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ENVIRONMENTAL ACCOONTING OF NASTE MANAGEMENT TECHNOLOGY IN KOTAH STONE MINING: A CASE STUDY

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ABSTRACT: Extractive industries, like mining, are viewed by many as écologie pariahs that spoild nature and feed the over consumption of finite resources. Indeed, the results of past practices, often insensitive to environment contribution to the mining's poor public image. However, it is always possible to reduce environmental damage at a cost by modifying production process, altering the nature of technology used, recyclingh the waste for product recovery and rehabilitating the residuals. In Kotah Stone mining, solid quarry wéste has caused the most serious environmental concern. In the paper, the author discusses case studies on the cost involved in technology in curbing the environmental damages from waste visa-vis environmental advantages, social welfare benefits and financial gains obtained out of such technology in Kotah Stone Mining.

INTRODUCTION

A century ago RUSKIN had said that "God had lent us the earth for our life time. We are here as leaseholders. Leaseholders with a huge responsibilities. It falls on us to reconcile the needs of the living with our obligations to future generation". We have to find a balance bewtween the needs of people and environment in which they live. Natural resources of minerals are exploited to meet the needs of people. The production activities depend on exploitation of minerals and disposal of waste. Environmental problems are created where generation of waste exceeds the recycling and or and or absorption capacity of sink. Some such conditions have been created in Kotah Stone Mining. Today KOTAH STONE mining industry is facing increasing pressure to eliminate or atleast reduce waste and pollution.

KOTAH STONE

Kotah Stone is fine grained natural riven limestone. It has natural splits. It comes in two colours; greenish blue & warm brown. It is very tough, compact and has a crushing strength of about 25,000 lbs. per Sq.inch, which is 2^ times that of York, Portland and Traventine Stone. The abrassion value being proportionately higher, the relative surface wear loss is low. It has high resistance to delamination and failure under freezing and thawing conditions. It can be given an egg-shell finish or mirror polish for interior flooring and wall cladding. It is an excellent flooring stone and has proved popular within the country and abroad.

OCCURRENCE

Flaggy limestone beds/layers yielding Kotah Stone Slabs are associated with Suket Shale stage of Semri Series of Lower Vindhyans. The limestone beds dip 1 IN 13 to as steeply as 1 IN 2.5 and runs over a strike of 51.5 km. Fig.l gives a typical secton across the deposit. Naturally splittable layers which yield flooring slabs are confined in 15m. zone. It is overlaid by 12-16m. thick non-splittable layers/beds of limestone. There are some 200 splits with thickness between 12mm to 75mm and concentrated in four prominent zones. Each such zone is separated from the other by an interbedded waste bands. Waste bands consists of thick non-splittable layers.

