Indian Journal of Science and Technology, *Vol 9(43), DOI: 10.17485/ijst/2016/v9i43/104976, November 2016*

ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Resistance of Building Materials from Recycled Rubble using Lime

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Abstract

Objectives: Recycling the waste materials and debris especially rubbles from demolished buildings. Methods: Environmental problems that have emerged by the non-normative and non-technical disposal of materials, has attracted researchers attention to the recycling of these materials. Available statistics on the composition of the rubbles from buildings in large cities show that bricks and mortar sand, cement, concrete, tile and soil are five main materials of construction rubbles. In this research the possibility of recycling these materials and using them after consolidation and improvement in the litter layer were examined, and to enhance the quality of the materials lime was used for stabilization. Results: Addition of lime increases CBR as well as the resistance of uniaxial compressive of these materials.

Keywords: Anomaly Detection, Data Mining, Healthcare Fraud, Outlier Detection, Unsupervised Method

1. Introduction

In developing countries, construction rubbles occupy the large proportion of municipal solid waste, in addition to high costs for the disposal, they have adverse consequences for the environment. The volume of construction rubble is to the extent that, in all developed countries has become a social and environmental problem[1-4].Construction rubble recycling, not only helps to preserve natural resources and the environment, but also by applying scientific methods makes below economic senses:

- Due to urban development and expansion and increased distance of carrying rubbles from city centers to out of the city, this plan is highly economic due to increasing fuel prices and rising land prices and also the lack of vehicle depreciation and time-saving.
- Loading and transport of materials naturally creates problems for cleaning the town that can be prevented.
- Transportation for the means of carrying rubbles causes traffic, air pollution and also pavement damage that can be avoided by this project.
- Removal of rubbles from the site and replacing with high quality and standard materials, allocate high costs in road construction. It is also possible that near the project site there are no suitable materials.
- On the other hand excessive exploitation of natural resources to build roads, production of concrete, bricks and other building materials, causes shortage of natural materials, after which it can be prevented.
- Since chemicals are used in building materials, we can refer to injuries that can harm the environment and surface water caused by burying rubbles that can be prevented by this project[5,6].
- Reduce health risks and issues.
- Prevent inappropriate landscape around the city.
- Stipulation and the benefit of restoration of damaged roads to execute passive defense.

In addition to the issues, due to the growing need to construction materials, harvesting of natural resources, which often exist in the along river, causes dangerous floods. It is clear that recycling rubble costs a lot which cannot be justified economically in the short term, but the increasing

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cost of raw materials and irreversible environmental damage in the long term, makes the subject of construction rubble recycle an important one. The places of using recycled construction rubble, depends on many factors such as the size and composition of rubble, rubble recyclers, demand, quality of manufactured materials, project development and cost of raw materials. One of the uses of recycled rubble is pavement layers, as in most countries, this issue is being investigated. Due to the lack of suitable construction materials, often stream or stone materials are derived from mining and the high costs of extraction and transportation of these materials, the use of recycled materials in most developed countries such as Germany, Holland, Belgium and Norway, much research has been done and specific standards for has been developed the use of these materials[7]. Rubble recycling issue in Iran does not have a long history and therefore access to data about the production and composition of the rubble of previous years is difficult. In Mashhad which has an old and worn context, nearly one million tons of building rubbles are produced which are buried in three different landfill sites[8]. The main components of construction rubble possible to recycle more, brick, concrete and soil cement and fines and mortar can be mentioned which the approximate percentages of each is given in Figure 1.

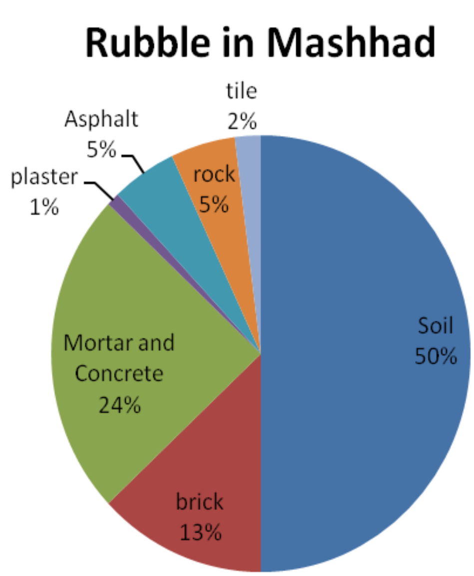

Figure 1. Block diagram of the proposed algorithm.

