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Use of Demolished Building Waste & TPP Pond Ash with Cement as Substitute of Road Metal in Pavement

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Abstract : This study has been conducted to investigate the effects of replacement of Natural Coarse aggregate (NCA) by Recycled concrete aggregate (RCA) and use of pond ash (PA) and cement as stabilizing agents on the strength characteristics of sub-base/base course. For pond ash, the disposal is quite a costly affair for the coal burning utility plants, can be very conveniently used for the economical construction of low cost roads having treated surfaces and for the stabilization of base/sub-base underneath the high type flexible or rigid pavements A laboratory program is conducted to study the feasibility of using recycled concrete aggregate (RCA) and Pond ash in base/sub-base course. In this study the experiments are conducted on locally available recycled concrete aggregates mixed with varying percentage of Pond ash (10-20%) and cement (2-8%). Soil-cement-pond ash samples are prepared for unconfined compression strength (UCS) and California bearing ratio (CBR) tests at its maximum dry density corresponding to its optimum moisture content. The percentage of cement by dry weight of mix is taken as 2%, 4%, 6% and 8% and similarly pond ash content levels 10% and 20% by dry weight of mix are taken and UCS tests are conducted in the laboratory. The optimum cement content corresponding to UCS strength of 17.5 kg/cm^2 is determined from cement content v/s UCS curve and the California bearing ratio (CBR) tests were conducted to find out the CBR value of mix at optimum cement content. The observed CBR values 22.11% and 26.16 % for two compositions.

Use of RCA and pond ash in civil engineering for improving properties is also advantageous because they are cheap, locally available and eco-friendly. The pond ash stabilization causes significant improvement in UCS strength, CBR strength and other engineering properties of the soil. The tests are performed by mixing different percentages of cement (2.0, 4.0, 6.0 and 8.0%) in the RCA- pond ash mix in order to optimize it. The optimum percentage of RCA-I (retained on 4.75 mm sieve): RCA-II (passing through 4.75 mm sieve): pond ash mix is arrived at 50:30:20 with 5.25% of cement content. The direct pavement cost is found to be economical up to a lead of 50kms for RCA but the increase in cost up to 100kms is very marginal and can be used in pavement. Even beyond 100 km's the increase in cost is not so significant that the indirect benefits can be ignored. Hence addition of these waste materials (Pond ash + RCA) in sub-base course results in less thickness of pavement base course due to increased CBR and hence economy of the construction of highway will be achieved.

Keywords: Recycled Concrete Aggregate, CBR, UCS, Pond Ash etc.

I. INTRODUCTION

In recent years, the emphasis was given to increase the sustainability of environment and better ways have been explored to manage wastes materials such as coal ash, plastic, rubber, construction and demolition waste, broken glass, scrap tyres, steel furnace slag etc. which are creating a number of problems in handling and disposing. These waste materials are disposed off either in low lying areas or in land fill sites which result in filling of land fill site at a very fast rate. So, reducing, reusing and recycling are the need of hour to save the natural resources as well as to save the land fill site which are otherwise going to create space problems for disposal of waste material. It is estimated that 10-12 million tons of construction and demolition waste (CDW) is generated in India every year which needs a huge space for disposal. It is also surveyed that there is a huge deficit of about 750 million cubic meter aggregates to achieve the targets of road sector in India (www.urbanindia.nic.in). So, CDW can prove to be very useful to meet the demand and supply gap of road sector. The bricks, metal and wood items are reused in new construction but the concrete and masonry waste which forms more than 50% of CDW are still not recycled in India. Therefore, there is need to recycle these concrete waste which are creating disposal problem in construction industry. These recycled concrete aggregates (RCA) which are cheaply available from construction and demolition sites can be used in highways construction *i.e.* in base or sub-base layers of pavement. As the finance and funds are major problem in construction of rural roads, RCA can prove to be best alternative for rural roads which is cheap and sustainable option. There are many advantages that lead to the use of RCA materials as pavement material in bases/sub-bases of roads. The main advantages of using RCA in the construction industry are of sustainable values and environmental issues. The wastes from construction and demolition works are of large volume and increasing over time. To overcome this issue, sustainable construction is one of the strategies to be considered by the construction industry. One way of achieving this is to introduce recycled aggregates from these wastes of construction and demolition works into pavements.

