Experimental Analysis of Polyethylene Coated Aggregates in Road Construction

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Abstract: The most widely known wellsprings of waste items are from the development of different enterprises and increment in population. The sort of waste which is generally dangerous to the nature is the Plastic Waste. The primary worry about the plastic waste is its non-biodegradability. As per later explores, plastic waste when blended in with bitumen gives it desired mechanical properties. Bitumen is basically utilized in the development of adaptable asphalts and when it is blended with plastic waste it improves the water resistivity and strength of the blend. Tests have demonstrated that it can be utilized as a binder material in the bitumen blend for development of adaptable asphalts. Plastic waste percentage in bitumen must be checked. The tests which we perform after the modification of an aggregate with modified bitumen layer are los Angeles abrasion test, impact test, aggregate crushing strength test, specific gravity test and water absorption test of an aggregate. The percentage of plastic we add in this experiment includes 0%, 5%, 7%, 9%, 11%. The result shows that the value goes on decreasing if we increase the amount of plastic in case of los Angeles abrasion test. In the case of aggregate impact value test and aggregate crushing strength test the value goes on decreasing as we increase the amount of plastic. The essential goal of the test is to discover the ideal level of plastic waste which can overrule the bitumen content in the blend for the structure of adaptable asphalts. The essential goal behind this investigation is to supplant bitumen by a customary and non-biodegradable material which is the plastic waste.

Key Words: *Coarse aggregate, Polyethylene, Aggregate impact value, Los Angeles value, Aggregate crushing strength value***.**

I. INTRODUCTION

Disposal of different kinds of waste in better place from different sources has involved worry from a long time. These materials influence various kinds of contamination to the earth. The plastic material is non-biodegradable making them boundless in nature and begin to gather at an exponential rate. The expense of extraction of good quality material has expanded because of the impact of presence of these materials in our condition. Exponential increment in the population and the development of enterprises has come about into the extensive removal of the plastic wastes. Thermoplastics have properties by the assistance of which it extends and mellow at the point when warmed and recaptures its typical shape at the room temperature. Thermoplastics can undoubtedly be shaped or formed into different items, for example, milk containers, floor covers, and floor covering strands. These sorts of plastics are known as phenolic, melamine, unsaturated polymers, epoxy sap, silicone and polyurethane. Later contemplates tell that plastics stay unaltered for more than 4500 years relying on the ascent in food requests and basics. Likewise, the expanding population results into progressively waste created from the family unit's day by day. As indicated by reviews plastic establishes 5% in metropolitan waste which is harmful. Plastic bags are the most normally discovered wellsprings of plastic wastes, we come to see littering of plastics result into the stifling of channels and so on these outcomes into stagnation of water and results to sick cleanliness of the locality. The best way to conquer these issues is to reuse the plastic adequately.

During late investigates it has been derived that waste plastic when stirred up with hot total will frame a fine plastic coat over it and when stirred up with the cover invigorates it a higher, high water obstruction and improved execution over a period of time. Waste materials generally establishes of plastic bags, expendable cups and so on. The utilization of plastic with bitumen in development of adaptable asphalts not just expands its perfection and life yet helps in diminishing the expense of task and furthermore contributes into an ecofriendly condition. Use of waste reused bundling plastics is of extraordinary significance, especially for bitumen preservation and for bitumen change to find its utility in bituminous blends for laying Flexible pavements.

The plastic streets are found to give better results and execution contrasted with the customary bitumen streets. It moreover upgrades the quality and execution of the streets. Plastic filling expands the dissolving purpose of the bitumen. The plastic waste blending improves the abrasion and slip resistance of adaptable asphalts permits us to figure out rigidity, when the plastic blended is beyond 30% of the heaviness of the blend. Generally plastic roads is now made in India at a faster rate and it help India to remove the problem of disposal of the plastic and it also help out India to make a eco-friendly environment.