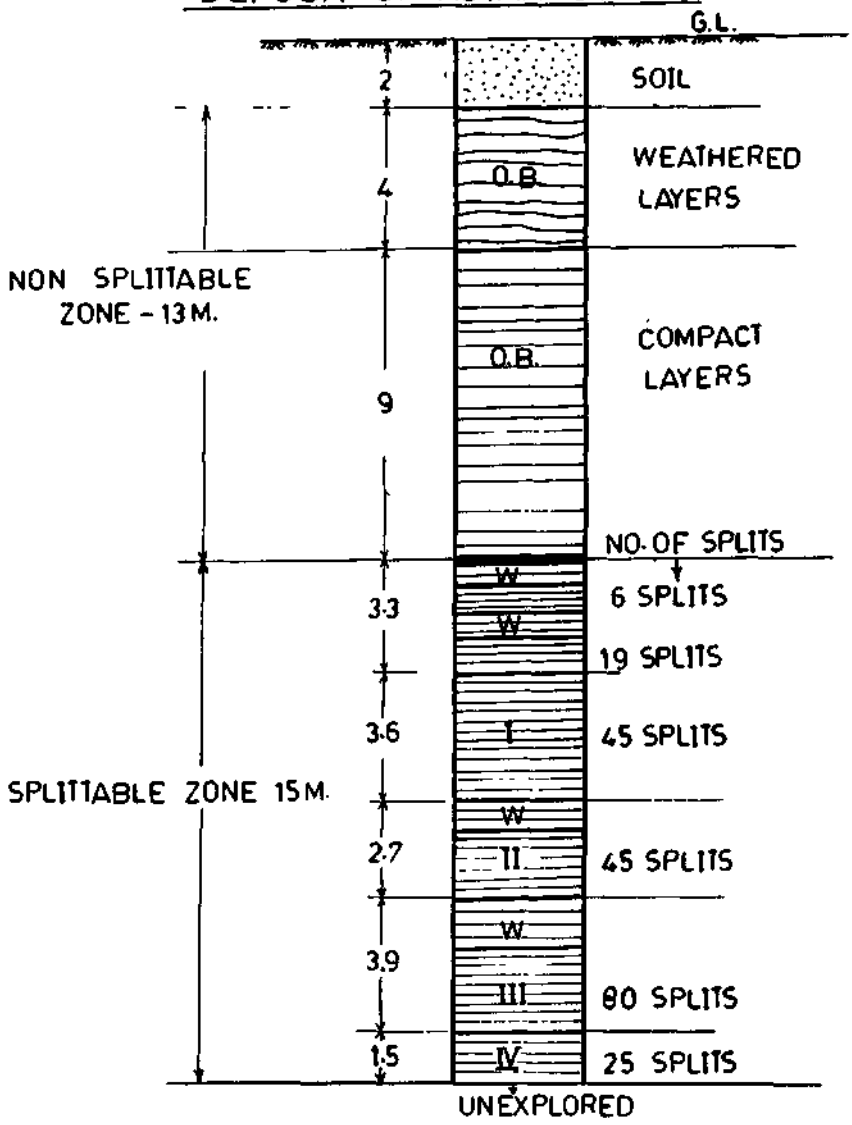
MINING

Kotah Stone mining has taken place for seven decades starting with a few thousand Sq.ft. to the present annual level of 180 million Sq.ft. The need of economical flooring stone like Kotah Stone has increased over the years and perhaps its rising demand may not be ruled out. Being an economical stone, unfortunately the industry has attracted enterprenures in an unorganised sector excepting Associated Stone Industries (Kotah) Limited.

Over the years mining of Kotah Stone has been all manual. Productive zone 15m. in thickness and consisting of 220 naturally splittable layers, has been exposed by excavating and removing some 12-15m of O.B. mechanically.

Mining for Kotah Stone starts with separating the layers from natural bondage by crowbar and chiesel. The

Fig. 1. GEOLOGICAL SECTION ACROSS THE DEPOSIT OF KOTAH STONE



DETAILS	SPLITTABLE LAYERS	W NON-SPLITTABLE LAYERS
NO. OF SPLITS	220	NO COUNTING YET
AGGRE GATE THICK-NESS	6.9	8.1

ALL Fig. IN METER

stone layer breaks non-dimensionally depending free face available. It is then sized to largest possible by chiesel and hammer. Finally/ it is splitted along natural slip planes to yield single solid slab ready to use.

The natural surface of Kbtah Stone has roughness of 2-3mm. It snoothend by rubbing one stone above the other mechanically. Sand is used as abrassive for polishing and after polishing it is discharged inform of tailing waste with water.

WASTE

Waste in Kotah Stone Mines has its own definition and includes:

1 Top soil, subsoil, weathered brownish bedded limestone. Total thickness is about 6m.
2 All layers thicker than 75mm which are non-splittable and also all those layers which can not be cut to size by chiesel and hammer. These are confined in 9m. below the brownish zone and also anywhere in the production zone.
3 All splits thinner than 12nni.
4 All pieces of splits in any thickness smaller than 30cm x 30cm.

The soil rocks beds occurring under group 1&2 are presently classified as overburden while rock beds/layers appearing in group 3&4 are termed as production waste.

ECONOMIC S ENVIRONMENTAL PROBLEMS

Economic Problems:

Over these 70 years of Kotah Stone mining the generation of total wate for each unit of Kbtah Stone has appreciably increased, Fig.2 A. The increasing cost of waste handling per unit/ Fig.2B.has threatened the economic viability of the Kotah Stone mining. It alone constitutes 40% of the total cost of production, the capital investment on waste handling equipment constitutes 80% of the total investment in mining of projects.

