THE USE OF RECYCLED CONCRETE AS A SUBBASE LAYER FOR HIGHWAYS

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ABSTRACT

The use of recycled "reclaimed" materials has been increased during the last decades in order to obtain environmental benefits and to reduce the pressure on natural material resources. This paper focuses on using recycled concrete as a subbase material for highways. Concrete cubes produced from concrete tests such as compression strength, have been crushed to produce different particle sizes so as to satisfy the gradations requirements according to the Iraqi specifications for subbase martial. These recycled samples as well as the samples obtained from ordinary subbase have been subjected to maximum dry density, California bearing ratio (CBR) and Atterberg limits tests.

The results obtained from maximum dry density test suggested that the waste materials could be compacted to reach reasonable density. The CBR test's results suggest that the CBR values obtained from recycled concrete is significantly higher than those CBR values obtained from the ordinary subbase. The Atterberg tests showed that the waste concrete material is satisfying Iraqi specifications for roads and bridges (SORB).

1. INTRODUCTION AND LITERATURE REVIEW

Recycling is a process to change waste materials in order to be reused for the same or different purpose of the initial use. Recycled materials usually include many kinds of glass, paper, metal, plastic, textiles, and electronics. The tends of societies/countries to replace the old building with new modern ones, caused in creating of millions of tones from the waste construction materials like concrete and asphalt mixes. This produces a new challenge about where to place such materials since such wastes could dramatically affect the environment and land use, if not handled properly. Therefore, new research has focused on reusing such waste materials in new industrials and construction projects. Such reusing of construction materials may produce more economical resources and help in making friendly "sustainable" environment. However, great attention should be given before recycling to check the suitability of these materials.

The UK design manual for roads and bridges (2004) stated that the United Kingdom government policy encourages conservation and facilitate the use of recycled "reclaimed" and marginal materials wherever possible, in order to obtain environmental benefits and reduce the pressure on natural reserves of primary aggregates.

Several waste materials have been used for highway construction. The most common materials are obtained from recycling of old pavement's materials such as asphalt and aggregate to build new highways. The old embankment materials such as soil and subbase are also been used for new highways' projects.

The use of recycled asphalt material for hot mix design was adopted since 1980 (Al-Qadi *et al.* (2007)). Hunsucker and Whayne (1992) reported that up to 1992, about 80% of the two-million miles of street and highways of the USA are made of recycled asphalt materials.

Many researchers have tested the effect of using recycled concrete as aggregate for concrete structures (see for example: Malesev *et al.* (2010), Yang *et al.* (2008), Poon *et al.* (2003) and others). This research focuses on using recycled crushed concrete as a subbase material for highways. Therefore, the derived materials have been subjected to most of the required tests for subbase materials according to Iraqi specifications for Roads and Bridges (SORB).

2. <u>METHODOLOGY</u>

In this research work, waste concrete cubes (produces from concrete tests such as compression strength test) have been crushed (see **Figure 1**, which shows the concrete cubes before and after crushing) to produce different particle sizes. This is to satisfy the gradations requirements according to the Iraqi specifications for subbase martial. Three different subbase types have been obtained from the crushing process; these are types B, C and D. The mid of gradation specifications has been used in the preparation of these three types as shown in **Table 1)**. Similarly, three types from the ordinary subbase materials have also been prepared for comparison purpose. Figure 2 shows the sieve analysis for the selected samples for subbase types B, C and D.

Table (1) suggests that the best quality of subbase is type "A" which has coarser aggregate and therefore higher California bearing ratio (CBR). This type is usually used for high quality pavements such as those used for freeways and airports. The lowest quality of subbase is represented in Type "D" and therefore this type is only used for shoulders. The common type which is used in most highways is type "B". It should be mentioned here that since subbase type A is rarely used for highway constructions and because the difficulties of obtaining such type from recycling of concrete, no attention is given to use of type A in this study. The adopted tests are:

- Maximum dry density according to AASHTO T-180.
- California Bearing Test (CBR) according to AASHTO T-193
- Atteberiq limits test according to AASHTO T-90

3. <u>TEST RESULTS</u>

This section explains the results obtained from testing the ordinary subbase samples (i.e. without waste materials) and the samples obtained from the recycled concrete.

