RESEARCH PAPER | Engineering | Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

Influence of Waste Materials on Flexible Pavement Construction

KEYWORDS: Clay tile waste, demolished concrete waste, CBR test, subbase layer

Bindu C.S

Associate Professor, Division of Civil Engineering, School of Engineering, Cochin University of Science& Technology, Kochi

ABSTRACT *The construction of pavements is costly due to the non-availability of a strong subgrade. This paper focuses on the suitability of clay tile waste as stabiliser in subgrade and demolished concrete waste as subbase in flexible pavement. Clay tile wastes mixed in different proportions to the soil and their influence on geotechnical properties are studied. A study of CBR strength of demolished concrete waste as sub base(GSB) layer underlain by the stabilized subgrade layer is conducted. The optimum percentage of tile waste in the soil is 45%. The demolished concrete waste selected is a combination of 20% of greater than 20mm aggregates,40% 20mm down aggregates and 40% dust with a CBR of 48% and qualifies for GSB-III and can replace the GSB layer in the pavement. The effect of demolished waste thickness as subbase layer on the overall strength of pavement considering only sub base and subgrade layers is determined.*

INTRODUCTION

Long term performance of pavement structures often depends on the stability of the underlying soils. Conventional waste disposal methods are found to be inadequate. The existing soil at a particular location may not be suitable for the construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling. For sustainable development use of waste material should be encouraged.

It is crucial for highway engineers to develop a subgrade with a California Bearing Ratio (CBR) value of atleast 10. Research has shown that if a subgrade has a CBR value less than 10 (Ayothiraman etal.2002) the subbase material will deflect under traffic loadings in the same manner as the subgrade and cause pavement deterioration. Stabiling the weak soil with suitable waste material as stabilizers (Palaniappan, and Stalin, 2009) is an effective method. A lot of research work has been reported on the stabilization of soil by waste materials in powdered form. Ceramic dust (Ameta etal,2013). Quarry Dust (Sabat, 2012) , marble dust (Sabat,2011; Baser ,2009; Swami,2002), Foundry Sand and Fly Ash and Tile waste (Amrendra etal, 2014) are some of the prominent dust/powder like waste materials which have been successfully utilized for stabilization of subgrade. A large percentage of clay tile waste is produced during formation, transportation and placing of tiles. 55% of tile waste remains unutilized and its disposal is a problem which can be effectively utilised as a stabiliser in subgrade soil. The available literature shows that only a limited amount of experimentation is done with tile waste as an additive for soil stabilization.

The subbase usually consists of crushed aggregate or gravel or recycled materials. As the granular subbase provides both bearing strength and drainage for the pavement structure, proper size, grading, shape and durability are important attributes to the overall performance of the pavement structure. In recent years demolished concrete waste handling and management is a challenging issue. It is desirable to completely recycle demolished concrete waste in order to protect natural resources and reduce environmental pollution. This paper presents the feasibility of the application of Construction Demolition Waste (CDW) for improving the performance of subbase layers in the highways. The strength of CDW underlain by subgrade layer stabilized with clay tile waste is studied.

OBJECTIVES

The main objectives of the studies are to investigate the influence of waste material, clay tile as stabiliser on the strength characteristics of subgrade soil and to study the feasibility of the application of Construction Demolition Waste (CDW) as granular sub base layer in the pavement.

The sub objectives are to study the improvement in strength characteristics of subgrade soil and CDW-soil subgrade composites, to propose a mix composition which can be economically used for the stabilization of subgrade soil , to arrive at the gradation of demolished concrete waste to qualify for GSB-III as per MoRT&H specifications to determine the effect of CDW thickness on the overall strength of pavement considering only sub base and subgrade layers and the influence of CDW/Total thickness ratio on the CBR value of the CDW- soil subgrade composite simulated for the study.

MATERIAL CHARACTERISATION

The materials used in this study are Subgrade soil (kaolinite clay), Clay tile waste, Demolished cement concrete waste.

3.1 Subgrade soil (Kaolinite clay)

The soil used in this study was locally available kaolinite clay (Fig.1), collected from kizhakambalam, Ernakulam district of Kerala.

3.2 Clay tile waste

A lot of clay tiles waste is produced during formation, transportation and placing of tiles. This wastage or scrap material is inorganic in nature and hazardous and its disposal is a problem which can be tackled by utilizing it as an admixture to stabilization. Tile waste (Fig.2) used in this study is obtained from a construction site, Aluva in Kerala. It is crushed into the size range of 20mm to 4.75mm with the help of a hammer.

3.3 Demolished cement concrete waste

Cement concrete wastes obtained during the demolition of

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

concrete structures are taken for the study (Fig.3).

