

# Muck Disposal and Rehabilitation of Disposal Sites: A Review

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**Abstract:-** During the construction of dam, large quantity of muck has been generated from different structure, from which only small quantity of muck has been used and balance have to be dispose off. In order to reduce the quantity of muck excavated can be possible by improving in the blasting process such as change in the parameter of blasting from which less amount of muck will generate and fragmentation is of desire size, so it can be directly use as aggregate and very less amount of muck have to dispose. Disposed quantity of muck may alter the water quality due to erosion from the site, vegetation at the site will control the erosion. It can be quite useful for taking various priority based mitigating measures such improved blasting, management for control quantity of muck generation as well as different biotechnical measures for controlling the soil erosion and made the site useful by growing vegetable and grain on the site which considered only a waste land during disposal process.

**Keywords:** *Muck generation, Fragmentation, Aggregate.*

## I. INTRODUCTION

A large quantity of muck has been generated as a result of tunneling and other underground excavations, and construction of roads in mountainous areas. Some quantity of muck may be utilized at the site after processing and balance quantity of muck have to transport and dispose. Muck needs to be disposed in a planned manner so that it takes minimum space and will not be hazardous to the environment. To avoid the adverse impacts, the management of muck requires an environmentally sound manner of its disposal and rejuvenation of disposal sites using engineering and biological measures.

S. Strelec *et al.* [1] stated about to obtain beneficial cost for entire production system and fragmentation of muck in control. Fortunately, different technologies are available today for estimation and prediction of size of fragmentation. So, applying the available methods by the construction engineers carefully, optimum size of fragmentation can be obtained and it also reduce the cost of drilling and blasting which therefore cut the cost of whole production system.

Muck disposal sites or location need to be identified in conjunction with the several features such as afforestation easement, proximity to source of generation, little alternation to the surface water and ground water regime, landscape and effectiveness of cost. Muck dumping and rehabilitation of dumping sites has to done to achieve following purposes i.e.:

- For protection of soil erosion.
- Reduce the impact of muck on the project areas due to muck spoilage.
- To develop the dumping yard of muck in combination with the surrounding landscape.

## II. REQUIREMENT OF FRAGMENTED ROCK AS AGGREGATES

E.M. Harboet *et al.* [2] describe that the workability of concrete is largely affected by the selection of aggregates. For each compressive strength level to be obtained with a given aggregate and cement, there is optimum maximum size of aggregates in order to have a maximum cement efficiency. Any change in aggregate quality can be depicted quickly by the specific gravity. Porous, weak, or absorptive material indicates low specific gravity. For use of mass concrete, generally the aggregates having a specific gravity less than 2.5 are not considered. The workability of the mix may be affected by deviation in aggregate gradation. The following table shows the generally practiced grading limits for fine and coarse aggregates, published by the American Concrete Institute Committee of mass concrete. Grade limit for different type of aggregate used in dam construction are shown in Table 1 and 2 [3].

**Table 1:** Grading limit for Fine Aggregates.

S. No.	Sieve Designation (mm)	Percentage retained by weight	
		Individual	Cumulative
1.	9.53	0	0
2.	4.76	0-8	0-8
3.	2.38	5-20	10-25
4.	1.19	10-25	30-50
5.	0.60	10-30	50-65
6.	0.30	15-30	70-83
7.	0.15	12-20	90-97
8.	Pan fraction	3-10	100

**Table 2:** Grading limit for Coarse Aggregates.

Max. size Aggregate in Concrete (mm)	Cobbles (76-152mm)	Coarse gravel (38-76mm)	Medium gravel (19-38mm)	Fine gravel (mm)		
				(5-19)	(10-19)	(5-10)
19	0	0	0	100	55-73	27-45
38	0	0	40-55	45-60	30-35	15-25
76	0	20-40	20-40	25-40	15-25	10-15
52	20-35	20-32	20-30	20-35	1-20	8-15

Keeping this grade requirement in mind for aggregate, a suitable method of muck generation should be adopted so that a defined/controlled quantity of muck can be generated, which could be used directly or with minimum aggregate processing in construction process.

### III. BLASTING AND BLAST INJURIES

For hundreds of years the controlled use of explosives for the excavation of the rock has been a constituent of construction engineering. Consideration of geology structure of rock is important parameter in blasting. Scarring degree of rock is another important consideration that is essential for satisfactory cost and safety. Rock blasting can be classified as Presplit blasting, Step drilling, Cushion blasting, Ripping, Smooth blasting and Horizontal drilling. The details of these methods are shown in Table 3 [4]. All these conventional blasting method may produce an effect on health as well as there can be generation of flyrock, which can be dangerous to the workers available at the site.

