VIABILITY OF USING DEMOLISHED CONCRETE AS A MATERIAL IN SUB BASE APPLICATIONS

M. A. C. D. Wijewardana, A. D. E. De Alwis, S. A. D. Lakmini and K. M. L. A. Udamulla*

Department of Civil Engineering, The Open University of Sri Lanka

INTRODUCTION

Recycling and reuse of waste materials is a topic of global. The urgent need for recycling is driven mainly by environmental considerations, due to the increased scarcity of natural resources and the increasing cost of landfills in most countries (Aulrajah et al. 2013). Construction and Demolition (C&D) materials are generated as a result of regeneration of infrastructure and demolition activities, and contribute the major proportion of waste materials present in landfills (Aatheesan et al. 2009). Demolished concrete is a viable substitute material for natural construction materials in engineering applications such as its use as a road sub-base material.

Currently, materials used for sub-base constructions are taken from gravel excavation and these resources are depleting rapidly due to large excavations. Therefore, there is an urgent need of finding alternative materials. Recycled demolished concrete and blends are viable substitute material for natural construction materials (gravelly soil) in engineering applications needing sub base materials for pavements. This will help reduce the waste material added to the environment from demolished buildings and will save gravel. In this context, the project seeks to find out the viability of using demolished concrete as a material in sub-base construction.

METHODOLOGY

The physical properties (moisture content, water absorption and specific gravity) of gravelly soil and demolished concrete were determined to compare the properties of demolished concrete with that of gravelly soil. These tests were conducted according to the specifications given in Table 4.

The material blends of gravelly soil and demolished concrete were prepared with varying proportions as shown in Table 1. Sample 1. with 100% gravelly soil was kept as the control sample.

Table 1. Mix Proportions of Gravelly soil and Demolished Concrete

	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
Gravelly soil	100 %	80 %	70 %	60%	50%	0%
Demolished concrete	0 %	20 %	30 %	40%	50%	100%

The particle size distribution, California Bearing Ratio (CBR) test, Atterberg limits test and Modified Proctor compaction tests were carried out on the above blends of gravelly soil and demolished concrete.

The results obtained from the tests were compared with the ICTAD specifications given in Table 2 and Table 3.

* *Corresponding author: Email -* ***lakshika0807@hotmail.com***

Table 2. ICTAD Requirement of Sub-base (ICTAD, 2002)

PROPERTY	TEST METHOD (AASHTO)	UPPER SUB-BASE		
			Flexible	Rigid
Liquid Limit (LL)	T-90	Not to exceed	40%	25%
Plasticity Index (PI)	T-90	Not to exceed	15%	6%
Maximum Dry Density (MDD) (Modified)	T-180	Not less than 1750 kg/m^3		
4- day soaked CBR at 98% MDD (Modified)	T-193	Not less than 30%		

Table 3. Grading Requirement for sub-base as per ICTAD Specifications (ICTAD, 2002)

SIEVE SIZE		PERCENTAGE BY WEIGHT PASSING SIEVE
mm	µm	
50		100
37.5		80-100
20		60-100
5		30-100
1.18		17-75
	300	9-50
	75	5-25

RESULTS AND DISCUSSION

Physical properties of gravelly soil and demolished concrete

The physical properties of gravelly soil and demolished concrete are given in Table 4.

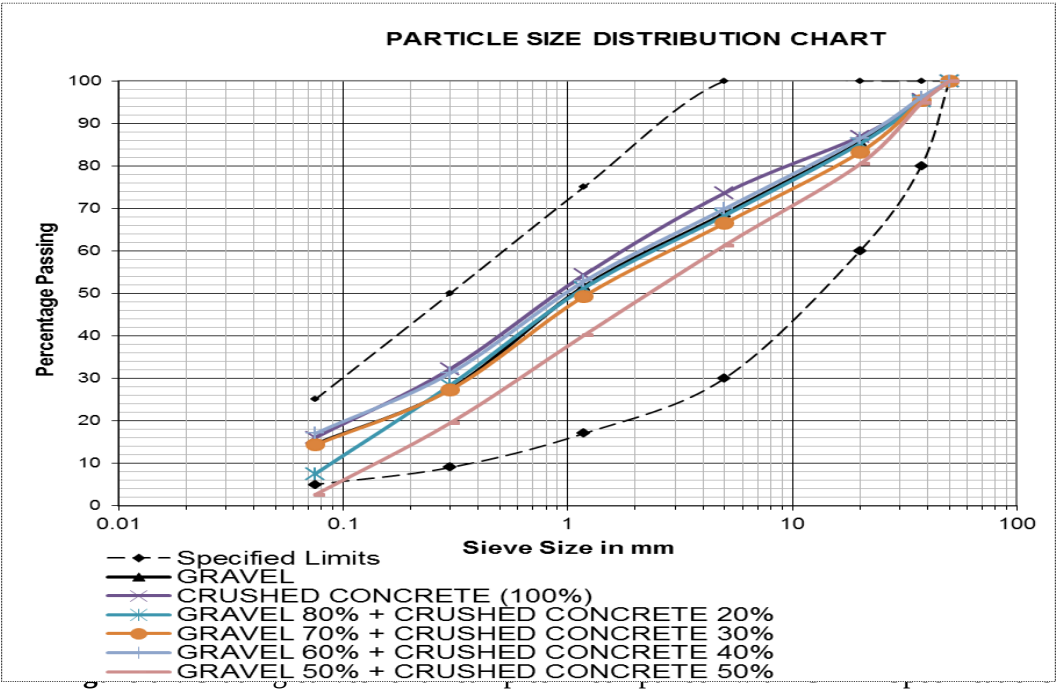
Table 4. Physical Properties of Gravelly soil and Demolished Concrete