II Literature Review

Rajneesh Kumar (2020) published a paper which deals with the Use of Plastic Waste Along with Bitumen in Construction of Flexible Pavements. In this experimental work there are various tests performed which include los Angeles abrasion test, Aggregate impact value test, Aggregate crushing strength tests for aggregate and for bitumen he performs penetration tests, ductility test, flash fire point test, softening point test and viscosity test. In the analysis the aggregate impact value is 5.43% when no plastic is added and when 8% plastic and 10% plastic are added then the values are 4.91% and 4.26% respectively. This tells that the more we added plastic the more value goes on decreasing in the case of aggregate impact value. Same as the los Angeles and crushing strength value are also decreases at 8% and 10% addition of plastic.

Pradeep Soyal (2015) published a paper which deals with the use of waste polythene in bituminous concrete mixes. In his experimental work he added plastic up to 5%. The value of softening point increases up to 5% whereas the value of penetration and ductility test the value goes on decreasing as we added plastic up to 5% and the Marshall stability flow value generally decreases as we increase the plastic percentage.

Amit Gawande (2012) examined the quantum of plastic waste in civil solid waste is expanding because of increment in population, urbanization, advancement exercises and changes in way of life which driving far reaching littering on the scene. Along these lines removal of waste plastic is a danger and become a major issue all-inclusive due to their non-biodegradability. Since these are not arranged logically and probability to make ground and water contamination. This waste plastic incompletely supplanted the customary material to improve wanted mechanical qualities for specific street blend. In regular street making process bitumen is utilized as cover. Such bitumen can be changed with waste plastic pieces and bitumen blend is made which can be utilized as a top layer of flexible pavement. This waste plastic altered bitumen blend shows better restricting property, dependability, thickness and increasingly impervious to water.

Rahman and Wahab (2013) utilized reused polyethylene terephthalate (PET) as incomplete substitution of fine total in adjusted black-top in their examination. In term of financial worth, it shows this reused PET could lessen cost of street development since this reused material is less expensive than bitumen and simple to acquire, which likewise improves the degree of execution and the life of the road.

Yadav Santosh (2013) published a paper that deals with the performance evaluation of waste plastic and bitumen concrete mix in flexible pavement. In this experiment he performs various test which include crushing test, impact test, water absorption test. The result shows that the crushing value is about 24.8 which is good and impact value is about 20.8% which is good and in case of los angeles abrasion value the value cames around 32 which is suitable for water bound macadam roads.

Ahmadinia et al. (2012) did a test look into on the use of waste plastic containers (Polyethylene Terephthalate (PET)) as an added substance in stone mastic black-top (SMA). Wheel following, dampness vulnerability, flexible modulus and channel down tests were done in their investigation on the blends that included different rates of waste PET as 0%, 2%, 4%, 6%, 8% and 10% by weight of bitumen content. Their outcomes show that the expansion of waste PET into the blend has a critical constructive outcome on the properties of SMA which could improve the blend's obstruction against changeless disfigurement (rutting), increment the firmness of the blend, give let fastener channel down and advancement of re-use and reusing of waste materials in an all the more ecologically and prudent way.

Khan and Gundaliya (2012) expressed that the procedure of change of bitumen with squander polythene upgrades protection from breaking, pothole arrangement and rutting by expanding relaxing point, hardness and lessening stripping because of water, in this manner improving the general execution of streets over an extensive stretch of time. As per them the waste polythene used in the blend structures covering over totals of the blend which lessens porosity, retention of dampness and improves restricting property.

Sui and Chen (2011) examined application and execution of polyethylene as adjusting added substance in black-top blend. They added polyethylene as added substance to hot mineral total for few moments, and afterward included the black-top combining which rearranges the development procedure and diminishes the expense of development. They reasoned that there is enhancement for high temperature solidness, low temperature splitting obstruction and water opposition adjustment and assess polyethylene as added substance in the specialized, monetary and ecological perspectives.

Panda and Mazumdar (2002) used recovered polyethylene (PE) acquired from LDPE convey sacks to adjust black-top concrete. They contemplated the essential properties, for example, Marshall steadiness, versatile modulus, weakness life, and dampness helplessness of blends in with 2.5% of PE and contrasted and those of black-top concrete.