**Table 3:** Description, advantages and disadvantage of common excavation techniques.

Methods	Description	Advantages	Limitations
Presplit Blasting	Use before production blasting.	Generates steeper cut with less maintenance.	Blasting depth only upto 15 m.
Step Drilling	Used as production blasting.	Good to use in moderately to highly fractured rock.	Applicable between slope of (H:V) 0.7:1 and 1:1. Only good for soft rock.
Cushion Blasting	Perform after production blasting.	Good for blasting any type of rock.	Traces of borehole are still present in competent rock and hard rocks.
Ripping	Required external force to break the blasted materials.	It can be used on different angle of cut.	It is used on the rock with low density.
Smooth Blasting	Used after production blasting.	Best to use on hard, competent rock.	Limits blasting depth to 15 m. In highly fractured, weak rock, traces goes beyond the boring length.

Horizontal Drilling	For production style blasting use large dia.	If it drill perpendicularly, can eliminates the bore holetraces. It is good for massive rock.	If it not loaded properly may produce extensive radial fractures.
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Blast injuries can be classified into four categories. The primary, secondary, tertiary and quaternary are the basic mechanisms of blast injury. Their detailed aspects are given in Table 4. From the Table 4 it is clear that, primary factor to need control for desired fragmentation is blast design [5]. So, therefore excavated muck can be directly use as aggregates in construction.

**Table 4:** Injuries related to blast.

Category	Characteristics	Body Part affected	Types of Injuries
Primary	Unique to high explosive, results from the impact of the over pressurization wave with body surfaces.	-More dangerous to gas filled structure. - GI tract, Lungs, and middle ear	- Blast lung (pulmonary barotrauma) -Damage to middle ear. - Eyes rupture
Secondary	Results from flying debris and bomb fragments	Pose danger to any body part	-Blunt injuries or fragmentation. -Penetration to eye.
Tertiary	Results from individuals being thrown by the blast wind.	Pose danger to any body part	-Fracture and painful amputation - Brain injuries (close and open)
Quaternary	All injuries rather primary, secondary and tertiary	Pose danger to any body part	-Brain injuries (close and open) -Asthma -Hyperglycemia, hypertension

### IV. PROPERTIES OF MUCK USE AS CONSTRUCTION AGGREGATE

Excavated rock or muck if used as aggregates must equipped with some chemical and physical properties. L. Gertesch *et al.* [6] depicted that, the various properties of rock when used as aggregate in construction depends upon the particular purpose for which it is used. The various properties required for muck are as follows:

**Physical properties:** For construction purpose the physical properties required includes particle size distribution (grading), bulk density and maximum particle size. Material should maintain high mechanical strength rather than mechanical, chemical and thermal attack.

**Chemical properties:** This property play very vital role when it is mixed with binder. There must be a chemical compatibility between the material and the binder. Clean particles must be free from of any coatings such as dust, salt, or clay which can prevent bonding with binding agents.

4.1 Improvement in Quality of Muck for use as an Aggregates

To improve the quality of generated muck, the blast design needs to be improved. All blast design must meet the existing condition of formation and overburden of rock, and also bring out the desired end result. Since rock is not a homogeneous material therefore there is no single solution to the problem. Because of this fact, it can be estimated that the theoretical blast design is just the initial phase for the blast operation in field. Therefore always a trial blast is performed, which either validates the initial assumption or provides the information to predict the design of final blast.

R.L. Peurifoy *et al.* [7] defined the different parameters that should be controlled at the time of blasting to obtain the desired fragmentation. The different parameters are as follows:

**Burden distance:** It is the most critical dimension in the blast because when it is not sufficient, rocks may be thrown away to excessive distance from the face, also very fine fragmentation may be formed and the air blast level will be high. An empirical formula to control the burden distance at first trial shot is

$$B = \left( \frac{2SG_e}{SG_r} + 1.5 \right) D_e$$

Where B= Burden distance, SG<sub>e</sub>= Specific gravity of the explosive, SG<sub>r</sub>= Specific gravity of the rock and D<sub>e</sub> = rock Diameter of explosive, in inches.

**Stemming:** In order to confine the explosive energy to the blast hole, stemming is carried out. If the stemming distance is too large, the top breakage after the explosion will be poor and there will be an increase in backbreak. Under normal condition, properly designed burden distance, good stemming material and stemming distance, T will be given by

$$T = 0.7 \times B$$

**Sub drilling:** To attain a specific grade, one needs to drill below the desired floor elevation known as sub drilling. The sub drilling distance, J, required can be estimated by the following formula.

$$J = 0.3 \times B$$

**Stiffness ratio:** The stiffness ratio for the blasting purpose is the bench height divided by burden distance. In some situation, as in a quarry, the blast can be optimized by adjusting the bench height. Table 5 shows the relationship between the stiffness ratio and critical blasting factors.

