FOUNDRY SLAG WASTE BASED CONCRETE PAVER BLOCK PRODUCTION

TECHNOLOGY PACKAGE

Technology development support by:
Foundation for MSME Clusters (FMC)

Research support by:
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Catalyzed and Supported by:
SEED DIVISION
Department of Science & Technology
Government of India

Technology developed by:
TARA

INTRODUCTION

Paving blocks have been used since Roman times for the construction of aesthetically pleasing and durable functional surfaces. At present times these functional surfaces are used for a variety of purposes such as roadways, parking areas, pedestrian walkways, shopping and civic malls, patios and simple decoration of landscape features. In recent times the Indian Government has put increased emphasis on upgradtion of rural infrastructure. A majority of the efforts are going into upgradation of village roads, small roads in cities and towns and also slum upgradtion. It has been mandated to use paving blocks for all of the above purpose.

Foundry slag waste (FSW) is widespread by-product of industrial process in India. This technology package highlights upon the utilization of granular foundry slag as replacement of natural aggregate in production of concrete paver block.

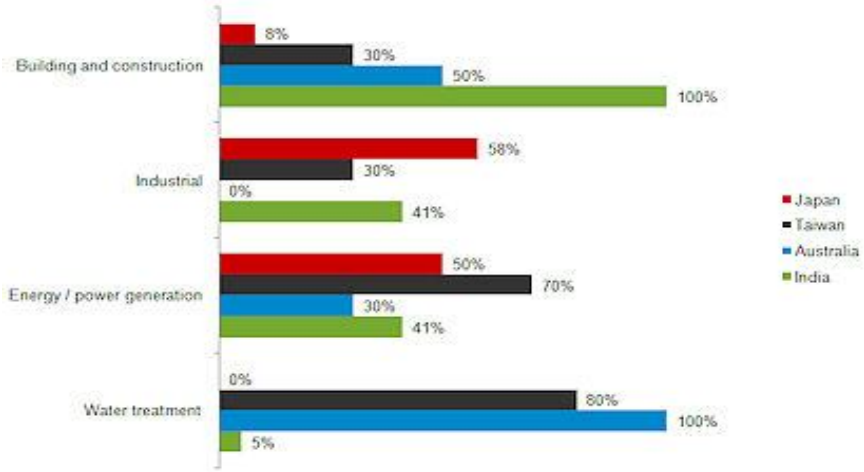
Concrete paver block are precast solid products made out of cement concrete. The product is made in various sizes and shapes viz. hexagonal, I-shape, dumble blocks of different dimensions with designs for interlocking of adjacent blocks. The raw materials required for manufacture of the product are Ordinary Portland Cement and foundry slag aggregates which are available locally in the country.

OPPORTUNITY/ MARKET ASSESMENT

India has one of the fastest growing and most environmentally aware construction industries in the world. The construction industry in India has been witnessed to a strong growth wave powered by large spends on infrastructure development. The Indian construction industry forms an integral part of the economy and is poised for growth on account of industrialization, urbanization and economic development for improved quality of living. Construction constitutes 40% to 50% of India's capital expenditure on projects in various sectors and is the second largest industry of the country after agriculture. With a share of around 8.2 per cent, the construction industry has contributed an estimated 670,778 crore (at current prices) to national GDP at factor cost in 2011-12.

Demand Assessment:

Chart: Big on Green in India



Source: GIA interviews with construction industry players, Jan – Apr 2010

Paving Blocks find applications in pavements, footpaths, gardens, passengers waiting sheds, bus-stops, industry and other public places. The product is commonly used in urban areas for the above application. Hence, the unit may be set up in urban and semi-urban areas, near the market.

A lot of face-lift is being given to roads, footpaths along the roadside. Paving Blocks are ideal materials on the footpaths for easy laying, better look and finish. Whereas the tiles find extensive use outside the large buildings and houses, lots of these materials are also used in flooring in the open areas of public offices and commercial buildings and residential apartments.

TECHNICAL ASPECTS

1. Raw Materials

In foundry slag based concrete paver block production, it is important to use only the best quality raw materials. Using inferior quality will result in low quality and automatically bad business.

The raw materials commonly used to make foundry slag based concrete paver blocks are

- Crushed foundry slag waste (nominal maximum size of 12 mm)
- River or quarry sand/ stone dust
- Ordinary Portland Cement (43 grade) and
- Potable water

In general, the mixture used for blocks has a higher percentage of aggregate and lower percentage of cement (around 90% of aggregate and less than 10% of cement by weight).

