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Design of Bituminous Mix with and without Partial Replacement of Waste Ceramic Tiles Material

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***Abstract*— Past few decades were the witnessed of tremendous growth in construction industry, this has both positive and negative impact on the society or we can say on environment. This construction activity leads to many kind of wastes in our society. This research mainly concentrates on the use of such industrial construction waste in the road pavement construction and optimizes their use for better replacement of natural aggregates. In the present study, using ceramic waste aggregate 5, 10, 15 & 20 % replacement of natural aggregate in bituminous macadam pavement. Marshal stability, flow value and were determined by replacement of ceramic aggregates and compare with the natural aggregate stability and flow value. It is observed that by replacing 5%, 10%, 15 % natural aggregates with ceramic waste there in not remarkable reduction in stability values.**

Keywords: Ceramic Waste, Bituminous Macadam Pavement, Marshal Stability, Marshal Flow

1. INTRODUCTION

Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods. Highway engineers must take into account future traffic flows, design of highway intersections/interchanges, geometric alignment and design, highway pavement materials and design, structural design of pavement thickness, and pavement maintenance. Pavements are one of the main components of our transportation and infrastructure systems. Smooth, comfortable and well maintained pavements for roadways, runways etc. are not only expected by a nation, but are important for safety of vehicle movements, aesthetics of landscape and economic, social and cultural development of any country. In modern days due to huge increase in traffic load, sufficient good strength is necessary for different layers of pavement. Depending upon the nature and mode of loads to be supported and distributed, pavements are classified as flexible, semi-flexible and rigid, but the essential common component of all these types is bituminous layer. One of the major component of pavement is its bituminous top layer which not only protect the other layers of pavement, it also provide a flexible cushion for the smooth and comfortable rolling of wheels over pavement. This bituminous layer should be capable to withstand the dynamic wheel load of vehicles as well as it should be stable against different climatic, environmental and geological conditions also.

Every year India produces over 300 million tonn industrial and agricultural waste. In recent years, many countries around the globe have started showing their interest in utilizing this Industrial waste in road construction activity. Globally various researches have been conducted by Scientists and Engineers to understand the use of this waste material in road construction with the key objectives of effective disposal of these materials to save environment and also to reduce overall road construction cost without impacting construction quality. These studies try to match society's need for safe and economic disposal of waste materials with the highway industry's need for better and more cost-effective construction materials. At present road construction activity is continuously increasing day by day demanding natural resources enormously. This may result in deterioration /depletion of the naturally available materials like sand and rock with in short time. Therefore, it is advisable to preserve and curtail the use of natural materials and to think about reuse, recycle the waste products which are suitable to replace the natural materials. Some of the industrial wastes like flyash, blast furnace slag and ceramic waste materials can be effectively utilized for road construction work. These materials may be economic for the places which are close to these industries. Many researchers now concentrating their efforts to decided efficient techniques and proportions for replacing the waste materials in place of natural materials in construction activity. The proposed study is aimed to determine the applicability of ceramic waste material in bituminous mix for the flexible pavement design. The ceramic industries are established near Himmatnagar city produce the waste (broken tiles) in large quantity and dumping the stacks surrounding the industry creating hazardous environment. Looking at this problem the proposed study can suggest the suitable application of ceramic waste in road construction which may result in improvement of environment.

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2 MATERIALS AND METHODS

2.1 Ceramic waste

Ceramic waste is produced from ceramic bricks, roof and floor tiles and stoneware industries**.** Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15%-30% waste material generated from the total production. The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution.

2.2 Ceramic properties

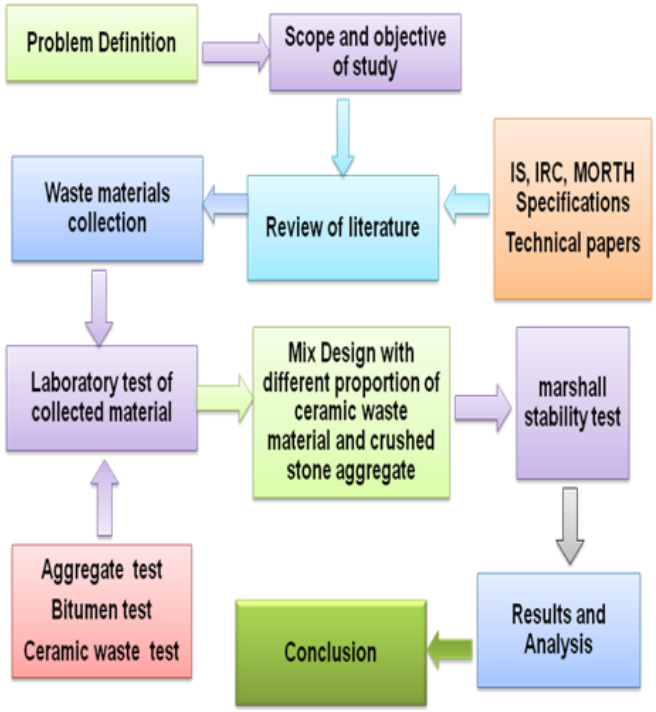
The properties of ceramic materials, like all materials, are dictated by the types of atoms present, the types of bonding between the atoms and the way the atoms packed together. This is known as atomic scale structure. Most ceramics are made up of two or more elements. This is called compound.

