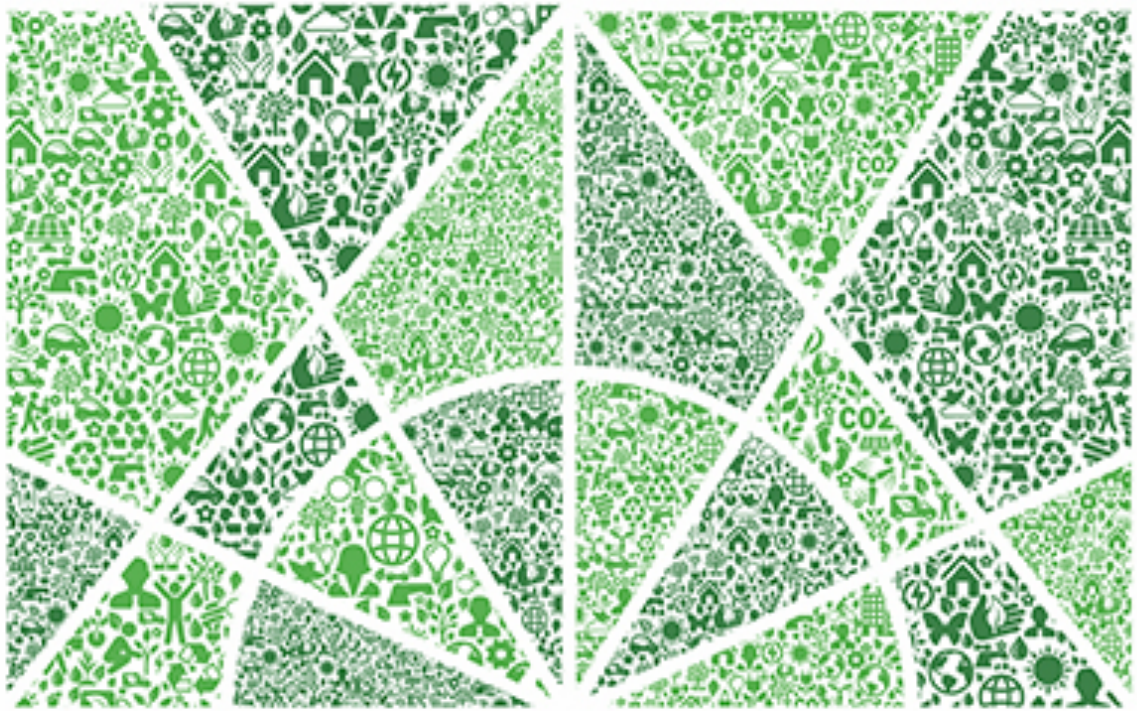
Effective Utilization of Red Mud (RM) / Bauxite Residue (BR)