Crushed foundry slag waste

Coarse foundry slag wastes are crushed through jaw crusher to coarse aggregate. Crushed foundry slag chips broken into particle sizes passing through 4.75 mm sieve may also be used as fine aggregate. The nominal maximum size of the coarse foundry slag aggregate is 12 mm.

River or quarry sand/ stone dust

All fine aggregate viz. river or quarry sand/ stone dust should be cleaned and not contain more than 5% clay/ silt or any organic matter such as leaves, roots or humus. It is normally possible to make blocks directly with the available fine aggregate on its own. Alternatively, the aggregate should be sieved through number 4 or 4.7 mm Indian Standard sieve are known as fine aggregate. Natural sand is often used as fine aggregate in concrete paver block mixture.

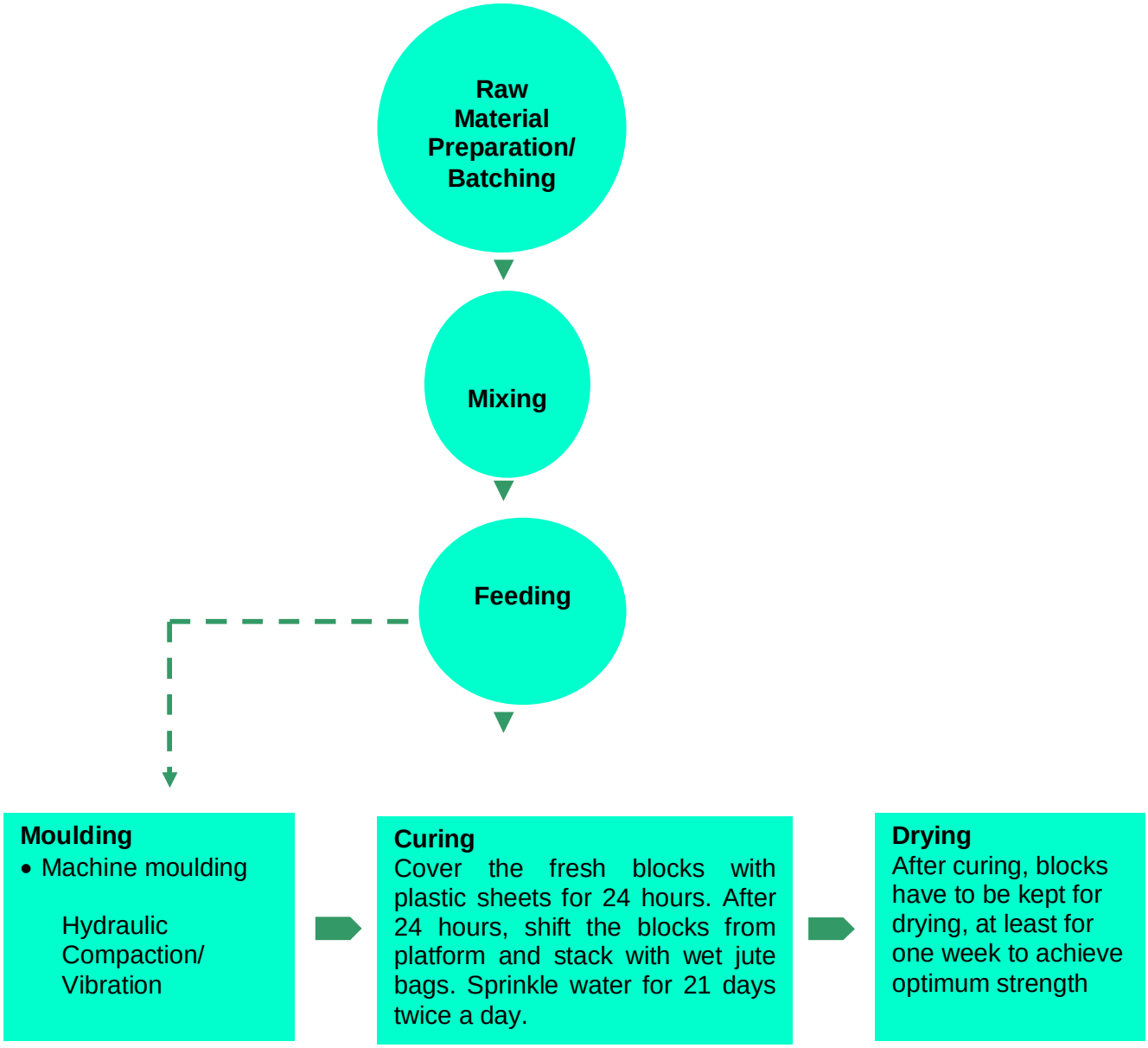
Ordinary Portland Cement

Since cement is an expensive element in the production of the blocks, the fine and coarse aggregates are combined in such proportions that the resulting mixture is workable and has minimum cement content for the desired quality production of the blocks. This will further ensure better surface finish and required strength.

