Utilization of marble tailings in some industries for environmental awareness

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Abstract

Turkey is ranking as one of the top exporters in the marble industry throughout the world with a 46.5 export percentage of commercially sold slimed thick blocks (STB) of marble and travertine. However, marble tailings come out from all stages of the mining and processing activities such as exploiting, cutting, slicing, grinding and polishing. The total waste generated from the entire mining and processing practices through the production operation resulting with the finished product is in the range of 50-60% of the mineral itself. This situation contributes to come up with the major environmental pollution problems. On the other hand, these tailings can be used as the potential reserve of raw material in some industries. The importance of evaluating these tailings is increasing day by day. The main purpose of the present paper is to exhibit the significance of marble tailings and the utilization of these tailings in some industries as a raw and/or additive material for preserving the environment.

Key words: Marble tailing, utilization of tailings, Turkey

1. Introduction

Marble is a kind of metamorphic rock composed of recrystallized carbonate minerals, mostly known as calcite or dolomite. However, the name of "marble" is used in a different way in the stone trade. Any crystalline carbonate rock that has ability for polishing is called "marble".

The marble industry is one of the largest industries in worldwide. Turkey has many assorted types and large volumes of marble reserves due to its location. The map of marble reserves of Turkey is illustrated in Figure 1. Different structures of marble upon 80 varieties can be found in Turkey such as limestone, travertine and onyx with various colours (above 200) and patterns. These stones are known as Supren Salome, Elazig Cherry, Aksehir Black, Manyas White, Bilecik Beige, Tiger Post, Denizli Travertine, Aegean Bordeux, Milas Lilac, Mugla White, Gemlik Diabaz and Afyon Sugar. Therefore, these varieties in Turkish marbles have a certain demand from all over the world. Some of these marbles are exported to the several countries and others are used in the domestic markets such as coating of surfaces, base slabs, steps of staircases, figurative columns and kitchen counters etc. The marble plates are also utilized as gravestones, sculptures or furnitures in many manners.

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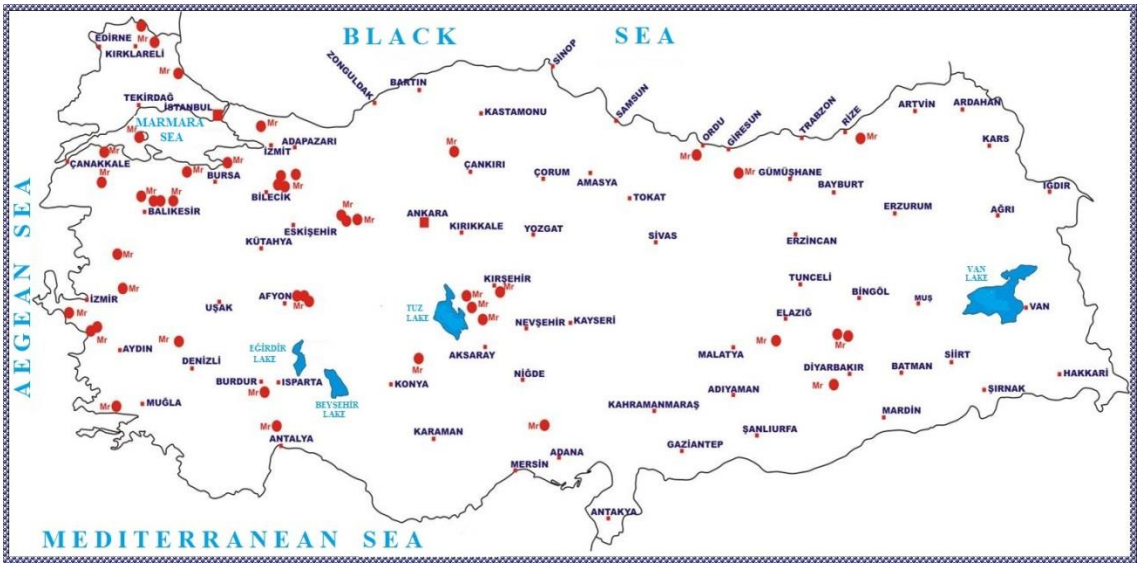

Figure 1. Marble reserves of Turkey [1].

Turkey counted for 650 million dollars ($) of total export of STB in 2012. Turkey had also 46.5 percentage of 1.4 billion dollars ($) of world export in 2012 (Table 2). Therefore, this made Turkey to become one of the primary exporters of STB in the world. Besides, the main importer of STB is China in the world. The demand of STB was 5 728 086 tonnes in China and China provided 3 001 546 tonnes of its requirements from Turkey (Table 3). Turkey has no share in the Arabian market which is the third importer of the world. When thinking of the generated waste is almost 50% of the production, the amount of waste has significant priority.

Table 1. The trade circumstances of STB [2].

