

Sustainable exploitation of building stone in India – emerging issues

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Stone aggregates are one of the most important construction materials obtained through conventional mining and crushing of building stones. The construction mining sector is highly unorganized, despite alarm calls raised by individuals and corporates regarding high accident rates and rapidly declining stone deposits. We may soon run out of quality stone deposits to support our aspiring infrastructure development plans. This article aims to create awareness on the importance of stone quarrying in supporting our infrastructure development plans, challenges faced by this sector, and eliciting appropriate and concrete action plans for the future.

Keywords: Construction aggregates, health, safety, stone quarry, sustainability.

INFRASTRUCTURE development and maintenance is a major factor for the economic development and sustained growth of a country. As India continues its path of development to get into the league of developed nations, infrastructure is no less important. The market size of Indian construction industry is around Rs 248,000 crores (US\$ 37.6 billion), and it currently employs a workforce of nearly 32 million, the second largest sector after agriculture¹. Investment planned in construction during the 12th Five-Year Plan itself accounts for more than 15% of India's total gross domestic product (GDP). A hefty budget is planned for investment in roads, airports, ports, railways, power, city infrastructure and telecommunication, which would provide a huge boost to construction activities in the subcontinent².

A common answer given by the economists to the question regarding why Indian economy cannot grow at double digit rate is that the country, as of now, does not have enough infrastructure to support a double-digit growth rate. This answer is further consolidated when we compare the status of physical infrastructure at present vis-à-vis what is required.

1. Thirteen major ports and around 200 minor ports along the Indian coastline of 7517 km are capable of catering to only 75% of the total required port capacity².
2. A 5 million-odd kilometre road network, which is the second largest in the world, consists of only 1% of four-lane paved highways, 34% of two-lane paved highways and a cumulative 47% of paved roads. The

road network, both in terms of quality and spread, needs rapid augmentation considering the economic, demographic and strategic requirements of the country².

3. India's total installed capacity of power generation is close to 305 GW and actual power production is approximately, 1100 BU. This is not sufficient to meet its domestic and industrial demand for power amounting to 1230 BU, which is estimated to increase to 2336 BU by 2026–2027 (ref. 3).
4. Likewise, 125 airports in India can handle 184 million passengers per annum and 2.65 million metric tonnes of cargo per year against expected annual traffic of 270 million passengers and 4.4 million metric tonnes of cargo by the end of 2017 (ref. 4).
5. Out of 33 urban conglomerations accommodating more than 1 million people, only 8 have metro rail transit system under operation⁵.
6. The fourth largest railway network in the world and the second largest in Asia operates on 115,000 km of track length, and handles 1100 million tonnes of freight and 8600 million passengers per year. However, due to the size of the Indian population, these figures need substantial improvement⁶.

Niti Aayog, using the 12th Five-Year Plan as its reference document, plans to invest heavily for augmenting the physical infrastructure in India, which amounts to a whopping Rs 2.21 trillion in 2017–18. It is also estimated that planned investment in physical infrastructure in India is expected to grow at a Compound Annual Growth Rate of approximately 10% till 2030. Some of these planned investments are listed below^{4,7,8}.

1. Capacities of Indian ports are planned to be increased to 1750 million metric tonnes by 2020 against the currently available capacity of 1000 million tonnes.

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2. Nearly 25,000 km of highways are yet to be constructed as part of the prestigious National Highways Development Programme (NHDP), including its flagship projects like Golden Quadrilateral, Port Connectivity and NS–EW Corridors. Also, 1000 km of expressways, 14,000 km of roads in areas affected by extremism and 10,000 km of other roads to be developed.
3. At least 10 Ultra Mega Power Plants (UMPP) based on thermal/gas power with installed capacity of 30,000 MW are planned to be constructed in the next 10 years. This is to be supplemented by a planned investment of Rs 250 billion and Rs 120 billion in hydroelectric and nuclear power plants respectively.
4. India plans to add 180 green field airports by 2030.
5. Thirty-five cities are being planned for metro rail transit system with a total track length of 3000 km.
6. Massive capacity addition in the railway infrastructure is underway in the form of Eastern and Western Dedicated Freight Corridor totalling 3338 km, laying of 4000 km of new rail lines, 7653 km of track doubling and six high-speed corridors.