Water

Water that is fit for drinking is suitable for the production of paver blocks. Clean river and borewell water may also be used.

2. Production Phase



Appropriate method of concrete mixing, moulding and curing as per the condition plays vital role in the quality production of concrete paver blocks.

Paw material preparation/ Batching

The determination of suitable amount of raw materials needed to produce desired quality of concrete paver block under given conditions of mixing, moulding and curing is known for raw material preparation/ batching. Specific proportions of any mixture used for foundry slag based concrete paver blocks will depend on locally available materials, manufacturing equipments, and desired final texture and quality of the final product. A low water – cement ratio (usually between 0.25 and 0.40) is used to produce a non-slump concrete with high strength and durability for paver block making in hydraulic compaction machine. The water – cement ratio of 0.50 to 0.60 by weight basis can be used for vibration technique.

Suggested compositions for various grade of concrete paver block

Code	Foundry slag aggregate (>10 mm)	Stone dust	Cement (OPC – 43 grade)
M30	6	2	1
M35	5	2	1
M40	4	2	1

Mixing

The objective of proper and homogeneous mixing of aggregate, cement and water is to ensure that the cement – water paste completely covers the surface of the aggregates. All the raw materials including water should be mixed in mechanized concrete mixer to achieve the thorough mixing. The prepared mix should be consumed within 30 minutes.

Feeding

The concrete mix is fed into the appropriate mould and is then subjected to intensive compaction/ vibration.

Moulding

Moulding includes compaction or vibration of the mix concrete. In general, all concrete products should be well vibrated or compacted for achieving a quality block. Based upon the scale and size of production unit, the vibration or compaction system will be different.

The purpose of compacting is to fill all air pockets as a whole without movement of free water through the concrete. Excessive compaction would result in formation of water pockets or layers with higher water content and poor quality of the products.

Semi-automatic vibrating table machine are widely used for making concrete paver blocks. The machine consists of an automatic vibrating unit with a choice of PVC moulds for manufacture of concrete paver blocks.

Curing

The day after production, blocks should be shifted to the stacking area for curing. Stacks should be carefully built to avoid chipping edges and corners. Curing is the process of maintaining satisfactory moisture content and a favourable temperature in the blocks to ensure hydration of the cement and development of optimum strength. Thus, proper curing is a must for all cement products. To achieve the optimum strength all the concrete paver blocks have to be properly cured for atleast 21 days.

Drying

Concrete shrinks slightly with loss of moisture. It is therefore essential that after curing is over, the blocks should be allowed to dry out gradually in shade so that the initial drying shrinkage of the blocks is completed before they are used in construction work.

Generally, a period of 7 days of drying will bring the blocks to the desired degree of dryness. After this the blocks are ready for use in construction work.

3. Quality Control

IS 15658: 2006 specifies the requirements of these parameters:

a. Dimensions and tolerances
b. Grades of concrete paver blocks
c. Water absorption and
d. Compressive strength

These aspects should be regularly checked to ensure final products quality.

4. Do's and Don'ts for the Concrete Paver Block Production

DO'S

Use correct Raw Material

- Use Ordinary Portland cement grade 43
- Use graded foundry slag as recommended
- Use portable water

Use correct ratios of materials

- Always measure cement and foundry slag aggregate in weight
- Use converting of mix ratio from weight to volume and vise versa
- Water/ Cement ratio is very critical, so always perform several trials to identify the optimum w/c ratio for different mix and types of machine

Follow standard Operating Procedures

- Follow standard mixing process and time sequence
- In mechanical process provide optimum compaction/ vibration after the upper mould head is pulled down into cavity mould
- Fill mould properly upto top level
- Always use the prepared mix within 20 – 30 minutes
- Wipe off the moulds after every 10 minutes by soft brush
- Check for proper mixing by homogeneous colour and required moisture content

Check for the correct setting of machine

- Machine should be set on the level ground. The mould base and the plate should be absolutely horizontal
- Stationary machine should have concrete foundation and be levelled preciously
- Always clean the machine moulds and tools after the days work is finished

Check for uniform compaction and vibration

- Compaction/ vibration at four corners should be identical

Handling and transportation

- Handle and transport the fresh blocks with care
- Put batch number and date on each batch and stack

