EXPERIMENTAL STUDY OF CONSTRUCTION AND DEMOLATION WASTE IN FLEXIBLE PAVEMENTS

Submitted in partial fulfillment of the requirements the degree of

MASTER OF TECHNOLOGY

In

CIVIL ENGINEERING

By

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2017

CERTIFICATE

This is to certify that the Thesis entitled "EXPERIMENTAL STUDY OF CONSTRUCTION AND DEMOLATION WASTE IN FLEXIBLE PAVEMENTS Submitted by Yaser Alawi (REG NO: 11610318) in partial fulfilment of the requirement for the award of degree M.Tech In Transportation Engineering to Lovely Professional University, Phagwara, Punjab is a record of the candidates own work carried out by him under my supervision. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

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ACKNOWLEDGEMENT

I gratitude towards all the people who helped us to convert an idea into a practical application. I am very thankful to our internal guide Assistant professor Rajesh Chouhan for his guidanceand support in holding our project at college. I am thankful to all teaching and non-teaching staff members, who had extended their valuable time for help and making the task easy.

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ABSTRACT

With the steep increase in the population, construction and demolition of buildings around the world has increase with the same pace, which has led to the accumulation of C&D waste. Their disposal is one the major problems as huge amount of land is required for landfill. IN this research possible use of construction and demolition wastes in semi dense bitumen macadam has been studied, so these C&D can be disposed properly furthermore the natural aggregate which is depleting at very fast rate can be saved for the future generation. In this study test are conducted to check the feasibility of C&D waste in the asphalt pavement .various tests such a marshal stability test, tensile strength test and rutting test is conducted to determine the optimum percentage of C&D waste which can be used in semi dense bitumen macadam.

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CHAPTER 1

Introduction

1.1 General

One of the main sources of solid waste production is construction. Large amount of raw material is used in the construction. Construction of buildings consumes about 40%of total energy and about 50% of total resources are used in the construction. About 3.7 %of total buildings are pulled down annually in the world. About 1100000000 tons of materials are generated from the industry. And this construction waste is increasing at rate of 6.8% annually and more trends in developing countries.

The construction and demolition waste is increasing at rapid pace while its disposal is one of the major problems. It has become major problem due top less availability of landfills and oversaturation of C&D waste. Furthermore it has resulted in increase in global warming.so the countries are facing environmental as well as economic problems. Use of recycled aggregate is an important both in the view point of environment and sustainable development. The construction and demolition waste can be in the concrete, bricks, tiles, glass etc. The use of these recycled can be used in the asphalt pavements and it has been observed that it has given the satisfactory results. Some problem is associated with the use of C&D wastes are high water absorption, low specific gravity, and low strength.to deal with these anti stripping agents are used to give the satisfactory performance. In USA about 35 % of the waste is used in the renovation works. In California government uses about 15 % RAP .the waste material from buildings can also be used in semi dense bitumen macadam and various tests like Marshall, stability, tensile strength etc. are checked to know if these material can be used in the construction also to determine the optimum content of C&D waste which gives us the satisfactory results. Use of these waste will result in the saving off natural aggregates and can be used by the future generation. The problem of disposal can also be solved by using C&D waste in the semi dense bitumen macadam.

1.2 C&DW after crushing:

Figure 1 C&DW

1.3 C&DW Location :

Figure 2 Location of CDW

CHAPTER 2

Scope of study

1. As construction and demolition wastes are increasing which results in the problem of disposal and wastage of resources, an attempt is made to address these issues to achieve sustainability up to certain extent.
2. The usage of demolition and construction waste in a controlled manner has proven to be effective and not compromising the strength of the material. This will help in reducing the cost and hence be economical.

CHAPTER 3

Research Objectives

The main objectives of this study are:

1. To determine physical properties of natural aggregate as well as the C&D waste by conducting the aggregate tests.
2. To conduct the rutting test and determine the permanent deformation as compare it with the conventional asphalt pavements

CHAPTER 4

Literature Review

Fabiana da Conceição Leite et al. (2010)

In this study laboratory investigation is made to check the feasibility of the recycled aggregate and other demolition wastes. Bearing capacity of tests and also tri axial tests were conducted to study the geotechnical properties. The results showed that composition of the waste material as well as amount of compaction and type of compaction influence the physical characteristics of the construction and demolition waste .The compacted has resulted in the chain of grain size distribution due to crushing of particles and there is increase in the cubic grains. Which resulted in the increase in the density and hence the bearing capacity also there is improvement in the elastic modules and decrease in pavement deformation. From the results it can be concludes that these RCDW can be used in base and sub base courses of the pavement .