II. LITERATURE REVIEW

Nowadays concrete is the most widely used construction material. Durability is one of the most important considerations in the design of new structures and assessing the condition of existing structures. The last 20 to 30 years have seen a growing awareness amongst engineers of the need to ensure that provisions are made for durability in component of pavement structures. More recently, there has also been a growing awareness of the importance of sustainability in pavement construction and in particular the more effective and efficient use of materials. This chapter deals with the review of the existing literature on the use of RCA in base and sub-base layer of pavement. The most important investigations, related to the current investigation, are summarized and salient facts which seem to emerge from the research discussed. The discussion is generally confined to the strength and durability characteristics of pavement layer with RCA and mineral admixtures such as pond ash (PA). Scientific knowledge on the potential for the use of recycled concrete aggregates in unbound road applications has advanced considerably. In India and many countries and regions, however, the production of recycled concrete aggregate is much lower than the generation of mixed recycled aggregate obtained from the treatment of mixed rubble. This is made up of materials of various types, such as concrete, ceramics, asphalt, natural stone, as well as organic impurities (such as wood, plastic, and paper-cardboard), and inorganic impurities (metal and gypsum).

III. METHODOLOGY

A. Collection of waste material *i.e.* pond ash and recycled concrete aggregates (RCA).
B. Crushing, sieving and Laboratory testing of aggregates i.e. RCA
C. Evaluation of compaction characteristics by performing Modified Proctor test
D. Evaluation of strength characteristics by performing UCS test
E. Optimization of cement content for the mixes.
F. Evaluations of CBR for the mix at optimum cement contents.
G. Cost analysis of rural road with different lead of material availability.

IV. EXPERIMENTAL RESULTS & ANALYSIS

The experiments are conducted on recycled concrete aggregates (RCA) mixed with different percentages of cement and pond ash. The main parameters that are studied include compressive strength and C.B.R. Effect of addition of pond ash and cement in mix on the U.C.S and C.B.R values is studied in this investigation. The experimental results are carried out in the following laboratory works.

Grain Size Distribution

Type	Sieve (mm)	% passing for Sub-base Layer	% passing for Base Layer	% passing taken for preparing samples
RAC-I	75	100	100	100
	53	100	100	100
RCA-II	26.5	95-100	95-100	100
	19	-	45-100	90
	9.5	50-80	35-100	65
	4.75	40-65	25-100	50
	2.36	30-50	-	35
	.600	-	8-65	25
	.425	15-25	5-40	20
	0.075	3-10	0-10	10

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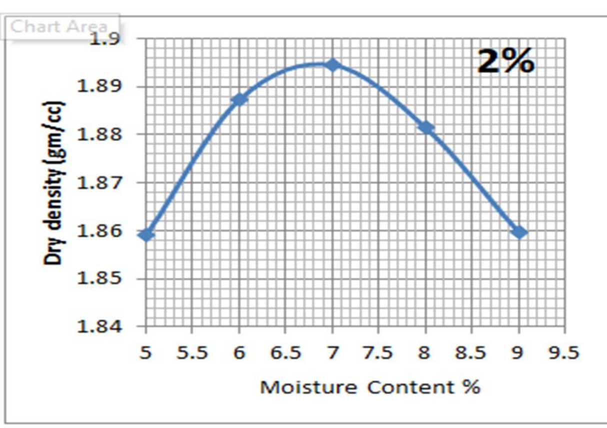
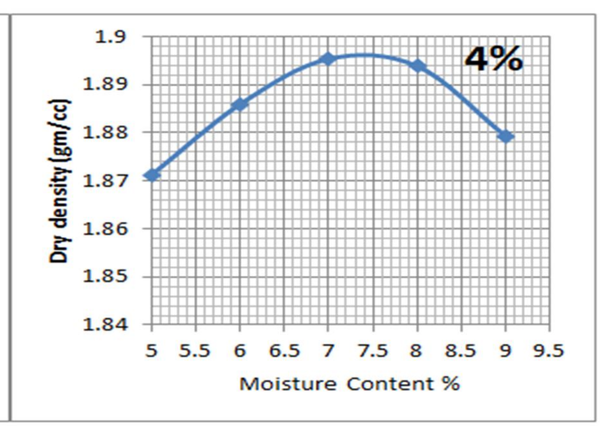
Sieve Analysis Of Pond Ash