Proper curing

- Keep blocks under shed for 24 – 48 hours
- Start wet curing after 48 hours
- Curing should be done twice a day
- Conduct wet curing for 21 days
- Make sure the products are always moist during the whole curing period
- Put batch number and date on each batch and stack

Safety

- Always work with safety; using gloves, aprons, mask, ear-plug or ear-muffs,

gum boots etc. to protect from cement, dust, and noise
- Always keep first aid-box in the work shop for immediate treatment

DONT'S

Do not use raw materials that violate specification

- Reject cement that is lumpy
- Never use poor graded foundry slag aggregate (reduces the quality of the product)

Do not violate standard operating procedures

- Always use the proper raw material mix as specified
- Discard mortar that has partially set, never re-tamper by mixing in additional water
- Do not speed up the dry mixing procedures
- Do not add extra mortar after compaction

Do not misuse the equipment

- Do not alter the lifting assembly while machine is in operation
- Do not run machine before checking of hydraulic oil and other movable parts
- Avoid hammering the moulds

Do not ignore Quality Control guidelines

- Avoid changing the mix compositions
- Avoid repairing or filling cracks observed during production

Do not mishandle the fresh moulded products

- Do not tilt the fresh moulded block
- Do not stack the blocks with more than 5 blocks above during curing
- Do not stack the blocks on an uneven ground
- Do not stack more than 5 bricks one above the other

FINANCIAL ASPECTS

The economical highlights of foundry slag waste based paving block technology are given below:

- ✓ Cost of TARA PaveMek machine is INR 3,00,000 (USD 4,850)
- ✓ Technology transfer fee is INR 2,00,000 (USD 3,225). Services of technology transfer package are
  - Selection and testing of raw materials (stone aggregate, foundry slag waste, stone dust)
  - Determining the optimum mix design through laboratory testing
  - Supply customized machines and accessories
  - Operational recommendation and commissioning of production
  - Paving block making through use of foundry slag waste supervision and quality control training of paving block production
  - Onsite training of workers and entrepreneurs

- ✓ **Additional capital investment for retrofitting the existing production system** (might vary from place to place)
- ✓ Machinery and equipment Rs.7,00,000
- ✓ Technology transfer fee Rs.2,00,000

TOTAL **Rs.9,00,000**

Cost of land has not being included in the total investment cost.

Approximately 3,000 square meter of land is required for moulding, drying, curing and stacking of blocks including office setup and provision of working sheds.

Production cost analysis for 1,000 blocks (based on production cost at Ludhiana, Punjab as on 30 September 2014**:**

1. Raw material
   a. Cement = Rs. 3,700
   b. Foundry slag waste = Rs. 340
   c. Stone dust = Rs. 330

2. Paver block production charges
   a. Fabrication charges = Rs. 1,500

3. Overheads
   a. Equipment maintenance charges = Rs. 170
   b. Electricity/ diesel etc. = Rs. 2,200

Total cost of foundry slag waste based paving block = Rs. 8,240
(Exclusive of VAT/Sales Tax and profit)

Annual turnover for 240 days of production is around INR 35,59,680 (USD 58,200). The production cost for the same period is around INR 29,66,400 (USD 49,400).

With an internal rate of return (IRR) of approximately 65% the payback period is 2 yeras of full production only with retrofitting of existing paving block making unit.

Disclaimer:

The above figure does not attribute the exact monetary claims. It only gives an idea on the production cost of foundry slag waste based paver block production. Figures may vary from place to place.

LIST OF MACHINERY SUPPLIERS

Below are some potential concrete paving block machinery and equipments suppliers

1. Shri Engineering Enterprises
   13, Sukhnivas Apartment, S No. 102/2/A1, Senapati Bapat Road, Behind Housing Society, Near Asha Nagar, Shivaji Nagar, Pune – 411016, Maharashtra, India
   Website: http://www.shriconstructionequipments.com/

2. TARA Machines & Tech Services Pvt. Ltd.
   29, Ghitorni, Near Metro Station, Mehrauli – Gurgaon Road, New Delhi – 110030, website – www.taramachines.com

3. Balaji Engineering Works
   3 Arihant Ind. Estate Girnar Scooter Compound, Odhav Ring Road, Near GVMM, Ahmedabad – 382415, Gujrat, India
   Website: http://www.balajiengineeringwork.com/paver-hydraulic-press-machine-1141632.html
4. Aimil Ltd.
   Naimex House, A-8, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi – 110044,
   Email – info@aimil.com