UTILIZATION OF SLATE MINE WASTE: A STUDY

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ABSTRACT

The extraction of slate generates huge amounts of waste. As much as 50% of the material is wasted during the extraction, cutting and dressing operations. Based on laboratory work carried out by author it is analysed that the slate waste can be used in the preparation of concrete blocks for application in building construction. These blocks will be cheaper and economically viable for use in hills where conventional bricks are in short supply.

Thus, this paper provides a case study for utilisation of slate mine waste in to value added product , to be used for application in building industry.

Key Words: Slate, slate waste, concrete blocks, hill area.

1.0 INTRODUCTION

Slates are regionally metamorphosed argillaceous rocks. These are found in nature in both thinly and thickly bedded formations with slightly undulating surfaces and well-developed cleavage planes. It is a low value mineral, which is used principally as *roof tiles in buildings* or as *writing pads.* These are being mined at a number of places in India and distributed through dealer networks all over India. The present study of waste utilisation generated by the mining of slate, is a site-specific study characterised by some important topographical and ecological features such as -

(a) Hilly Topography and Slate Mining on Acute Angled Slopes - The site, where slate waste generation took place has a hilly topography and due to this, there is a limited availability of space for waste storage and movement of man and material. This has resulted into the dumping of waste all along the hill slopes causing environmental hazards and an eyesore (Fig.-1).

(b) Fragile Environment – The study site has a fragile ecology (a characteristic feature of Himalayan land area). Excessive generation of slate and its progressive accumulation over hundred of years of exploitation has resulted in the destruction of the ecology of the region.

About 400 small-scale manual mine leases (called "pits") are operative for slate extraction in the area of study and are the principal source of waste generation. Manual extraction, an age-old and outdated methodology of ‘pick and axe’ has led to generation of huge amount of slate waste in these pits (Fig.-2). According to the estimate made by the author [1] it is revealed that ratio of - *Usable slate : Slate waste* are in the ratio of 1:1 (based on field evaluation). This means that as much as 50% of the slate waste is generated, mainly during slate cutting, slate dressing and slate extraction operation, which is a purely manual exercises carried out by both skilled and unskilled local workers.

Fig.1: A View of Degraded Slope Due to Dumping of Slate Waste

Having assessed the actual field conditions by the investigating agency (Central Mining Research Institute) and discussions among concerned state and local authorities (Department Of Industries, Shimla), it was decided that the waste generated from this area must be studied from technical angle for development of some value-added product. Its possible industrial application should also be explored in detail. As a result, this investigation work was initiated and during the course of this endeavour, laboratory investigations were undertaken and conclusions were subsequently drawn. In this paper an attempt has been made to explore possible usage of the slate waste for concrete block making, to be used in building construction subsequently.

Fig.2: Manual and Age old method of Slate Mining Generates Huge Amount of Waste (Clockwise)
(a) Waste Generation During Slate Extraction (b) Waste Flow into River Block Water Channel
(c) Waste Generation During Slate Dressing, (d) Waste Generation During Slate Cutting

2.0 SLATE WASTE UTILISATION

2.1 Site of Study

The slate waste are generated from *Khanyara Slate Mines* (also pronounced as *Ghanyara)* which are located between longitude 76'20' and 76'25' and latitude 32°11'and 32° 15' (Fig-3). *Khanyara* and Dari villages are the principal centres associated with slate mining activities which are situated, nearly 10-15 Km N-E of *Dharamshala, the* district town of *Kangra Valley* in the state of *Himachal Pradesh, India.* The mines are sited on the southern side of the *Dhauladhar Ranges of* hills overlooking the *Kangra Valley. Narwana and Yole* in the S-E and *Bhagsunag (Kajlot* village commune) in the N-W are the two other slate bearing areas in the vicinity where slate mining is continuing. The slate deposits studied have a strike length of approximately 5 km extending from *Kajlot (Bhagsunag) to Narwana* and has an average altitude ranging from 1750 m to 1850 m above sea level (Fig -3).