**Table 5:** Stiffness ratio's effect on Blasting Factors.

S.No.	Stiffness ratio			
	1	2	3	4 and higher
Air Blast	Severe	Fair	Good	Excellent
Flyrock	Severe	Fair	Good	Excellent
Fragmentation	Poor	Fair	Good	Excellent
Ground Vibration	Severe	Fair	Good	Excellent

**Spacing:** There should be proper spacing between the blasts. If the spaces are too close then on instantaneous firing, energy venting may occur which results in air blast and flyrock. Beyond certain limit, fragmentation becomes harsh if the spacing is extended.

**Powder factor:** It is a measure of the economy of a blast design assessed on the basis of required amount of explosive for fracturing a cubic yard of rock.

4.2 Case study on improving the grade of muck by modifying blast design

Fragmentation are shown in Figure 1 that exemplifies the effect of acquiring a single blast pattern (or similar blast patterns relatively) which does not include variation in the rock properties. The key issue was that it was not able to predict how the fragmentation of the material will take place on the basis of ore type or metal assays before actually drilling the pattern.



**Fig. 1:** Examples of fragmentation for two ore types.

A highly varying fragmentation size and mill throughput was the outcome of blast pattern designed on the basis of metal assay instead of rock properties.

**Preliminary Blast Trial Results:**

For the improvement in fragmentation, the historical blast pattern along with the modified pattern was recommended for difficult zones which is summarized in the Table 6. With tightening of the pattern, there was an increase of 41% in powder factor and an increase in the drill and blast cost per tonne by 40%. The modelling and simulations of fragmentation anticipate a finer 80% passing size (P80) of 175mm compared with 401mm and an increase in the -25mm fraction of 14%. On the recommendations of Process Technology and Innovation (PTI), for the recognized difficult zones, operation is currently trialing the modified blast design.

**Table 6:** Modifying blast design to improve the fragmentation.



S.No.	Design	Current	Modified
1.	Burden x Spacing (m)	7x8	6x7.5
2.	Cost (\$ / tonne)	0.20	0.28
3.	Hole Dia (mm)	311	311
4.	Powder Factor (kg/m <sup>3</sup> )	1.14	1.62
5.	Predicted % - 25mm	30.7	44.4
6.	Predicted P80 (mm)	401	175

Figure 2 shows two images of the muck piles (with one meter scale) resulting from the modified blast. The above Figure 1 may be compared with the historical results as shown on the right hand side of Figure 2 along with some alterations effect of higher powder factor in stemming length as well as explosive formulation can be clearly depicted from the Figure 2.



Figure 2: Resulted Fragmentation from Modified Blast.

Here in the Table 7 showed some of the cases of Hydro power in which muck is used as construction material [6].

Table 7: Utilization of Muck for Construction by some tunnel boring projects.

S. No.	Hydro power projects Tunnel	Tunnel length	Geology	Muck utilization
1.	Kobbel, Norway	NA	Granitic Gneiss, high brittleness	Surface of temporary construction road.
2.	Jostedal, Norway	9 km	Gneiss	Muck mixed with natural gravel or crushed stone for concrete
3.	Meraker, Norway	3.9 km	Phyllite	For bicycle path and Gangways superstructure
4.	Klippen, Sweden	11 km	Mainly Schistose	Light vehicle road and for fill under airfield for light aircraft.

### V. MUCK DISPOSAL AND MANAGEMENT PLAN

Before disposal of muck some features may be evaluated such as, calculation of muck to be generated with swell factor, quantity of muck to be utilized in construction activities and balanced quantity of muck that needs disposal/management plan. These all help in selecting the suitable dumping for balanced quantity of muck. Poor selection of dumping site may affect the river ecosystem by increasing the turbidity level of river downstream, as described in the report below:

1. A report published in Hill Post on July 3, 2014 by Sanjay Dutta [8], had raised the impact of muck disposal along the side of River Beas as shown in Figure 3. Muck generated during construction of Kanchan Janga (24 MW) hydro power project in Manali valley being dumped along the tributary of Beas river has disrupted the natural course and has posed threat to downstream farmlands and habitat.



Figure 3: Muck disposal along the side of River Beas.

Therefore it is very necessary to select a proper dumping site in this context. The site selected should not be along the side of river and also a sound rehabilitation plan should be adopted for muck disposal site [9].

2. Second report published in Digital Edition of Rising Kashmir, showed that NHPC was fined of Rs 29.54 lakh for damaging the trees at the approved dumping site and further issues related to the problems caused by muck disposal sites were raised by Pollution Control Board. The dumping commenced only when the mitigation measures were adopted for rehabilitation of the site. Another issue at the site was the washing away of muck in the nallahs during disposal of muck at approved site this could only be solved once the muck disposal site was fully stabilized [10].