Jiqing Zhu et al. (2011)

In this paper experimental investigation is done on the use demolition waste obtained from earthquake damaged buildings in asphalt pavements. Waste material is converted into the aggregate size of less than 20 mm, since this waste has high water absorption property pretreatment in the form of liquid silicone resin. The different tests that where conducted in the study were moisture susceptibility test, rutting test and three point widening beam test.

It was observed using silicone resin in pretreatment has resulted in increase in strength, water susceptibility also decreased. But there is decrease in resistance to the permanent deformation. But at higher temperature permanent deformation has superior resistance than the conventional asphalt pavements.

Marius-Teodor Muscalu et al. (2011)

The author in this study has investigated the use of recycled aggregate in cement concrete pavements. The aggregates are obtained by the crushing of concrete from the demolition wastes .Objective is to find economic aspect as how much economy can be

saved by using these kinds of wastes obtained from the demolition of buildings both in plain cement concrete and compacted concrete pavements .also the technical estimation is done to check the quality of these wastes from the demolished buildings. It is concluded that using these wastes natural aggregates which are depleting fast can be saved and landfill for these wastes can be reduced.

A.R. Pasandín et al. (2012)

In this paper use of demolition waste as coarse aggregate in hot mix asphalt was studied and to find the optimum percentage of demolition waste which can be used as coarse aggregate in the asphalt pavements. Different percentages of demolition waste i.e. 0%, 20%, 40%, and 60% were used by the total weight of natural aggregate in this study filler were also used in the form of lime and cement. Marshall stability is found which is within the limits for the low volume roads .The mixture has shown good improvement for the rutting of pavements, the rutting test was done by the wheel tracking test .But it was observed that the durability of the mixture decreased due to the high susceptibility to the moisture which was found out by stripping test.

Saeed Fatemi et al. (2016)

Performance evaluation was made on asphalt pavements which used the construction and demolition wastes .construction and demolition wastes were used by 10 %,20%,30%,40% weight of natural aggregate .Different performance tests were conducted like rutting test, creep test, indirect tensile strength to study the performance of pavement .Moisture susceptibility is found using indirect tensile strength ratio .It was found using the construction and demolition waste has resulted in increase in the optimum binder content , there was improvement in the rutting resistance by 30%there is also increase in the increase in the tensile strength which means resistance to the cracking has increased..

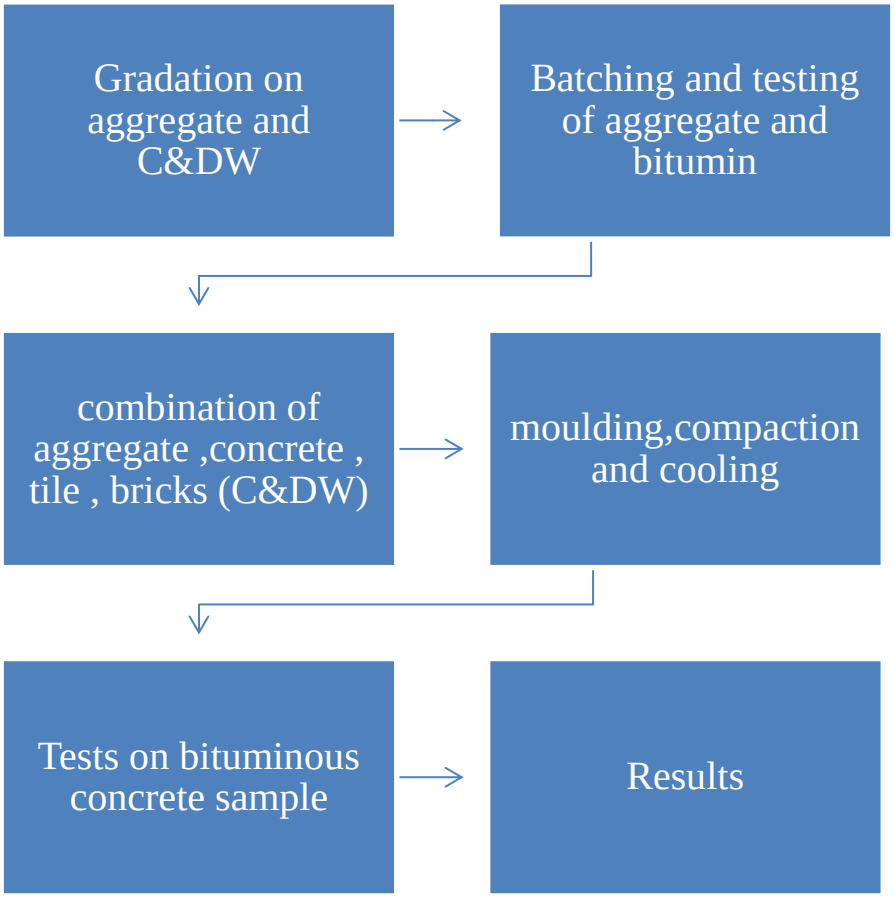
Dr. Soosan George et al. (2016)