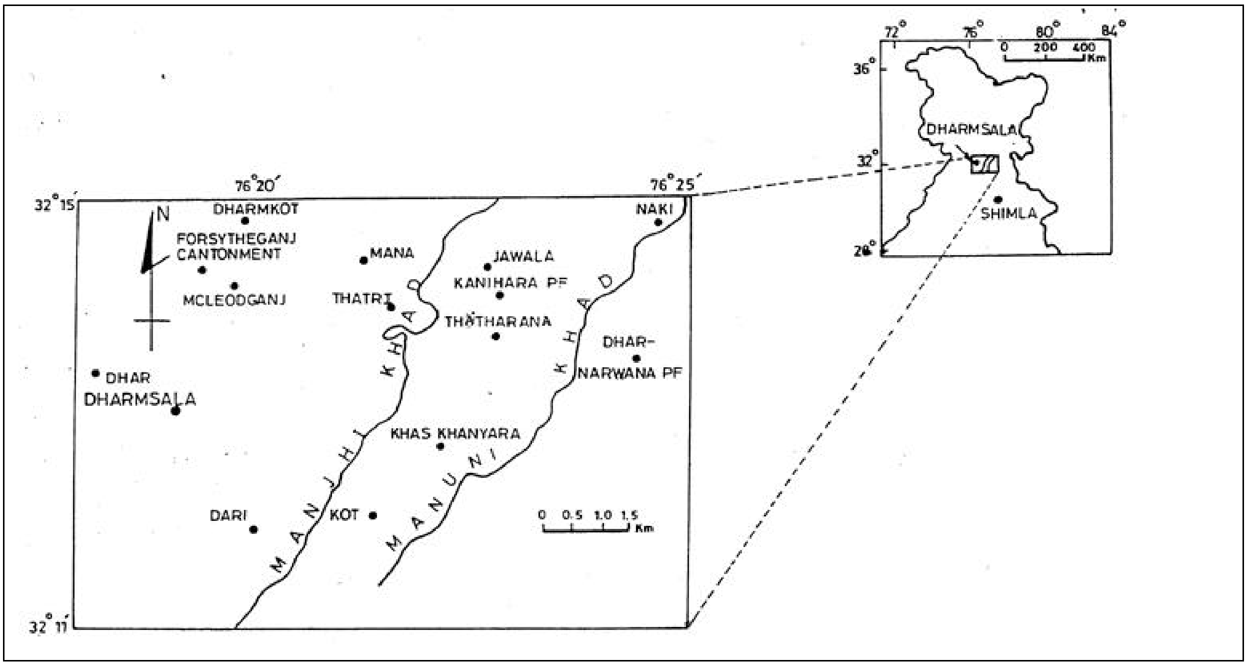

Fig.3: Location Map of Study Area

2.2 The Mining Operation

The method of slate extraction consists of dislodging of slate rocks/beds from their in-situ position by loosening or removing the contact with the host rocks. This is done manually using crowbars, chisels and *other digging tools. When the host* rocks are difficult to remove one or more blast holes are made in the rock (using digging tool and not by drilling machines) and local explosives (These may be *gunpowder* or other local make explosives procured from Dharamshala town). Explosives are placed in the holes to create fracture line. Since, the slate formations are horizontal by its vary nature, even small fractures are good enough for dislodging of slate. The *bigger* pieces of slate (called *Pauri* in the local language) are dressed into smaller sizes by labourers trained in slate dressing. The slate size (thickness * length * width) depends on the market demand. The bigger the size of slate, the higher the price it will fetch.

2.3 Laboratory Investigations

To assess the possible uses of slate waste following work was carried out in the laboratory.

- ⇒ Slate waste were collected from different sites of field in jute bags and transported to laboratory for investigation.
- ⇒ Part of the waste material was crushed to make aggregate and some of it was used as in its original form for block making.

