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NATURAL STONE FLOORING: A BETTER ALTERNATIVE TO CEMENT FLOORING TO SAVE ENERGY AND REDUCE POLLUTION

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ABSTRACT: *Cement has been used as one of the best building material in construction of house, roads, industrial building dams, bridges etc. Indian cement industry is the 2nd largest producer in the world with a total capacity of 277.46MTPA.in 2016 led by the growth in the sector of real estate and construction. It is process of making Clinker, the key constituent of cement that emits large amount of CO2 in cement manufacturing beside emission of greenhouse Gases including CO2, NOX, Sulphur dioxide causing serious concerns. The cement manufacturing is highly energy both electric and thermal, consuming industry Cement. Lafarge Holcim the worlds largest cement and Cemetose SA cement co of Brazil are advising consumer to plan and innovate alternative to cement which will reduce CO2 emission substantially. However it is not possible to replace cement entirely but certain specific applications, Natural Stone can be used in place of cement with confidence and reliability. Natural stones include variety of stones such as granite, sandstone, marbles, limestone (kotah stone), quartzite, slates, phylites, etc. In this article I have concentrated on use of Kotah Stone (Natural Stone). Kotah Stone has unique physio-mechanical and chemical properties. Kotah Stone if laid properly it will last over 70 years. Natural stone, Kotah Stone consumes comparatively much less energy and causes much less pollution. Flooring using Natural Stones instead of Cement reduced energy by 75% and heavy reduction in emission of greenhouse gases to less than 1% and sharp reduction in dust particulates. However natural stones can't be used for roofing, or high rise building or high structures.*

KEY WORDS: cement, clinker, energy emissions, natural stone, kotah stone

INTRODUCTION

Over centuries cement has been used as best building materials. It has been used extensively in construction of house, roads, dams, bridges, industrial building etc. Indian cement industry is the 2nd largest producer in the world with a total capacity of 277.46MTPA. Per capita consumption has increased from 28kg in 1980-81 to 176kg in 2016 led by the growth in the sector of real estate

and construction. Economic growth is contingent upon the growth of Cement Industry. Consumption of cement has been taken to be the growth of economic development. The greater the infrastructure growth in the country, greater will be consumption of cement.

In the process of making clicker - making clinker constitutes of cement emits the large amount of Co2 in the cement making. In 2016 world cement production produced 2.2 billion T of Co2, amounting to 8 % global emission. More than half of this came from manufacturing of clinker. Cement Industry is resource and energy intense. Indian cement sector has recognized this aspect very well and during last two decades, it has reduced its greenhouse gas emissions through improved energy efficiency; increased use of alternative fuel and optimisation of resources use efficiency. The investments made in pollution control measures have dramatically reduced air emissions, water pollution and waste generation. However, there are numerous challenges that still need to be addressed to make this sector environmentally sustainable and regulatory compliant.

Global Warming and Climate Change

The subject of Global Warming and Climate Change is most talked subject and showing serious concerns. Emission of Greenhouse Gases including CO2, NOX, Sulphur dioxide causing serious concerns. The emission of greenhouse gases are leading to rise in temperature. There is direct link between CO2 emission and global warming. A concentration of 300 PPM is taken as acceptable level but when it increases to 400 PPM there is rise of 1.2C in global temperature. It is estimated that Cement production pollutes air much more than vehicular traffic. Building materials used for construction contributes 7% of total world's CO2 emission.

Slitting firm Mudeej has forecasted that by 2100 due to climate change if temperature rises 2C Global Economy will be adversely by 69 billion dollars. In Paris Agreement it is agreed to restrict temp rise to 1.5C. Economist has suggested to avoid use of coal in any way, reduce use of petroleum by 50% and natural gas by 10% besides reducing Carbon Emissions appreciably.

