Technique and economic possibilities of the reuse of quarry wastes as crushed stones in a wide mining basin in the Alps: an application of the Environmentally Adjusted Cost Benefit Analysis

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1. INTRODUCTION

The industry, connected to the natural stone quarries, represents a very important mining area in Italy. However the difficult morphologic conditions, which are one of the main character of Alps, are a handicap for the management of big quantities of mineral wastes (and most of all spoil rock strip). There are many possibilities for a reuse of mineral wastes: not only the employment of rip-rap (which have been using for several years in the river rehabilitation), but also as prill for building industry. This second chance is necessary not only to improve the economic and environmental balance in mining activities, but also to have considerable volumes of good qualities crushed stones. Basing on the example of the operations done in North - Eastern Alps with local stone wastes (porphyry wastes), also in Piedmont, in the North - Western Alps (Coltian Alps), some consortia concerns are trying to reuse systematically the local quarry wastes (gneiss wastes). In fact there are many requires, for that kind of material, to realize lots of the works which have to be built before the opening of 2006 Olympic Games in Turin.

2. THE STUDY CARRIED OUT

The paper outlines a peculiar situation, for quarry industries, in the North - Western Alps (Luserna S. Giovanni Basin). It also reports the results of a Cost-Benefit Analysis which shows the advantages connected to the use of a consortia plant for the quarry wastes treatment and the contextual increase of value of lithoid wastes in applied fields.

From the studies carried out, a few alternatives for re-using the quarry wastes have been valuated. These possibilities concern:

- The production of aggregates for concretes;
- The production of prill for ballast, filling, etc.;
- The application on road surfaces or sub floor layer for constructions;
- The applications in the binder industry.

The work method used for evaluating the feasibility of these alternatives is based on:

- **Chip sampling** of the quarry wastes,
- **Ore reduction tests** with different kind of machines,
- Execution of **quality tests** on the ore reduction products obtained.

It is necessary to classify the ore reduction products, with reference to the anticipated uses, on the bases of specific regulations. The references have been the national regulation, for re-using the quarry wastes both as aggregates for concretes and employed in the road field, and the specific technical regulations of the National Railway to classify the aggregates for railway ballast.

After having verified the correspondence of the material proceeded from the quarry wastes to the regulations, a comparison of the direct costs of the products obtained with traditional materials an[illegible]ned using the quarry wastes has been carried out. In the end, the advanta[illegible]ect, deriving from re-using these materials have been investigated.

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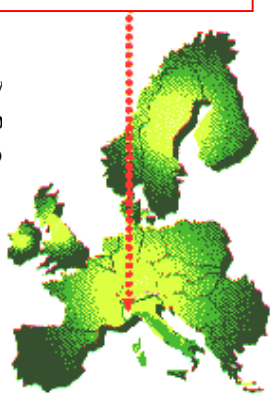


Fig. 1 The mining basin of the Luserna Stone

With these data, a comparison between two alternatives has been created; the two possibilities considered can be described as follows:

- standard solution: it proposes the **prosecution of the actual statement** with dump and occasional re-using of the quarry wastes
- innovative solution: it considers to change completely the destination of the wastes produced in the cultivation in order to carry out a **systematic treatment for re-using**

A real economic study[1], the **Cost Benefit Analysis**, has been applied for a period of 10 years, starting from the 2002 (at the end of this period the dumps used nowadays will be exhausted). The objective of the Cost Benefit Analysis (which is a monetary evaluation method where all the advantages and disadvantages of a project are considered and translated in monetary units) is to determinate the best choice between different alternatives in order to supply the biggest *net social benefit*.

The alternatives considered have been:

- prosecution of the actual state: dump + sale of rip-rap + transfer of materials for filling
- breaker proposal: crushing + sales of the grinded products + sales of rip-rap

The analysis carried out could properly considered as a *Environmentally Adjusted Cost Benefit Analysis*; in fact the in the two alternatives compared it is contemplate the passage from creating of a damage (prosecution with the actual state) to producing a new resource.

For the first alternative, the output of the analysis is described in the table 1 (values are expressed in thousands of Euro).

year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
COSTS											
Cost for the material in the dump	206,6	206,6	206,6	206,6	206,6	206,6	206,6	206,6	206,6	206,6	206,6
Cost for activating the dump	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5	15,5
Cost of material for filling	13,9	13,9	13,9	13,9	13,9	13,9	13,9	13,9	13,9	13,9	13,9
Total costs	236	236	236	236	236	236	236	236	236	236	236
BENEFITS											
Sale of rip-rap	591	591	591	591	591	591	591	591	591	591	591
Total benefits	591	591	591	591	591	591	591	591	591	591	591
CASH FLOW: benefits – costs (F_t)	355	355	355	355	355	355	355	355	355	355	355

Tab. 1 Prosecution with the actual statement

The analysis of the second alternative represents the most original and innovative part of the work. A generic plan of a breaker for the quarry wastes has been realised[2], considering its possible location and valuing both the investment and management costs and the benefits obtainable, consisting essentially in the sale of the crushed materials.

The data taken into account in the project have been the flow rate (54.000 m^3/anno) and the size (less than 0,2 m^3).

- The investment cost of the plant results composed by:
- The cost of the machines
- The cost for building
- The cost for the plant design and installation
- The cost for the assembly and the testing.

The voices considered as management costs are related to:

- The energy
- The maintenance
- The wear of the machines

[1] See also: BADINO V., MONDINI G., BUZIO S., PRIZZON F. (1998) – *Evaluation of the technical-economic aspects of the project for the increase of the Monte Cros quarry proposed by the company Italcementi S.p.A*, Polytechnic of Turin – DIGET (internal working paper).