⇒ From the crushed material and waste chips, concrete blocks of size (290* 190* 140 mm) were made using cement as the binding material *(Fig. - 4)*.

Fig.4: Concrete Blocks Made Out of Slate Waste

In different aggreate: cement ratio as mentioned in Table-1 total 80 blocks were casted (twenty blocks for each category). Out of these eighty blocks ten blocks (1,3,2 and 4 blocks in category no. 1,2,3 and 4 respectively = 10 blocks total) were broken and could not be tested for drawing results. Available intact blocks were tested to determine their properties, namely compressive strength, water absorption and drying shrinkage etc. The details are as reported in *Table* - 1&2. The reported results summarised in table-1 are the average values of seventy samples / blocks tested.

⇒ Laboratory tests for masonry strength, its use etc. were carried out using blocks of different compressive strength and results are summarised (Table - 1).

2.4 Results and Discussions

The test result shows (*Table–1)* that blocks made out of the slate waste -

- Have a strength varying from 7.8 to 10.2 MPa for different cement consumption rates.
- Have 25% more strength compared to the brick masonry units.
- Concrete blocks made from slate waste has a low cement consumption and drying shrinkage percentage (minimum = 0.026 at aggregate: cement ratio of 15)

Hence, following inference can be drawn -

- The slate waste concrete blocks having strength of 7.8MPa strength (with 1:6 cement, sand mortar) are suitable for use in two storied residential buildings using 20cm wall thickness.

- On the basis of the review of the existing building construction practices as adopted in India, such concrete blocks of slate waste are suitable for use as load bearing walls in residential buildings.
- The slate waste material cannot be used for producing coarse aggregates as the material is small / thin (>3mm but <10mm approx.). It can be used to produce fine aggregates for building and road construction activities e.g. mortar making, reinforced cement concrete (RCC) and plain cement concrete (PCC) work.

2.5 Economic Viability

The tested blocks were found economical compared to brick masonry or random rubble masonry because of its low cement consumption. The cost of blocks is estimated as 0.80 to 1.00 Rupees per equivalent brick cost (Each brick cost 1.2 Rupees to 1.8 Rupees). Since, the major cost of producing concrete blocks depends on the cement consumption they are cheaper than bricks. It will be more economical in hill areas as bricks are not freely available and if available they are costly due to high cost of transportation. For more details of casting and costing of waste blocks and their economical viability reference can be made of Building Research Notes No.69 and 70 [6&7]. Such blocks can be made using portable machine (egg-laying type) at the site of waste production or at a desired site in the vicinity. *(Fig - 5).* Block making machine is available locally and its details can be collected from *Central Building Research Institute, Roorkee, Uttranchal, India.*

Table 1 : Details of Concrete Mixes and Properties of Concrete Blocks Made from Slate Waste

S. No.	Aggregate : Cement Ratio	Compressive Strength - 28 days (in Mpa)	Water : Cement Ratio*	Cement Content (Kg/m^3)	Water Absorption* (in %)	Drying Shrinkage (in %)	Moisture Movement (in %)	Remarks
1.	18	7.8	1.2	120	4.7	0.02	0.028	--
2.	15	9.2	1.0	150	4.6	0.026	0.022	--
3.	12	10.2	0.85	183	4.5	0.031	0.027	--
4.	10	5.0	--	--	10.0	0.10	0.02	As per BIS:2185 (1979) Part-I Concrete Masonry Unit.

Note: The average values reported above are based on testing of 70 blocks.