Environment Problems:

The conventional mining of Kotah Stone over these years has posed a serious threat to the regional environment. The most serious impact of mining on regional environment is due to generation and disposal of huge quantity of solid waste from mines and tailing waste from polish units.

1. The average rainfall has gradually reduced from 86cm during 1960-69 to 78cm during 1980-90.
   Due to poor recovery and huge waste, land has been fast degraded.
   General water table has gone down creating severe scarcity of drinking water.
   There has been increase in general ambient temperature.
   Due to hafazard dumping of waste, the general water courses, drains have been blocked. General highways have been damaged due to flooding.
   There has been a change in job pattern with people diverting from farming to stone mining.
   Extensive and frequent use of high explosive for waste excavation has changed the general water regime by including and widening the cracks in rocks.

MANAGEMENT OF WASTE

The battle against the weaste has to be fought simultaneously on all fronts to win it in totality.

1. Reducing the General of Waste:

It is rightly said that prevention is better than cure. This if we can reduce the waste generation, we need not to worry to manage it. It is always possible to reduce environmental damages by altering the production technology.
The Rio Declaration extends the willingness of different countries for exchange of scientific & technological knowledge, diffusing new and • • innovative technology to reduce environmental degradation.

A. Upgrading Quarrying Technology:

The conventional way of quarrying Kotah Stone comprised separating the layers by crowbars; splitting them along cleavages and finally sizing them all mannually. Now if the process is reversed i.e. sizing the layers insitu mechanitally, then separating by crowbar and finally splitting along natural split; there shall not be any waste except when there is natural crack. Globally many new machines for quarrying dimensional stones have been innovated, tried, modified and perfected. A perfect combination of right machine has been tried on Kotah Stone.

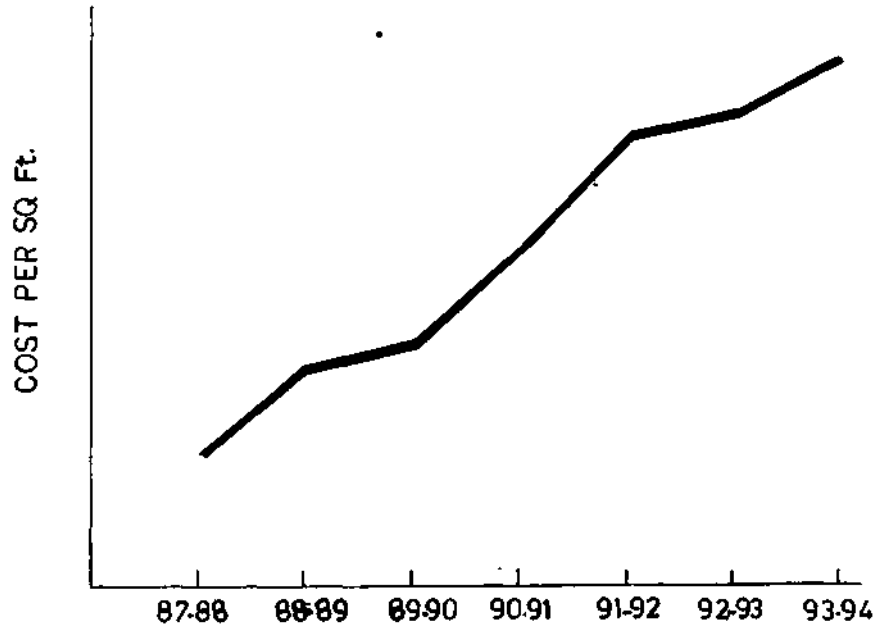


Fig 2B COST OF WASTE HANDLING PER SQ. FT.