“Pavements Using Domestic Aggregates” Test consequences confirm that domestic aggregate is a moral substitute for new aggregate. In deduction Reclaimed Asphalt Pavement and Reclaimed Cement Aggregate are not waste products and contribute in conserving natural resources and providing extra miles of pavement from obtainable revenues. As virgin resources convert more incomplete and prices rise, the use of reclaimed aggregate in pavement construction is certainly an eco-friendly innovation.

CHAPTER 5

Methodology

The methodology employed in the study is as follow:



5.1 Gradation

Gradation test gives us the particle size distribution under a set of IS Sieves. The coarse aggregate was sieved through the sieves, thereby calculating percentage aggregate retaining and passing through all the sieves, mean aggregate passing aggregate, cumulative passing per sample.

Table 1. Gradation Test.

S.NO	Grading	Gradation used	Aggregate retained (%)	Mean aggregate passing (%)	Cumulative mean aggregate passing (%)	Aggregate passing per sample (1200g)
	Normal agg size	10 (mm)				
	Layer thickness	20-30 (mm)				
	IS sieve (mm)	Cumulative % by weight of total aggregate passing				
1.	13.2	100	0	0	0	0
2.	9.5	90-100	10-0	5	5	60
3.	4.75	35-51	65-49	57	52	624
4.	2.36	24-39	76-61	68.5	11.5	138
5.	1.18	15-30	85-70	77.5	9	108
6.	0.6	-	-	-	-	-
7.	0.3	9-49	91-81	86	8.5	102
8.	0.15	-	-	-	-	-
9.	0.075	3-8	97-92	94.5	8.5	102
10.	0.075-				5.5	66
	Total Wight					**1200**

5.2 Impact Test

It is carried out to find the resistance of aggregates to the impact loads. First aggregate passing through 12.5 mm sieve and retained at 10 mm sieve is filled in cylinder of impact testing machine in 3 layer and each layer is compacted by 25 blows, then hammer of weight about 13,5 to 14 kg is made to drop in free fall from 38 cm and 15 blows are given to the sample in mould. The crushed aggregate is passed through 2.36 mm IS sieve. Impact value is measured as material passing through that sieve to the total weight of sample. As per IRC for wearing coarse impact value should be less than 30%.

Table 2 For Demolition and construction (concrete ,tile , brick) randomly

Total Wight of agg.(g)	weight of neutral agg.(g)	weight of demolition waste (g)	Wight retained (2.36mm sieve)	Difference in weight	Impact value
480	480	0	452	28	5.833%
480	360	(%25) 120	436	44	9.1667%
480	336	(%30) 114	425	55	11.458%
480	312	(%35) 168	420	60	12.5%

Table 3 For demolition and construction waste using

(60% of concrete , 30% of tile and 10% of bricks)

Total Wight of agg.(g)	weight of neutral agg.(g)	weight of D&C waste (g) (60%concret,30%tyle, 10%brick	Wight retained (2.36mm sieve)	Difference in weight	Impact value
654	654	0	590	64	%9.785

654	490.5	(%25) 163.5	578	76	%11.62
654	457.8	(%30) 196.2	572	82	%12.53
654	425.1	(%35) 228.9	568	86	%13.15

5.3 Shape test: Shape of aggregate is determined by the flaky and elongated particles. When the least dimension of aggregate are less than 0.6 times the mean dimension it is called as flaky and if the greatest dimension of aggregate is greater than 1.8 times the mean dimension it is called as elongated. Flakiness gauge is used to test for flakiness and elongation gauge is used for the calculation of elongation index. The procedure in the test is followed as per IS: 2386 part 1.The total value of elongation & flakiness index should be less than 35%.

