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USE OF INDUSTRIAL WASTE IN WET MIX MACADAM (WMM) BY PARTIAL REPLACEMENT TO CONVENTIONAL MATERIALS

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Abstract: This study has been undertaken to examine the feasibility analysis of Industrial waste unlike Foundry sand, Ferromanganese slag and Tyre Chips in Wet Mix Macadam (WMM) by partial replacement to the natural aggregates and stone dust used in WMM. Various mix designs were conducted using different proportions of the Industrial waste and aggregated mix together by partial replacement of industrial waste products to the natural aggregates especially fine aggregates and stone dust. Various laboratory tests i.e. Grain Size Analysis, Standard Proctor Test to determine the MDD and OMC of the mix, Permeability Test, California Bearing ration (CBR) were carried out to analyze the properties of the newly formulated mix in accordance with the conventional mix design of WMM. Further field applications and field results were conducted to analyze the practicability of the mix.

***Index Terms* – Industrial Waste, Foundry Sand, Ferromanganese slag, Tyre Chips, Wet Mix Macadam (WMM).**

I. INTRODUCTION

Generally, roads are typically constructed from compacted materials due to which its strength decreases downward. For application of conventional materials, numbers of tests are conducted & their acceptability depends upon the test results & specifications. These ensure necessary level of performance of chosen materials, in terms of its stability, toughness, permeability, shape, durability, specific gravity etc. Studying the Pavement performance on these industrial waste materials for construction of roads. Before construction of pavement with industrial waste materials, there is need to select these industrial waste materials on some predefined criteria. Also, it is an expedient that develop some acceptability criteria for selection of industrial waste materials.

The tests & specifications which are applicable for conventional material are appropriate for evaluation of non-conventional materials, such as industrial waste materials. This is because of the material properties. Hence, for appropriate assessment of these materials, new tests are to be advised & new acceptability criteria are to be formed. Above flow chart helps us for the evaluation of industrial waste for suitability in road construction.

An aggregate grading that produces maximum solid density and determined particle interlock is highly favorable for both bound mixtures, such as asphalt concrete and plain and reinforced concrete, and for unbound mixtures those used in base courses. Maximum particle interlocking ultimately leads to high strength.

II. LITERATURE REVIEW

G.D. Ransinchung R.N., Praveen Kumar discussed about innovations in the mix design of W.M.M. They have proposed to use moorum by partial or complete replacement to the aggregates. The research concluded with the design mix of moorum and 3% OPC have shown results with better CBR value with respect to the conventional WMM mix with retained permeability leading to cost savings. **[1]**

Robin L. Schroeder reviews about the current research about the waste materials which cab be utilized as an alternative to the conventionally used materials. The main focus of the research is on the new innovative uses of the waste or the byproducts in relation with the commonly followed practices in the Highway industry. **[2]**

Mr. Sagar B. Patil and Prof. Dhananjay S. Patil reviewed the various industrial waste materials or the byproducts. The study mainly focusses on the industrial byproduct Foundry sand used in casting industry for making molds. After multiple uses of the sand in casting process, the characteristics of the sand are further depleted making it unsuitable for the manufacturing process. This waste Foundry sand can be used as a partial replacement to the fine aggregates or the stone dust. **[3]**

Krishna R. Reddy and Aravind Marella discussed about the various uses of the shredded scrap tires as drainage material. For feasibility study of the scrap tires properties unlike unit weight, compressibility, hydraulic conductivity, interface shear strength and shear strength observed. The engineering properties of shredded tyre is briefed in this paper. The differences in the size and composition shows different values in each property and the testing methods. For effectiveness the properties of the shredded tyre scraps shall meet the specified requirements. **[4]**