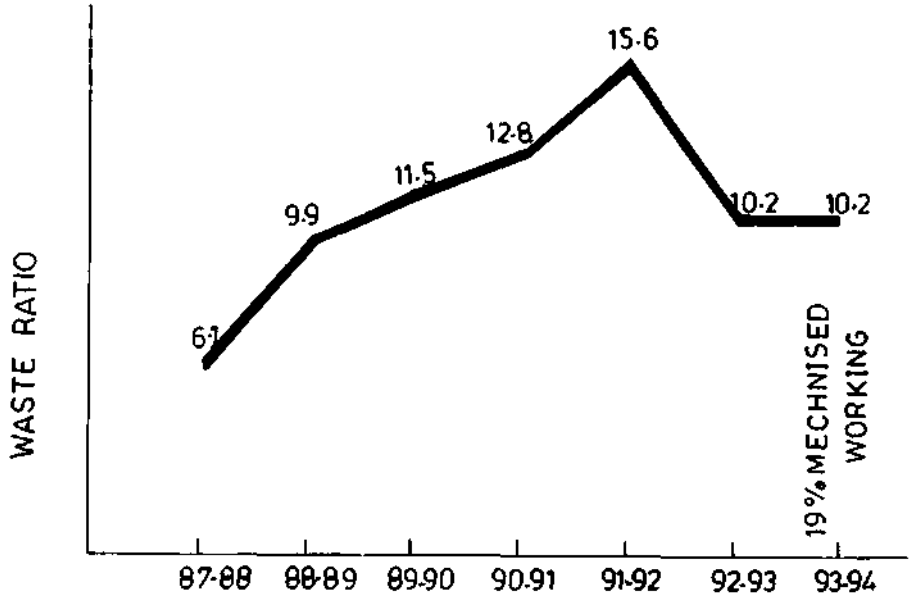


Fig. 2A MINERAL TO WASTE RATIO

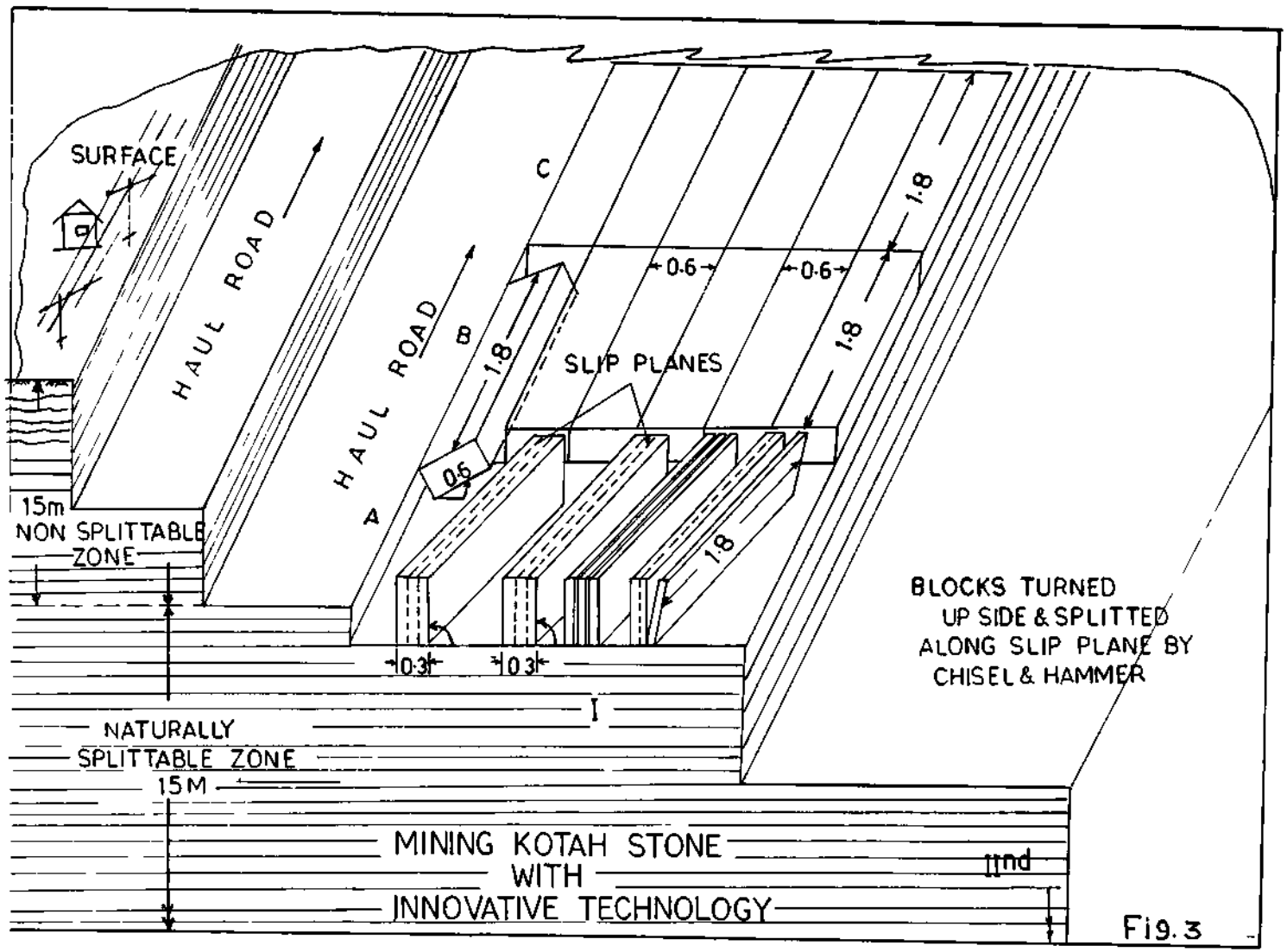

SURFACE
HAUL ROAD
HAUL ROAD
A
B
C
1.8
0.6
0.6
1.8
1.8
SLIP PLANES
0.5
1.8
15m
NON SPLITTABLE
ZONE
0.3
0.3
BLOCKS TURNED
UP SIDE & SPLITTED
ALONG SLIP PLANE BY
CHISEL & HAMMER
I
NATURALLY
SPLITTABLE ZONE
15M
MINING KOTAH STONE
WITH
INNOVATIVE TECHNOLOGY
IInd

Fig. 3

An appropriate technology of quarrying Kotah Stone has been adopted by the author in some 12 pits covering an area of 25,000 Sq.m. Portable diamond wheel cutters using 800mm to 900mm dia circular discs with diamond tips have been extensively used. The layers over the area are cut in a check-board fashion with an interval of 0.6m along the dip and l.im along strike and to a depth of 0.30m yielding a block of 1,8x0.6x0.30m. Each such block is then separated from natural bondage with crowbar and turned side way. The blocks are then slatted along natural cleavages to yield finished slabs ready to be used as rough or after sand smoothing the surface, Fig.3. .

During the process it was not only the identified 220 splits which were quarried with optimum recovery(85-90%) but also the thick layers so far been broken and thrown as waste, were mined. Such thick unsplittable blocks were sliced mechanically to yield saleable slabs in thickness desired. Such slabs have been found to be identical in chemical and physical qualities, with one or two sides getting polished when being sliced.

An attempt has been made to workout the economics of waste reduction technology and tabulated in Table No.i .

From the above it is well evident that environmentally clean technology does not only reduce the pollution from waste but ensures economical growth of the Kotah Stone Industry.