Fig.1 Locally available kaolinite clay

Fig.2 Clay Tile Waste

Fig. 3 Crushed demolished cement concrete waste

EXPERIMENTAL INVESTIGATIONS

Laboratory studies are carried out to determine the properties of soil and to access the suitability of demolished building wastes as granular sub base for pavement construction.

4.1 Determination of physical properties

The physical properties of the kaolinite clay (Table 1),clay tile waste (Table 2) and demolished cement concrete waste (Table 3), are determined. The particle size distribution curve for kaolinite clay is given Fig.4 and clay tile waste in Fig.5. The soil consists of grains mostly of fine sand to silt size.

Table 1 Physical properties of subgrade soil

Properties	Value
Specific Gravity	2.5
Grain size analysis	
a)>4.75mm(Gravel)(%)	**1.7**
b)4.75-0.75mm(Sand)(%)	**46.6**
c)<0.75mm(Silt+Clay)(%)	**51.8**
Consisteny Limit	
a)Liquid Limit,W_L(%)	**41**
b)Plastic Limit,W_P(%)	**22.7**
c)Shrinkage Limit,Ws(%)	**10.4**
d)Plasticity Index,I_P(%)	**18.3**

Table 2 Physical Properties of clay tile waste

Properties	Value
Particle size distribution	
D_{10}mm	2.36
D_{30}mm	10
D_{60}mm	12.5
Coefficient of curvature,Cc	3.38
Uniformity coefficient,C_u	5.3
Fineness modulus	2.96

Table 3 Physical properties of demolished cement concrete waste

Properties	Value	Range of values as per MoRT&H specifications
Specific gravity	2.6	2.5-3.0
Aggregate impact value(%)	14	10-30
Aggregate crushing value(%)	31	Max. 45
Combined Flakiness and Elongation index value(%)	13.9	Max.30
Aggregate abrasion value(%)	32	Max.40%
Compaction characteristics		
a)Maximum dry density(g/cc)	1.9	
b)Optimum moisture content(%)	16.0	
California bearing ratio value(%)	47.8	

Gradation analysis of proportioned CDW is carried out and is given in Table 4. By trial,a mix of demolished concrete waste in proportion of 20% of greater than 20mm aggregates,40% of 20mm down aggregates and 40% of dust yielded a GSB material satisfying gradation-III as per MoRT&H specification.

Table 4 Gradation analysis of proportioned CDW materials

IS sieve size,mm	Specification as per MORTH,Table 400.2 for close graded GSB(% Passing)	Obtained gradation
26.5	100	100
9.5	65-95	81.08
4.75	50-80	50
2.36	40-65	41.6
0.425	20-35	20
0.075	3-10	4.3

4.2 Determination of engineering properties

The compaction test(IS: 2720 Part-VII, 1980) and CBR test (IS: 2720 Part-XVI, 1987) has been performed on soils with different clay tile waste contents varying from 0% to 60% at an increment of 5 %. The tests are performed with optimum percentage of clay tile waste (obtained from CBR test) on different thickness combinations of CDW as sub base and subgrade layers together. Table 5 shows the engineering properties of clayey soil.

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

Table 5 Engineering properties of clayey soil

Properties	Value
Modified Proctor Test	
a)Maximum Dry Density,γ_{dmax}(g/cc)	1.65
b)Optimum Moisture Content(%)	18.9
California Bearing Ratio(%) (4 days soaked)	3.03

Compaction curve for clayey soil is shown in Fig. 6 and for CDW in Fig.7. Variations of CBR with various % of tile waste are shown in Fig.8. The tests were performed on different thickness combinations of CDW sub base and subgrade layers together. The total thickness of two layers together is denoted as "T". The total thickness T in CBR test is 127.5mm.The different combinations of height of CDW sub base and sub grade layers are as shown in Table 6 and is designated as type I to type V henceforth. Thickness of CDW layer is taken as "h"and T as the total thickness. For the CBR test, compaction was done in 5 layers with 56 blows for each layer as per the requirements. In case of combined layer composition (for type II, type III and type IV), CDW layer is compacted first for a corresponding volume before sub-grade soil. After compaction, the mould is reversed. The prepared specimen is soaked for a period of four days and later tested. Fig. 9 shows the variations of CBR value for different h/T ratios and effect of h/T ratio on CBR is shown in Fig. 10.

