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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

*Asian Journal of Science and Technology*
*Vol. 09, Issue, 11, pp.8973-8975, November, 2018*

# RESEARCH ARTICLE

# USE OF INDUSTRIAL AND CONSTRUCTION WASTE MATERIALS IN HIGHWAY CONSTRUCTION: EVALUATION OF THE SELECTED WASTE PRODUCTS

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## ARTICLE INFO

***Article History:***
Received 25th August, 2018
Received in revised form
10th September, 2018
Accepted 24th October, 2018
Published online 30th November, 2018

***Key words:***
Waste,
Road,
Construction,
Oman.

## ABSTRACT

Extensive amounts of waste materials from excavation waste, modern industrial waste and development construction squander are being produced. The utilization of waste materials in highway construction in Oman and uses of chose waste materials are talked about. An assessment in view of specialized, natural and financial components has been required. The fundamental target of this paper is to exhibit the outcomes on the utilization of steel slags and concrete block waste to enhancethe bases and sub-base materials. Additionally, utilizing the marble powder squander as added substance in expanding the quality of subbase material. Physical properties were resolved. All materials were examined as per Oman development particulars. Results can possibly swap ordinary materials for different applications in thruway development and ought to be anticipated for future development. The properties of tried waste materials demonstrated that it is attainable to utilize these materials in the blend of road sub-bases. The materials meet Oman standards, for example, liquid limit, plasticity index and sieveanalysis results.

**Citation:** ***Osama Ragab, Maryam Al-Naaimi, Amani Al-Tourshi, Abir Al-Jahowary, Ali Abdullah Al-Jabri, Khaloud Al-Sadrani and Ahmed Al-Dhli*, 2018.** "Use of Industrial and Construction Waste Materials in Highway Construction: Evaluation of the selected Waste products", *Asian Journal of Science and Technology*, 09, (11), 8973-8975.



## INTRODUCTION

Enormous amounts of local, modern industrial, and mining waste are created in Oman. There are three procedures for transfer of these waste materials: (a) reusing, (b) cremation with or without generation of energy, and (c) internment. The distributed information on current practice show that the bulk of household reject is either burned or land filled. Waste materials are generally utilized as a part of development extends so as to spare regular assets. Increasing the use of these materials in base and sub-base layers will give a progress in the country by saving the main materials, preserving vitality, occupying other materials (El-Assaly and Ellis, 2001). Reused waste materials utilized as a part of black-top asphalts and unbound base/sub-base applications for the most part originate from pulverization waste and results from mechanical procedures. Most normally utilized ones incorporate coarse and fine aggregates, tiles, blocks, coal fly fiery remains, impact heater slag, boiler slag, steel slag, base cinder, glass waste, reclaimed paving materials and elastic tires (Horvath, 2003). There is a limitation of main materials like sand and aggregates which make it more expensive, these wastes can be used in solving other main issues like construction issues. These materials are formed due to construction work and industrial processes consists of some other materials that can be used in strengthen the main material. Population development in Oman will create expanding measures of materials that must be reused. Like squanders keeps on developing, the endorsement and accessibility of offices for waste handling and appropriate transfer will turn out to be more hard to acquire. Oman produces huge amounts of building, development and modern industrial waste which could be reused in road development. In the choice of a stabilizer, the elements that must be considered are the sort of soil to be balanced out, the reason for which the settled layer will be utilized, the kind of soil change, the required quality and solidness of the settled layer, and the cost and ecological conditions. The principle target of this research was to research the potential for utilizing some waste materials created in Sohar territory in Oman in developing road bases and sub bases. Achieving the target, main properties of concrete blocks and mining slags were resolved. Results were contrasted with Oman specifications

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(El-Assaly and Ellis, 2001) with build up the feasibility of utilizing these materials in the construction of sub-base and base layers. Likewise, the accessibility of marble powder squander in expanding the quality of base and sub base material.