Polluting Emission in Cement Industry

It's the process of making clinker, the key constituents of cement, that emmit large amount of CO2 in cement manufacturing. In 2016 World cement production generated about 2.2 billion T of CO2 - which is equivalent to 8% of global emission. More than half of that came from clinker manufacturing. The essential issues associated with cement are raw materials and energy as well as emission in air. The key polluting substance emitting in air are:

Dust particulates, Oxides of Carbon, Nitrogen, Sulphur, Methane, Greenhouse gases, volatile materials, HCL. Overall emission in a cement plant covering all activities is as below:

Carbon dioxide : 0.86 T/ T of cement

Sulphur dioxide : 1.5 kg / T of cement
Nitrogen oxides : 3 kg / T of cement
Dust particles : 0.234 kg / T of cement.

Though Indian standards set for cement plant: 150 mg/ Nm3, but in reality it always exceeds the limit. EPC is provided to control dust emission but plants don't run the unit to save on electric energy. From the above we may derive that about 43 kg of CO2 is emitted per one bag of cement.

Use of Cement in Construction

Normally cement is not used singly but along with sand in various applications in various proportion depending on use as mortor in masonry, plaster and with aggregates in cement concrete. Extraction of sand is again causing serious concerns on river environment. Illegal mining of sand is at rampat so much so that Appex Court and NGT have banned sand extraction. Further source of aggregate is breaking rocks and sizing through crushers. This process again leads to air pollution through emission of particulates.

As said earlier cement manufacturing is energy intensive. Status of Energy Consumption of Electric Energy in Cement Manufacturing:

Crushing : 2 Kwh / T of OPC
Raw Mill : 26 Kwh/ T of OPC
Kiln and Cooler : 31 Kwh / T of OPC
Coal Mill : 4 Kwh / T of OPC
Cement Mill : 30 Kwh / T of OPC
Packing : 7 Kwh / T of OPC
Misc : 7 Kwh / T of OPC
Grand Total for all sections : 100 Kwh / T of OPC.

Summary for total Energy Consumption:

Electric Energy : 100 Kwh/ T of OPC
Or 5 Kwh / Bag of cement
Thermal Energy : 770 Kcal / Kg of clinker
Or 193 kg of Coal/ T of Clinker
Or 193 Kwh / T of Clinker
Or 160 Kwh / T of OPC
Or 8 Kwh / Bag of cement.
Total Energy : 13 Kwh / Bag of cement.

Use of Natural Stone as Alternative to Cement

Lafarge Holcim the world's largest Switzerland cement co. and Cemetose SA cement co of Brazil are advising consumers, architects and builders to think, plan and innovate building materials alternative to cement which will reduce CO2 emission substantially. Lafarge Holcim's head of Sustainability, Mr Jane's Daibold goes on saying that he would be happy if people use such building materials which is free of any pollution, solid.

Looking to large emissions of greenhouse gases by cement, as suggested above, we have to innovate and plan alternative building materials which is free of emissions and solid enough to meet requirements. However it is not possible to replace cement entirely but certain specific applications Natural Stone can be used in place of cement with confidence and reliability. These including flooring of houses, industrial building, pharmaceutical building , ware-houses, hospitals or public places, walk ways, arena, courtyards, even on roads having minimum or no vehicular traffic. See figure 1&2. Arena beautifully paved with cobblestone from natural stones. Inner part with stood tiles; adding to aesthetic look. Walking road in paved with cobble stone. No cement flooring anywhere.

Natural Stone

Ever since the human life came to existence on the earth planet, stone has been used for construction. Stone is the noblest building material which comes from nature. As Stone Age it gained nobility and blends in nature. Finally when it ruins, it does so with extreme grace. Natural stone that comes from nature has been sized, shaped with least of energy and used in construction, may it be flooring, walking, cladding, or paving on roads. Monumental buildings were constructed when much was not even felt of shortage of energy or air pollution by particulates and CO2 and other gases.

Nature has gifted us a variety of Stone which could be sized, shaped, and polished to meet requirements in building construction. These are widely known as dimensional and decorative stone.