2. The Materials used in this Study

In the present study the possibility of using all the rubble from the demolition of buildings that can be soil, brick, cement sand mortar and tile formed as a layer of pavement base materials have been studied. According to ASTM D1883 standard for CBR test, grain diameter must be less than 19 mm, but because one of the goals of this paper is to compare the results of available uniaxial and CBR materials, therefore from the beginning all the rubbles were sieved by 19 mm sieve, and then been used in[9-12].

2.1 The Combination of Existing Rubble

The use of brick in the building industry in Iran has a long history, So that the use of load-bearing brick walls for buildings over one floor and even three floors has been common in recent years. The use of brick for the ceiling (ceiling MUL) is the most common type of roof in Iran. Due to the above point, after the separation about 30 percent of the rubble from demolishing was consisted of bricks that can be used again. In the present study, the percentage of the material from the demolition of old buildings is given in Table 1.

Table 1. Percent of the material consisted of the demolition of old buildings

Fine materials	Coarse Material				
	Brick	Plaster	Asphalt	Rock	Tile
60	30	1	2	3	4

2.2 The Physical Properties of Materials

To evaluate the efficiency of construction rubble as pavement base materials, the mechanical properties of these materials were separately performed experiments to obtain the initial specifications. The physical properties of the raw materials for the experiment are described in Table 2.

Table 2. Physical properties of available rubble

Basic features	Soil
The initial wet (w)	6
Density (G_S)	717/2
Fluidity level (LL)	25
Basic features	Soil
Pasty level (PL)	21
Pasty indication (PI)	4
Optimum wet(w)	12
Maximum dry density ($\gamma(d\ max)$)	54/1
The maximum compressive resistance q_u (kpa)	50
Undrained adhesion C_u (kpa)	25

3. Lime

The lime used to stabilize the rubble was of blowing type and formed of chemical structures in Table 3.

Table 3. Chemical structure of lime consumption

Chemicals	Percent used
SiO_2	0.45
Al_2O_3	0.36
Fe_2O_3	0.23
Cao	95.12
Mgo	3.36
SO_3	---
L.O.I.	0.48
total	100

3.1 The Testing Program

To assess the resistance properties of the rubble, in this experiment presented tests in Table 4 were used. In this project, Mix designs with different percentages of available rubble and lime used varies according to the CBR and uniaxial tests conducted. These designs are presented in Table 5.

Table 4. The tests were done on the rubble from the demolition of buildings

	Standard code	number
CBR	ASTM D1883	9
Uniaxial	ASTM D5102	9
Density	ASTM D188	9

Table 5. The composition of the sample made

Designing	Mixed sample (%)	
	Available Rubber (B)	Lime (L)
L0- B100	100	0
L1.5- B100	100	1.5
L3- B100	100	3
L5- B100	100	5

3.2 Not Limited Test of Compression Resistance

Uniaxial tests conducted on samples of soil stabilized with lime have shown that the resistance of soil stabilized with lime is increased, so that in some cases the resistance increases over than last 10 years. Test results show that the uniaxial compressive resistance of soil stabilized with lime that are condensed with more wetness than optimal wetness is more than when the soil has been compacted at optimum wetness of slightly less wetness. Samples constructed in this research, in the form of uniaxial using ASTM D5102 instruction in a cylindrical mold with 15 cm diameter and a height of 11.8 and optimal wetness and condensation were prepared which has the maximum dry density. To stabilize the samples composition mix 1/5, 3 and 5% lime was used and for processing samples made, first the samples were kept into plastic and incubated for 48 h at 50°C that after that period, the samples were removed and tested.

3.3 California Bearing Ratio (CBR)

In many transportation departments in America, understanding the CBR test and simplicity of the method, they use this experiment to determine the bearing strength of the soil stabilized with lime. This test on soil samples stabilized with lime is possible before processing them when the soil is not resistant, but the results of this test were carried out on materials with CBR resistance greater than 100 is not usable and these materials should be evaluated using the uniaxial compressive strength test. CBR testing can be used to assess the response of soil stabilized with lime before processing. Tests conducted on soil samples stabilized and non-stabilized with lime, have been shown that regardless of whether or not the reaction of the soil and ignoring the processing of samples, CBR of all samples stabilized with lime are more than CBR of non-stabilized sample. The experiments conducted in this study according to the standard ASTM D1883, was conducted on the sample with optimum wetness. In present study, samples made by lime with weight percent of 1/5, 3 and 5 available rubble were prepared and processed and each sample was dense in 3 layers and each layer with 30 strokes in molds of 15 cm diameter with a height of 8.11. Because available samples are with different percentages of lime, the diagram is as a function of changes in CBR and different percentages of lime. For processing the samples made, first the samples were kept into plastic and incubated for 48 h at 50°C and after that period, the samples were removed then for saturation was kept in water for 96 hours and then examined.