### Research approach

There are many types of roads pavement, many of which are called according to the structural material used to construct it. According to the nature of the use, the cost and the materials available, there are random sand roads and dirt roads pavement established by mixing the soil, gravel and sand selected according to the specifications. The surface layer is more or less dispersed with the soil, gravel and sand, Rainwater drainage pipes that obstruct the construction track and require continuous maintenance and refinement of the Wadi and flood banks in addition to continuous maintenance of the water and these types of asphalt have a far off limited use. As to turn up consideration to the main and vital roads that are based on the flexible highway pavement in asphalt or solid pavement roads such us concrete and all have their scientific foundations and standards for the mentioned areas are adopted in determining the type of material that will form the road which depend on the capacity, volume and determine the thickness of the appropriate paving layers that must be so as to give thicker well levelled under the traffic without any drop or collapse. Indeed, our target achievement is to used waste disposal materials from the landfill of industrial and construction waste in the sub-base and base layers of the pavement to encourage and develop waste recycling processes in a manner that takes into account human and environmental protection and specifically at economic reduction in the construction of pavement costs by replacing it with waste materials. As a part of subbase properties which primarily used to support capacity layers and provide strength that serves the whole overlying pavement structures. The changing of construction materials and general disinfection to waste disposal materials is still an importation of Omani politicians.

## MATERIALS

Three waste materials, namely marble waste, slag and concrete block waste were collected from several locations around Sohar industrial area. Treatment was not performed to these waste materials that used in this research. 15 pails for each material were collected from waste place to be tested in Sohar University. There are some experiments were done on these materials according to British Standard (BS EN 1463-2:2000). These tests are sieve analysis, bulk density, specific gravity and absorption, Los angles abrasion, liquid limit and plasticity index tests and California Bearing Ratio (CBR).

## ANALYSIS AND RESULTS

This section analyses the result of the experiments that have been done for all waste disposal materials such us (slag, concrete block waste, marble) that have been used in the highway laboratory at Sohar University for thesis project. Firstly, from table (1) showing the perectanages of abrasion characteristics by using Los Angeles (L.A.) abrasion test for slags and concrete block waste which seems less than 45% based on to the British standard result (BS EN 1463-2:2000).