The phenomenal amount of development in physical infrastructure in India cannot take place without mining of building stone or construction material, which is commonly known as coarse and fine aggregates (construction aggregates) or stone chips. India's growth story largely depends on timely, economical and sustainable availability of construction aggregates. It is apprehended by a few leading infrastructure companies in India that stone mining and crushing must be overhauled and brought to the mainstream of industry followed by immediate implementation of reforms to ensure that the country's growth is not hampered because of unavailability of construction aggregates – and that too in the near future².

Coarse aggregates and stone quarrying

Coarse aggregate is one of the most important ingredients of a construction mix. Riding on the infrastructure boom, the annual production of coarse aggregates in India had crossed 750 million metric tonnes in 2011, with a market size of more than Rs 175 billion². With ambitious infrastructure development plans in a decade down the line, requirement of coarse aggregates is expected to be 2.5 billion MT per annum by 2020, with a market size of Rs 750 billion (not adjusted for inflation).

Coarse aggregates are produced from raw stone boulders which are obtained from a mine (generally called stone quarry) through the conventional cycle of operation, i.e. drilling, blasting, loading and transportation. After separating out the unwanted material, stone boulders of desired physical and mechanical properties are fed to a crushing system of pre-determined stages for further comminution to achieve the desired quality product.

Table 1 shows the project category-wise approximate consumption of coarse aggregates.

Approximately 25–30% of the total cost of production of coarse aggregates is spent on capacity building and maintenance in the form of mining and crushing equipment, which projects Rs 200 billion approximately to be added per annum to the sales figures of automobiles and capital goods companies by 2020. There are other industries which help the quarry and crushing units, e.g. explosives manufacturers, casting and fabrication agencies, petrochemical companies, utility providers, etc. With regard to the revenue, the sum of Government royalty on quarry products (dimensional and ornamental stones excluded) will be approximately Rs 75 billion by 2020 (refs 9–16). The amount collected as taxes on provision of quarrying services and sales (intra-state and inter-state) of product will be even more.

However, there is no effective enforcement of rules and regulations for ensuring safety and good health of workers in stone quarries and crushing units as well as restoration and rehabilitation of thousands of hectares of land degraded by improper operational activities. With scientific development and exploitation of mineral wealth, we can certainly manage the sustainability of mineral deposits all over the country for today and tomorrow, apart from eradication of unscientific techniques of mining causing rapid frittering away of precious natural wealth, which otherwise could be used for all infrastructural development plans.

Challenges in the stone quarrying sector

Real-time challenges in the quarrying sector can be categorized under six sub-heads, i.e. health challenges, safety challenges, environmental challenges, socio-economic challenges, sustainability challenges and statutory challenges.

Health challenges

The health challenges cover such working and occupational shortcomings or lacunae those result in health hazard. Stone quarrying and crushing sector suffers from two major health challenges.

(i) Stone quarrying and crushing operations give rise to a large amount of fine dust containing free silica (Figure 1). The workers involved are exposed to air laden with high levels of free silica. The inhalation of such siliceous dust for long periods is known to cause silicosis and other dust-related lung diseases. The exposure to silica dust is known to predispose to tuberculosis, chronic airflow limitation, lung cancer and renal diseases¹⁷.

