

Utilization of Reclaimed Asphalt Pavement and Ceramic Waste in Pavement Construction

P Akhilesh Rao¹, Prof. Vinay Deulkar²

¹M.E. Student JIT Borawan Khargone (M.P.) INDIA

²Asst. Professor JIT Borawan Khargone (M.P.) INDIA

Abstract - Today environmental and ecology concern has become a global issue and almost every industry is putting emphasis on environment friendliness use of material, technology etc. Construction industry is also one of them. Recently, there have been tremendous increasing in the prices of bituminous pavement materials which led to attempts to find alternative use of materials. As we all know, day by day the quarries are disappearing with the extensive mining work and as a result of it, we are in crisis of quarry materials. Many industries are successfully and effectively using the "Recycling". The same can be utilized in construction industry and that too in road construction. In addition, more attention is focused on the use of Reclaimed asphalt pavement (RAP) materials in new pavement design. So, recycling is one of the option by which more concerns are directed to preserving natural resource and reducing environmental impact of using fresh asphalt binders. Environmental wastes caused by technological and industrial development are increasing, whereas natural resource and disposal areas for those wastes are decreasing day by day. So recycling and reuse of waste materials has become crucial in terms of protection of environment and economy. Hot mix asphalt (HMA) which is used substantially in road construction, contains approximately 95% aggregate and 5% bitumen materials by weight. Because of high cost of aggregate, scientists focus on studies about using recycled waste in HMA nowadays. In Turkey tens of thousands of tons of ceramic wastes (CW) are disposed every month. One of the most effective ways to eliminate those CW and protect our environment is recycling them by using in HMA. This paper gives a brief details of recycling of using RAP materials and ceramic waste in pavement Construction specially in surface layer. And also discuss about their properties and laboratory test details.

Key Words: Introduction, Material, Methodology, Test result

1. INTRODUCTION

In the ceramic industry, about 15%-30% waste material generated from the total production. In roadway transportation system, highway can be differentiated functionally and structurally. According to functional classification it may be - National Highways, State Highways, Major District Road, Village Road etc and according to structural classification it is - rigid and

flexible. It should be noted that major portion of highway in our country is flexible. Generally flexible pavement is preferred in many cases over rigid pavement because in flexible pavement, material and construction cost are low and these material is locally available. At the same time it can be easily constructed and maintained and upgraded. The study of ceramic waste can determine whether it is suitable to be used in road construction. Moreover, it may reduce the cost of road construction, other than this study will increase the awareness about environment problem which cause by disposal industrial waste. MA which is composed of bitumen and aggregate is used in road construction all over the world. HMA contains approximately %5 bitumen and %95 aggregate materials, by weight. Bitumen is obtained from the distillation of petroleum. Because of the reduction in natural resources like petroleum and high quality aggregate, the production cost of HMA is increasing day by day. On the other hand at the construction of base and sub-base courses under pavement, the usage of determined aggregate gradations due to natural subgrade increases the importance of aggregate. Day by day industrial waste reduction becomes priority for governments due to pollution and because of that the importance of waste material usage in road construction increases. RAP is one of the most recycled materials in the world. In Europe and United states, studies have concluded that 80% of the recycled material is utilized in road construction. Some studies have been carried out with 100% recycling of materials. 100% recycling can provide true sustainability by closing the materials cycle and to allow use of reclaimed asphalt in the same high value application as that of conventional asphalt. Strict regulations are still allowing mixes of RAP material in proportions range between 5 to 50 % for hot mix asphalt (HMA) mixtures. Recent researches have established that RAP replacement at proportions above 50% is feasible to produce new HMA mixtures, and also obtaining satisfactory results in the mechanical properties.

In this paper, The Marshall Design Method was used for HMA preparation. Different waste ceramic and RAP material ratio were used as aggregate for preparation of HMA specimens. And the experimental results were compared with specification values.

2. MATERIAL -

2.1 Aggregate- Aggregate is a collective term for the mineral materials such as sand, gravel, and crushed stone that are used with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to form compound materials (such as bituminous concrete and Portland cement concrete). . Aggregates can either be natural or manufactured. Natural aggregates are generally extracted from larger rock formations through an open excavation (quarry). Extracted rock is typically reduced to usable sizes by mechanical crushing. Manufactured aggregate is often a by-product of other manufacturing industries



2.2 Ceramic waste - Ceramic waste from ceramic industries is used into production of new concrete by replacing natural coarse aggregate and fine aggregate. In INDIA it has been estimated that nearly 30% of the daily production goes on waste during the manufacturing, transportation and usage. The ceramic waste is mounting up day by day, because of its enormous usage in modern way of construction activity. So, one solvable solution has to be necessary for the ceramic industries for diminishing the waste dump at ceramic industries is recycling, reusing and substitution of concrete ingredients.