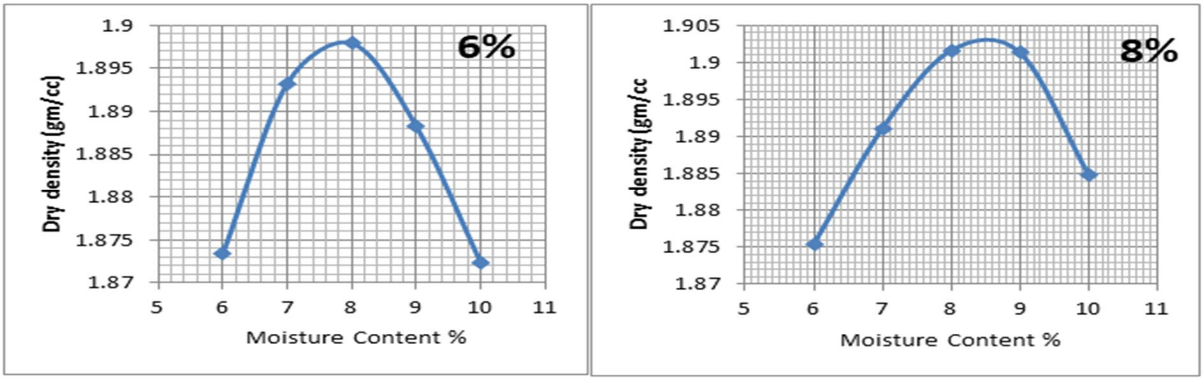
S. No.	Sieve (mm)	Wt. of retain Soil (gm.)	% Retain	Cumulative %	% Finer
1	4.75	0	0	0	100
2	2.36	0	0	0	100
3	1.18	0.4	0.04	0.04	99.96
4	0.6	0.5	0.05	0.09	99.91
5	0.425	0.5	0.05	0.14	99.86
6	0.3	0.9	0.09	0.23	99.77
7	0.18	4.5	0.45	0.68	95.32
8	0.075	802.3	80.23	80.91	19.09
9	0	0	0	0	0

Modified Proctor Test Result For Compaction

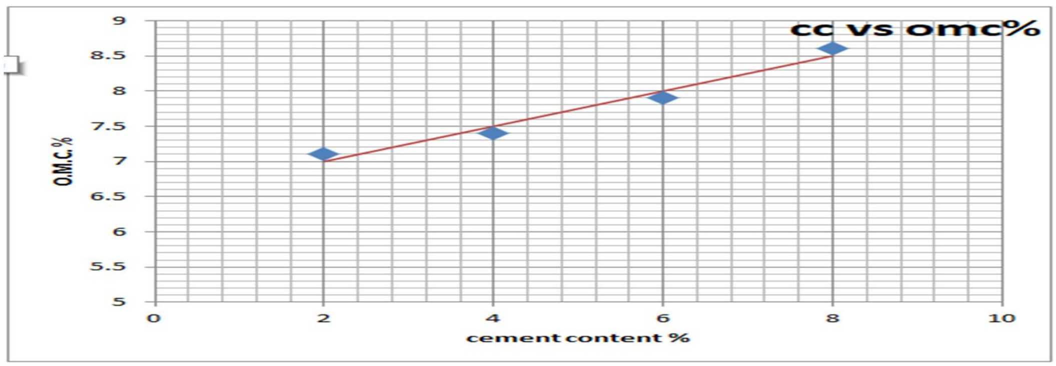
S.NO.	Soil Mix- RCA-I : RCA-II : Pond Ash	Cement content	MDD (gm/cc)	OMC (%)
1	50:40:10	2 %	1.894	7.1
2	50:40:10	4 %	1.895	7.4
3	50:40:10	6 %	1.897	7.9
4	50:40:10	8 %	1.903	8.6
5	50:30:20	2 %	1.753	9.1
6	50:30:20	4 %	1.767	9.6
7	50:30:20	6 %	1.781	10.1
8	50:30:20	8 %	1.790	10.5