A study conducted by the National Institute for Miners' Health (NIMH), Nagpur, in Karauli district, Rajasthan from 2011 to 2014 revealed that silicosis among miners

Table 1. Project category-wise approximate consumption of coarse aggregates²

Structure	Approximate consumption of coarse aggregates
A four-lane road with paved shoulders	50,000 metric tonnes/km
An airport, including runway, taxiways, aprons compatible for A-380 aircraft	4,000,000 metric tonnes
A breakwater	1,500,000 metric tonnes/km
A hydro power project	6,000 metric tonnes/MW
A nuclear power plant	750 metric tonnes/MW
An elevated metro rail corridor	40,000 metric tonnes/km
A five-star hotel consisting of 1000 rooms	50,000 metric tonnes

**Figure 1.** Dust generation from crushing activities at Dholera crusher zone, Mahendragarh, Haryana.

was at a dangerous level with as much as 60% sample population showing evidence of the disease¹⁷⁻¹⁹. An affidavit filed by the Government of Madhya Pradesh in the Supreme Court of India on prevalence of silicosis in Alirajpur and Jhabua districts states that more than 50% miners were diagnosed with the disease²⁰.

Silicosis is an incurable disease and the fact remains that workers in majority of stone mines are not protected by any means of health insurance or medical facilities by the mine or crusher owners. Indian laws pertaining to the health of miners mention initial and periodic medical check-up, intimation of occurrence of silicosis and other occupational health diseases and rehabilitation of miners detected with occupational diseases²¹. But its enforcement in stone mines of India is not up to the mark which leaves miners to their fate.

(ii) The exposure of miners to high levels of noise is a cause of concern. The impact of prolonged exposure to high noise levels can range from bursting of eardrum, permanent hearing loss, stress, fatigue, irritation, inefficiency, adverse effect on motor and auditory functions headache, etc.²². Most of the stone mine and crushing plant owners in India do not provide ear plugs to their workers.

Safety challenges

Although all operations/activities carried out in a stone quarry are similar to core mining industry, the standards of actual safety compliances differ to a great extent. Most of the quarries in India lack in basic standards of health, safety and environment protection. The Mines Act 1952, the umbrella framework applicable to all mines in India, encompasses full-fledged and all-inclusive guidelines to prevent accidents and ensure 100% safety in mines and health of miners. So is the Factory Act, which is applicable to stone crushing and grinding units. Under these laws, all intermediate operations and activities which pose safety risk – directly or indirectly – have remedies. Few of the relevant norms of these acts are – provision and maintenance of first-aid room, all-time availability of ambulance, free supply of personal protective equipment like hard helmet, boots, reflective jackets, ear plugs, nose masks and eye shield, enactment of emergency response plan, dust sampling and suppression, reporting of accidents and investigation thereof, restriction on height of benches, minimum standards of illumination, provision of conservancies, to name a few.

It is believed that serious and fatal accidents occur at high frequency in stone quarries in India, but these are not reported by the mine owners and operators. Lack of awareness about statutory framework by workers and locals, absence of labour unions in stone mining field pan-India, reluctant villagers and lack of a system to record such accidents further encourage their non-reporting in this sector. Figure 2 shows an example of such unsafe working conditions in a stone quarry.

Unsafe working conditions also leave the mineral deposits unexploitable in future. Due to unscientific workings, complete mine or a part of it become unsafe for employment of persons and regulatory bodies prohibit mineral winning activities in such mine or part of it either temporarily until the danger is removed, or permanently if the damage caused by unscientific workings is irreversible. This not only deprives the country of its exploitable mineral wealth, but also disrupts the supply chain of commodities like construction aggregates.



Figure 2. Working faces with unsafe heights and slope – a stone quarry on the outskirts of Jaipur, Rajasthan.

Environmental challenges

The quarrying industry in general and the stone industry are yet to learn how to tackle air, water and noise pollution. The material covering a mineral load or stone bed that needs to be removed before the stone can be quarried is called overburden, which also includes the topsoil. Quarry waste consists of overburden plus production waste. This waste is dumped in some cases in unauthorized areas, thus destroying the natural vegetation and ecology of the regions.

Due to scanty and irregular rainfall in some parts of the country where agriculture is grossly monsoon-dependent, output from farming has decreased considerably. So farmers find it more profitable to rent their lands to quarry owners for dumping quarry waste. This is a gross misuse of the nation's land mass and ecology²³.