2.3. Bitumen - Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark coloured solid or viscous cementitious substances consists chief high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon

disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.



2.4. RAP - This Reclaimed Asphalt Pavement (RAP) is recycling material which is generated from Rehabilitation or reconstruction of pavement. This material contains fine aggregate and bitumen binder. These are large quantities which produced during a highway reconstruction maintenance as well.



3. METHODOLOGY - In this portion we need to discuss the procedure that is used to check the suitability of use of ceramic waste with different proportions of RAP and need to check the optimum content of RAP and ceramic waste mixed with virgin aggregate that gives better results for the best use of this ceramic waste and RAP. For this we performed marshall test so, first of all we need to know the optimum bitumen content that is used to prepare samples of different percentage of RAP, ceramic waste and virgin aggregate. For the optimum bitumen content the marshall sample is prepared with collected bitumen and virgin aggregate and mix up for DBM 50-75 mm thickness (IRC 111 : 2009) and make sample with 4%, 4.5% and 5% bitumen content. For 4.5% bitumen content sample it gives better results as compare to 4% and 5% bitumen

content. So we decided to take 4.5% bitumen content and virgin aggregate are replaced with ceramic stone waste and RAP material. In gradation the nominal size of aggregate is 26.5mm i.e. according to IS 111 2009. According to above gradation the virgin aggregate is replace by ceramic stone waste and RAP material, the proportion of ceramic stone waste and RAP material which is used is given as below :-

Marshall sample combination

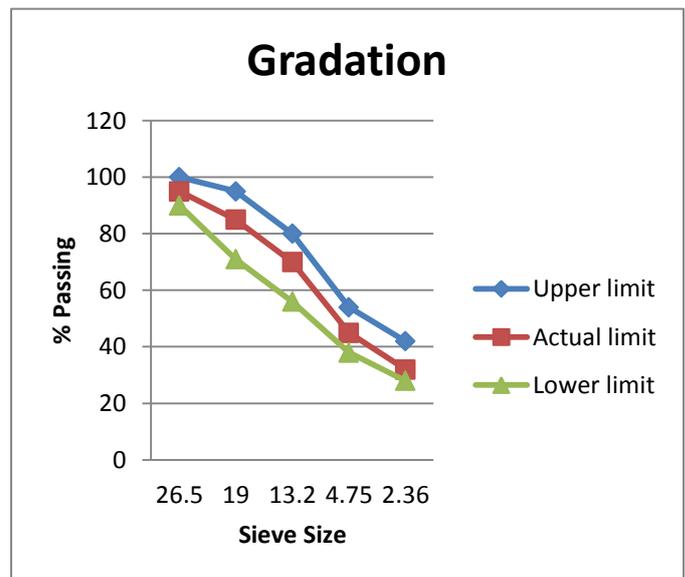
S.no.	Sample no.	Ceramic stone waste	RAP material	Total
1	CS-1	100%	0%	100%
2	CS-2	90%	10%	100%
3	CS-3	80%	20%	100%
4	CS-4	70%	30%	100%
5	CS-5	60%	40%	100%
6	CS-6	50%	50%	100%

From the above results of marshall sample test results CS-4 gives perform better as compare to other samples. Marshall stability of value of all the sample is low as compare to virgin aggregate marshall samples so we perform one more combination of sample that include the virgin aggregate, ceramic stone waste and RAP material, for these combinations the proportions of ceramic stone waste and RAP material is nearly equal to the optimum combinations of the marshall samples performed as shown in table above i.e. CS-4. The proportion of virgin aggregate, ceramic stone waste and RAP material which is used is given as below:-

S.no.	Sample no.	virgin aggregate	Ceramic stone waste	RAP material	Total
1	VAS-1	100%	0%	0%	100%
2	VAS-2	50%	25%	25%	100%
3	VAS-3	33%	33%	33%	100%

Gradation for above samples of CS and VAS is based on the IRC-111(2009) the i.e.