	Testing specification	Gravelly soil	Demolished concrete
Moisture content dry%	BS 812-109:1990	2.13	2.19
Moisture content wet%	BS 812-109:1990	1.97	2.14
Water absorption %	BS 812: Part 2:1995	1.12	1.52
Specific gravity	(AASHTO T 85)	2.28	2.64

The dry and wet moisture contents of gravelly soil and demolished concrete do not show a significant difference whereas the water absorption and specific gravity of demolished concrete is slightly higher than that of gravelly soil.

Sieve analysis

The particle size distribution test (sieve analysis) was performed according to BS 812-103.1:1985 and is given in Figure 1.



The gradation requirements of all samples were satisfied as the curves lie within the upper and lower boundaries of ICTAD specified particle size distribution curves.

Liquid limit

The Atterberg limits of gravelly soil and demolished concrete are given in Table 05.

Table 5. Liquid Limit and Plasticity Index

Sample	Limit		
	LL (%)	PL (%)	PI (%)
Requirement	**<40**		**<15**
Gravelly soil	36	27	9
Demolished concrete	-	-	NP

Liquid limit and plasticity index of samples were within the standard limits. Plastic limit for demolished concrete with the samples could not be found because demolished concrete is a non-cohesive material.

Maximum dry density of Modified Proctor Compaction test

The maximum dry densities of samples are given in Table 06.

Table 6. Maximum Dry Density

Sample	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
MDD (kg/m^3)	1808	1876	1896	1912	1935	1960
Requirement (MDD > 1750 kg/m^3)	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

Maximum dry density of demolished concrete and in the samples was higher than the value achieved for gravelly soil while all the values satisfied the ICTAD requirement.

4- Day soaked CBR at 98% MDD (Modified)

Table 7. CBR Values of Samples

Sample	Sample 01	Sample 02	Sample 03	Sample 04	Sample 05	Sample 06
CBR (%)	42	55	62	75	101	120
Requirement (4- day soaked CBR at 98% MDD >30%)	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

4 – Day soaked CBR at 98% MDD for all samples tested were above 30% as per the ICTAD requirement and therefore the ICTAD specification of CBR value was satisfied.

CONCLUSIONS

The moisture content of gravelly soil compared to demolished concrete does not show a significant variation. However, water absorption and specific gravity of demolished concrete is slightly higher than that of gravelly soil. Plastic limit test results shows that demolished concrete is a non-plastic material. The gradation requirement of all samples was satisfied as the curves lie within the upper and lower boundaries of ICTAD specifications. The addition of demolished concrete to gravelly soil increases the maximum dry density of the samples and its CBR value. The requirement of ICTAD specifications for all the samples was fulfilled. According to the test results, demolished concrete can be used as either a partial or full substitute material for gravelly soil in sub-base applications.

REFERENCES

Aatheesan T., Arulrajah A., Newman G., Bo M.W. and Wilson J., 2009, “Crushed brick blends with crushed concrete for pavement sub-base and drainage applications”, Australian Geomechanics, 44(2), 65-72.

Arulrajah, A., Piratheepan, J., Disfani, M. M. and Bo, M. B., 2013, “Geotechnical and geoenvironmental properties of recycled construction and demolition materials in pavement sub base applications”, Journal of Materials in Civil Engineering, 25(8), 1077-1088.

Chidiroglou, I., Goodwin, A. K., Laycock, E., and O'Flaherty, F., 2008, “Physical properties of demolition waste material.” Proc. Institution of Civil Engineers: Construction Materials, 161(3), 97-103.

Institute for Construction, Training and Development (ICTAD), 2002, Standard Specifications for Construction and Maintenance of Roads and Bridges (SCA/5) -Second Edition.

Mandal J.N. and Divshikar D.G., 1995, Soil Testing in Civil Engineering, A.A. Balkema Publishers.

Neville A.M., 1995, Properties of Concrete, fourth and final edition, Longman Group Limited, England.