It includes granite, sandstone, marble, limestone, slates, quartzite, phylites etc. These stones occur in nature in different colours, shade, design in massive form and even Splittabl layers. These stones possess varied physical and chemical properties which are the deciding factors of their application. My studies are primarily based on use on Limestone commercially world Wide known as KOTAH STONE, Figure-I.

Kotah Stone

Kotah Stone is an excellent flooring Stone. It is naturally splittable low grade limestone. Mining for Kotah Stone has been going on since 1945. Mining of Kotah tone has gone full circle since then. May see Figured 1/2/3 for current system of mining. It has been used worldwide as flooring stone (Figure-II) and for cladding, pathway, courtyard, hospital. It is most economic industrial flooring stone. Production has multiplied from a few lac sq ft to 1700 lack sq ft annually as on today. Kotah Stone has unique physico mechanical and chemical properties as below which makes the Stone most favorable:

Table-I Kotah Stone Physio mechanical properties

Density kg/m^3	: 2660 --2690
Water absorption	: 0.09 to 0.10
Hardness No (ISN'T)	: 62
Uni axial strength	: 90.31 to 149.68
Modulus of Rupture (MPAs)	: 44.38 to 45.12
Abrasion Resistance	: 27 to 77

Kotah Stone take high polish equivalent to Galaxy Granite. For its high silica content (23.7%) that it takes high gloss when polished. However the silica is not freely but intrinsically held. Hence when emitted in air is not injurious. For its very lowest water absorption and high compressive strength that it is most preferred flooring Stone for warehouse, pharmaceutical industries and public utilities. Kotah Stone if layed properly it will last over 70 years.

Air Pollution While Extracting Natural Stone

Unlike cement manufacturing no such process involved in winning of natural stone. No manufacturing processes, burning, calcination or any chemical process id involved in winning natural stone. It is not that extraction and processing of natural stone is free of air emission or that it doesn't require energy. Yes it does. But when compared with cement, natural stone causes much less air pollution and require much less energy. It is rightly said that mining activities contributes heavily to air, water and soil pollution.

A. Stone quarries pollute air through emission of dust particulates and CO2 emission. Sources of air pollution broadly are:

1. Removal of over burden:
a. During drilling,
b. Blasting,
c. Excavation of broken rock.
d. Transportation of waste to dumps yards.

For excavation stone quarries mainly deploy HEMM which run on diesel as fuel. It is estimated that about 1 liter of HSD is consumed per cumt of excavation. Each liter of HSD emit 2.7 kg of CO2. It is also estimated that for 1Mill sqr mtr of Kotah Stone production about 3.7 Mill Cu mtr of OB and other waste is handled. This consumes 3.7Mill Liter HSD which on consumption by HEMM emits about 1000 T of CO2. Further use of explosive for rock breaking add to CO2 emission.

B. During extraction of slabs and tiles at quarry floor. Since electric operated portable sawing machines are used for cutting stone layers in- situ at quarry floor, there is no generation or emission of any foul gases. As water is used to clean the cutting and cool the cutting tool it creates clean and cool atmosphere at quarry floor.

C. During transportation of mined products from quarry floor to surface or to processing unit for final finish. The vehicular traffic deployed for transportation up- hill from quarry floor to surface emits carbon dioxide in atmosphere.

Emission of Dust Particulate

Ambient Air Quality In and Around Kotah Stone Mines

Air quality as recorded in core area of Kotah stone mines are as below:

Value	Minimum	Maximum
RSPM	70.6	99.6 (Dumps)
SPM	210.0	360.9 (Dumps)
SO2	13.8	36.8
NOX	11.6	25.7

The values are well within the permissible limits.