Hindalco Industries Limited

Presentation At Indo European Meet, New Delhi

19 September 2019



Transforming towards a
Resilient Responsible & Reliable Future

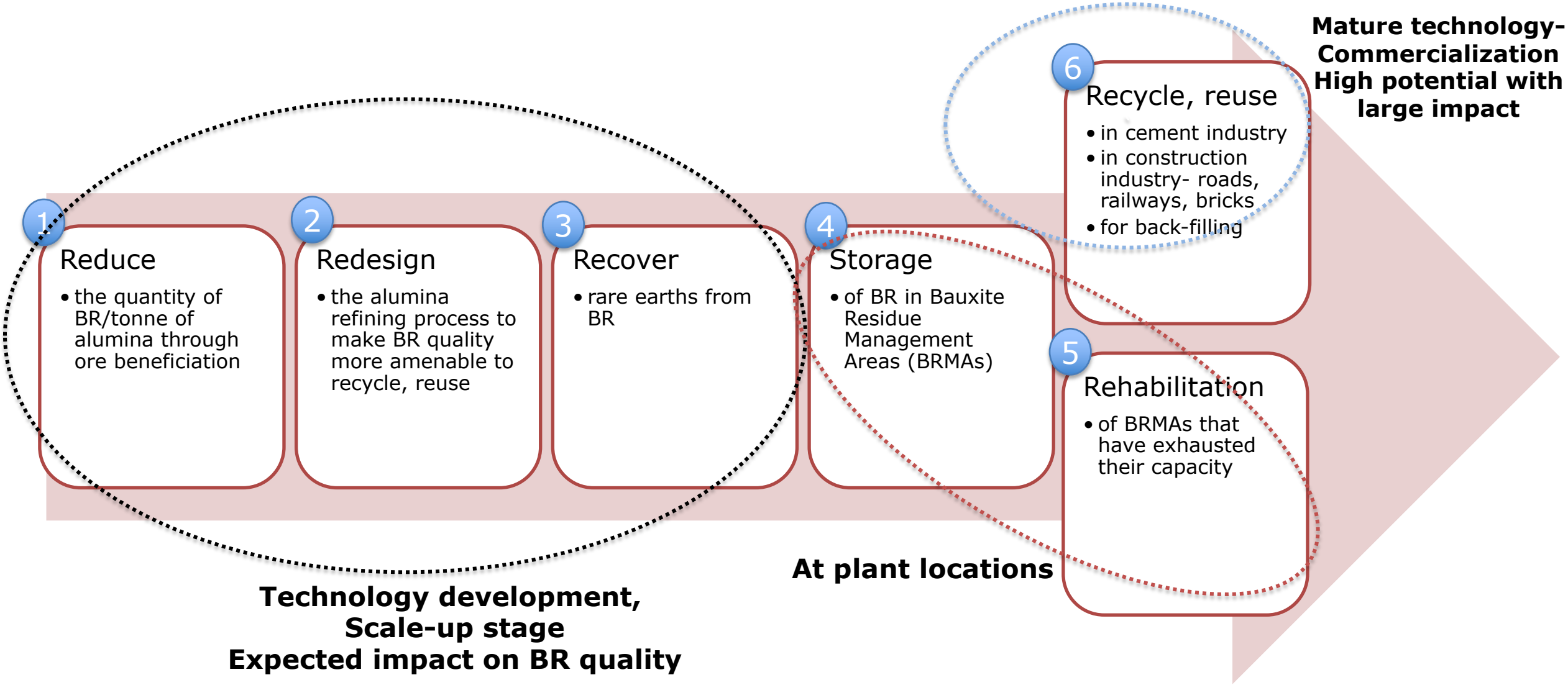
Hindalco is now a part of Dow Jones Sustainability Index

One of 12 companies from India to make the list

Only company from ABG to have entered the index this year

Hindalco's Approach on Bauxite Residue Management

Combination of 5Rs + 1 S



Hindalco's Approach on Bauxite Residue Management

Prioritization of the six pillars for our discussion

1. Maturity of solution → 2. Size of Impact on utilization of BR → 3. Cost of implementation → 4. Timelines for implementation

- Storage
- Reuse For Rehabilitation Of Mine Pits
- Reuse In Cement
- Reuse In Construction
- Reduce
- Redesign & Recover

Hindalco's Approach on Bauxite Residue Management

Storage of BR at Hindalco Refineries

Hindalco Plant Location	Pre-Storage Treatment	Characteristics of BR Management Area (BRMA)	Good Practices
Renukoot, Uttar Pradesh	Pressure Filtration & Vacuum Filtration Combination Solids: 65-66%	Dry Mud Stacking at the factory location with facility for leachate collection through garland drain	• BRMA design at older plants through national geotechnical experts, at Utkal through international experts • SoPs for storage/ stacking in line with BRMA design • Regular stability assessment through premier academic institutions • Belagavi rehabilitated BRMA cited as good practice • Following the *"Bauxite Residue Management: Best Practice (2004)"* of IAI
Utkal, Odisha	Pressure Filtration using High Pressure Filters Solids: 78-79%	Dry Mud Stacking at the factory location with Gabion Wall and leachate collection facility	
Belagavi, Karnataka	Pressure Filtration & Vacuum Filtration Combination Solids: 65-66%	Dry Mud Stacking at the factory location with boundary wall	
Muri, Jharkhand	Pressure Filtration using High Pressure Filters Solids: 74 to 75%	Dry Mud Stacking at the factory location with Gabion Wall and leachate collection facility	