IS sieve size(mm)	Cumulative percent by weight of total aggregate passing		
	Upper limit	Actual limit	Lower limit
37.5	100	100	0
26.5	100	95	90
19	95	85	71
13.2	80	70	56
4.75	54	45	38
2.36	42	32	28



4. RESULT & DISCUSSION - Strength test including Aggregate Impact value and Crushing strength test, particle shape test i.e. Flakiness and elongation Index (combined), Water absorption test, test for Specific Gravity and Stripping test for Coating and Stripping of bitumen .

4.1 aggregate mixtures performed and the results of all these tests are in the tabular form:

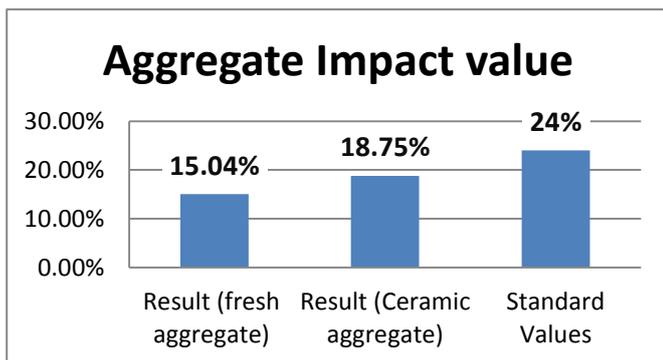
Sr. No.	Property	Test	Result (Ceramic aggregate)	Result (fresh aggregate)	Standard Values	Test Method
1	Strength	Aggregate Impact value	18.75%	15.04%	Max. 24 %	IS : 2386 Part IV
		Crushing strength test	19.40%	16.23%	Max. 30 %	IS : 2386 Part IV
2	Particle shape	Flakiness and elongation Index (combined)	32%	19%	Max. 35 %	IS : 2386 Part I
3	Water absorption	Water absorption	1.03%	0.45%	Max. 2 %	IS : 2386 Part III

4	Specific Gravity	Specific Gravity	2.35-2.6	2.76	2.6 - 2.8	IS : 2386 Part IV
5	Stripping	Coating and Stripping of bitumen aggregate mixtures	96%	97.50%	Min retain coatin g 95%	IS : 6241

viscosity test, specific gravity test performed and the results of all these tests are in the tabular form :-

Sr. No.	Characteristics of tests	VG 30	Min limits	Test Method
1	Penetration test (mm)	65	45	IS : 1203
2	Softening point	54	47	IS : 1205
3	Ductility (cm)	93	40	IS : 1208
4	Viscosity (poise) @150*	2483	2400	IS : 1206 Part II
5	Specific Gravity	1.036	0.99	IS : 6241

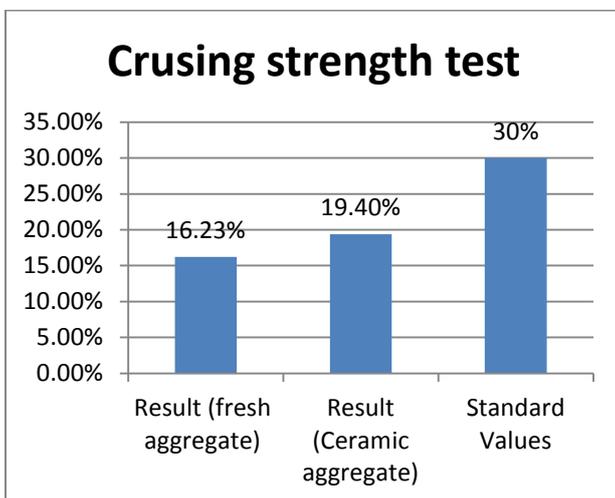
Comparison for all the tests are in the graph form that gives the idea of values of test values with their standard limits :-