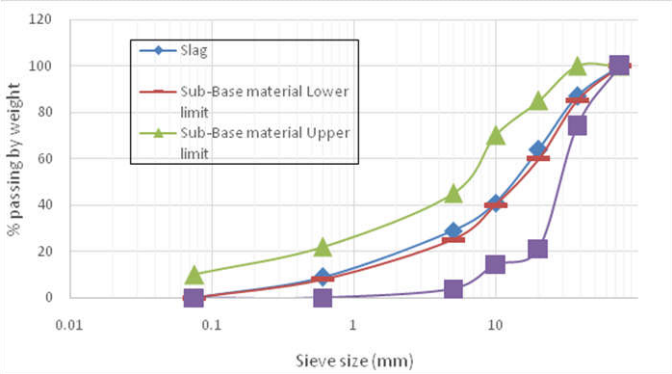


**Figure 1. Sieve analysis results for slag and concrete block waste compared with sub-base upper and lower limits**

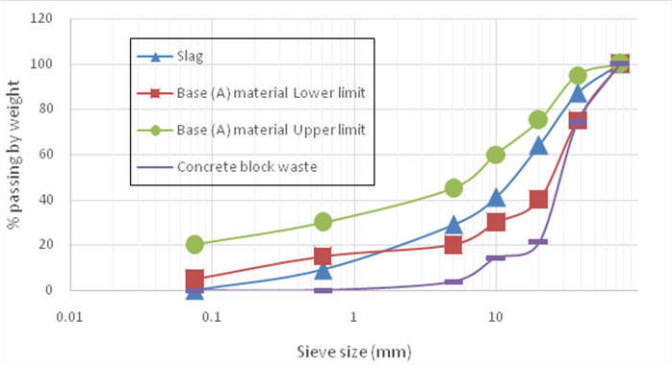


**Figure 2. Sieve analysis results for slag and concrete block waste compared with Class A base upper and lower limits**

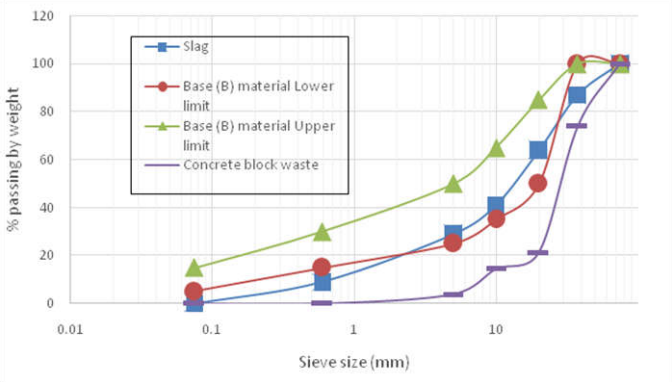


**Figure 3. Sieve analysis results for slag and concrete block waste compared with Class B base upper and lower limits**

Therefore, abrasion value found from Los Angeles test for slag and concrete waste are 22% and 42% respectively and the smaller the result is, the better hardness of aggregates which can hold up more resistance. As it noticeably sees that abrasion test for marble material has been neglected because it is subjected for coarse aggregate sample only. Continuing in table (1), result of Atterberg limit performed of [liquid limit (LL), plastic limit (PL)] that defined as the water content in the three materials slag, concrete waste and marble which appears of higher result than other according to BS Standard both in PL and LL. To come up to grain size distribution, particle grading test is used for all the materials classification using sieve analysis with opening from (75 mm to 0.075mm). As it shown in table (2) that slag and concrete block waste at 75mm sieve is 100 % and 0.075 is 0% because of it coarse hardness large material. Also, specification covers quality and grading for the subbase materials have been achieved by sieve analysis

**Table 1. Physical properties of used waste materials**

| Property | Steel slag | Concrete block waste | Marble waste (Stabilizing agent) | BS-2000 |
|---|---|---|---|---|
| Los Angles abrasion (%) | 22 | 42 | | ≤ 45 |
| specific gravity | 3.03 | 2.293 | 2.37 | N/A |
| Water absorption (%) | 3.34 | 3.65 | 8 | ≤ 4 |
| Liquid limit | 18 | 23 | 35 | ≤ 25 |
| Plasticity index | 4.5 | 5.8 | 35 | ≤ 6 |
| Bulk density (Ton/$m^3$) | 3.2 | 2.21 | 2.37 | |

**Table 2. Sieve analysis results and gradation limits**

| Sieve size (mm) | Percent passing | | | | |
|---|---|---|---|---|---|
| | Slag | Concrete block waste | For sub-base material | Class A For base material | Class A For base material |
| 75 | 100 | 100 | 100 | 100 | ---------- |
| 37.5 | 87 | 74 | 85-100 | 75-95 | 100 |
| 20 | 64 | 21 | 60-85 | 40-75 | 50-85 |
| 10 | 41 | 14.5 | 40-70 | 30-60 | 35-65 |
| 5 | 29 | 3.9 | 25-45 | 20-45 | 25-50 |
| 0.6 | 9 | 0.03 | 8-22 | 15-30 | 15-30 |
| 0.075 | 0 | 0 | 0-10 | 5-20 | 5-15 |

from ASTM Standard which result the specified selected grade is A of type I material. Therefore, the mixture of type was collected from opening sieve of (9.5 mm to 0.075) neglected below sieve of number 0.063 and the pan in order to prevent any damages by frost action as to provide the best gradients, stability and largest carrying capacity. Furthermore, the specific gravity for the three materials have meet the limit of range standard that should be around 3 %. Indeed, of achievement of CBR that been utilize with three main materials (slag, concrete block waste, marble) with changing respected in their percentage rate of 27 triers as to reach to the maximum and the most economic mixed. Thus, with high potential of marble perform consequence high standing results of strength which this method is used to assess the underlying resistance of sub-base layer of reused materials roads that CBR value extracted of many integral part for flexible pavement design approaches.

**Conclusions and recommendations**

Three different wastes allocated from different locations in Sohar, Oman can be used in subbase and base layers for roads in Oman. Different tests were performed for these materials to determine their efficiency according to BS. According to the data resulted from these experiments, the following conclusion can be made:

- Concrete block waste and slag can achieve the Abrasion index, liquid and plasticity index limits for wasted materials as mentioned in BS.
- Marble waste did not satisfy all standard requirements to be used as base or sub-base.
- Marble powder waster can be used as stabilizing agent instead of Portland cement to increase the strength of the layer.
- Slag material has the ability in using for road structure in Oman.
- Concrete block waste is not efficient with its original status to be used as subbase layer in roads of Oman.

**Future Work**

a- Enhancing of these waste materials using Portland cement combined with marble powder waste to improve their strength.

b- Blending the concrete waste material with other original aggregates to meet the requirements.

c- Mixing with outcast aggregate made in Oman such as aluminium, glass waste and other materials.

d- Changing the percentage of marble powder waste to get the best percentage can be used to increase the strength of base and subbase layers.

e- Comparing economically between the virgin aggregates by mixing with cement and marble.

**Acknowledgment:** This research was granted by Sohar University under the exchequer of undergraduate final year project. It is a good opportunity to acknowledge the lab technician of Highway and transportation lab in Sohar University for her support to students during this research.

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