Table 4 Elongation index of natural aggregate

Aggregate Size	Total Weight (g)	Elongated	Normal
12.5	620	65	555
12.5-10	385	40	345
10-6.3	135	15	120
TOTAL		120	1020

(100*120)/1020 = 11.764%

Table 5 Elongation Index for construction and demolition waste (25%)

Aggregate size(mm)	T.W	D&C waste(25)	Natural aggregate	Elongated	Normal	Elongation Index
12.5	620	155	465	69	551	11.13%
12.5-10	385	96.25	288.75	42	343	10.9%
10-6.3	135	33.75	101.25	13	122	9.63%
Total				124	1016	

Table 6 Elongation Index for construction and demolition waste (30%)

Agg size	T.W	D&C waste(30%)	Natural agg	Elongated	Normal	Elongation Index
12.0	620	186	434	62	558	10%
12.5-10	385	115.5	269.5	35	350	9.1%
10-6.3	135	40.5	94.5	16	119	11.85%
Total				113	1027	

Table 7 Elongation Index construction and demolition waste (35%)

Agg size	T.W	D&C waste (35%)	Natural agg	Elongated	Normal	Elongation Index
12.5	620	217	403	60	560	9.67%
12.5-10	385	134.75	250.25	37	348	9.61%
10-6.3	135	47.2	87.8	20	115	14.81%
Total				117	1023	

5.4 Flakiness Index

The flakiness index of aggregate is the percentage by weight of particle who least dimension (thickness) is less than 0.6 of their mean dimension.

The test results are tabulated below:

Table 8 Flakiness Index

Aggregate Size	Total Weight (g)	FLAKINESS	NORMAL
12.5	620	50	570
12.5-10	385	55	330
10-6.3	135	20	115
TOTAL	1140	125	1015

120/1140*100= 10.964%

TOTAL %age = F.I %age + E.I %age

= 10.964 + 11.764

=22.728% < 30

Table 9 Flakiness Index for construction and demolition waste (25%)

Agg size	T.W	D&C waste (25%)	Neutral AGG	Flakiness	Normal	Flakiness Index
12.5	620	155	465	62	558	10%
12.5-10	385	96.25	288.75	41	344	10.64%
10-6.3	135	33.75	101.25	18	117	13.3%
Total	1140			127	1013	

Table 10 Flakiness Index for construction and demolition waste (30%)

Agg size	T.W	C&D waste (30%)	Neutral	Flakiness	Normal	Flakiness Index
12.5	620	186	434	59	561	9.5%
12.5-10	385	115.5	269.5	38	347	9.87%
10-6.3	135	40.5	94.5	14	121	10.37%
Total	1140			111	1029	

Table 11 Flakiness Index for construction and demolition waste (35%)

Agg size	T.W	C&D waste (35%)	Neutral	Flakiness	Normal	Flakiness Index
12.5	620	217	403	68	552	10.96%
12.5-10	385	134.75	250.25	44	341	11.4%
10-6.3	135	47.2	87.8	17	118	12.6%
Total	1140			129	984	

5.5 Abrasion Test

This test is done to check the hardness property of the aggregates or the abrasion value of the aggregates. IN this study Los angles abrasion test is done to find the abrasion value as per IS 2386 part 4.it consists of drum having diameter 70 cm and length equal to cm.spherical balls are used whose weight is about 350 grams. No of balls vary according to grading.500 revolutions are given to the sample with steel balls @33 rpm .After that the sample is sieved through the 1.7 mm sieve. Abrasion value is calculated as the weight of material passing through the mentioned sieve to that of total weight of sample. Abrasion value according to IRC should be less than 35 % for wearing coarse.