B) Working of Overburden.

An attempt is being made to even work compact part of O.B.to yield Kotah Stone slabs. It is being planned. to remove top 6m. weathered O.B. without using heavy explosive. The remaining 9m. compact overlying zone will be cut by diamond chain saw to form long benches 6m. wide and 3m. high.

The benches will then be cut into 6m. blocks by diamond wire saw. Each such block will be worked by diamond wheel cutters to yield blocks of 1.8mX0.6mXthickness. The blocks will be processed as above on multiblade gang saw or disc saw to yield saleable slabs in desired thickness (20mm to 40mm.) Fig No. 4-

It is expected that out of 15m O.B. at least 6m. will be recovered in the 1st year and subsequently upto 8m. Thus it will help in further reducing the waste generation and its disposal to a large extent as is evident from Table. 2-

C) Prohibition of Use of Explosive.

Explosive on detonation includes cracks, widens the existing hair cracks and reduces and recovery of mineable slabs and tiles. Its use is to be restricted and finally banned to avoid the mineral turning into waste. It will also allow the soil and subsoil to retain rainwater & make available for recharging the wells.

While working on the economics of the prohibition on the use of explosive, it is revealed that at the present level of annual production of 150 Million Sq.ft., 390 M.T. of explosive will be saved annually. With the commercial working of part of O.B. zone, this saving will go upto 600 M.T.

Thus the restriction on the use of explosive will not only help in reducing generation of waste, but also will minimise damage to natural water regime and reduce cost of production.

