QUARRY WINNING OPERATION AND SCREENING PROCESS

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RINGKASAN

Makalah ini mengetengahkan aspek pengadaan batuan dan pemroresannya. Lokasi serta pemilihan quarry dijelaskan, dan dilanjutkan dengan peralatan serta metoda yang digunakan untuk kegiatan operasi. Mengingat pengopersian quarry banyak berkaitan dengan "tenik penambangan", maka dalam makalah ini penekanan lebih diarahkan dari sudut pandang efektifitas biaya. Persiapan bahan dasar, pemecahan, penyaringan dan penyimpanan hasil produk diuraikan secara detail. Klasifikasi umum dan kesesuaian alat pemecah batu diuraikan dengan jelas.

SUMMARY

This paper deals wiht some aspects of hard rock extraction and processing of aggregate. The location and selection of a quarry are described, and followed by the equipments and methods used for the operation. Considering that the quarry operation is largerly concern with "mining engineering", more emphasis is given from the point of view of cost-effectiveness. The preparation of raw material, crushing, screening and the storage of the products are detailed. Broad classification and suitability of crushers are outlined.

I. INTRODUCTION

On construction projects, aggregate is a frequent requirement such as for surfacing, base, subbase, as well as for improving the subragde on a highway construction. This material is found in large quantity in the river gravel deposits or hard rock quarries. As compared to the river gravel pits, hard rock quarries are relatively more difficult to operate, and normally require driling and blasting equipment

II. QUARRY WINNING OPERATION

2.1. Quarry Site

To decrease the unit transport costs, the best location of a quarry is usually at as close as possible to its market, both current and future market. Other factors need to be considered whether or not a quarry will be explored, are the quantity and quality of material itself.

However, the quarry industry not only the one that will concern about a particular area. The nature conservation, tourism, recreation, archaelogy, and environment interests will also involved, and could produce some pressures to the quarry industry. As a result, the deposits of construction materials which could be required by the market are sterilised by other land uses, and existing quarries have their operations threatened by development close to quarries [1] Haywood [2] stated that the planners,the public and the industry have each an important part to play in resolving these pressures, and should look for solution rather than confrontations.

Restoration, a return to the pre-quarrying past, is likely to be impossible, especially in hard-stones quarries. Therefore. another after-use treatment must be proposed before the site will be explored, such as: landscaping, debriss filling, forestry, agriculture (rarely possible in stone quarries), water storage, sport area, industrial or residential uses Each treatment will influence the method of quarry operation, and determine the investment (i.e. equipment) for that particular site.

For certain locations, such as near the subur bans, the least possible disturbance to the neighbourhood during the working period must be arranged. Hence, low noise operations become increasingly important on those areas.

Generally speaking, The location and selection of a quarry involves economic considerations as well as technical ones.

2.2. Equipments

There are many kinds of good equipment available on the world market today. Hence, the type, size, number and specifications for equipments can be set up so that they fit to the need of the quarry operation.

A partial calssification wiht some overlapping depending on the degree of hardness of the rock, has been suggested by Hodges [3] for the pit equipment, as follows:

a. Loading operation.
   - Free digging: dragline, bucket-wheel.
   - Ripping: scraper, front-end loader.
   - Drill and blast: front-end loader, shovel.

b. Hauling operation.
   - Hydraulicking: pumping.
   - Free digging: dragline, conveyor belt.
   - Ripping: scraper, trucks.
   - Drill and blast: trucks, trains, inclined skips, conveyors.

Assisting to the above operations will be: bulldozers, road patrols, mobile cranes, water trucks and a fleet of miscelaneous service and maintenance vehicles.

Any equipment is usually manufactured for a specific duty, so if not used for the purpose it was made for, it will not always give the best results. Furthermore, a properly matched combination of equipment will ensure maximum productivity with minimum unit costs. For example, the size and number of trucks to be operated should be balanced with the work load of the excavators (shovel).

An efficient fleet of quarry equipment essentially must be maintained with proper procedure. It is therefore reasonable to have one or more units of equipment in reserve to ensure that the production is maintained while another equipment are withdrawn from the pit for the required servicing. Good after-sales service is a prerequisite to selection of equipment [4].

Summing up, the final selection taking into account overall economics will be based on the balance of the following factors againts each other: capital cost, technical suitability, maintenace/repair considerations, and acceptability of the equipment's manufacturer [3]

2.3. Operation

Quarries and open pit mines produce most of the rock and minerals required for construction and industry. The term "open pit" usually refers to an operation mining a specific mineral that must be extracted from a matrix or donor formation. After the mineral is removed, the remaining material is considered waste and must be disposed in a convenient and economical manner consisted with quarries where all the material mined is usually consumed as an end pro duct [5].

Depending on the area's topography, a quarry will be developed as a side hill or pit type operation. Where the area is hilly and the rock outcrops, the quarry will be developed by opening a face into the side of the hill. When the terrain is almost flat, it is necessary to ramp down into the seam creating a pit that is entirely below the surface of the surrounding terrain.