Table 12 LOS Angeles Abrasion values for natural aggregates

Gradation type	W Total Wight (kg)	W1 Wight retained (kg) (1.70 mm sieve)	W-W1 Wight passed (kg)	W-W1/W2 Abrasion value
D. Type 6 ball 500 result 2.36-4.75 sieve	5	4.180	0.820	16.4
Type 8 ball C. (4.75-6.3) (10-6.3)	 2.5 2.5	4.235	0.765	15.3
				Mean = 15.85

Table 13 Abrasion Value for construction and demolition waste

(60% concrete , 30%tiles and 10%bricks)

Total weight of aggregate (kg)	weight of neutral aggregates (kg)	Weight of C&D waste(kg)(60%concre, 30%tyle,10%brick)	Wight retained (1.70mm sieve)	Difference in weight	Abrasion value

5	0	0	4.225	0.745	14.9%
5	3.75	1.25	4.105	0.895	17.9%
5	3.5	1.5	4.060	0.94	18.8%
5	3.25	1.75	3.98	1.02	20.4%

5.6 Crushing Test

Crushing test: It is done as per IS 2386 part 4, it is used to determine the crushing strength of aggregates or resistance to crushing by gradual load. Aggregates are dries and aggregates passing through 12.5 mm sieve and retained on 10 mm sieve are used for the experiment. Aggregates are filled in the cylinder with dimension of 11.5 mm diameter and18 cm height and compacted in 3 layers. After that load on the mould is applies at rate of 4 tonnes per minute for 10 minutes such that total load applied is 40 tonnes. Crushed aggregates are then sieved through 2.36 mm sieve. Crushing value is calculated which is equal to loss in weight to that of total weight of aggregates.as per IRC the crushing value should be below 35% for wearing coarse.

Table 14 Results of natural aggregate crushing value test

Total weight of Aggregate in kg	Weight after crushing test (retained on 2.36 mm sieves)	Loss in weight in kg	Crushing value(%)
3.690	3.110 Kg	0.58	15.72%
3.690	3.057	0.633	17.15%

Table 15 Results of construction and demolition waste crushing value test

(60%concrete,30%tiles and 10% bricks)

Wight of aggregate	weight of neutral	weight of demolition waste (kg)	Wight retained	Difference in weight	Crashing value

	agg.(kg)	(60%concret,30%tyle, 10%brick	(2.36mm sieve)		
3.690	3.690	0	3.110	0.58	15.7%
3.690	2.7675	0.9225	2.950	0.74	20.05%
3.690	2.583	1.107	2.860	0.83	22.49%
3.690	2.3985	1.2915	2.775	0.935	23.61%

CHAPTER 6

EXPECTED OUTCOMES

- Increase in Marshall stability
- Skid resistance will be increased
- Reduction in the cost of pavement
- To reduce the natural aggregate

CHAPTER 7

Proposed Work Plan with Timelines

Month	**Work plan**
October	Material Testing
November	Material Testing
December	Report making for Dissertation I
January	Bituminous tests
February	Marshal tests
March	Write the report
April	Write report
May	Discussion

CHAPTER 8

Results and Discussion

Impact test for demolition and construction waste randomly value :

Weight of construction and demolition waste	**Impact value**
25%	9.167%
30%	11.458%
35%	12.5%

For impact test according to (60% of concrete , 30% of tiles and 10% of bricks)

Weight of construction and demolition waste	**Impact value**
25%	11.62%
30%	12.53%
35%	13.15%

Elongation index test value:

Aggregate size	**25%**	**30%**	**35%**
12.5	11.13%	10%	9.67%
12.5-10	10.9%	9.1%	9.61%
10-6.3	9.63%	11.85%	14.81

Flakiness test value :

Aggregate size	**25%**	**30%**	**35%**
12.5	10%	9.5%	10.96%
12.5-10	10.64%	9.87%	11.4%
10-6.3	13.3%	10.37%	12.6%

The results for abrasion test:

C&DW	Abrasion value
25%	17.9%
30%	18.8%
35%	20.4%

The value for cashing test :

C&DW	Abrasion value
25%	20.05%
30%	22.37%
35%	23.61%

CHAPTER 9

Summary and Conclusion

The demolition waste from building were used in proportion of 25%,35%,35% by the weight of aggregate .the aggregate tests with demolition waste were in limits as per IS codes, hence it can be used as a substitute material in the construction of semi dense bitumen macadam .The marshal stably value and tensile strength was also in limits. Furthermore the using demolition waste in semi dense bitumen macadam will reduce the waste material and the land required for the dumping of the waste can be saved .Also the natural aggregate can be saved for the future generation and overall it will prove to be economical.

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