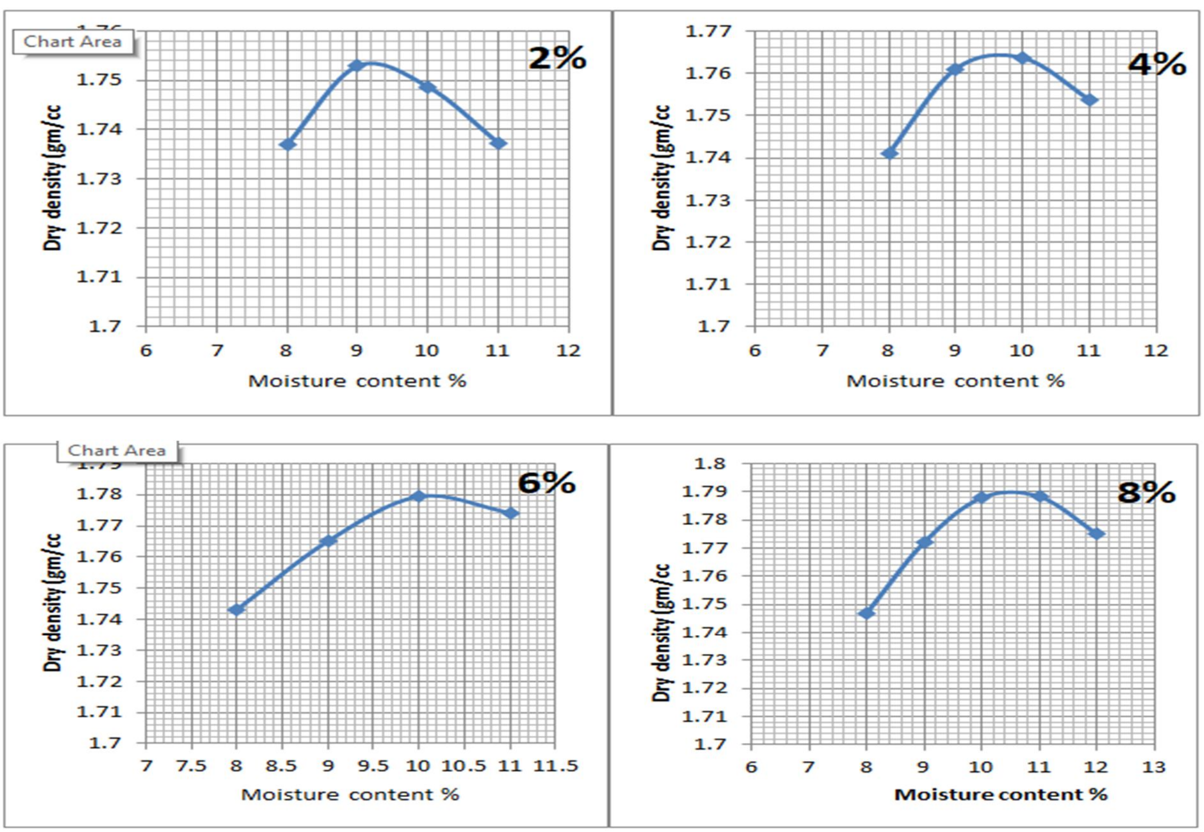




{Graph of Compaction Test For PA10 Mixes at Different Cement Content}



Graph b/w Cement Content & O.M.C (@respective Cement%)