Material Used

A. Aggregates: The aggregates are bound together either by concrete or by bituminous materials. sometimes the stone residue itself when blended in with water structures slurry which acts as an authoritative medium.

The aggregates might be characterized into:

1) **Natural Aggregates:**

Further characterized into

• Coarse aggregates comprising of crushed stone aggregate.

• Gravels and fine aggregates or sand.

2) **Artificial Aggregates**

Stone aggregates utilized for road work ought to be hard, extreme, tough and hydrophobic for bituminous surface. Rock ought to be all around reviewed (6.4mm to 38mm) and ought to have a fineness modulus of at the very least 5.75. Sand ought to be sharp, very much evaluated, clean all things considered, earth and natural matter. The amount of aggregates utilized in first layer of surface dressing ought to be 0.15 m3 per 10 m2 region of 12mm nominal size. Then again, the amount of aggregates utilized in second layer of surface dressing ought to be 0.15 m3 per 10 m2 regions and of 10mm nominal size.

Fig 1 Coarse aggregates

Fig 2 Coarse aggregates along with fine aggregates

B. Plastic Material

Plastics are generally arranged by their concoction structure of the polymer's spine and side chains. Some significant bunches in these characterizations are

- Acrylics
- Polyesters
- Polyurethanes
- Halogenated plastics
- Silicones

There are two kinds of plastics:

• Thermoplastics: They are the plastics that don't experience substance change in their synthesis when warmed also, can be formed over and over. Models incorporate polyethylene, polypropylene, polystyrene, polyvinyl chloride, and polytetra fluoro ethylene (PTFE).

• Thermosetting: In the thermosetting procedure, a concoction response happens that is irreversible. The vulcanization of elastic is a thermosetting procedure. Previously warming with sulfur, the polyisoprene is a tasteless, somewhat runny material, yet after vulcanization the item is unbending and non-tacky.2

Fig 3 Plastic waste

Fig 4 Plastic waste broken into pieces

C. Classification of Plastic Waste

1) Polyethylene:

• LDPE (Low Density Poly-Ethylene): Low thickness poly-ethylene plastic waste accessible as convey packs for the most part in stores these plastic sacks are very dainty and furthermore effectively accessible.

• HDPE (High Density Poly-Ethylene): Generally High-thickness poly-ethylene sort of plastic waste is accessible as convey sacks and effectively accessible in the market.

2) Polypropylene: This plastic might be accessible as convey sacks or strong plastic it's rely on the utilization and need of the businesses. It is accessible as plastic jugs and tangle sheets and so on.

EXPERIMENTS AND RESULTS

Test For aggregates

1, Aggregate crushing strength test

2, Impact value test

3, Los angles abrasion value

4, Specific gravity

5, Water absorption value

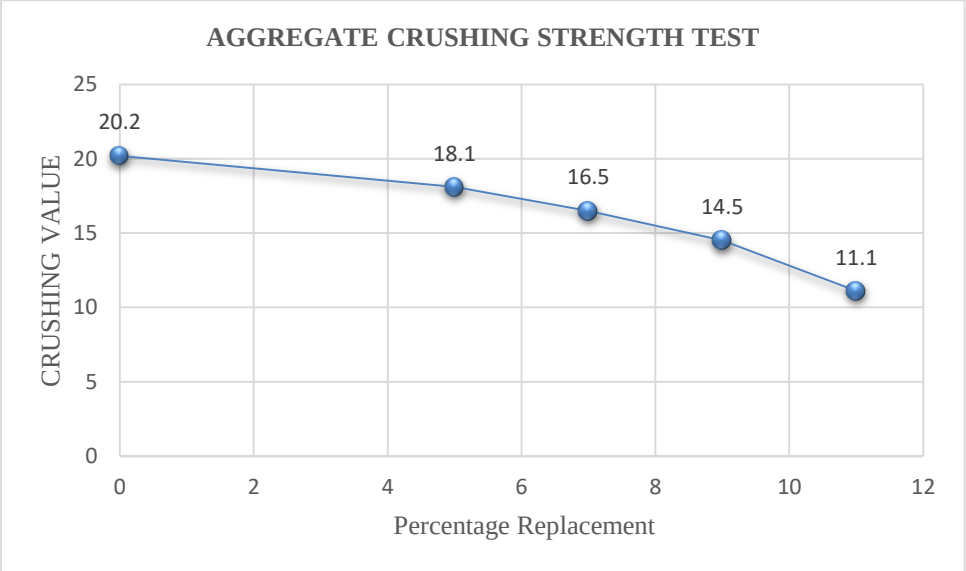
1, Aggregate crushing strength test: Aggregate crushing value test on coarse aggregates gives a relative measure of the strength of an aggregate. The percentages of polyethylene which we used in this test includes 0%, 5%, 7%, 9% and 11%.