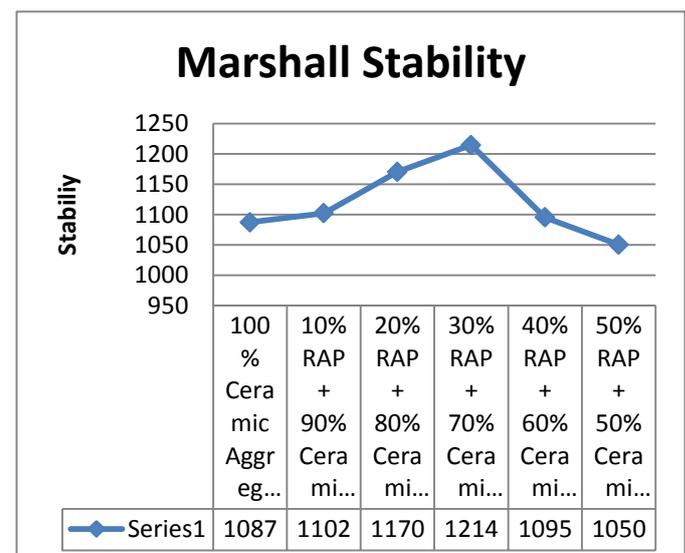
As the graph shows Aggregate Impact value of virgin aggregate & Ceramic aggregate is less than standard values, the more value of impact means it has less impact strength so, virgin aggregate is tougher than ceramic aggregate.

Marshall test results -

Marshall samples are prepared by 4.5% bitumen content that is already discuss in methodology 6 samples CS1 to CS6 are prepared by using ceramic stone waste and RAP material with different proportions. In these proportions RAP material is varies from 0% to 50%. The results of sample CS1 to CS6 are in below.



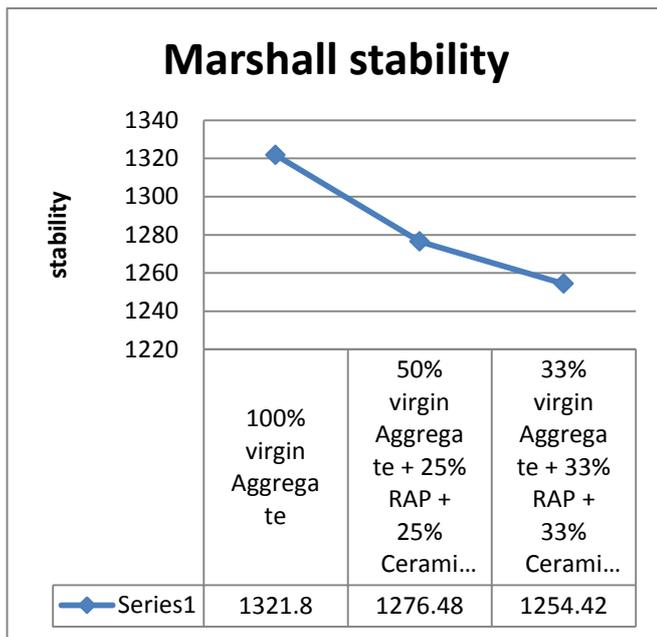
As the graph shows crushing value of virgin aggregate & Ceramic aggregate is less than standard values, the more value of crushing means it has less crushing strength so, virgin aggregate is harder than ceramic aggregate.



From the above results of marshall sample test results CS-4 perform better as compare to other samples. So we perform one more combination of sample that include the virgin aggregate, ceramic stone waste and RAP material, for these combinations the proportions of ceramic stone waste and RAP material is nearly equal to the optimum combinations of the marshall samples performed as shown in table above i.e. CS-4. The results of stability of optimum content of RAP ceramic agg and virgin agg are given as below -

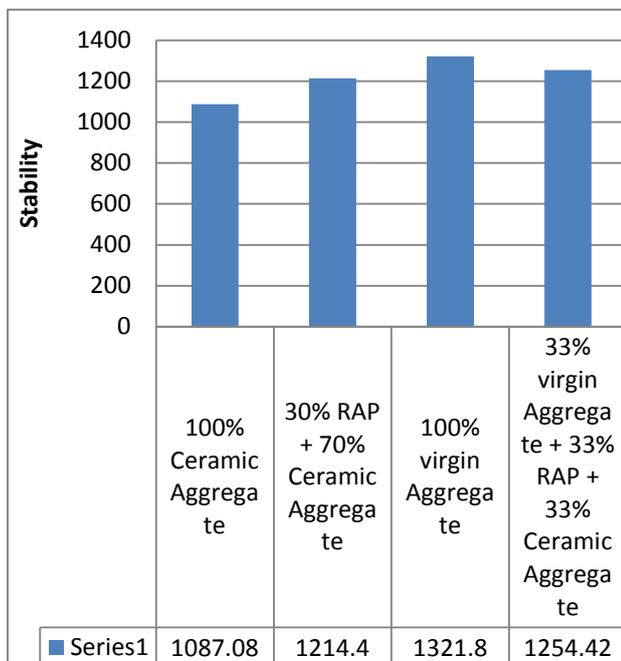
4.2 Tests on Bitumen:-

Bitumen VG 30 is used in all sample of ceramic Sample (CS) and virgin aggregate sanple (VAS) marshall samples, penetration test, softening point test, ductility test,



From the graph it is clear that the stability value decreases from VAS1 to VAS3. As we decrease percentage of virgin aggregate and increase the percentage of ceramic aggregate and RAP material.