Progressive negligence of the environmental aspects of stone-quarrying operations is also detrimental to sustained growth of a quarry. The Sirohi Khor stone quarry on the outskirts of Delhi was in operation for more than 15 years before its closure in 2008–09. Despite repeated alarm calls raised by environmental activists, and relevant state departments, mine owners continued to operate without correcting/refining their work practices. The quarry was producing more than 50,000 metric tonnes of raw boulders per day. Due to lack of proper measures for environment protection after several warnings, the Supreme Court of India finally put a stay on any type of operations in the quarry. Millions of tonnes of good-quality building stone could no more be used. Post-closure of the quarry, the National Capital Region became fully dependent on the neighbouring state of Haryana to meet its skyrocketing demand of coarse aggregates. Due to increased demand, mine operators in Haryana too adopted haphazard practices without worrying about the environmental degradation they were caus-

ing. The Ministry of Environment, Forest and Climate Change, Government of India banned almost all stone quarries in Haryana in 2010, which could only be resumed in 2016 (refs 24, 25). The entire production pressure was shifted to neighbouring districts of eastern Rajasthan, which again forced unscientific practices to be adopted. Such practices are detrimental to the sustainability of stone quarries as well as infrastructure development in nearby areas.

Few northern and all the northeastern states of India meet their demand for stone boulders from the beds of rivers like the Ganga, Yamuna, Ghagghar, Sutlej, Gandak, Kosi, Sone Teesta, Brahmaputra and their tributaries. With increased awareness of people, environmental activists and the Government over depleting water table and shrinking river banks, it will become difficult to continue riverbed mining operations in the years to come. Can we imagine the day when construction of a strategically important road or bridge in Punjab or Himachal Pradesh is supported by coarse aggregates produced somewhere in Rajasthan or Madhya Pradesh, with a transportation lead of 1000 km?

Socio-economic challenges

Several socio-economic issues need to be addressed in stone quarry and crushing activities in India, which include prevalence of bonded labour, child labour, informal employment agreements, gender-based wage discrimination, poor living conditions and health and safety measures, non-payment of minimum wage, overtime and social benefits, and prevalence of debt bondage²⁶.

Human rights violations in Indian stone mines are particularly egregious. Child labour is common, with as many as 375,000 children working in Rajasthan's mines alone²⁷. A national study conducted in 2010 found that districts which are entirely dependent on mining have a lower literacy rate than the national average. Karnataka, Madhya Pradesh, Jharkhand and Tamil Nadu also have to deal with child labour, debt bondage and pathetic livelihood conditions of mine workers.

Women are systematically relegated to the lowest paying jobs. Frequently, the workers have no documentary evidence of identity or employment; so in cases where human rights violations occur, it is nearly impossible to hold any business responsible. Government regulation in this sector suffers from particularly high levels of confused and overlapping authority, as well as major loopholes. Trade unions in the stone sector are non-existent, which leaves the suffering workers without any resort of relief²⁷.

Sustainability challenges

Sustainable development of mines and minerals includes mine development and exploitation operations in a well-planned, scientific and lawful manner, so that present as

well as future generations can be benefited with mineral wealth. Mining societies in India are concerned about fast-depleting reserves of coal, major minerals and rare earths. In the same manner, concentrated efforts are required for conservation and development of building stone. Though there are state-wise minor mineral concession rules, these are mainly focused towards revenue collection and conservation and sustainable development of minor mineral resources; building stone remains unnoticed.

Generally, quarry leases for extraction of building stone and production of coarse aggregates are granted to individuals and enterprises for a long tenure, which is further renewable. Mine owners try to exploit the quarry 'as much as possible' for the first 3–5 years with haphazard practices to maximize their profit and then sell it to someone else, and the cycle goes on. A quarry with a life potential of 30–40 years is exhausted in 10 years so that the balance quantity of mineral reserves cannot be exploited. If such damage continues, soon we will not have enough stone quarries to support our ambitious plans of infrastructure development; also distances between production points and application points shall surge to out-of-budget scales. With no substitute available for coarse aggregates and if corrective measures are not adopted in time, it seems difficult to augment the capacity of our highways or increase the number of airports, in a timely and economical manner.