2) Utilisation of Thick Waste Layers for Recovery of Kotah Stone Slabs:

As mentioned earlier, 9m. of 15m. productive zone consists of thick non-splittable layers. These layers have so far been categorised as waste layers and broken to pieces to expose next splittable layer. This has been a matter of serious concern both financially and environmentally. In 1990, a proto type splitting machine was designed and fabricated to split 75mm thick slabs vertically into two halves by 900mm circular diamond wheel. The two halves each of about 35mm were found to be as good as natural split and with better smooth surface. Being encouraged with the results, the machines have been modified to suit 1200mm & 1600mm dia circular diamond wheels. This made it possible to split 0.60m wide blocks.

Now that trial are being made to design horizontal splitting machines which will be more productive, economical, versatile being a continuously operating machine. Yet one morealteration in the splitting technology has been made by using multiblade system. Here a number of blocks thicker that 75mm are arranged together and are sliced by a frame

ECONOMICS OF WASTE REDUCTION TECHNOLOGY IN KOTAH STONE MINING TABLE: 1

Case Study: Waste Reduction: 5 lac T P.A. Production: 100,000 Sq.ft.(S.F.)

Sr. No.	ADDITIONLA INPUTS Particulars	Capital Investment Lac Rs.	Cost/S.F. Rs.	SAVINGS Particulars	Physical Achievements	Cost/S.F. Rs.	Nett Savings
1		2	3	5	6	7	8
1.	Portable Diamond Wheel Cutters	35		1. Savings on O.B. handling	3.5 Lac T	0.30	
2.	Handling Equipment	10		2. Saving on Production Waste	1.5 Lac. T	0.13	
3.	D.G. Sets	26		3. Savings on Labour due to better product -ivity	From 40 To 60 Sq.ft.	0.30	
4.	Electrical+Pumps	14					
		85		4. Addition to Sale Value due to better size & quality.		1.50	
5.	Cost of tool for in-situ cutting		0.42				
6.	Cost of fuel/ Lub.		0.30	5. Reduced Int. + Depreciation on HEMM due to less waste handling.	Reduced Capital Investment of Rs. 51 lacs.	0.12	
7.	Cost of Addl. labour		0.10	6. Recovery from reclaimed land put back to agriculture flow		0.06	
				7. Saving from supply of drinking water by tanker due to better water table .		0.08	
						2.49	Rs. 1.43 per S.F. Rs.143 lac per annum.
				8. Savings on drilling & blasting due to reduce waste handling.	Cleaner environment . Reduced damage to dwelling.		
				9. Savings on mandays lost an accident.	1000		
				10. Aesthetic value	Much better view due to reduced height of dumps.		

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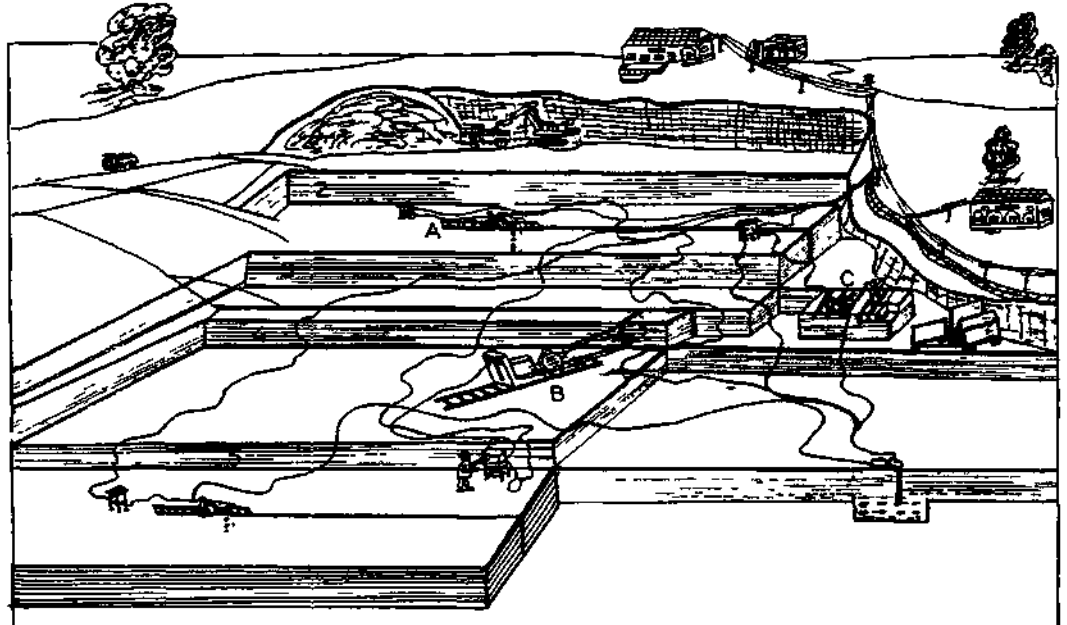
CONCEPTUAL MODEL OF ALL MECHANISED MINING FOR KOTAH STONE