One more table is prepared that shows 100% ceramic aggregate, 100% virgin aggregate and optimum % of RAP, ceramic aggregate and virgin aggregate.



CONCLUSIONS

The reuse of old Asphalt in the production of new asphalt mixes is certainly one of the procedures that enable a more rational and environment friendly

construction of new asphalt pavement. An internationally accepted name for reused asphalt is the RAP (Reclaimed Asphalt Pavement). It is the asphalt obtained by tearing, crushing of the existing old pavement. That contains about 30% of good quality and well graded bitumen aggregate.

Ceramic waste from ceramic industries is used in the production of new concrete by replacing natural coarse aggregate and fine aggregate. In India it has been estimated that nearly 30% of the daily production goes on waste during the manufacturing, transportation and usage. The ceramic waste is mounting up day by day, because of its enormous usage in modern ways of construction activity. So, one solvable solution has to be necessary for the ceramic industries for diminishing the waste dump at ceramic industries by recycling, reusing and substitution of concrete ingredients.

Both materials (RAP & Ceramic waste) are useful materials. On the basis of test and study we concluded that if mixed up both materials with suitable proportions with optimum bitumen content then it gives enough stability and flow value.

Based on laboratory tests, the following conclusions were prepared-

1. Impact test result - Aggregate Impact value of virgin aggregate is 15.04% & Ceramic aggregate is 18.75% which is less than standard values, the more value of impact means it has less impact strength so, virgin aggregate is tougher than ceramic aggregate.
2. Crushing value of virgin aggregate 16.23% & Ceramic aggregate is 19.40% which is less than standard values, the more value of crushing means it has less crushing strength so, virgin aggregate is harder than ceramic aggregate.
3. Flakiness and elongation Index (combined) of virgin aggregate 19% & Ceramic aggregate is 32% which is less than standard values, the more value of Flakiness and elongation Index (combined) means it is more elongated and flaky so, ceramic aggregate is more elongated than virgin aggregate.
4. Water absorption of virgin aggregate 0.45% & Ceramic aggregate is 1.03% which is less than standard values, the more value of water absorption means it has less water resistance so, virgin aggregate is good water resistant than ceramic aggregate.
5. Aggregate Stripping value of virgin aggregate 97.50% & Ceramic aggregate is 96% which is more than standard values, the more value of Stripping means it has good coating and stripping of bitumen aggregate mixtures value so, virgin aggregate is better than ceramic aggregate.
6. We performed Marshall test so, first of all we need to know the optimum bitumen content that is

used to prepare samples of different percentage of RAP, ceramic waste and virgin aggregate. For the optimum bitumen content the marshall sample is prepared with collected bitumen and virgin aggregate and mix up for DBM 50-75 mm thickness (IRC 111 : 2009) and make sample with 4% ,4.5% and 5% bitumen content. For 4.5% bitumen content sample it gives better results as compare to 4% and 5% bitumen content. So we decided to take 4.5% bitumen content and virgin aggregate are replaced with ceramic stone waste and RAP material. In gradation the nominal size of aggregate is 26.5mm i.e. according to IS 111 2009.

After adopting 4.5% bitumen content we prepare marshall sample for bitumen content and ceramic waste and RAP material.

We prepare 6 marshall sample with 100% ceramic waste to 50% ceramic waste with remaining portion use RAP material with 0% to 50% increase.

_ After applying marshall test on 6 sample and we go on point that CS4 (70% ceramic waste and 30% RAP) sample has enough marshall stability and flow value as compared to other samples.

_ From the above results of marshall sample test results CS-4 perform better as compare to other samples. So we perform one more combination of sample that include the virgin aggregate, ceramic stone waste and RAP material, for these combinations the proportions of ceramic stone waste and RAP material is nearly equal to the optimum combinations of the marshall samples performed. From these combination VAS 3(33% of Virgin aggregate+ 33% of ceramic waste stone + 33% of RAP material) performed good in all criteria.

After all result and analysis we found CS 4 and VAS 3 as a good material which is useable in pavement construction.

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