Policy and regulatory challenges

Many Government institutions are in place to ensure proper implementation of policies, e.g. Director General of Mines Safety (DGMS), Pollution Control Board, Inspectorate of Factories, to name a few. In stone quarrying and coarse aggregates production also, several rules are applicable, but their correct presentation and enforcement are big challenges. Many quarries and crusher owners and operators remain oblivious to the laws applicable to their business and so also, statutory obligations they are liable to comply with.

The respective State Governments must address the issues on extent of lease hold areas and tenure of lease. In Rajasthan, for example, if lease is granted for 1 ha area, not all the rules can be followed without sacrificing a hefty amount of mineral output. Few state Governments like Telangana and Haryana have acted commendably to address these issues by halting scattered mining and formation of particular quarrying zones, enlargement of the lease hold area and connecting all the applicable regulatory bodies by means of lease deed. However, many Indian states are yet to address this concern.

Status of health and safety measures in quarrying adopted by the developed countries

Developed countries like Spain, Sweden, Poland, Australia, Canada and USA have duly enforced regulations in order

to ensure health, safety and safe environment in and around stone quarries^{28,29}. Some of them are listed below.

- (a) Trade unions representing the miners concerning social protection and occupational safety are headed by social labour inspectors (SLI) who work independently.
- (b) State and regional mining authorities supervise the mines on occupational safety, hygiene, rescue, environmental protection, land reclamation and management of mineral deposits during extraction.
- (c) Workers are educated about protection of their right to health and safety at work, which must be guaranteed by the employer.
- (d) Many European countries have government-aided social security scheme and economic benefits given to the workers. In case of an injury at quarries, this is met with the social security fund.
- (e) Few countries follow special laws related to mining which are stringent enough to withdraw all workers even from opencast mines and shutdown operations when levels of airborne dust, noise and noxious gases surpass cut-off values.
- (f) Operational health, safety and environment supervisors are employed and trained in order to ascertain that all engineering, environmental and ambient parameters which may affect general health, safety and environment in a quarry or crushing plants are under control.

Remedial measures to overcome the challenges

Several measures have been put forward by concerned individuals and institutions. However, a lot more is required to be done for a safe, sustainable stone quarrying industry. We suggest the following remedial measures to overcome the challenges faced by the stone quarrying sector:

1. Honouring the stone quarrying and coarse aggregates sector with a full-fledged industry status shall be the most effective way for a healthy, safe, environment-friendly and sustainable exploitation of building stone in India. Formalization of stone quarries will automatically ensure compliance of bare minimum statutory requirements like maintaining standards of health and safety, payment of minimum wages and overtime, eradication of child labour and bonded labour, encouraging trade unions and maintenance of a safe and healthy working atmosphere.
2. Recognized trade unions should be encouraged wherever there is a cluster of stone mining leases and/or crushing plants, i.e. designated quarrying and crushing zones to advocate for health, safety and minimum wages rights of the workers.