3.1. Maximum dry density

Figure (3) shows the relationship between the water content and the maximum dry density. The figure shows the maximum densities obtained from the ordinary subbase are 2.280, 2.250 2.245 gm/cm^3 for types B, C and D respectively. While the corresponding densities for the recycled samples were 2.23, 2.27 and 2.202 gm/cm^3.

Generally, the results more or less are identical and that suggest that the subbase material obtained from the recycled concrete can be compacted to reach reasonable density.

3.2. California Bearing Ratio (CBR) test

Figure (4) shows the results obtained from the CBR test for both ordinary and waste materials. The results suggest that the CBR values obtained from the recycled concrete give significantly higher CBR values when compared with those values obtained from the ordinary subbase. This could be related with the amounts of dust materials which are usually higher in the ordinary subbase. The whole materials quality maybe another reason since the concrete material should have more resistance for the applied load compared with the ordinary subbase materials.

3.3. Atterberg limits

Atterberg limits define the nature of fine-grained soils and can be used to distinguish between different types of soils. The specifications of subbase materials used for highways (SORB, 2000) stated that the liquid limit and plasticity index should not be exceeding 25% and 6% respectively.

For ordinary subbase materials, the results may vary depend on the amount of clay particles. The results obtained from the recycles concrete suggested no values for both plastic and liquid limits which mean zero plasticity index (PI-0). This is because the fine materials within the recycled concrete non-clay materials (i.e. sand particles) which prevent forming a sample tests according the Atterberg limits test's procedure. This is satisfying the Iraqi specifications requirements (SORB).

4. CONCLUSIONS AND RECOMMENDATIONS

This paper focused on using recycled concrete as a subbase material for highways. Concrete cubes produces from concrete tests, such as compression strength, have been crushed to produce different particle sizes so as to satisfy the gradations requirements according to the Iraqi specifications for subbase martial. These recycled samples as well as the samples obtained from ordinary subbase have been subjected to maximum dry density, California bearing ratio (CBR) and Atterberg limits tests.

The results obtained from maximum dry density test suggested that the waste materials could be compacted to reach reasonable density. The CBR test's results suggests that the CBR values obtained from recycled concrete are significantly higher than those CBR values obtained from the ordinary subbase. The Atterberg tests showed that the waste concrete material is satisfying Iraqi specifications for roads and bridges (SORB).

Therefore, it could be concluded here that the recycled concrete could be used as a subbase material for highways. However, further tests may be needed to show the effect of having different proportions from mixing the recycled concrete and ordinary subbase.

5. REFERENCES

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Table (1): Subbase types according to Iraqi specifications (SORB, 2003)

	Sieve size	Percent of passing			
		Type A	Type B	Type C	Type D
Gradation	75mm	100	-	-	-
	50mm	100-95	100	-	-
	25mm	-	95-75	100	100
	9mm	65-30	75-40	85 -50	100-60
	4.75mm	55-25	60-30	65-35	85 -50
	2.36mm	42-16	47-21	52-26	72-42
	0.3mm	18 -7	28 -14	28 -14	42-23
	0.075mm	8 -2	15 -5	15 -5	20 -5
CBR (minimum)		45	35	30	20
Liquid limit (maximum)		25 for highways and 35 for shoulders			
Plasticity index (maximum)		6 for highways and 9 for shoulders			