Graph of Compaction for PA20 at Different Cement Content

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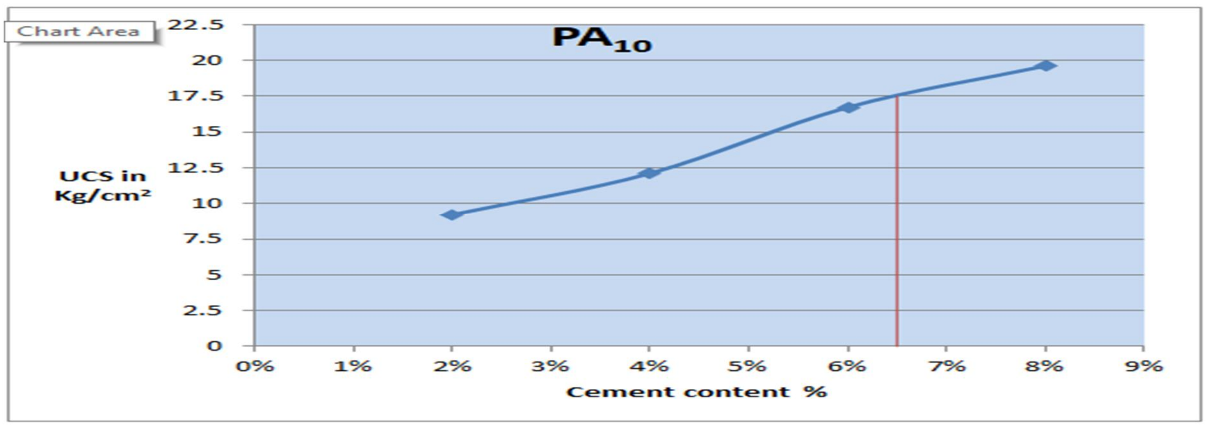
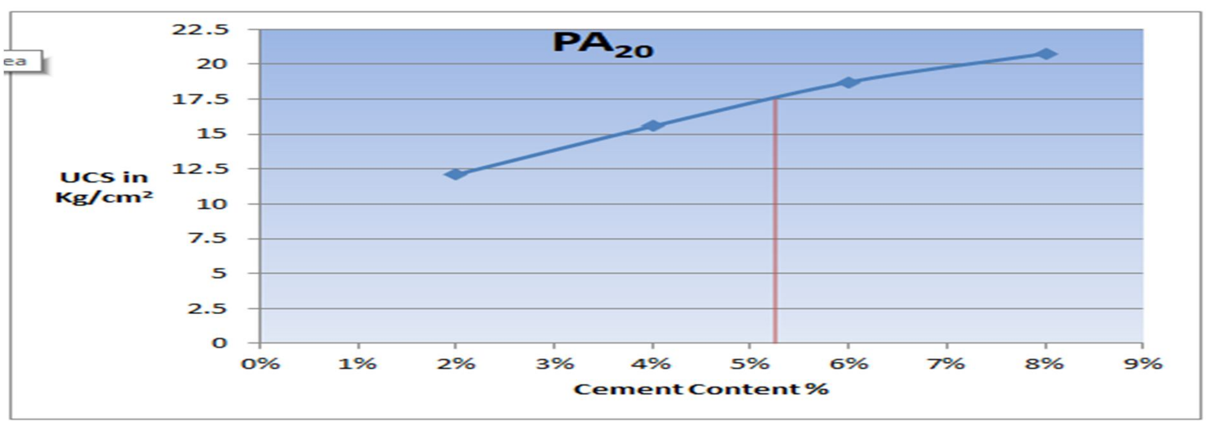
Unconfined Compression Test Result For Different Cement Content

Chart Area	Soil Mix RCA-I : RCA-II : Pond Ash	Cement content	Unconfined Compressive Strength (kg/cm²)
1	50:40:10	2 %	9.228
2	50:40:10	4 %	12.11
3	50:40:10	6 %	16.726
4	50:40:10	8 %	19.61
5	50:30:20	2 %	12.112
6	50:30:20	4 %	15.57
7	50:30:20	6 %	19.03
8	50:30:20	8 %	20.763



