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Utilization of Building Debris for Road Construction in the Northern Province of Sri Lanka

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ABSTRACT : Northern region of Sri Lanka is undergoing a massive infrastructure development especially in the road sector development during a shorter period. Northern region emerged with few new problems such as scarcity of construction material and disposal of construction debris. Roads are major consumers of aggregate and soil and the effect of transport cost of material is more than 50 % of total construction cost. In order to curtail the construction cost and reduce the industrial waste disposal, experimental studies were carried out in this research on selected building debris such as concrete, random rubble masonry, concrete block and plaster to find out the possibility of using building waste as road construction material. It has been observed that the random rubble masonry debris can be directly used for road base construction after removing cement plaster however; crushed debris can replace the soil for construction of roads after adding plastic particles.

1. INTRODUCTION

Construction industry in Sri Lanka attained a rapid growth in order to equip with sufficient infrastructure while is immensely needed for growing population and their demand. Infrastructure development will improve the standard of living, quality of the people in the country. The problems faced by the construction industries are the scarcity of construction materials and disposal of construction and demolished waste because of less landfill area which could be used as dumping sites.

After the three decades of war, Northern region of Sri Lanka is undergoing a massive infrastructure development within a shorter period especially in the road sector development. Road sector development will result in several social and economic developments to the area and country as well.

Recently, the Northern region encountered problems in finding out good quality of road construction material for their road projects. Roads are major consumers of aggregate and soil. The aggregates for these road constructions are transported from Medawachchiya, the approximated transport distance from

Medawachchiya is more than 150 km. Hence, transport cost will become approximately 70% of the project cost.

Example:

Cost analysis for Construction of Aggregate Base Course based on Highway Schedule Rate 2014 (HSR) is shown below,

Construction of Aggregate Base Course (without transport) = Rs. 2,105.80
Transport of Aggregate = $31.65 \text{ Cum/km} \times 150 \text{ km}$
= Rs. 4,747.50

In addition to that, disposal of huge quantity of building debris due to the remaining of abandoned buildings during the war is also a problem to the Government because of limited landfill area and huge cost of transportation. Major parts of the land in the Northern region are paddy fields, cultivation land and minor tanks and most of the people do farming. So, disposing industrial waste in these lands cause flooding, environmental problem and affect their livelihood activities. Hence, it is the best solution to reuse the construction waste and building debris for construction projects.

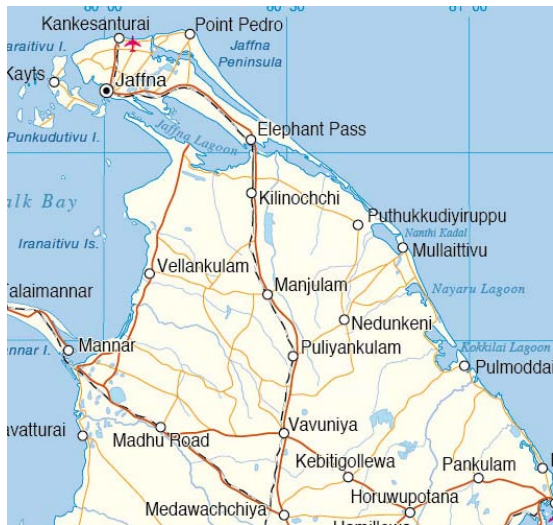


Fig. 1 Aggregate Transport Path to Northern Province from Medawachchiya

The environment of the Northern Region mainly consists of residential and agricultural lands including paddy fields and mixed cultivation. The majority of roads are ‘C’, ‘D’ and ‘E’ class roads (ie. earth roads) according to the classification of the Road network in Sri Lanka. The major construction material used in ‘C’, ‘D’ and ‘E’ class roads is soil. In addition, soil is used for construction of sub base, shoulder and embankment of all categories of roads. Hence, crushed building debris is tested to find out the suitability for replacing soil in road construction. The conventional soil testing adopted in highway sector are California Bearing Ratio test (CBR), Compaction Test and Consistency Test.

In this study plaster, concrete, concrete block masonry and random rubble masonry sample were collected from Jaffna District as shown in the map and standard aggregates tests were carried out for each sample separately according to the BS 812 and soil tests were carried out for crushed samples separately. The results obtained from the tests were analyzed and compared with the ICTAD publication No. SCA/5, Second Edition, June 2009; ‘Standard Specification for Construction and Maintenance of Roads and bridges (SSCM)’ issued under the authority of the Director General of the Road Development Authority.