Fig 4 Aggregate crushing strength testing apparatus

Aggregate crushing value = (W2 x 100) / (W1-W)

Table 1 Aggregate Crushing Strength

Description	**Percentage of Plastic Coated aggregates**				
	0%	**5%**	**7%**	**9%**	**11%**
Aggregate crushing value	20.2%	18.1%	16.5%	14.5%	11.1%



Graph 1 Crushing Value vs Percentage Replacement

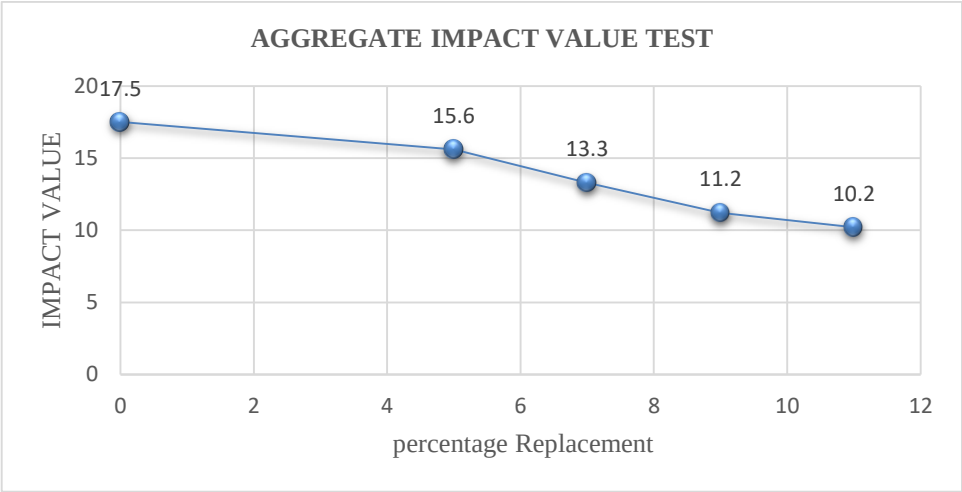
2, Impact value test: Impact test is generally used to determine the impact value and toughness of an aggregate. In this test we add polythene at different percentages of 0%, 5%, 7%, 9%, 11%.

Fig 5 Aggregate Impact testing machine

Aggregate Impact value = W2/W1 *100

Table 2 Aggregate Impact Value

Description	**Percentage of Plastic Coated aggregates**				
	0%	**5%**	**7%**	**9%**	**11%**
Aggregate Impact Value	17.5%	15.6%	13.3%	11.2%	10.2%