Graph showing cement content for 17.5 kg/cm^2 UCS for PA_{10}

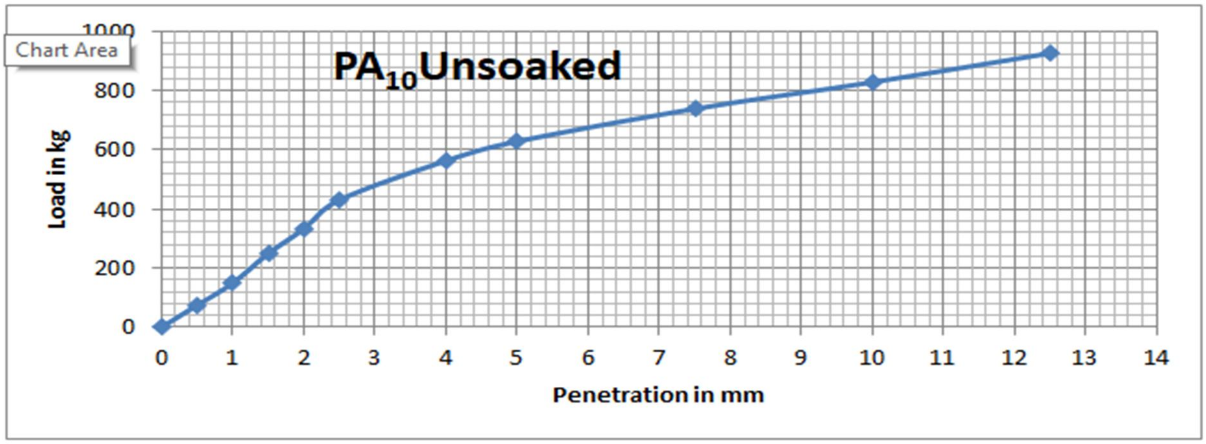


Graph showing cement content for 17.5 kg/cm^2 UCS for PA_{20}

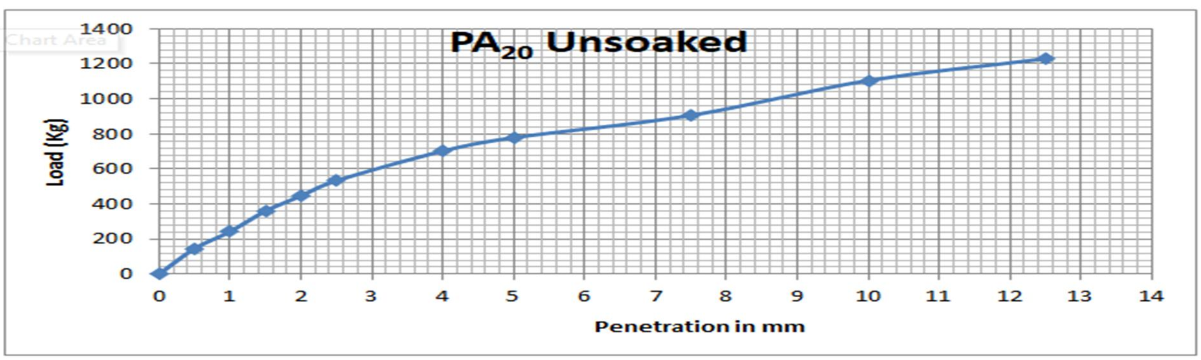
The Graphs 4.7 and 4.8 shows the cement content for average compressive strength of 17.5kg/cm^2. From these graphs it is clear that the mixes PA_{10} with 6.50% of cement content and PA_{20} with 5.25% of cement content give average compressive strength required for sub-base or base course in pavement. So it can be easily concluded from graphs that 6.50% and 5.25% are optimum cement content for PA_{10} and PA_{20} respectively.

CBR Test Result

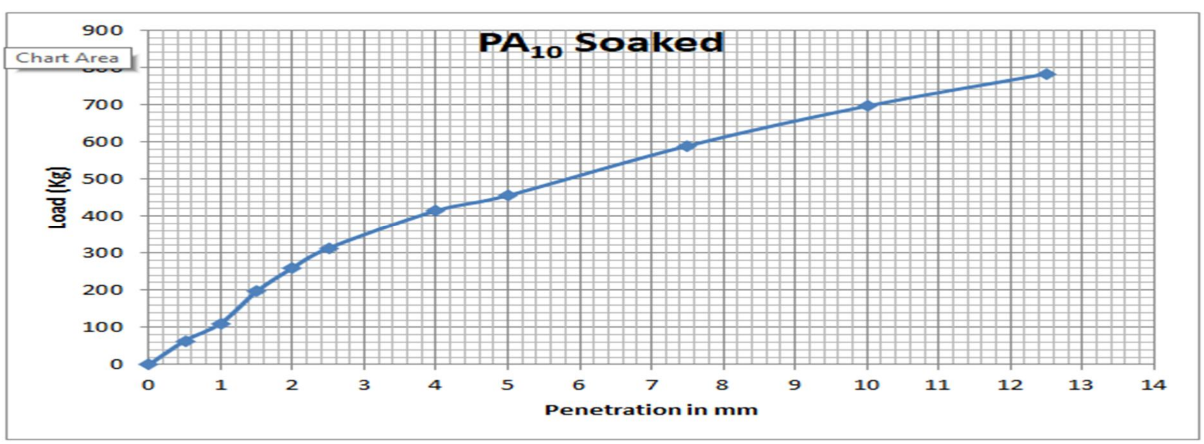
S.NO.	Soil Mix- RCA-I : RCA-II : Pond Ash	Cement content	Unsoaked CBR Value (%)	Soaked CBR Value (%)
1	50:40:10	6.50 %	31.04	22.11
2	50:30:20	5.25%	38.41	26.16