(x 1000$)	2009	2010	2011	2012
Import in the world	1 050 537	1 478 252	1 590 672	1 783 787
Export in the world	1 009 442	851 679	1 067 905	1 390 850
Turkey's Export	106 723	278 724	443 967	649 991
Turkey's Import	257	254	274	176

Table 2. The main exporters of STB in the world [2].

Exporter	Value (000$)	Quantity (ton)	Ratio (%)
World	1 397 573	6 673 887	100
Turkey	649 991	3 716 265	46.5
Italy	173 980	495 428	12.4
Spain	139 411	318 180	10
Egypt	103 990	246 873	7.4
Iran	83 107	436 218	5.9

Table 3. The countries exporting STB from Turkey [2].

Importer	Value (000$)	Ratio (%)	Quantity (ton)	Sorting in the World import
World	649 991	100	3 716 265	
China	560 163	86.2	3 001 546	1
India	32 157	4.9	118 331	2
Lebanon	3 296	0.5	23 564	4
Taiwan	13 016	2	59 654	5
Indonesia	4 083	0.6	19 233	6

1.1. Marble tailings from mining activities

Marble tailings are mostly resulted from due to the presence of fault, fracture and fissure through the reserves. The application of defective mining methods also assists in the occurrence of this kind of tailings. These tailings are also comprised in the consequence of forming blocks by cutting the edges. 50% of production of marble is thrown away in general. These tailing are usually dumped into landfills without any precaution to be taken.

1.2. Marble tailings from cutting plant

A certain plates are obtained and sized by the cutting of the marble blocks and the fine particles arise from at this period. Water is used during this preparation process. The fine marble powder formed during this process and the plant water is filled in a pond. On the other hand, the plant water is recovered by using certain techniques and the residue is quiet fine. 90% of the particles are below 0.2 mm [3]. Depending on the type of process involved, the sludge quantity generated is mostly equal to between 20% and 30% of the weight of the stone worked [4].

2. Utilization of Marble Tailings

2.1. Construction industry

Coarse marble wastes can be used as aggregates and fillers in construction industry. Besides, marble powders used as a raw and/or additive material in producing of cement, mosaics, mortar and artificial tiles etc. In the coating industry, fillers or extenders are added to polymers or binders for improving their properties or reducing cost. Marble tailings are also used as plaster mortar, coating and filling material, producing the terrazzo squire, production of lime, stone chips in the construction of highway and railway.

The usability of waste marble dust collected from marble deposits as an additive material in industrial brick was investigated. It was found that the amount of marble dust additive had positive effect on the physical, chemical and mechanical strength of the produced industrial brick

[5]. It was also reported that, light wall units which have enough mechanic properties were economically produced by using the marble powders settled in the tailing ponds [6]. The bricks produced by the addition of various amount of marble powder were heated up from 750 to 950 ºC resulting in no deformation on its structure [7].

When energy consumption in the furnace and in the milling processes is achieved and the decrease in clinker ratio is realized, the production of cement with additive may be said to be economic and feasible. Mineral additions result in the better performance of fresh concrete and mortar. Waste marble sludge can be used to produce clinker as an additive material in mortar. The possibility of utilizing waste marble dust in cement and concrete production was investigated and concluded that the marble dust blended with cement remained within the acceptable ranges of the Egyptian standards [8].

Another reported work was about the use of marble powder as a heat isolation material in roofs [9].

2.2. Ceramic industry

Calcium oxide (CaO) which is the basic material in the ceramic industry may be obtained from the calcination of marble powder. Ceramics can be glazed or unglazed, porous or vitrified. It provides an interlayer between glaze and mud. This layer is very important in ceramic industry. CaO helps for composing of glass via interaction with other oxides in the glaze.

The usability of the marble tailings as raw material in ceramic mud was also investigated by some researchers [10]. They found that the scouring reduction was achieved with an increase in the amount of marble powder contrary to that of water absorption.

2.3. Paper industry

$CaCO_3$ is used in producing of newspaper and magazine paper especially cigar paper in the paper industry. It provides the printing ink to dry quickly due to its oil intake property. Besides, it is a very well-known fact that the durability of the paper increases with the presence of $CaCO_3$. The marble powder is also used for the preparation of the liquid during the cooking process of cellulose. The liquid in concern is formed as the consequence of the reaction occurring between lime stone and SiO_2.

The utilization of marble tailings as raw material was made possible after increasing their percentage of $CaCO_3$ [11]. It was also declared that the whiteness value of these tailing is acceptable.

The marble powder should be under the size of 2 μm and should contain $CaCO_3$ in the range of 30 to 98 [12]. The technologic developments resulted in that the necessity of $CaCO_3$ during the production of paper in the alkali medium increased the demand of the marble powder.