2. METHODOLOGY

This research is an experimental study to find out the suitability of engineering properties of various

kinds of building debris and then comparing the results with conventional material properties published by ICTAD in Standard Specification for Construction and Maintenance for Roads and Bridges (June 2009).

Identified different types of building debris such as concrete, plaster, stone masonry and concrete block masonry have been collected separately from the Northern Province and transported to the laboratory for experiments.

Aggregate Impact Value Test (BS 812, Part 112), Aggregate Crushing Value Test (BS 812, Part 110), Los Angeles Abrasion Value Test- B grade (ASTM, C131), water absorption test and CBR test were carried out separately on selected debris according to the standard.

Debris of concrete block, cement plaster and concrete were crushed separately. At one trial, Clay and soil were mixed with crushed sample at the ratio of 1: 2: 3 (clay: soil: crushed debris) to prepare test samples.

1. Sample 1 - Clay: Soil: Concrete block debris – 1: 2:3
2. Sample 2 - Clay: Soil: Cement Plaster debris – 1: 2:3
3. Sample 3 - Clay: Soil: Concrete debris – 1: 2:3

Fine particle tests such as Atterberg Limit Test, Modified Proctor Compaction Test and CBR Test were carried out separately on crushed building debris after adding certain percentage of clay. In this research, Modified Proctor Compaction test has been carried out on the samples since CBR property requirement of material is given in the Standard Specification for Construction and Maintenance of Roads and Bridges under modified proctor compaction test.

Test Results were compared with the conventional material properties provided in Standard Specification for Construction and Maintenance of Roads and Bridges (June 2009).

3. RESULTS AND ANALYSIS

3.1 Results and comparison of Coarse Particle Test Results

The coarse particle tests results obtained for different kind of debris have been compared with

the standard properties provided in the SSCM of Roads and Bridges (June 2009).

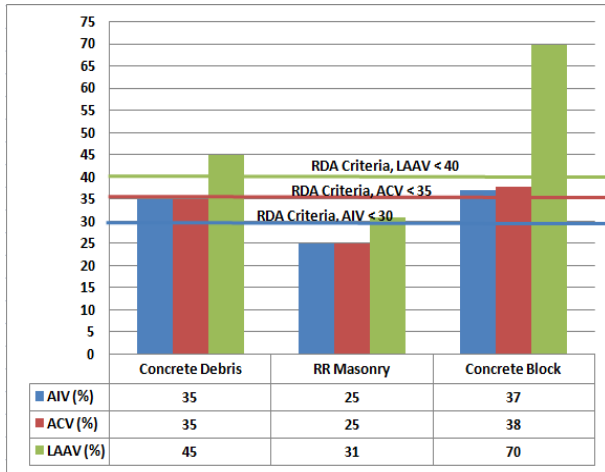


Fig. 2 Results and Comparison of Coarse Particle Test

The above figure shows the results and comparison of coarse particle tests. The properties of random rubble masonry debris are satisfied the criteria of road base material given in the SSCM of Roads and Bridges (June 2009). Water absorption of random rubble masonry debris is 1.4% (<2%) is also within the property limit of road base material.

3.2 Results and Comparison of Fine Particle Tests

3.2.1 Atterberg Limit Test

Results and comparison of Atterberg Limit test of different type of crushed debris using Casagrande's method are illustrated below,

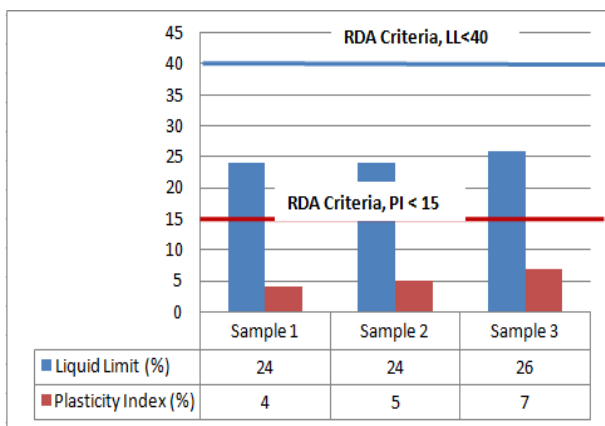


Fig. 3 Results and Comparison of Atterberg Limit Test

3.2.2 Compaction Test

Results and comparison of compaction test of different kinds of crushed debris are illustrated below,