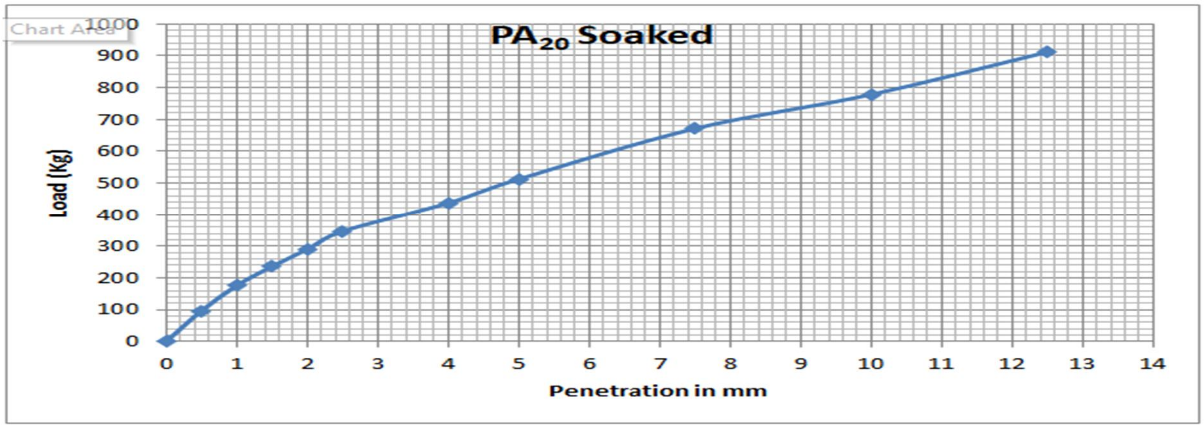
(a) Un-soaked Condition CBR Test for PA10



(b) Un-soaked Condition CBR Test for PA20



(a) Soaked Condition CBR Test for PA10



(b) Soaked Condition CBR Test for PA20

V. ANALYSIS OF COST FOR FLEXIBLE PAVEMENT

The cost analysis of flexible pavement on subgrade with CBR of 3% and 5% is done and the cost is calculated for 1 km length and 3.5 m width of rural highway. The cost is calculated with moo-rum sub-base as per DSR-2013. The design of flexible pavement is done on the basis of IRC SP 20.

VI. CONCLUSIONS & RECOMMADATIONS

RCA is a demolition waste which could be utilized with admixtures pond ash and cement in sub-base course of rural road pavements. The present study has shown quite encouraging results and following important conclusions and recommendations can be drawn from the study:

A. The OMC of mixture PA_{10} (50% RCA-I, 20% RCA-II, 10% Pond ash) and PA_{20}(50% RCA-I, 30% RCA-II, 20% Pond ash) increases with increasing the percentage of pond ash. The maximum dry density (MDD) is observed to decrease with increase in the percentage of pond ash.

B. The optimum moisture content (OMC) of RCA-pond ash-cement mix increases with increase in cement content of the mix and the increase is linear with increase in cement content.

C. The Unconfined Compression Strength increases with increase in Pond ash from 10% to 20% (i.e. from PA_{10} to PA_{20} mix) in mix for same cement content.

D. The mix with 50% RCA-I (retained on 4.75 mm IS sieve), 30% RCA-II (passing through 4.75 mm IS sieve), 20% Pond ash and 5.25% cement content which gives maximum 26.16% soaked CBR strength.

E. It can be concluded from the analysis of cost of Rural Road that there is decrease in cost of pavement up-to 50kms lead for 3% CBR sub-grade and up-to 50 km's lead for 5% CBR sub-grade by replacing Moo-rum with a mix of 50% RCA-I, 30% RCA-II, 20% Pond ash and 5.25% cement. Hence, this proportion may be economically used in road.

F. The cost analysis shows that the difference cost of construction on RCA sub-base and moo-rum sub-base is marginal up to a lead to 100kms and beyond 100 km's the increase is not so significant that the indirect benefits of using RCA sub-base can be ignored. So, having the indirect advantages of using RCA sub-base which can't be measured in terms of cost, the RCA sub-base can be used with marginal increase in direct cost.

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