#### 5.1 Selection of Muck dumping sites

While selecting a dumping site following criteria must be followed:

- a) Selected sites should always be near to adits and intake sites so that the cost of transportation can be minimized.
- b) There should not be any toe erosion and the slope of the dumping sites should not be susceptible to landslides.
- c) The dumping site should be at a higher elevation than the maximum flood level.
- d) Only those areas which are free from ecologically sensitiveness from pristine habitats, should be selected.
- e) It should be noted that, small channel streams should not flow through the dumping sites otherwise there will be erosion which may increase during rainfall.

### 5.2 Improving the utility of muck

E. Menashe [9] defined that, although immediate stabilization and erosion abatement can be provided by the engineering structures, yet over the time they progressively become weaker and do not change according to site conditions. Although, vegetation was not affected when it was established, but over the time it had become more effectively, adaptable and self-perpetuating. So, Vegetation and engineering measures should be coordinated to have effective erosion control measures at muck dumping sites. It is necessary to adopt some efficient measures to improve the utility of muck, so that, the vegetation is used for controlling the erosion, but after improving the muck fertility quality that vegetation can also be adopted as eatable vegetation for human being from the first day.

For this purpose, the quality of imported soil and type of seed mixture used should be improved. The different guidelines for using seeds as well as for applying fertilizer are as follows:

- Two or more than two species of normal grass- legume mix is used for erosion control.
- Separate mixing of seed and fertilizer.
- For initial application use of complete fertilizer (N-P-K) such as 19-19-19 or 20-24-15 applied at a minimum rate of 200 kg/ha.
- The need for nitrogen is reduced by legumes and high nitrogen levels can suppress the legume establishment.

D. Pettinelli *et al.* [11] suggested that while importing or purchasing soil from the native place, a visual inspection should be done. This soil must be free of trash and other debris since it will be used as a topsoil. It should be completely free of rock fragments bigger than 3 inches in diameter. Also the rock fragment volume should not be more than 5% of the soil volume.

- For instance, the checking of mushroom composts, should be done for high soluble salt.
- The level of heavy metal such as lead should necessarily be checked, which is responsible for the growth of vegetable.

At Kashang hydroelectric project [12], it was suggested to use mixture of soil in the pits & patches that consists soil which is imported from nearby areas mixed with compost /human/vermin composter or all of these. The mixing ratio of imported soil should be in the ratio of 5 parts i.e. Compost/manure: 2 parts, Sand: 2 parts, and humus or vermin-compost: 1 part. This will bring out availability for the plants in the preliminary stages. This will also increase soil aeration, permeability, porosity and improved moisture available for the plants.

### 5.3 Structure stabilization

Typical section of the dumpsite must be supported by boulder wire crates, which can work as a stakes, if there is wattling with the stakes, it may improve the soil stabilization at the site. Wattling is known as placing of bundles of interwoven live branches, which has a capability of rooted very easily, along the consecutive horizontal or diagonal rows on an embankment. As defined by Food and agriculture organization of the United Nations [13], wattling is a combination of natural and mechanical stabilization techniques where stakes are kept on the contour 0.5 m (1.6 ft.) apart and at 1.2 m (4 ft.) intervals between the rows. After that a trench is dug 20 cm (8 inch) wide and 25 cm (10 inch) deep against or just above the stakes of contour. Bundles of live vegetative materials (such as other locally available material) of diameter 13 cm and length of 3 m are placed in the trench overlapping end and tail. Then soil is placed to cover the wattling bundles such that leaves and part of the branches are left visible above the ground into the interstices of the wattles that the soil is worked thoroughly. Workers should walk on wattles as much as possible to ensure maximum compaction work on the soil into the bundles during the installation. After wattling if the mixtures of soil imported is mixed in improved ratio, it will improved soil erosion as well as vegetation at muck disposal site which is acted as a waste land before this practices.

## VI. RESULT AND DISCUSSION

Establishment of Hydroelectric Project to an area provides a great opportunity of employment as well as Electricity. But, during construction large quantity of muck is generated. Some quantity of muck used in construction whereas remaining quantity should be disposed at approved site, which may affect the downstream of the area, so mitigation measure should be adopted. From the discussion, it is clear that if there is control in fragmentation, then quantity of muck generation will be in control as well as the quantity of muck will come in desired size, which can be used as a construction material at the site directly or with minimum process. While disposal of balance quantity of muck, it must be in planned manner by considering measures such as soil conservation and erosion control by adopting different factors which includes: mixture of imported soil after checking the nutrient and moisture capacity of soil as well as engineering measures i.e. wattling process for stability of site. This not only controls the erosion

at the site but also provide good quality of land for the growth of vegetable and grains. So the muck disposal site change into production site in future which is till now treat as waste land.

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