Graph 2 Impact Value vs Percentage Replacement

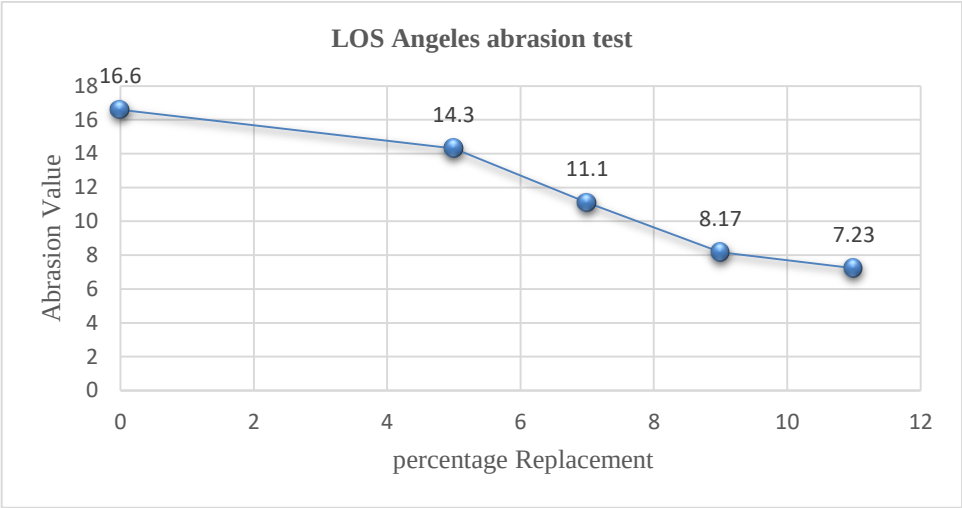
3, Los Angeles abrasion test: Los Angeles abrasion test on aggregates is the proportion of aggregates resistance and scraped spot obstruction, for example, squashing, debasement and crumbling. This test is done by AASHTO T 96 or ASTM C 131.

Fig 6 Los Angeles abrasion machine

$$\text{Abrasion Value} = (W_1 - W_2) / W_1 \text{ X } 100$$

Table 3 Los Angeles abrasion value

Description	**Percentage of Plastic Coated aggregates**				
	0%	**5%**	**7%**	**9%**	**11%**
Los Abrasion Value	16.6%	14.3%	11.1%	8.17%	7.23%



Graph 3 Abrasion Value vs Percentage Replacement

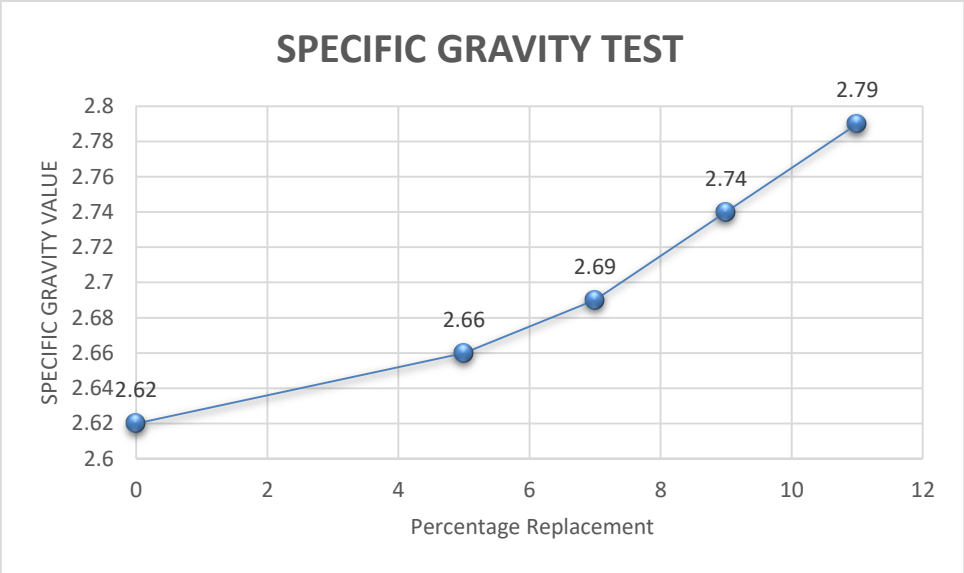
4, **Specific gravity test:** Specific gravity of aggregate is done to quantify the quality or nature of the material. We include different percentages in this test which includes 0%, 5%, 7%, 9% ,11%.