3. The states may grant quarrying leases for an area not less than 10 ha each for a period not less than 20 years, so that the lessee can make medium to long-term plans for investment in infrastructure and ensure that the mine works in a safe and scientific manner. As obtaining environmental clearance (EC) has been mandated for stone mines which provisions for penal action if the annual output of mineral from any mine is more than the capacity approved by the EC, unlawful production, generally fueled by demand, can be checked.
4. A copy of the lease deed should be sent to DGMS and subsequently, officials may inspect the workplace before the lessee starts work. Simultaneously, an especial clause in this respect should be included in the lease document and the lessee should ensure to approach the Directorate General of Mines Safety (DGMS) to execute operations in accordance with the provisions of the Mines Act 1952.
5. Few stone quarries should be reserved to cater to projects of national importance in each district/division. It should be ensured that those quarries are used repeatedly for such projects. A stone quarry planned for re-leasing 4–5 times shall not only be planned scientifically, but the mineral wealth also shall be utilized reasonably.
6. It should be mandated that the lease owner preserves the topsoil overlying the mineral load and this soil be used for development of green belt around the quarries. Waste material like overburden or weathered rock, which if not sellable, should be filled back inside the quarry once the mineral inside is exhausted or certain portion of the quarry reaches ultimate pit depth, whichever occurs earlier.
7. Processing wastes as applicable in dimensional stone quarries should be stacked only inside leasehold area or lands which are infertile or bear hard bed, so that fertile lands with potential of crop yield are not rendered useless.
8. Local administration like Panchayat and village governance should be advised to be vigilant about accidents and dangerous occurrences, at least fatal accidents. If all accidents are reported and investigated in accordance with the Mines Act, safety at the sites will definitely improve. Regular feedback should be sought from local governance bodies like Panchayats as regards the status of enforcement of law by a quarry or crusher located under them. This can also be done through Gramsabhas which are conducted periodically. Defaulters, after being served notice and granted reasonable time to rectify the shortcomings, may be subjected to termination of non-compliance.
9. Social licence to operate a quarry must be incorporated as one of the important factors while granting quarry lease and permission to operate crushing plant. Enterprises and entrepreneurs must be directed to submit their plans with clear timelines and budgets on benefits they would be extending to nearby villagers and dwellers. This plan should comprise objective details regarding areas where expenditure is proposed like corporate social responsibility, health and sanitation, environment protection, education and skill development, welfare amenities, job creation and land reclamation. Social licence must be granted to the business owners only when local society approves such plans with timelines and budget.
10. Periodical environmental surveillance in stone quarries and crushing plants should be made mandatory in order to assess whether ambience of operation and nearby habitations are healthy.
11. Annual medical checks for workers and nearby dwellers residing within a radius of 500 m should be made mandatory, especially for early detection and prevention of respirable diseases like silicosis and chronic obstructive pulmonary disease. Funds for such checks can be contributed by both the lessees and the respective state governments.
12. Executive teams constituting members from stone quarries and crushing plants should be formed for carrying out fortnightly inspections. Each of such teams should have members from various tiers and functions of organization. This committee should have authority to report unhealthy, unsafe and unscientific workings to the regulatory bodies like Pollution Control Board, DGMS and District Medical Board.
13. Policy of motivation clubbed with financial incentives should be framed. For those quarries and crusher owners who follow the norms and work in a safe, healthy and scientific manner, such incentives may be paid in the form of partial exemption of mineral royalty, preference over other applicants on granting mineral leases in other areas, exemption of fee payable to the Pollution Control Board on renewal of consent to operate a quarry or crusher, etc.

Conclusion

Stone quarrying and crushing in India are essential to support the country's infrastructure development. At present, this sector needs substantial attention of policymakers and regulators to ensure that stone aggregates are available for development of construction projects in a safe, timely, environment-friendly, economical and sustainable manner. This sector faces many challenges which may be categorized as health, safety, environmental, socio-economic, sustainability and statutory challenges. Many developed countries have formulated special laws

for minor mineral and quarrying sector which emphasize on overall well-being of miners, occupational safety, protection of environment and a strict watch on unplanned depletion of mineral wealth. India's stone quarrying sector can overcome its challenge with the help of regulatory bodies, quarry operators, workers, and local residents working in tandem with a strong will to set things right. Some of the key suggestions which will ensure safety of workers, protection of the environment, and sustained availability of mineral wealth for the generations to come are structural changes in quarry leasing policies, making social license mandatory before granting the quarry lease, encouragement to licensed trade unions to protect the health and safety rights of workers, periodic surveillance to measure quality of ambient air, water and land degradation, active involvement of local governance bodies like Panchayats, free and fearless reporting on non-compliance of laws, and financial incentives for those who follow the laws.

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