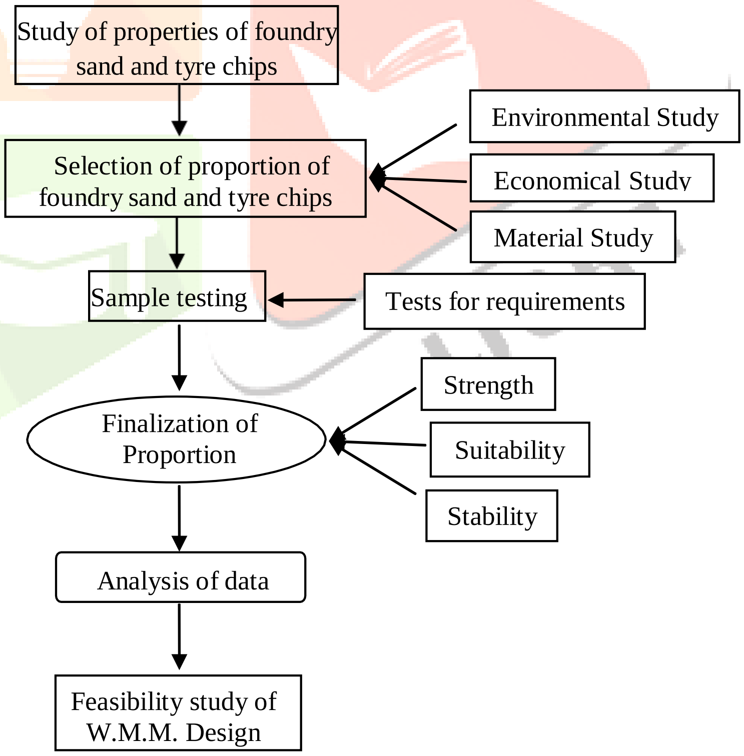
Yudell Guney, Ahmet H. Aydilek, M. Melih Demirkan reviewed about the various properties of the Foundry system sand. It was mentioned that the foundry sand consists of silica sand blend, bentonite and organic additives. Addition of excessive binders as well as additives to the foundry sand creates excess volume. This can be easily disposed in Highway sub bases further providing cost effectiveness and solution to disposal problems. They also proved that the study satisfied the mechanical properties and can be easily used in the highway sub bases. **[5]**

III. OBJECTIVES

i. To study the physical properties of Industrial waste used in the study mainly Ferromanganese slag, Foundry sand and Tyre chips.
ii. To conduct mix designs through partial replacement of industrial waste to fine aggregates and stone dust.
iii. To test the newly formulated design mixes.
iv. To evaluate and compare the difference between the proposed mix design with respect to the conventional mix method of W.M.M and cost analysis.

IV. RESEARCH METHODOLOGY.

The Research methodology shall be studying the basic design considerations of Wet Mix Macadam and the properties of Industrial waste that are proposed to be used or to be replaced by the basic raw materials used in the JMF of Wet Mix Macadam. Also, the upgrade or degrade in the properties of WMM shall be studies and the cost impact in accordance to the changes made in the JMF and the overall cost influence shall be calculated for a particular work.



V. WET MIX MACADAM.

Wet Mix Macadam (WMM) is a subbase used in the flexible pavement of the highway construction. The sub-base consists of coarse aggregate, fine aggregates and stone dust mixed in proportion with water as a binder, mixed at plant and laid over site in layers and rolled to create a hard-durable base for the top layer of the pavement. Various tests consisting of water absorption, soundness, wet aggregate impact value, combined flakiness and elongation index, heavy compaction and CBR value is tested for the design mix of WMM and the permissible limits are mentioned in MORTH Tb 400-12. The Grain size analysis is conducted in reference to MORTH Tb 400-13with aggregate size varying from 40mm, 20mm, 10mm and stone dust.
Properties of the WMM tested for the following properties;

Table 5.1: Properties of Wet Mix Macadam.

Sl. No.	TEST	TEST METHOD	OBTAINED RESULTS				PERMISSIBLE LIMIT (as per table 400-12 of MORT&H)
			40mm	20mm	10mm	Stone dust	
1	Water Absorption (%)	IS-2386 Part-III	2.08	2.25	3.48	6.41	2%
2	Wet aggregate impact value (%)	IS-2386 Part-IV	13.90	13.78	15.42	-	30% maximum
3	Combined Elongation and flakiness index (%)	IS-2386 Part-I	15.42				35% maximum
4	Soundness (%)	IS2386 Part-V	1.28	4.42	9.26	11.9	-
5	Heavy compaction	IS-2720 (Part-7)					
5.1	MDD (g/cc)		2.304				-
5.2	OMC (%)		8.0				
6	CBR value	IS-2720 (Part-16)	56.4				-

VI. Industrial Waste.

The Industrial waste used in the study mainly comprises of Foundry sand, Ferromanganese slag and Shredded tyre chips. The Ferromanganese slag and the shredded tyre chips can be used for partial replacement of fine aggregates and the foundry sand can be used as partial replacement to the Stone dust used in the conventional mix design of WMM.

