventional bricks. However, using recycled aggregates for concrete is currently not allowed according to the Indian Standards, and a significant policy overhaul has to take place before the market for recycled aggregates can take off in India.

CONCLUSION

India's use of Sustainable Materials in the construction industry has been limited to the use of blended cements. While the Indian cement industry is one of the most sustainable in the world, there are still marginal improvements possible. On the other hand, despite steel itself being a sustainable building material, sustainable manufacturing practices are yet to become the norm in the Indian iron & steel industry and there is a lot of scope for improvement.

The main opportunity zones for the use of sustainable materials in the Indian construction industry lie in using sustainable alternatives to clay-fired bricks and aggregates. Both of these present a large opportunity zone for investment and growth. AAC blocks do not need much of a policy push, since a business case already exists for use of AAC blocks over conventional bricks. However, using recycled aggregates for concrete is currently not allowed according to the Indian Standards, and a significant policy overhaul has to take place before the market for recycled aggregates can take off in India.

[16] Indian Minerals Yearbook 2011, Indian Bureau of Mines, http://ibm.gov.in/IMYB%202011_Slagl.pdf

About Sustainability Outlook

Sustainability Outlook is a market access, insight and collaboration platform tracking actions related towards enhanced resource management in the Indian economy. Sustainability Outlook provides market analysis and data tracking services, news and intelligence updates, and creates momentum towards specialised sustainability interventions by facilitating a structured process for multi-party collaboration.

Contact
Market Access & Insights Team
mait@sustainabilityoutlook.in