Table 6 Combinations of sub-grade and CDW layers

Thickness of subgrade layer(55%kaolinite clay+45%clay tile waste)	Thickness of CDW layer "h"	h/T ratio	Type
100%	0	0	I
75%	25%	0.25	II
50%	50%	0.50	III
25%	75%	0.75	IV
0	100%	1	V

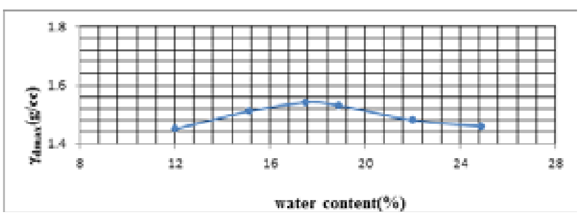

Fig. 6 Compaction curve for kaolinite clay

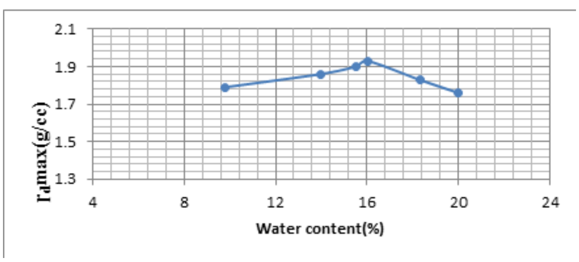

Fig. 7 Compaction curve for crushed demolished cement concrete waste

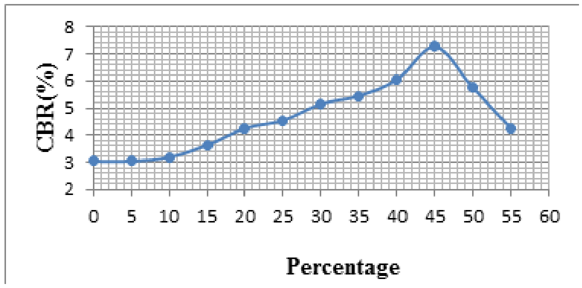

Fig .8 Variations of CBR with various % of clay

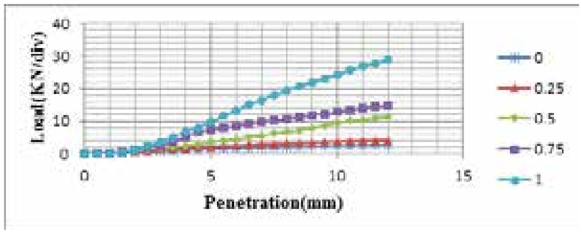

Fig. 9 Variations of CBR value for different h/T ratios

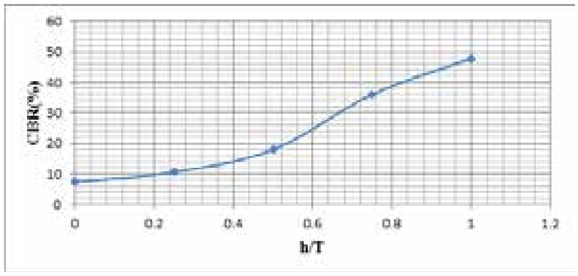

Fig. 10 Effect of h/T ratio on CBR5. RESULTS AND DISCUSSIONS

5.1 Effect of clay tile waste on California bearing ratio test

From Fig.8 ,it is observed that as the percentage of clay tile waste increases, the CBR value increases for every 5% increase in clay tile waste upto 45% and then decreases with the addition of tile waste. By the addition of 45% of waste , CBR value of the soil sample was increased from 3.03% to 7.26%. Further addition of tile waste resulted in a decrease in the value of CBR. Hence the optimum mix was the combination of 45% of tile waste and 55% of Kaolinite clay.

5.4 Effect of demolished cement concrete waste as sub base layer on California bearing ratio test

From Fig.10 showing the variation of CBR value with h/T ratio, It is observed that the CBR value increases gradually, with gradual progress of h/T ratio from 0 to 1.0.As the thickness of GSB layer increases, the CBR also increases proportionately. This is due to the pressure bulb(which has a depth of D=2B,where B is the diameter of the CBR plunger) lying within the soil layer in Type-I test with low CBR of 7.26% and then CBR increases to 47.82% where the pressure bulb is fully in GSB layer with h/T =1.0.

CONCLUSION

The present study has shown quite encouraging results and The following important conclusions can be drawn from the study:

The sub-grade selected with low CBR value of 3.03% qualifies as poor sub-grade which needs either stabilization or

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

reinforcing layers in between the base and subgrade.

Clay tile waste could be effectively utilized in the subgrade soil of pavements.

Based on the Standard Proctor test results it was observed that, for soil sample stabilized with tile waste ,the maximum dry density increases upto 20% tile waste content and then decreases. Percentage increase in maximum dry density with respect to the unstabilised mix is 6% at 20% clay tile waste content. Further addition of tile waste resulted a decrease in value of maximum dry density. The optimum moisture content increases as the percentage of clay tile waste increases.