Hindalco's Approach on Bauxite Residue Management

Storage – Rehabilitated BRMA at Belagavi

Process followed during Rehabilitation of Bauxite Residue dumping sites at Belagavi

Terracing

Spreading Amender

Tilling

Pits Preparation

Pipeline for irrigation

Plantation

Grass Sowing

Dip Irrigation

Plantation

Growth: 1 month

Growth: 3 month

Growth: 6 month

Hindalco's Approach on Bauxite Residue Management

Storage – Rehabilitated BRMA at Belagavi

Pictures from November 2018 of Bauxite Storage Pond at Belagavi

Hindalco's Approach on Bauxite Residue Management

Recycle – Rehabilitation of Mine Pits

Learnings from Rehabilitation of filled BRMA

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Challenge of using virgin land for creating new BRMAs

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How about we use BR to rehabilitate existing mine pits?

- Follow international best practices on stability, leaching, seepage control, dust control (during construction and in operational phase), profiling, etc.
- Vegetation, surface treatment to be as per local conditions (climatic, geophysical, etc.)
- Scientific study on design of structure done by IIT Mumbai
- Scientific design of the structure studied and requirements for backfilling developed through NEERI

Hindalco's Approach on Bauxite Residue Management

Recycle: Well Established Use In The Cement Industry

Most cement companies have now used this product in one or more of their plants

Hindalco's Approach on Bauxite Residue Management

Recycle: Well Established Use In The Cement Industry

Typical Raw Cement Clinker Mix Composition

Ingredient	% In Cement
Lime	60-65
Silica	18-25
Alumina	4-8
Magnesia	<5
Iron oxide	2-6
Calcium Sulfate	3-5
Sulfur Trioxide	1.8-3.5
Alkaline	0-1

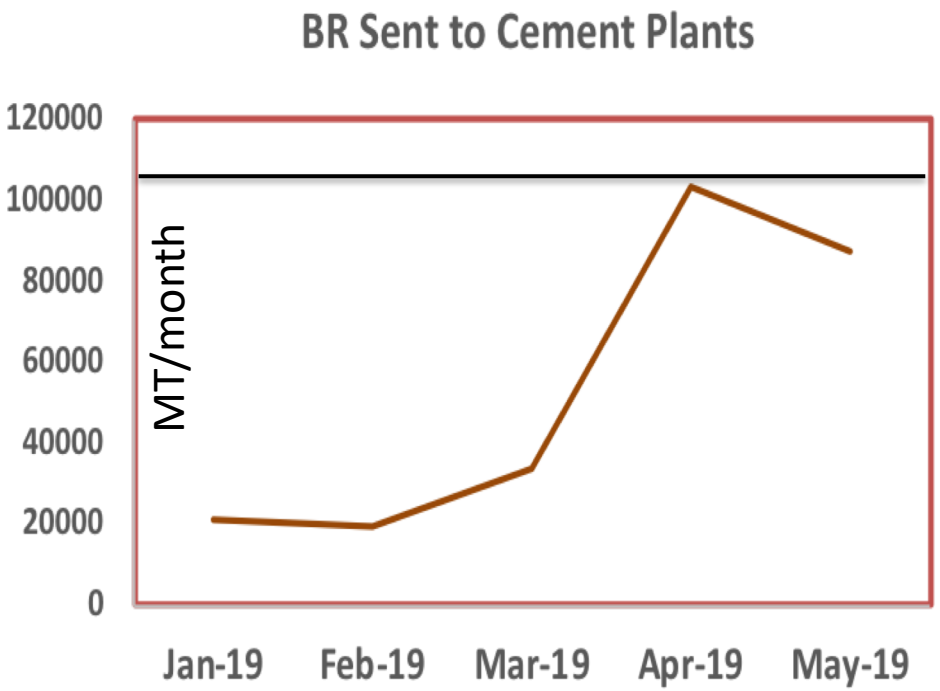
- Limestone is major ingredient in the raw clinker mix.
- Al/Fe rich clay is added to adjust the composition mix as per the desired value
- BR is direct replacement of this Al/Fe rich clay (E.g. Laterite) and thus serves as bringing value from waste and conservation of natural resources
- **No difference in quality of cement reported by use of BR**