6.1Ferromanganese slag

The ferromanganese slag used in the study was tested to the following properties;

Table 6.1: Properties of Ferromanganese slag.

Sl. No.	TEST	TEST METHOD	OBTAINED RESULTS	PERMISSIBLE LIMIT (as per table 400-15 of MORT&H)
1	Specific Gravity	IS 2720 Part-III	2.63	2.5-3
2	Water Absorption	IS-2386 Part III	0.78%	2%
3	Aggregate Impact Value	IS-2386 Part IV	18.62%	24%
4	Abrasion Value	IS-2386 Part IV	32.74%	35%
5	Combined Index	IS 2386 Part I	24.4%	35%

6.2Foundry Sand

The Foundry sand used in the study was collected from the alloy casting industry and was tested to the following properties;

Table 6.2: Properties of Foundry Sand.

Sl. No.	TEST	TEST METHOD	OBTAINED RESULTS
1	Specific gravity	IS 2720 Part III	2.55
2	Liquid limit, %	IS 2720 Part V	NP
3	Plastic limit	IS 2720 Part V	NP
4	Maximum Dry Density (g/cc)	Is 2720 Part VII	1.93
5	Optimum moisture content, %	IS 2720 Part VII	9.2
6	CBR (%)	Is 2720 Part XVI	14.0

6.3Shredded Tyre chips.

The Tyre Chips used in the study was collected from Tyre remolding factory and was tested to the following properties;

Table 6.3: Properties of Shredded tyre chips.

Sl. No.	TEST	TEST METHOD	OBTAINED RESULTS
1	Specific gravity	IS 2720 Part III	1.1
2	Maximum dry density (g/cc)	Is 2720 Part VII	0.622

VII Preparation of Mix Design by Partial replacement of Industrial waste and testing of newly formulated mix.

7.1Preparation of Design Mix.

A total 10 mix designs were conducted by partially replacing the industrial waste products to the aggregates and the stone dust in the conventional mix. The details of the mix are stated as below where design mix M1 is conducted using conventional method and materials and further the design mixes M2 to M10 are formulated by partial replacement by Industrial waste.

Table 7.1: Proportions of WMM Mix design.

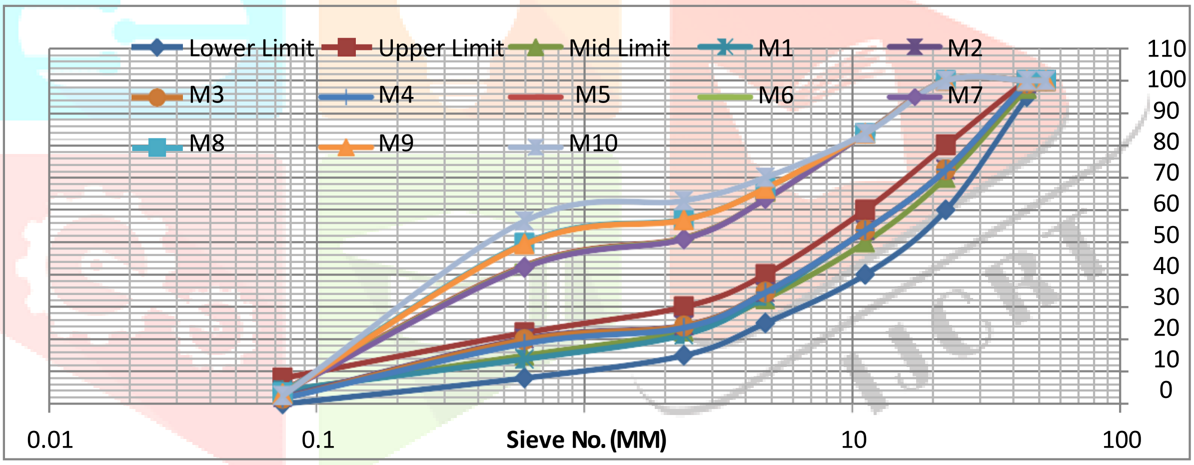
Mix Designation	Percentage by weight of						
	40mm	20mm	10mm	Stone dust	Ferromanganese Slag	Foundry sand	Tyre Chips
M1	10	28	27	35		-	-
M2	15	25	24	12	10	14	-
M3	10	25	24	10	15	14	2
M4	10	20	24	10	20	12	4
M5	-	10	25	25	10	30	-
M6	-	10	25	23	10	30	2
M7	-	10	25	21	10	30	4
M8	-	10	20	20	10	40	-
M9	-	10	20	18	10	40	2
M10	-	10	15	15	10	50	-