3.4 Density

Characteristics related to soil compaction and lime mixtures that include maximum dry density and optimum wetness are important for two reasons. The first reason is that for the perfect result of the soil stabilization, stabilized materials must be ground and dense to an acceptable level. The second reason which may be more important is that the soil stabilization control result in the workshop will be conducted according to the specific weight. Additionally, in cases where the aim of stabilizing the soil is soil resistance, for most duration of stabilized materials it is needed to minimize at a certain percentage of the energy density of empty space mix so that the mixture was exposed to excessive moisture resistance is not decreased. Less empty space reduces carbonate and higher density, increases the resistance of the soil stabilized with lime. Some research studies have shown that for every 1% increase in soil bulk density stabilized with lime, 10% will be added to their resistance. Soil stabilization with lime has a specific less dry weight and more optimum wetness of the non-stabilized soil and if the amount of lime used for soil stabilization is more, the difference will be greater. Also, with the passage of time, if more adhesive material stabilized in soil was formed, the maximum specific weight of less materials and optimum wetness content will be more. In this study, the evaluation of density was this way that the compacted samples for testing CBR saturation after 96 hours and completion of these tests, and weighed to determine the amount of wetness removed so as to obtain a sample of the dry density. This work has led in some cases to the results of experiments that previous researchers have done to be slightly different.

4. The Results of Experiments

4.1 Not Limited Compression Resistance Test

Available rubble in this research has been the uniaxial compressive resistance of 30 kilo Pascal which after the addition of 1.5% lime, bearing ratio has been approximately 5 times more and the uniaxial resistance is equal to 150 kilo Pascal. With an increase of 3% lime, compressive resistance has reached 300 kilo Pascal and almost 10 times more compared to bearing ratio than the sample grown without additives. Then, the samples were prepared with 5% by weight of lime rubble from the bearing ratio equal to 500 kPa. These samples were compared to samples without additives have a capacity equivalent to 17 times more. Uniaxial compressive tests conducted in this study show that, adding lime increases bearing ratio of made samples and if the amount of lime consumption increases the compressive resistance of the sample will also increase. Due to Figure 2 it can be concluded that almost with every 1% increase in the consumption of lime, the compressive resistance of stabilized materials will increase to the level of 100 kPa.

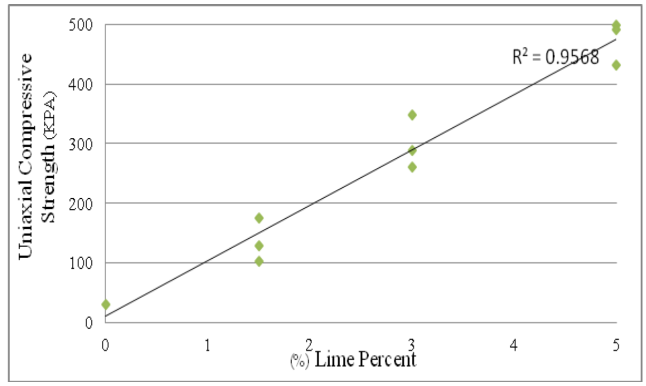

Figure 2. Uniaxial resistance changes with lime.

4.2 California Bearing Ratio

Made samples in this research which were without additive, had CBR equal to 2, with the addition of lime at the rate of 1.5% by weight of the rubble, CBR is the equivalent of approximately 9 and equivalent to 5-fold increase in bearing ratio. With the addition of 3% by weight of the available rubble with lime, CBR materials have been stabilized in 22 and 11-fold increase compared to samples without additives. Finally, the samples made with 5% lime with a CBR of 64 compared to the samples without additives, have grown 32 times. According to Figure 3, it can be concluded that if the amount of lime increases, the proportion to the amount of CBR materials increases and an average increase of 1% lime consumption, 10% is added to the CBR of the materials.