The first operation is to break the rock from its naturally occuring solid state into a form where it can be easily handled. The most effective practical means of breaking hard rock is by applyng explosive energy, placed in blast holes in the form of linear explosive charge [6]

As rock breakage by blasting is the first step in open cut hard rock production, it is necessary to define an optimum standard of rock breakage (i.e. an optimum fragmentation). Optimum fragmentation can be defined as that fragmentation which results in the minimum cost per unit of prepared rock, of the combined operations of drilling and blasting, loading, hauling and primary crushing. This is ilustrated in Figure 1.

Fig.1. Generalized cost optimisation plot illustrating the necessity to optimise fragmentation costs againts subseqquent costs [7]

In addition to fragmentation required, the geology of the material to be broken, the hole diameter, the depth of drilling, and the type of explosive, are the important factors in determining the overall blast design. It is often useful to conduct extensive field tests. The results from these tests can be used as guideline to assist in determining the hole spacing and burdens, the explosive ratio required, and the type of explosive. [5]

The next operations after breaking the rock are: loading, hauling, and primary crushing (material preparation). Three different possibilities of operational configurations have been suggsted by Guderley [8], as follows:

a. Conventional operation.

   Shovel- rear end dump truck transport - stationary primary crushing unit at the material preparation plant.

b. Semi mobile operation.

   Shovel - rear end dump truck transport - shiftable primary crushing unit in the open cast mine - transport by conveyor to the material preparation plant.

c. Fully mobile operation.

   Shovel - mobile crusher - transport by conveyor to the material preparation plant.

The mobile crusher-conveyor system is most economic when long hauls (uphill or downhill) are encountered. If there are only minor differences in the levels between mining and preparation areas, the conventional operation wiht loader and truck transport may still economic.

Above all, the choice of method of operation will be influenced by consideration whether higher investment and low operating costs or low investment and higher operating (and maintenance) costs are more favourable.

III. SREENING PROCESS

3.1. Processing Plant

Normally, quarry rocks are not readily suitable for use as construction aggregates due to its large size, and sometimes have been contaminated by clay. Crushing, screening, and probably washing, are needed in order to prepare various types of aggregates.

The hauling distance between the pit and the processing plant is more important to consider than that of the plant to the project or market. This is because the elimination of transporting effort for unused material such as clay and other by-products that the processing removes.

Processsing plants vary in size and sophistication, but generally there are only 4 tasks involved in the proccess, as follows [9]:

1. Reducing size of raw material by crushing.
2. Separating the crushed aggregate into standard particle sizes by screening.
3. Transporting material from one component to another and stock plie.
4. Eliminating by-products such as clay by washing.

To increase efficiency, a pre-screening of raw material is often necessary before loading it onto the crusher feeder. This process can be done using a grizzly, which is essentially constructed by building a screen with appropriate size openings. When raw material is loaded into a grizzly, all stones that are too large to be crushed are separeted. Dust and fine material are also separated, so that the unnecessary loads to the crusher is reducing.

Crushed stone for construction use should usually be free from dirt, organic material or other impurities. Various equipments are available for washing aggregate. The common practice is to wash the fines and dewatering it to produce clean sand. Coarse aggregate is commonly washed by spraying water on the screens, or by using a rotary scrubber. about 6 tonnes of water are required to wash 1 tonne of sand [10]. Due to a large amount of water required to wash the aggregate and other purposes, it is probably needed to recirculated water and reused it to avoid contamination of the surrounding streams, lakes or land.

The lay out (land equipment) of the processing plant are influenced by the following factors [11]:

a. Product requirements in sizes and ton/hour.
b. Site condition.
c. Stone quality.
d. Raw material grading.
e. The extend of contaminating materials.
f. Availability of water for washing.
g. Capital investment limitation.

The schematic diagram of processing plant is shown in Figure 2, illustrating the production of 800 tonnes/day.

3.2. Crusher

Amongst the processing plant equipments, the crusher plays the most important role, and the majority of the total investment made is for purcnasing crusher. The characteristics of the crusher will determine the output of the porcessing plant.

Depending on the proces stage of crushing, rock crushers may be categorised into primary, secondary and tertiary crushers. The number of crushers will depend on the overall reduction ratio desired, and the most practical ratio for each stage. The primary crushers handle the largest stones that can be processed, while the secondary and in turn the tertiary receive the stones and continue to crush into smaller sizes.

There are basically four ways of crushing rock materials : pressure (compression), impact, shear, and attrition. Classification of the types of crusher available to crush material in these ways, and the suitability of crushers for primary, secondary and tertiary stage of crushing, are shown in Tables
The reduction ratio (i.e. the ratio between the mean size of feed and the mean size of out put) has an effect on the shape and grading of the products. To obtain good particle shape, individual reduction ratios should not be more than 4 to 1. The recommendation of reduction values for different types of crusher is illustrated in Table 3.