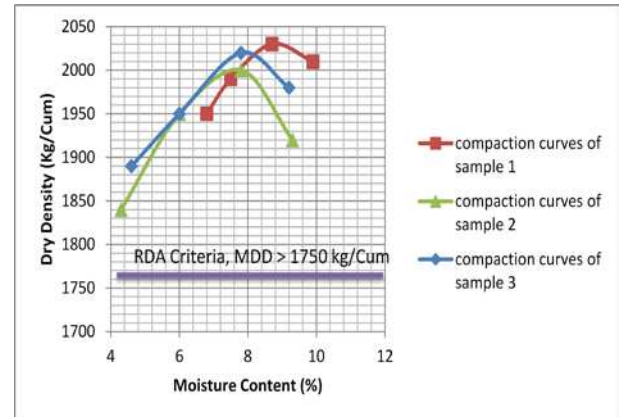


Fig. 4 Results and Comparison of Modified Compaction Test

3.2.3 California Bearing Ratio Test

Results and comparison of soaked CBR test of different type of crushed debris are illustrated below,

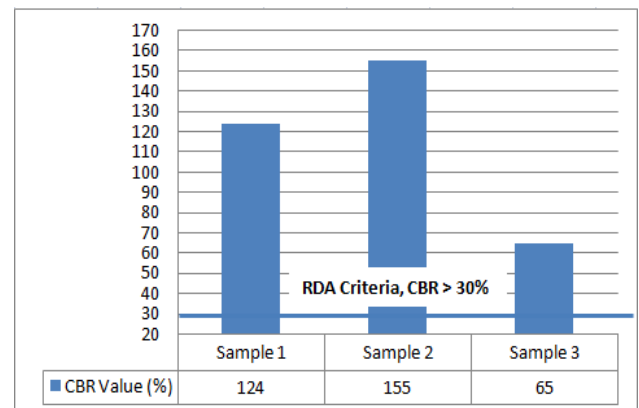


Fig. 5 Results and Comparison of soaked CBR Test Results

From the Figs. 3, 4 and 5, properties of crushed building debris of plaster, concrete block masonry and concrete are within the limit given in the SSCM for Roads & Bridges (June 2009).

4. SUGGESTED CONSTRUCTION METHODOLOGY

The following construction methodology is suggested to use crushed building debris as a fine particle material in road construction since non - availability particular specification for road construction using building debris in Sri Lanka.

1. Prior to site construction, laboratory testing such as sieve test, compaction test, CBR test and Atterberg test shall be carried out to the different sample which is prepared in different proportionate of crushed building debris, soil and clayey soil in order to determine the mix design.
2. The mix design is determined based on the criteria of fine particle material given in the SSCM, June 2009.
3. According to the mix design, construction material shall be prepared at the site.
4. Field trial test shall be carried out before the construction work to determine the effective thickness of compaction layer, rolling pattern and number of passes.
5. Site construction shall be carried out as per the results of Field trial test.

5. CONCLUSION

According to the results and analysis carried out as per the RDA standards, the conclusions could be summarized as follows,

1. According to the coarse particle tests carried out in the selected sample, Random Rubble Masonry debris only satisfied AIV, ACV and LAAV limit of road base material given in the SSCM for Roads and Bridges and it can be used for road base construction after removing cement plaster.
2. As per the fine particle tests such as compaction test, Atterberg test and CBR test carried out on crushed building debris, debris of plaster, concrete block masonry, concrete are within the limit provided in the SSCM for Roads and Bridges and shall be used for sub base and Embankment construction.
3. Crushed building debris of plaster, block masonry, concrete debris are suitable for shoulder and surfacing of 'D' and 'E' class

earthen road after adding clay particles. The ratio of clay, soil and crushed building debris depends on the properties of construction debris, type of soil, class of roads and type of usage in road construction. Therefore, it shall be decided based on field trial test prior to construction.

ACKNOWLEDGEMENT

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REFERENCES

- American Standards for Testing and Material
- British Standards Codes
- Standard Specification for Construction and Maintenance of Roads and Bridges, ICTAD SCA 5 (June 2009).