Fig 7 Specific gravity testing machine

Specific gravity = W3/(W3-(W1-W2))

Table 4 Specific gravity value

Description	Percentage of Plastic Coated aggregates				
	0%	5%	7%	9%	11%
Specific gravity value	2.62	2.66	2.69	2.74	2.79



Graph 4 Specific Gravity Value vs Percentage Replacement

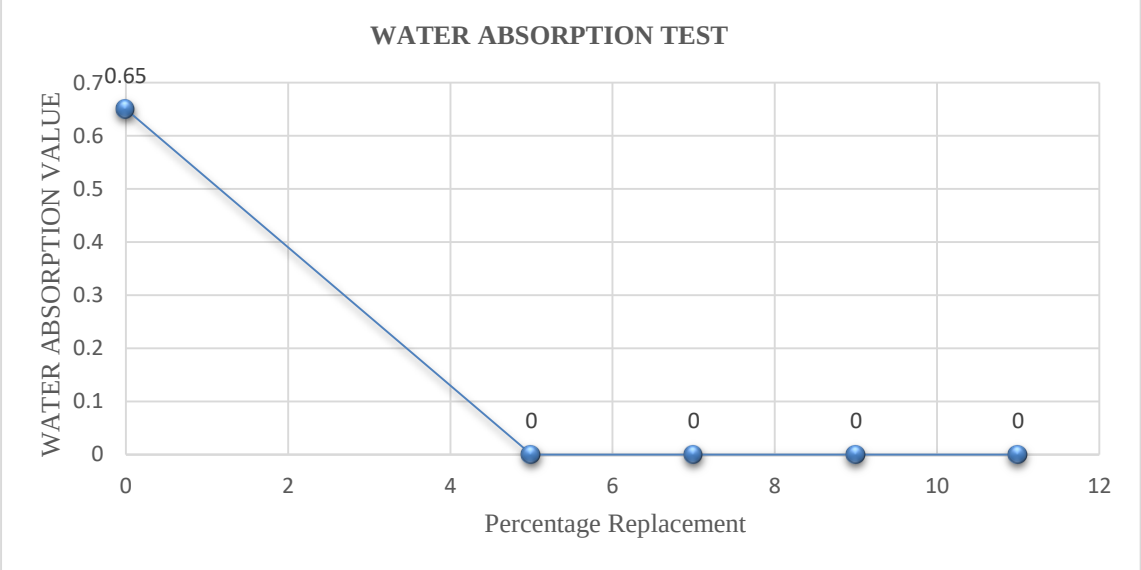
5, Water absorption test: Water absorption test determines the water absorbing capacity of the coarse aggregates. We add different percentages of plastic in it which includes 0%, 5%, 7%, 9%, 11%.

Fig 8 Water absorption testing machine

Water Absorption = **(**$W_3 - W_4$**)** / W_4) X 100

Table 5 Water absorption value

Description	Percentage of Plastic Coated aggregates				
	0%	5%	7%	9%	11%
Specific gravity value	0.65	0	0	0	0



Graph 5 Water Absorption Value vs Percentage Replacement

Conclusion: Plastic covering on aggregates is utilized to improve things execution of roads. This assists with having a superior authoritative of bitumen with plastic squandered coated aggregate due to expanded holding and expanded region of contact between polymers and bitumen. The polymer covering additionally decreases the voids. This prevents the dampness ingestion and oxidation of bitumen by ensnared air. This has come about in decreasing rutting, raveling and there is no pothole development. The roads can withstand overwhelming traffic and show better strength.
From the above experiment we conclude that,

1, In case of Aggregate impact test, when no plastic is added then the value for conventional aggregates is about 17.5.% which is good strong. But when we added 5% plastic the value is around 15.6 which is strong and then we added plastic within the range of 7%-11% the value comes in between 10-20 which is strong as per IRC recommendations. Therefore, our results show that, if we increase the plastic content the value of aggregate impact test is goes on decreasing.

2, In case of Aggregate crushing strength test, when no plastic is added the value is about 20.2% which is less than 30% and it is suitable for roads as per IRC recommendations. But when we add plastic in between 5%-11%, the value of aggregate crushing is goes on decreasing. Therefore, all the values in between 5%-11% replacement of plastic content are less than 30% which is suitable for bituminous surface dressing as per IRC recommendations.