2.4. Paint industry

Mineral based raw materials can be used in the paint recipe in the range of 20 to 50. Some examples of mineral based materials are titanium oxide, zinc oxide, zinc phosphate, calcite, calcined kaolin, talc, mica quartz, dolomite and barite. Filler materials can be substitute of titanium oxide and provide a decrease in the cost. Additionally, they can improve some physical properties such as hardness, abrasion, impact strength etc. A certain numbers of properties of fillers may be listed as particle size distribution, capacity of oil intake, whiteness, refraction index, density and hardness etc. The particle size distribution is the most important parameter amongst them. Brightness is one of the main reasons why carbonates can substitute kaolin and talc in some industrial processes. Depending on the impurities, a concentration of only 1 ppm is enough to change the colour of calcite [13]. Calcite is the cheapest filler among the minerals. Marble fines obtained from coarse crystalline white marbles as filler was utilized in water based paint production [14]. They found that the amount of titanium oxide was reduced by 4% compared to standard paint upon introducing calcite into the paint formulation. Titanium oxide is the most expensive raw materials used in paint.

2.5. Road-making purposes

The utilization of natural stone tailings in road and ground construction as a stabiliser increases day by day. The feasibility of marble waste for the utilization of it as the stabilisation material and as asphalt aggregates was also investigated.

2.6. Other industries

The investigations on the use of the marble tailings for some industries such as railway ballast, glass, chemistry, feed, plastic, agriculture and fertilizer etc. are still being kept on. There were used two different amendments (slurries of animal ranches and marble waste ($CaCO_3$) for reclamation purposes, in order to increase organic matters and nutrients in soil, decrease heavy metals availability, improve soil structure, and facilitate vegetation colonization [15].

Conclusions

The main objectives of any industry must corporate with the preservation and improvement of the environment as well as the conservation of natural resources. The utilization of the tailings arise from the mining activities such as marble quarries has major importance from the point of environmental and economic aspects. Therefore, they should be used where possible, to minimize their effects on the environment. However, it should be taken into consideration that the use of these tailings should not cause other side effects. As there are many areas to implement the usage of marble tailings, we should definitely prefer to realize it from the point view of environment as well as for the economical thoughts.

References

[1] www.mta.gov.tr

[2] Saricay O. GTIP 251512 Marble and Travertine (slimed thick blocks), ITC, Istanbul, Turkey, 2013, p.12.

[3] Aruntas HY, Guru M, Dayi M, Tekin I. Utilization of waste marble dust as an additive in cement production, Mater Des, 2010;31:4039–4042.

[4] Marras G, Careddu N, Internicola C, Siotto G. Recovery and reuse of marble powder by-product, Global Stone Congress, 2010.

[5] Bilgin N, Yeprem HA, Arslan S, Bilgin A, Günay E, Marsoglu M. Use of waste marble powder in brick industry, Construction and Building Materials, 2012;29:449–457.

[6] Demir I, Baspinar MS. The use of marble saw dust (sludge) in manufacturing of light weight constructional bricks, 4th International Marble and Natural Stone Congress, 18-19 December, Turkey, 2003;213–220.

[7] Saboya JS, Xavier GC, Alexandre J. The use of the powder marble by-product to enhance the properties of brick ceramic, Construction and Building Materials, 2007;21(10):1950–1960.

[8] Aliabdo A, Abd Elmoaty M, Abd Elmoaty, Auda, EM. Re-use of waste marble dust in the production of cement and concrete, Construction and Building Materials 2014;50:28–41.

[9] Ansari AA, Memon AB. Experimental study of thermal insulation capability of ceramics, marble dust and lime, Mehran University Research Journal of Engineering &Technology, 2005;24, no1.

[10] Sarici DE, Onal Y, Ozdemir C, Kizilkaya N, Basar CA. Investigation of utilization possibilities of marble powder waste which $CaCO_3$ origin in ceramic body, 8th International Marble and Natural Stone Congress, Turkey, 2012, p.67–75.

[11] Sayin ZE, Aksoy U. Evaluation of marble dust waste as industrial minerals, 8th International Marble and Natural Stone Congress, Turkey, 2012, p.121-129.

[12] Ceylan H. The economic evaluation of marble powder wastes from marble plant, Suleyman Demirel University, Bsc Thesis (in Turkish), Isparta, 2000, p.53.

[13] Tegethoff W. Calcium Carbonate: von der Kreidezeit ins 21. Jahrhundert,, 3-7643-6424-6Birkhäuser, Basel, Boston, Berlin, 2001, p.342.

[14] Karakas F, Celik MS. The use of coarse cyrstalline white marble wastes as filler material in water based paints, 8th International Marble and Natural Stone Congress, Turkey, 2012, p.111–119.

[15] Kabas S, Faz A, Acosta JA, Zornoza R, Martinez-Martinez S, Carmona DM, Bech J. Effect of marble waste and pig slurry on the growth of native vegetation and heavy metal mobility in a mine tailing pond, Journal of Geochemical Exploration 2012;123:69–76.