[2] See also: CLERICI C. (2002) – Dispensation of the class of *Rescue of the Secondary Raw Materials*, Polytechnic of Turin – DIGET.

- The labour
- The benefits obtainable are connected with the sale values of the materials coming out from the plant.

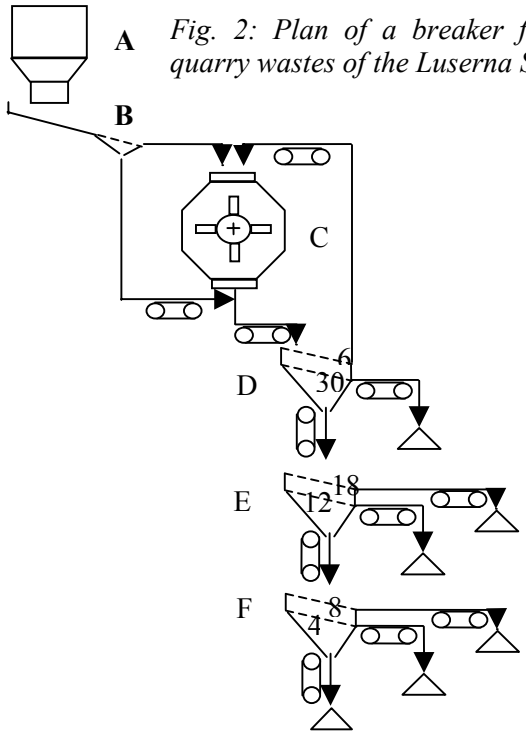


Fig. 2: Plan of a breaker for the quarry wastes of the Luserna Stone

The project of the plant should make provision of:

- A shol (**A**);
- An extracting pre-screening feeder (**B**);
- An impactor (**C**);
- Three vibrating screens (**D**, **E**, **F**);
- Eleven bel conveyors with different lenght.

The results obtained from the second alternative are shown in table 2 (values are expressed in thousands of Euro).

year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
COSTS											
Investment cost	140	140	140	140	140						
Energy cost		22	22	22	22	22	22	22	22	22	22
Maintenance cost		51,4	51,4	51,4	51,4	51,4	51,4	51,4	51,4	51,4	51,4
Wear cost		25,7	25,7	25,7	25,7	25,7	25,7	25,7	25,7	25,7	25,7
Labour cost		31	31	31	31	31	31	31	31	31	31
Transport quarry-plant cost		258,2	258,2	258,2	258,2	258,2	258,2	258,2	258,2	258,2	258,2
Total costs	140	528,3	528,3	528,3	528,3	388,3	388,3	388,3	388,3	388,3	388,3
BENEFITS											
Materials sale											
1) 30-60		153,4	153,4	153,4	153,4	153,4	153,4	153,4	153,4	153,4	153,4
2) 18-30		164,7	164,7	164,7	164,7	164,7	164,7	164,7	164,7	164,7	164,7
3)12-18		123,9	123,9	123,9	123,9	123,9	123,9	123,9	123,9	123,9	123,9
4) 8-12		96	96	96	96	96	96	96	96	96	96
5) 4-8		151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8
6) <4		151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8	151,8
Sale of rip-rap	591	591	591	591	591	591	591	591	591	591	591
Total benefits	591	1435,8	1435,8	1435,8	1435,8	1435,8	1435,8	1435,8	1435,8	1435,8	1435,8
CASH FLOW: benefits-costs (F_t)	454	907,4	907,4	907,4	907,4	1047,4	1047,4	1047,4	1047,4	1047,4	1047,4

Tab.2 Crushed proposal

3. RESULTS

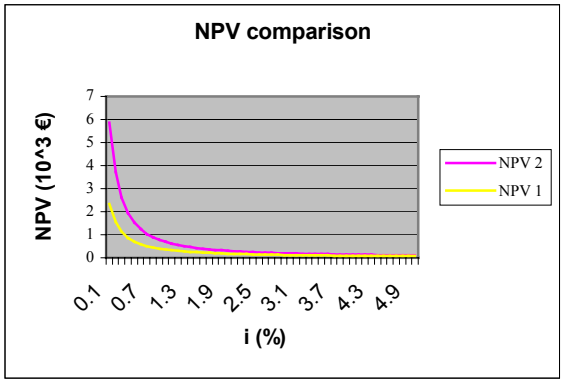
The criteria applied for the economic evaluation of the investments considered is the Net Present Value (NPV). It represents the most used indicator in this kind of monetary analysis.

For choosing between different alternative projects, you have to consider that the higher is the NPV, the bigger is the final net benefit obtainable from the operation.

$$NPV = \sum_{t=1}^{10} \frac{F_t}{(1+i)^t}$$

F_t: final cash flow for every year (difference beetwen the total benefits and the total costs for every year)
i: discount rate;
t: year considered in the project life

A comparison between the two alternatives can be done diagramming the NPV state related to the variation of the discount rate (between 0,1% and 5%).



NPV 1: Net Present Value state for the prosecution according to the actual condition

NPV 2: Net Present Value state of the crusher proposal

Fig. 3 NPV comparison for the two alternatives considered

Two are the main consideration which can be done:

- The Net Present Value curve of the crushed alternative is always higher than that of the prosecution with the actual condition. Even varying the discount rate the final result does not change: the proposal of a shatter plant still wins.
- Analysing the state of the NPV when the discount rate tends to 0, a few interesting considerations from the point of view of the environment economy can be done. To adopt a discount rate very low means to make no choice between the present and the future. In the case of environmental goods and services, the previous sentence is the same as saying that no generation can consider itself more important than the future generation. It is very important, therefore, to verify that just for a discount rate tending to 0 the crushed proposal supplies a NPV higher than the hypothesis of the prosecution with the actual condition.

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