3, In case of Los Angeles abrasion test, when no plastic is added the value came about 16.6% which is less than 30% and it is suitable for bituminous concrete surface courses. When we added plastic is in the range of 5%-11% the value goes on decreasing and all values which is in between 5%-10% are less than 30 therefore, it is suitable for bituminous concrete surface courses.

4, In case of specific gravity test, the value came around 2.62 when no plastic content is added. But when we added plastic content is in between 5%-11% the value of specific gravity goes on increasing.

5, In case of water absorption test, the value is around 0.65 when no plastic waste is added. but the value of water absorption is drastically reduced to zero when we added plastic content in between 5%-11%.

6, Hence, from all the above results it shows that all the values are lies between the ranges which is as per IRC recommendations when we replace plastic content up to 11% therefore it is useful for us to reduce plastic and it also make our environment ecofriendly.

References

[1] Das A. and Chakroborty P. (2010), "Principles of Transportation Engineering", *Prentice Hall of India, New Delhi, pp 294-299*
[2] Das A., Deol, M. S. Ohri S. and Pandey B. B. (2004). "Evolution of non-standard bituminous mix – a study on Indian specification", *The International Journal of Pavement Engineering, Vol 5(1), pp. 39-46.*3,
[3] IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", *Bureau of Indian Standards, New Delhi*
[4] IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P-IV): Mechanical Properties", *Bureau of Indian Standards, New Delhi*
[5] Ibrahim M. Asi (2005), "Laboratory Comparison Study for the Use of Stone Matrix Asphalt in Hot Weather Climates", *Construction and Building Materials, Volume 20, Issue 10, pp 982-989*
[6] Karasahin Mustafa, Terzi Serdal (2007), "Evaluation of marbal waste dust in mixture of asphalt matrix", *Construction and Building Materials, Volume 21, Issue 5, pp 616-620*
[7] Kamraj C., Kumar G., Sharma G., Jain P.K. and Venkanna Babu P. (2004), "Laboratory Studies on the Behaviour of Stone Matrix Asphalt vis-à-vis Dense Graded Bituminous Mixes using Natural Rubber Powder (Wet Process)", *Highway Research Bulletin, No 71, IRC, New Delhi, pp39-60*
[8] Khanna S.K. and Justo C.E.G. (2001), "Highway Engineering", *Nem Chand andBros, Roorkee, pp315-321*
[9] Kumar Pawan, Chandra Satish and Bose Sunil (2007), 'Laboratory Investigations on SMA mixes with Different Additives', *International Journal of Pavement Engineering, Volume 8, Issue1, pp 11-18*
[10] Mogawer W.S. and Stuart K.D. (1996), "Effect of Mineral Fillers on Properties of Stone Matrix Asphalt Mixtures", *TRR 1530, National Research Council, TRB, USA, pp 86 -94*
[11] Muniandy Ratnasamy and Huat Bujang B.K. (2006), "Laboratory Diameteral Fatigue Performance of Stone Matrix Asphalt with Cellulose Oil Palm Fibre", *American Journal of Applied Sciences 3 (9): 2005-2010*
[12] Punith V.S., Sridhar R., Bose S., Kumar K. Kantha and Veeraragavan A. (2004), "Comparative Studies on the Behaviour of Stone Matrix Asphalt and Asphaltic Concrete Mixtures utilizing Reclaimed Polyethylene", *Highway Research Bulletin, No 71, IRC, New Delhi, pp 61-76*
[13] Reddy K.S., Palit S.K. and Pandey B.B. (2004), "Laboratory Evaluation of Crumb Rubber Modified Asphalt Mixes", *Journal of Materials in Civil Engineering, ASCE, pp 45-53*
[14] Yongjie Xue, Haobo Hou, Shujing Zhu and Jin Zha (2009), "Utilization of Municipal Solid Waste Incineration Ash in Stone Mastic Asphalt Mixture: Pavement Performance and Environmental Impact", *Construction and Building Materials, Vol. 23, Issue 2, pp 989-996*