It was observed that as the percentage of clay tile waste increases, the strength increases with increase in clay tile waste upto 45% and then decreases. By the addition of 45% of clay tile waste ,CBR value of the soil sample was increased from 3.03% to 7.26%.The maximum value of CBR yielded was 7.26% .Further addition of tile waste resulted a decrease in value of CBR. The optimum percentage of clay tile waste in the soil mix is 45% and hence, this proportion can be economically used in road pavements.

The subbase selected is a combination of , 20% of demolished concrete waste greater than 20mm,40% of 20mm down aggregates and 40% of dust which yielded a subbase material satisfying gradation-III as per MoRT&H.

It was observed that the CBR value increases gradually, with gradual progress of h/T ratio from 0 to 1.0.As the thickness of subbase layer increases, the CBR also increases proportionately.

Utilization of waste clay tile and demolished concrete will eliminate the need for expensive stabilization methods and granular subbase layers and promotes cost saving through decreasing the pavement thickness and solving the disposal problems.

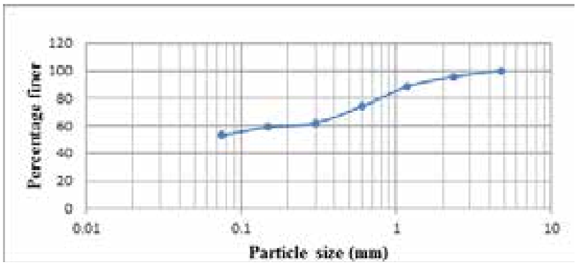

Fig. 4 Particle size distribution curve for kaolinite clay

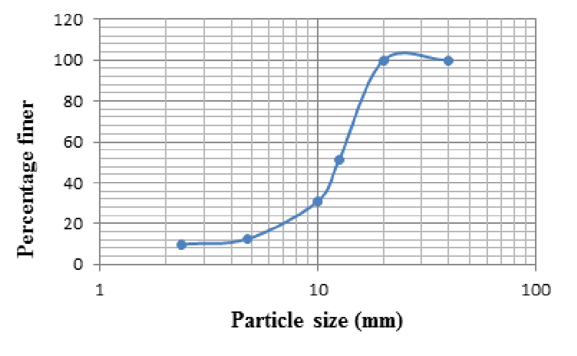

Fig. 5 Particle size distribution curve for clay tile waste

REFERENCE 1. Ayothiraman, R., Raghu Kanth, S. T. G. and Sreelatha, S (2002)., "Evaluation of liquefaction potential of Guwahati: gateway city to North-eastern India." Natural Hazards, Vol. 63, pp.449-460 | 2.N. K. Ameta, D, Wayal A. S., Puneet Hiranandani (2013) "Stabilization of Dune Sand with Ceramic Tile Waste as Admixture", American Journal of Engineering Research (AJER), , Volume-02, Issue-09, pp-133-139. | 3. Sabat, A.K. (2012) "A Study on some geotechnical properties of lime stabilized expansive soil –quarry dust mixes, " International Journal of Emerging Trends in Engineering and Development, Vol.1 (2), pp.42-49. | 4.. Sabat, A.K., and Nanda, R.P.(2011) "Effect of marble dust on strength and durability of rice husk ash stabilised expansive soil, " International Journal of Civil and Structural Engineering, Vol.1 (4), pp.939-948. | 5. Baser, O.(2009) "Stabilization of expansive soils using waste marble dust, " Master of Science thesis submitted to Civil Engineering Department, Middle East, Technical University. | 6. Palaniappan, K. A. and Stalin, V. K. (2009) "Utility effect of solid wastes in problematic | soils, " International Journal of Engineering Research and Industrial Applications, 2(1), | pp 313-321. | 7. Swami, B.L.(2002) "Feasibility study of marble dust in highway sector, " Highway | Research Bulletin, Number 67, December, pp 27-36. | 8. Amrendra Kumar, Ravi Kumar Sharma and Babita Singh (2014)," Compaction and Subgrade Characteristics of Clayey Soil Mixed with Foundry Sand and Fly Ash and Tile waste", International Conference on Advances in Engineering & Technology – 2014 (ICAET-2014) , pp 01-05, | 9. Ministry of Road Transport & Highways, Specifications for Roads and Bridge works, third revision, published by Indian Road Congress (IRC), New Delhi. | 10. IS: 2720 (Part-VII 1980), Standard Proctor Test. | 11. IS: 2720 (Part-XVI 1987), California Bearing Ratio tests |