A - Bench cutting by Chain Saw B - Block cutting by Wire Saw
C - Slab Production by Diamond Cutter



1. Removing the top weathered O.B
2. Mechanical working of O.B. for slab production.
3. Mech. working of Ist zone.
4. Mech. working of IInd zone.
5. Mech. working of IIIrd zone.
6. Mech. working of IVth zone.

Fig. No. 4.

TABLE: 2

TABLE: REDUCTION IN ENVIRONMENTAL POLLUTION

TECHNOLOGICAL APGRADATION	MINING TECHNOLOGY	PER 10MILLION SQ.FT. PRODUCTION OF KOTAH STONE			ANNUAL SAVINGS FOR ENTIRE PRODUCTION: 150 MILLION SQ.FT		
		Savings on Environmental Polluter as Compared to Manual Mining			Savings on Environmental Polluter as Compared to Manual Mining		
		Diesel (K.Ltrs) & cost (Mill.Rs)	Explosive M.T. & Cost (Mill.Rs)	Soli Waste Disposal (Mill. T.)	Diesel (K.Ltrs) & Cost (Mill.Rs)	Explosive (M.T.) & Cost (Mill.Rs)	Solid Waste Disposal (Mill. T.)
	Phase-II Mechanised working As in Phase I Plus Mechanised working of 9 Mtrs compact Stratified O.B. Layers	123 (0.96)	41 (0.37)	0.41	1845 (14.43)	600 (5.4)	6.15
	Phase-I Mechanised Working of Natural Split & 3 Inter-Bedded Bands	78 (0.6)	26 (0.24)	0.26	1200 (9.36)	390 (3.5)	3.9
	Manual working only 220 Natural Split (Present Status	-	-	0.5			

consisting 30 diamond blades arranged at 35mm spacing. The blades have reciprocating motion rather than circular.

The splitting technology of thick waste layers proved to be a big break through. It has made it possible to utilise commercially all those layers which have broken to waste pieces over last 70 years. Its impact on reduction of environment degradation has been felt/ besides improved mineral conservation. The economics of the technology has been worked out and tablulated in Table No.3

3. Utilisation of Broken Mine Waste:

An attempt has been made to utilise the part of mine waste which cannot yield any dimensional stone. This is indues:

A) Manufacturing Calcium Silicate Bricks. Lime waste from mine has been calcined and suitably blended with sand or polish waste which Contains + 78% SiO^2 and finally auto claved. The bricks so manufactured are found to be 5 times stronger than ordinary clay bricks.

This whole process is found to be highly environmentally friendly:

1) Manufacturing such bricks does not require clay. This results direct saviing of fertile agriculture land and increasing output of food grains.

2) These bricks consume less energy than burnt clay bricks and a saving of about 30% is envisaged.

3) The manufacturing process converts the pollutants into useful building material and thus getting rid of pollution hazard.

B) Indirect calcination of lime waste from mines is expected to yield good quality hydrated lime. This can be used in building construction.

Any quantity of mine waste that can be utilised to meet varied social need of humanity will reduce the environmental degradation by solid waste disposed otherwise. The economics of the above process of waste utilisation is found to be very favourable.

4) Rehabilitation of Waste Dumps:

Even with the optimum conservation of mineral and recycling waste layers for the recovery of Kotah Stone Slabs; there will be good residual quanlity of waste from quaries. This is filled back in the areas void of mineral. With the sharp reduction in waste generation/ it is now possible to reduce dump heights from past 13-15m to just 1m above ground level. The dumps are levelled. Soil from the advancing faces of quarry is the excavated separately and transpored to thee levelled waste dumps. A cover of 1-1.5m of soil is provided all over the stone dumps. The edges are protected by stone walling from soil erosion during rains. The reclamation of waste dumps proceeds in stagees with the advancement of mine workings.