D. Energy Consumption

During actual extraction of Kotah stone slabs using electric operated jhiri machines. During pumping out rain filled water from open quarries using electric pumps. Misc use to electricity for quarry lighting, at maintenance workshops and other requirements. At processing plant for smoothening, edge cutting, polishing, and other jobs to make final commercial product ready to use.

For winning Kotah Stone slabs and tiles portable electric operated diamond cutter machines are used to cut layers in- situ at quarry floor, Fig- 4. All side cut blocks are the splitted along cleavage

plains to yield smooth slabs and tiles, Fig - 5. It is estimated that for a production of100 sq. ft , some 10 Kwh (units) of power is used in the entire operation.

Some 30% of total production is layed as it is in rough. The remaining 70% of production is further processed either for smoothening, polishing, edge cutting etc. It is estimated that 7 units (Kwh) is consumed in this process per 100 sq. ft.

Now having worked out air pollution and energy consumption both in cement manufacturing and natural stone quarries, comparative studies have been carried out before we establish that use of natural stone is good alternative to cement in specific applications. Comparative study between cement concrete floor and floor layed with Kotah Stone, assuming 100 sq. ft floor area.

Laying Floor.

For laying floor either cement concrete Or flooring with natural stones, Kotah stones, we have to prepare thick base, 50 mm thick, in cement concrete in ratio of say 1; 4: 6 according to wear and load expected on the floor.

A. Then in case of cement concrete floor, top cement concrete is laid on base only after the base has completely set. Top cement concrete will be 50 mm thick in ratio of 1: 2: 4 mix. Minimum amount of water should be used so that no scum is formed on the surface when concrete is beaten and consolated. The mix ratio and thickness may vary as per requirements. Concrete floor under heavy loads may be reinforced. It is after 15 days of water curing the floor is ready for use.

B For laying floor with natural stones, first a thick base layer in 100 mm/4" thickness is laid in lime concrete. The lime concrete layer should be well beaten and consolidated. After this base layer is well set, it is moistened before laying cement mortor to fix the stone slabs/ tiles. Now the top, above the plain and consolidated base, is laid with Kotah stones slabs or tiles of given size and thickness. For a floor of 100 sq ft we may choose stones in size of 2'x2' or 2' x 1.5'. For domestic floor the stone tiles may be in 3/4" “Or 1" thickness. Stone tiles are laid and jointed in cement mortor. For larger floor larger size and thicker stones are used. For industrial flooring we may use stones up to 3" thickness. After 2 days of fixing it is polished by portable machines to finish required. The floor is then ready for use.

Table Comparative study for two flooring:

Parameters	Flooring with Cement concrete	Flooring Kotah Stone
Items used		
Cement	6 Bags	1.5 Bags
Sand	0.62 cum	very little
Agreegate	1.24 cum	nil
Energy KWh	78	36.5
Emission per T/clinke		SPM
Carbon dioxide	258 kg	210--369.9
NOX	900 kg	11.6--25.7
Sulphur dioxide	450 kg	13.8--26.8
Dust particulate	258 kg	RSPM 70.6 --99. 6

From the above comparative studied it icon be safely concluded that we save 41.5 KWh per 100 sq ft of flooring using Natural Stones instead of Cement. Besides saving energy, there is heavy reduction in emission greenhouse gases and dust particulates by substituting cement with natural stones. Natural stones can be usefully used for cladding instead of cement plaster. However natural stones can't be used for roofing, or high rise building or high structures. Type of natural stones will depend on application.

CONCLUSION

Natural stones can replace cement as much as 75% in flooring.
Natural stone when used in flooring instead of cement reduces electric energy by 75%.
Natural stone when used in flooring instead of cement reduces carbon dioxide to 0.23%.
Longevity of flooring with Natural stone is at least 6 times more than cement flooring.
Cobblestone can be used in arenas, courtyards and other public places instead of cement to last longer and adding beauty.
Thus Natural Stones can replace cement in flooring to form a solid and rigid floor with aesthetic beauty and to last much longer and save energy and reduce pollution.

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