Comparison of BR Vs Laterite

	Laterite, %	Bauxite Residue, %
Moisture	11.9	21.2
SiO_2	22.3	17.1
Al_2O_3	18.9	17.4
Fe_2O_3	41.0	36.5
CaO	0.1	0.7
MgO	0.2	0.7
TiO_2	2.2	7.3
K2O	0.3	0.7
Na2O	0.0	6.4
LOI	14.7	12.4

Hindalco's Approach on Bauxite Residue Management

Recycle: Well Established Use In The Cement Industry



Potential utilization based on annual cement production capacity:

Total Cement Production in India in 2018	297	Mi Tonnes
3% Use of BR in Raw mix	**10.7**	**Mi tonnes**
BR Generation in India	**~10.0**	**Mi tonnes**

Current utilization of red mud is about 30% of annual generation @ Hindalco due to the prohibitive logistics cost of transport

Utilization Of BR In Construction Industry

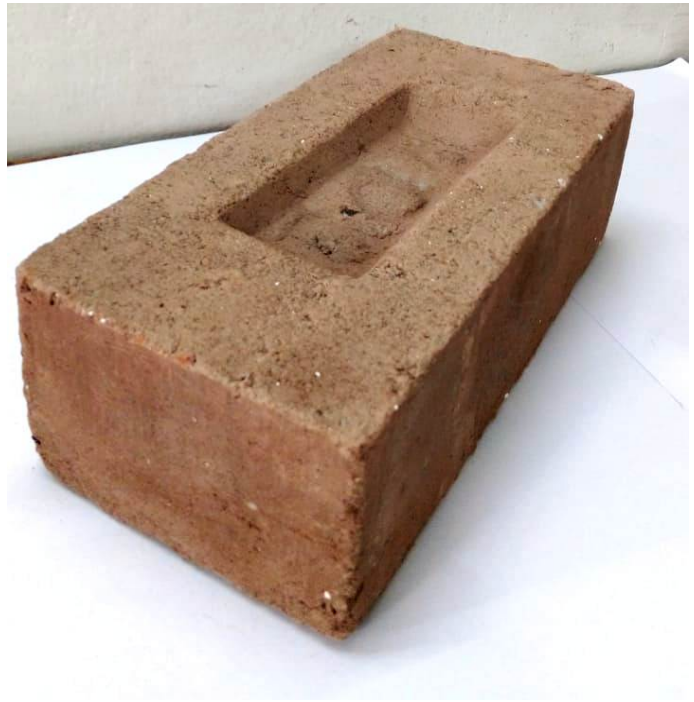
1. Building through bricks, paver blocks, roof sheets, plastering material
2. Making roads
3. Making railway embankments
4. Soil conditioning

Hindalco's Approach on Bauxite Residue Management

Recycle Of BR To Construction Industry

Red Mud Bricks at Hindalco Renusagar

- Using Red Mud : 25-35% , Bottom Ash + Fly ash :30-45% , OPC cement :5-15% & Natural River :15-25%
- Alternative to Fired Clay Bricks and quality parameters as per IS 13757:1993, IS 3495:1992
- Equivalent to Class Designation-10 & 7.5 / Grade –A &B
- Tested through IIT-BHU on Compressive Strength, Water Absorption and efflorescence
- Manufacture started from 22.03.2018
- Applications: Boundary walls; Non load bearing walls; Flooring; for different schemes of Govt like PM Awas Yojna, Swachh Bharat etc.