Table 2 : Masonry Strength and Use of Masonry Wall*

MASONRY STRENGTH :

Blocks Used	:	7.8 MPa compressive strength blocks
Size of Wallet	:	29* 19*45 cm
Mortar	:	1 : 6 = cement : sand
Actual	=	4.1 MPa at H/T ratio = 2.7
Modified failure stress H/T - 6	=	4.1 * 0.7 = 2. 87 MPa
Expected Failure Stress H/T- 6	=	0.58 * 4.0 = 2.32 MPa (as per IS 1905 - 1987)
Efficiency against **brick**	=	2.87 / 2. 32 = 1.237
For vertical load carrying capacity		

USE OF MASONRY WALLS:

for span of	= 2.5 m
storey height	= 3.0 m
for opening in wall equal to	= 20%
stress on central wall per storey	= 0.17 MPa
allowable stress	= 0.59 * 0.84 = 0.47 Mpa

CONCLUSION : Hence, blocks of 7.8 MPa strength with 1:6 ratio of cement and sand mortar can be used safely for two storey residential building construction as load bearing walls.

*** = For the puprose of laboratory work, the material used include:**

- Coarse, Aggregate : Chips 0.6 cm to 0.9 cm Thick = 44.6%
- Fine Aggregate : Fineness Modulus (FM) = 3.0 made out of waste material from the same source.
- Concrete Block Size : 29*19*14cm and
- Weight of Block : 18 to 19 kg

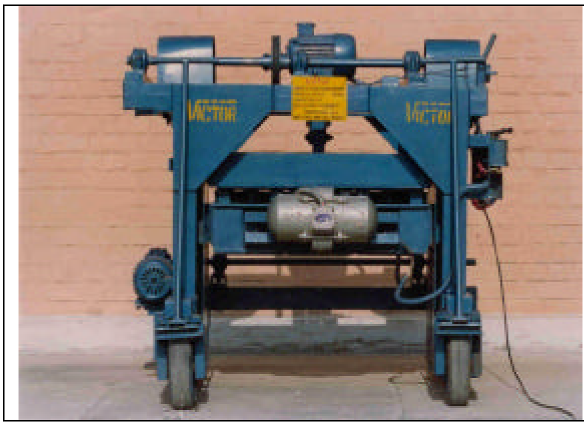


Fig.5: Block making Machine and Block-Making Operation

Based on the laboratory investigations and explanation given above it can be easily inferred that as an alternative/substitute to the conventional bricks or concrete blocks made out of cement, slate waste blocks can be used. Such, waste material blocks are strength-wise competent and has commercial viability as well. Such applications are particularly useful in hill areas where bricks are not easily available.

Concerted efforts in the direction of slate waste utilisation will also help in cleaning of environment and generation of new business avenues for local people.

It may be noted here that efficacy of concrete blocks for building construction is already well tested for construction of *Navodaya Vidyalaya School buildings* in Himachal Pradesh (Chamba), Madhya Pradesh and Andhra Pradesh states of India [6&7]. Rajasthan Housing Board has set up many building centres where concrete blocks are being casted and used as masonry units for residential buildings as load bearing walls.

3.0 CONCLUSIONS

Since, slate waste and its management is a major problem of the area under study waste generation at the source should be as much less as possible. Our first attempt should be - not to generate waste. If generated, it should be utilised for application in building industry as mentioned in this research paper. In order to provide solution to waste utilisation and to keep the environment clean, it is strongly recommended to make "Concrete Blocks" from the slate waste as it is not only eco-friendly but economically viable too. Such applications since require minimum financial investment and are a source of employment generation for local population it should be promoted as far as possible. Promotion of utilisation of waste in this manner will also solve the problem of –

⇒ shortage of bricks for building construction in hill areas.
⇒ provide alternate employment for another 10-20 years in slate bearing horizons.
⇒ availability of cheap construction material for check dams construction (using the slate waste blocks) for slope stabilisation.
⇒ indiscriminate cutting of trees can be controlled to a limited extent as the trees are excessively used for fuel in brick making in the brick kilns.
⇒ Aesthetics of hills plus ecology and environment of the region can be saved from further destruction.

Since the expertise for production of concrete blocks is locally available and economical as well, authors feel that it can be implemented in to practise without any difficulty.

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