TYPE	DESCRIPTION	PRIMARY	SECONDARY	TERTIARY
Jaw (Pressure) (Impact)	Double Toggle Crusher Single Toggle Crusher	• •	•	•
Gyratory (Pressure) (Impact)	Gyratory Crusher Cone Crusher	•	• •	•
Roll (Pressure) (Shear) (Impact)	Double Roll Crusher Single Roll Crushe Triple Roll Crusher	•	• •	• •
Impact (Shear) (Attrition)	Impact Crusher Hammer Crusher Cage Mill		•	• •

Tabel 1.A broad classification of crushers.[11]

Material Characteristics	Extremely Hard	Hard To Very Hard (Abrasive)	Hard To Very Hard (Mildly Abrasive)	Brittle or Friable	Soft Non Plastic	Soft Plastic
Primary Crusher Types	Jaw	Jaw Gyratory	Jaw Gyratory Impact	Jaw Gyratory Impact Single Roll	Jaw Impact Single Roll	Impact Single Roll
Reduction Crusher Types	Roll Cone	Roll Cone	Roll Cone	Roll Cone Hammer mill	Hammer mill Cone Roll	Hammer mill

Tabel 2. The suitability of crusher type to crush materials (11).

Crusher type	Reduction ratios	
	Best	maximum
Roll	2 - 3	4
Jaw	3 - 4	5
Gyratory	3 - 4	5
Impact	4	8

Tabel 3. Recommended reduction ratios for different types of crushers. [10].

3.3. Screens

Screens made of open mesh wire are used for separating stone from crushers into a standard sizes for construction use. The most typical arrangement is several layers of screens mounted in rectangular shape base. The aggregate is separated into different sizes determined by the size opening by vibration (and oscillation). This particular type can handle relatively small sized materials, and can be stacked in 2 to 4 layers of screen.

As mentioned previously, if necessary, a grizzly can be used for a pre-screenning of raw material. Meanwhile, for screening of large materials (6 cm size and large), a rotary trommel is the most suitable.

3.4. Storage

The products of various sizes can be stored in bins, stock piles or reclamation tunnels. Bins provide clean storage and can be filled by means of conveyor belts. Bins are usually elevated to facilitate gravity loading onto trucks. They are commonly used to store small amount of products, because it is expensive to install high capacity bins.

The most common method of storage is stock piling. Provided there is adequate space, stock piles are cheaper than any other methods. Stock piles are built straight away from the elevated conveyor belts and front-end loader are used to load the material onto trucks for further supply. If the basement is not hardened, e.g. using concrete, the bottom part of the stock piles should be left (approximately 10 cm), because the material is usually mixied with dirt.

The reclamation tunnel is usually under the ground level, and conveyor belts are used to empty the material. Despite its high cost of installation, a reclamation tunnel facilitates production of blending aggregate, by means of varying the speed of conveyor belts and adjusting the gate openings of the tunnel.

IV. CONCLUSION

The optimum size and location of a quarry operation depend on several factors: the geological nature of the deposit, the cost of working that deposit, market size, competing sources, distance to the market and, importantly, the environ mental impact of extraction.

The error in judgement in the selection of equipment can have serious consequences on the economics of an open pit project, to the extent that avoidable costs may more than offset the benefit in arriving at optimum pit designs.

All the associated processes of breaking, loading, transporting, crushing and screening should be considered collectively. Experience has often indicated that inadequate fragmentation during primary breaking has led to expensive secondary breaking or spiralling cost of loading and transporting.

Since the output of the quarry is governed by the capacity of the crushing plant, it is important to recognize that the primay crusher must be able to handle the production.

REFERENCES:

1. Departement of Environment and Planning, " Sidney's Extractive Industry", Regional Environmental Study, Sydney, 1984.
2. Haywood, S.M. "Quarries and the Landscape" The British Quarrying & Slag Federation Ltd, London, 1974.
3. Hodges, P.A. "Principles Underlying Pit Equipment Selection", Open Pit Mining Symposium, Johannesburg, 1970.
4. Shand, A.N. "The Basic Principles of Equipment Selection for surface mining", Open Pit Mining Symposium, Johannesburg, 1970.
5. Du Pont de Nemours (E.I.) & Co. "Blasters' Handbook", 1978.
6. Brown, A.N. " Theory of blasting as Applied to Open Pit Mines", Open Pit Mining Symposium, Johannesburg, 1970.
7. Toll, G.L. "Assesing Rock Fragmentation in Open Cut Mines"Drilling and Blasting, Australia Mineral Foundation Incorporated. Adelaide, 1973.
8. Guderley, W. "In-pit Crushing and Conveying"' Surface Mining and Quarrying, The Institution of Mining and Metallurgy, 1983.
9. Russel, J.E. "Construction Equipment", Reston Publishing Company, Inc., Virginia, 1985.
10. Yandell, W.O. "Lecture Notes on Pavement

Materials"' University of New South Wales (unpublished), Sydney, 1989.

11. Wylde, L.J. "Work shop on Aggregate and Road Base Production with Mobile Equipment", Proceeding ARRB Report, ARR No.98. Vermonth South, 1978.

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