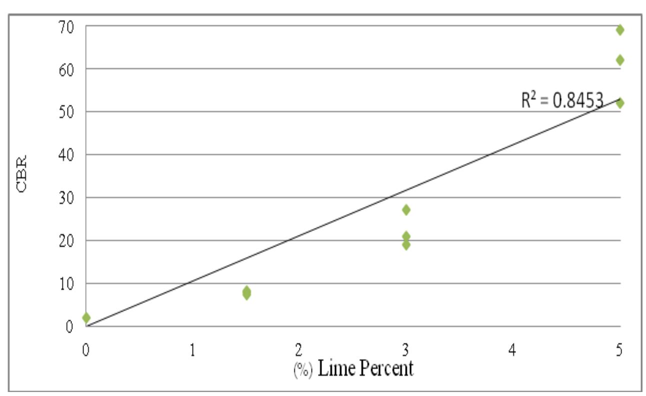

Figure 3. CBR test results according to different lime.

4.3 CBR Result Comparison with the Uniaxial Compressive Resistance

By the comparison made between the results of CBR and uniaxial compressive resistance samples available, it can be concluded that by increasing the amount of CBR, uniaxial compressive resistance is increased. According to the Figure 4 it can be concluded that by increasing the amount of lime, the distance between the CBR and the uniaxial compressive resistance is decreased as the distance between the two tests are closer together.

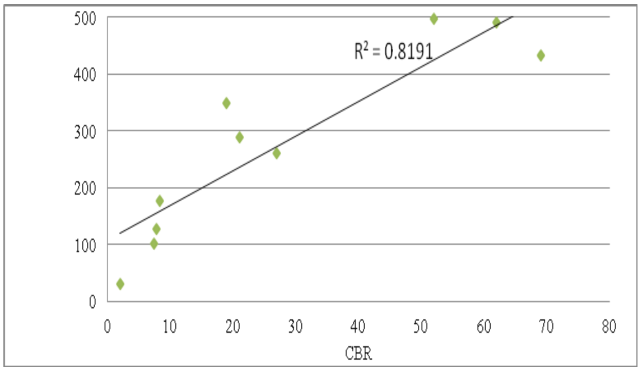

Figure 4. CBR results comparison with uniaxial compressive resistance.

4.4 Density

The specific weight of the available rubble in this study is equal to 1/54 grams per square centimeter, with the addition of lime to 3% by weight of rubble, the adhesion between particles, dry density increased, but to increase the weight of lime used because of low specific weight of lime, dry density decreased. This can be seen in Figure 5.

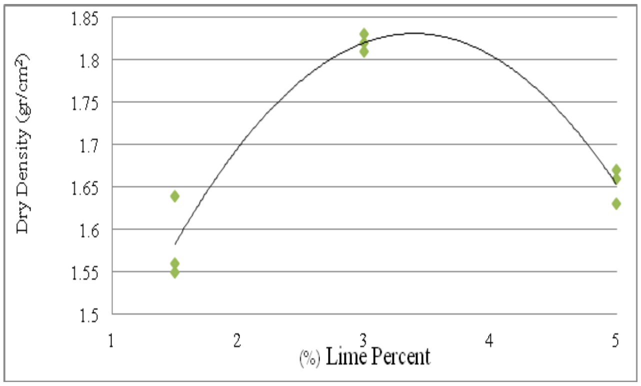

Figure 5. Density Experiment with different percentages of lime.

5. Conclusion

Due to the increasing volume of rubble resulting from the demolition of old buildings and the problems created by the need to recycle, although initially the economic issues, are presented but must first of all examine the possibility of using construction rubble. This study which is an attempt in this direction has produced the following results:

- When the amount of lime consumption is increased, proportioned to that the sample compressive resistance is increased and approximately by 1% addition of lime, uniaxial compressive resistance of 100 kPa is increased.
- When lime increases, the CBR will increase and almost by every 1% increase in lime consumption, CBR existing materials will increase by 10 units.
- Fine grits were used in this study that, were reduced by adding lime and by increasing lime consumption, this amount decreases more. This is due to the adhesion between the particles produced by the lime.
- Materials used in this study had a low PI which by increasing 1% lime, the PI is less than materials without lime. In the following by the addition of 2% lime materials were without PI.
- Raw materials contained in this research has had little uniaxial compressive resistance which with the addition of lime, the resistance increases and when the proportion of lime is more, the compressive resistance of samples increases. Almost by the addition of 1% lime, uniaxial compressive resistance sample increases of 100 kPa.
- Available rubble had low CBR that in road construction is not suitable for the roadbed. By adding lime to these materials, the amount of CBR samples increased with increasing proportion of lime, CBR of existing materials are more appropriate.
- By the comparisons made between uniaxial compressive resistance tests and CBR tests, it can be concluded that the tests had an almost linear relationship with each other and by increase of one the other increases accordingly.

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