It is then followed by plantation of hardy species like Prosopis Julifro, Acacia Tortitis, Ailanthus Excels and some species of local orgins. Water collected during rainy season in advancing pits is pumped back to plantation area for watering. Within a period of 5-7 years/ plants bloom to full trees fetching good commercial value. May be after creating original bio-environment, the reclaimed land is put back even to original land use for agriculture.

It is estimated that with improved water regime and the agriculture yield will improve. A case was made to keep the account of land reclamation practice and is tabulated in Table .

From the table it is evident that the systematic reclamation of waste dumps not only helps in restoring the land for original land use of agriculture but also offset the entire cost incurred additonally on the reclamation and even at times generate additional funds for further waste rehabilitation. Thus land loss has been only temporary. However/ there has been some loss of soil during handling/ transfer or storage.

TABLE: 3

ECONOMICS OF UTILISATION TECHNOLOGY FOR THICK WASTE LAYERS OF KOTAH STONE

Case Study: Annual Waste Utilisation: 30,000 M.T. Final Produce: 19 Lacs Sq.ft.

Additional Inputs				Savings			
Sr. No.	Particulars	Capital Investment (Rs.in lac)	Cost per Sq.ft. Rs. (4" thick)	Particulars	Physical Achievements	Cost per Sq.ft. Rs. (1.7"thick)	Nett Savings
1.	Splitting Machine & Equipment	30		1) Produce available after splitting at 80% recovery	19 Lac Sq.ft		
2.	Handling equipment Load Haul. Mobile Crane	15		2) Cost of sale @ Rs.12/-x 2 pcs		24.00	
3.	Foundation, Building	5		3) Savings from polishing not required on splitted material		3.00	
4.	D.G. Set Elec.	5		4) Savings from handling equivalent quantity of waste.		0.25	
		55				27.25	
5.	Cost of raw material 4"thick(12 lac Sq.ft)		12.00	5) Savings from tailing waste disposal	2000 M.T. per annum		+Rs.5.00/Sq.ft. Rs.96 lacs p.a.
6.	Splitting cost 1 cut each block 2 pcs. @ Rs. 3 x 2		6.00	6) Air & Water Pollution	Much clean atmosphere		
7.	Cost of handling from mine & plant		3.00				
8.	Cost of depreciation & interest.		1.25				

ECONOMICS OF LAND RECLAMATION IN KOTAH STONE MINING.

Case Study:

Land area	100,000 Sq.ft.
Total Mineral Resources	20 Mill.Sq.ft.
Annual Rate of Production	3.5 Mill.Sq.ft
Mining Period	6 Years.

Table: 4.

Additional Investment Made		Benefits Drawn	
Particulars	Amount Lac Rs.	Particulars	Amount Lac Rs
Cost of level1 -ing the stone dumps.	0.50	Sell proceed from the 1500 trees after 6 years.	2.25
Cost of soil transfer (in any case the soil had to be excavated alongwlth over burden).	Nil	Value of land after réclama -tion and giving back for agriculture 75% of original 25% area not back filled and works as Water	5.00
Spreading & levelling of soil.	0.50		7.2Ö
Planting and afforestation 1500 plants, rep.[1] acement casualties.	0.25	Net gains available for further land development	
Providing water, fencing beautification etc.	2.00	Rs.one lac per hectre.	
Watering, caring etc. for 6 years	3.00		

CONCLUSION

By allocating money value to each damage component, organisation have realised the magnitude of environmental damages inflicted over 70 years of Kotah Stone mining.

Environmental Accounting (EA) of various waste management technologies has given freedom to the management to choose the least cost method of reducing waste load and the one which confirms maximum gains.

EA of waste management techniques in Kotah Stone mining, which was thought to be complex position, has proved to be a valuable cost reduction management tool and has helkped in protecting the environment.

EA has infused confidence in adopting an appropriate technology which is a radical departure from conventional method of Kotah Stone mining organisations are now investing large capital with confidence in modernising the mining techniques of Kotah Stone.

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