PRODUCTION & SALES (In No)- FY: 2019-2020 (April to 22nd July 2019)				
Production	Sales			Balance
53,108	Internal	External	Total	
	5,000	31,500	36,500	16,608

Hindalco's Approach on Bauxite Residue Handling

Recycle Of BR To Construction Industry

Project Title – Alternative Mortar

- Made from a combination of Red Mud: 10-15%, Bottom Ash & Fly ash: 50-60%, OPC Cement: 10-15% and Natural Sand:10-15%
- TECHPLAST is ready to use Ordinary Cement based plaster/render with a high quality additives.
- Applications
  - It can be used inner & outer surface of masonry & concrete structures and for jointing the bricks.
  - It gives smoother finish than conventional cement sand mortar.
  - It requires low water demand for curing

We used 943 MT of TECHPLAST from FY 17-18 to till 22nd July 2019 in the following areas-

- Boundary wall , Drains in Renukoot & Renusagar.
- Plant Masonry Buildings like DGL & CBL Buildings, Recycling plant building , Office Buildings, MCC & control rooms in Renukoot.
- Truck parking offices in Renukoot

Hindalco's Approach on Bauxite Residue Handling

Recycle Of BR To Construction Industry

Project Title : Road Construction using Geopolymer

Status :

- First trial conducted at Utkal site connecting plant to BR Pond.
- No visible cracks observed on the road even with light vehicle movement

Hindalco's Approach on Bauxite Residue Handling

Recycle Of BR To Construction Industry

Project Title : Paver Block Manufacturing using BR

Status :

- Geo-polymerization technique was utilized to prepare paver blocks using BR, fly ash and Cement
- Lab & pilot scale trials concluded at NML with desired strength of 20 MPa after 28 days
- Paver Blocks were laid at two identified locations at Muri Alumina Plant & observed for few weeks
- Paver blocks remained mostly unaffected even after exposure to open atmosphere , except some white patches due to efflorescence

Hindalco's Approach on Bauxite Residue Handling

Recycle Of BR To Construction Industry

Project Title : Roofing Sheet manufacture using BR

Status :

- Plant trial conducted with 10 t of BR from UAIL at Balasore plant in Odisha
- There was an increase in strength of roofing sheets by ~ 15%
- Roofing sheets manufactured from UAIL BR were sold in the market
- HIL is working on further improving the properties of sheets

In Conclusion On Utilization Of BR

Aligning BR Generation and Utilization

1. Potential of utilization of BR for the 3 purposes to be aligned to generation.
2. Criteria for alignment would mainly be geographical location since it influences:
   - ***Quantum of generation:*** highest quantities in Odisha (~75% of total BR generation in India, all of NALCO and Vedanta and 45% of Hindalco)
   - ***Logistics cost:***
     - Proximity to cement plants, mines pits, road, railway construction projects
     - Proximity to end users of construction products
     - Proximity, access to railway network, highways

Generating locations	Potential End Use of BR
Odisha	• For backfilling and rehabilitating mine pits • Road making
Others – UP, Jharkhand, Karnataka	• Cement • Road making • Construction products • For backfilling, rehabilitating mine pits, stone quarries, among others

Need to agree on dates for various stakeholder interactions and inputs

In Conclusion On Utilization Of BR

Aligning to agenda set by Mr. Nayak:

- Scaling up of laboratory projects to commercial scale
- Technologies to reduce quantity and improve quality of BR
- Requisite regulatory framework for utilization of BR
- Incentives to cement and construction sector for using BR
- Cost effective ways to store BR – the way it is currently stored seems both hazardous and expensive
- JNARDDC to document all deliberations

Aligning to agenda set by EU- REI team:

- Sharing of experiences and knowledge from applied research projects
- Screening of ways and means for commercialization of innovative technical solutions
- Technologies to reduce quantity and improve quality of BR
- Suggest required policy framework and standardization of products made from BR
- Possible future cooperation on 4 topics:
  - Utilization in Cement
  - Utilization in construction and building sector
  - production of stabilized bricks & blocks
  - extraction of metals

Thank you