Figure (1) Concrete cubes before and after crushing

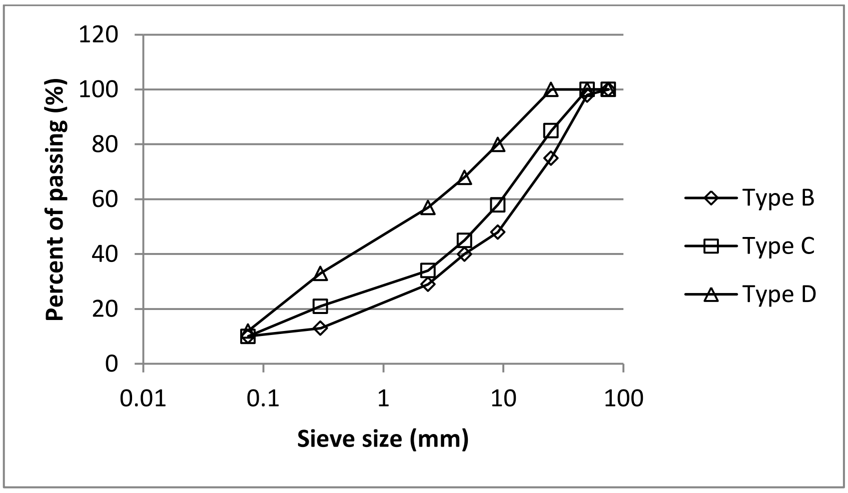

Figure (2) The gradations of used subbase

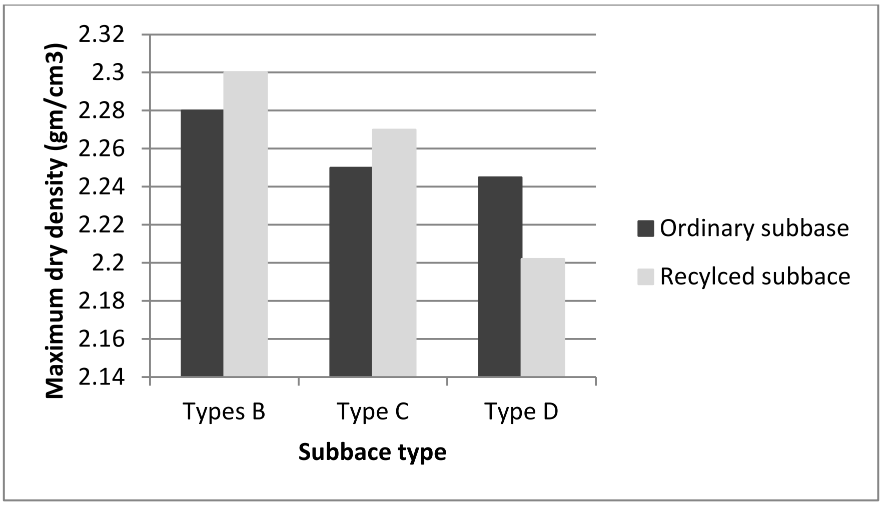

Figure (3) Maximum dry density results

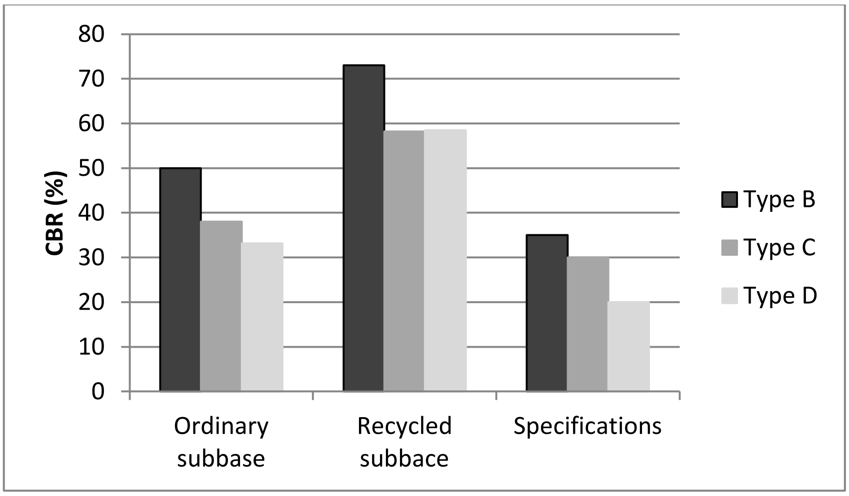

Figure (4) California bearing ratio (CBR) results