The two most common chemical bonds for ceramic materials are covalent and ionic. The chemical bond is called the metallic bond ceramic materials wide range of properties; they are used for a multitude of applications.

In most ceramics are:-

- Hard
- Wear-resistant
- Brittle
- Refractors
- Thermal insulators
- Electrical insulators
- Nonmagnetic
- Oxidation resistant
- Prone to thermal shock
- Chemically stable

2.3 Methodology chart



3. RESULTS AND ANALYSIS

3.1 Tests on Ceramic Waste + Natural Aggregate

- 10% Ceramic waste + Natural Aggregates
- 15% Ceramic waste + Natural Aggregates
- 20% Ceramic waste + Natural Aggregates

Ceramic Waste %	Flakiness %	Elongation%	FI + EI %	Impact Value%	Crushing Value%
10%	13.69	12.05	25.74	21.7	17.85
15%	14	13.33	27.33	23.37	18.96
20%	14.18	13.96	28.14	25.45	21.36
Limits as per MORTH	-	-	F+E Max 30 %	Max 30 %	Max 30 %

3.2 Marshall Stability Tests on Ceramic Waste + Natural Aggregate

- Natural Aggregates
- 10% Ceramic waste + Natural Aggregates
- 15% Ceramic waste + Natural Aggregates
- 20% Ceramic waste + Natural Aggregates

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Marshall Parameters	Natural Aggregate		
Bitumen by wt. Of Mix	3.3	3.4	3.5
Sample Height (mm)	64	64	63.5
Stability in Kg	1025	1035	1029
Flow in mm	2.31	2.41	2.52
Air Voids (%)	6.7	5.9	5.5
Voids in Mineral Aggregate (%)	14.34	13.81	13.57
Voids filled with Bitumen (%)	53.3	57.3	59.5

Marshall Parameters	10% Replacement		
Bitumen by wt. Of Mix	3.3	3.3	3.3
Sample Height (mm)	63	63	63
Stability in Kg	985	985	985
Flow in mm	2.85	2.85	2.85
Air Voids (%)	6.9	6.9	6.9
Voids in Mineral Aggregate (%)	14.41	14.41	14.41
Voids filled with Bitumen (%)	52.1	52.1	52.1

Marshall Parameters	15% Replacement		
Bitumen by wt. Of Mix	3.3	3.4	3.5
Sample Height (mm)	64	64	63
Stability in Kg	935	944	952
Flow in mm	3.41	3.76	3.98
Air Voids (%)	6.78	6.25	5.47
Voids in Mineral Aggregate (%)	14.32	13.95	13.43
Voids filled with Bitumen (%)	52.7	55.2	59.3

Marshall Parameters	20% Replacement		
Bitumen by wt. Of Mix	3.3	3.4	3.5
Sample Height (mm)	65	63.5	64
Stability in Kg	907	914	923
Flow in mm	4.25	4.52	4.87
Air Voids (%)	6.2	5.7	5.26
Voids in Mineral Aggregate (%)	13.57	13.33	13.09
Voids filled with Bitumen (%)	54.3	57.2	59.8

Marshall Parameters	BM Limits as per MORTH		
Stability in Kg	Minimum 917.73 kg	Minimum 917.73 kg	Minimum 917.73 kg
Flow in mm	2-4	2-4	2-4
Air Voids (%)	3-5	3-5	3-5
Voids in Mineral Aggregate (%)	Minimum 13%	Minimum 13%	Minimum 13%
Voids filled with Bitumen (%)	75-85	75-85	75-85

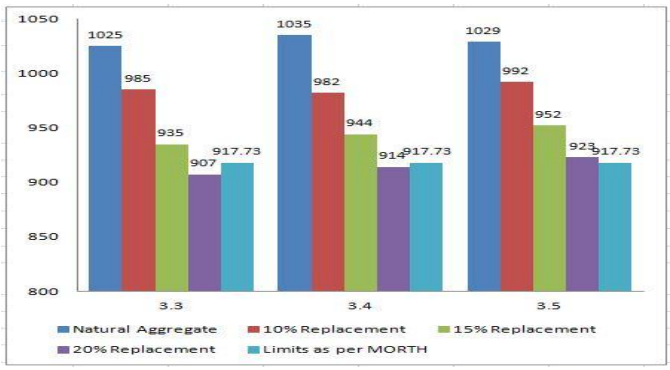

Fig. Comparision of ceramic waste and natural aggregate stability

4. CONCLUSION

From the above observation following conclusions were drawn out.

1. Ceramic waste used in bitumenous macadam upto certain limits give considerable value of marshal stability and lower marshal flow value.
2. By increasig the value of ceramic waste in replacement of natural aggregate decrease in marshal value and increase in flow value.
3. Optimum bitumen content vary with the increse with the the ceramic waste content.

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