7.2Grain Size Analysis of Various Mix.

Grain size analysis was conducted and the results are displayed as under;

Table 7.2: Gradation of WMM Mix design

IS Sieve (mm)	Gradation limits	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
53	100	100	100	100	100	100	100	100	100	100	100
45	95-100	99.12	99.12	99.12	99.12	100	100	100	100	100	100
22.4	60-80	72.42	72.42	72.42	72.42	100	100	100	100	100	100
11.2	40-60	53.66	53.66	53.66	53.66	83.66	83.66	83.66	83.66	83.66	83.66
4.75	25-40	33.35	34.56	34.56	34.47	63.35	63.35	63.35	66.68	66.68	70.01
2.36	15-30	21.38	24.26	24.05	23.55	51.38	51.17	50.96	57.10	56.89	62.83
0.6	8-22	13.85	20.17	19.81	18.63	42.83	42.47	42.22	49.72	49.36	56.61
0.075	0-8	4.22	2.02	1.69	1.69	4.22	3.88	3.54	3.37	3.04	2.53

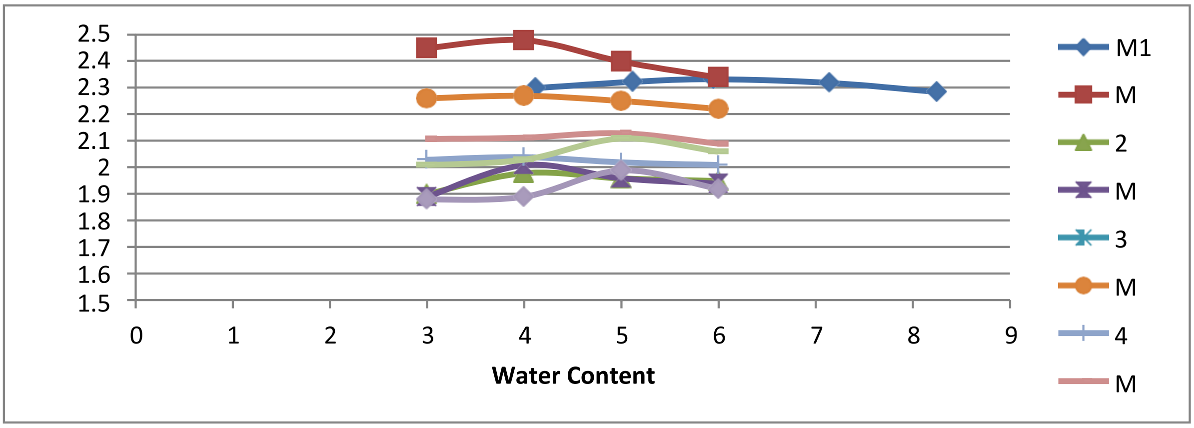


7.3Standard Proctor Test.

The test results of Maximum Dry Density are displayed as under;

Table 7.3: MDD and OMC of Design Mixes.

Mix Designation	Maximum Dry Density (g/cc)	Optimum Moisture Content (%)
M1	2.304	8.0
M2	2.28	6.0
M3	2.24	6.0
M4	2.22	5.8
M5	2.15	5.5
M6	2.16	5.4
M7	2.26	5.8
M8	2.28	6.0
M9	2.35	7.0
M10	2.22	6.8

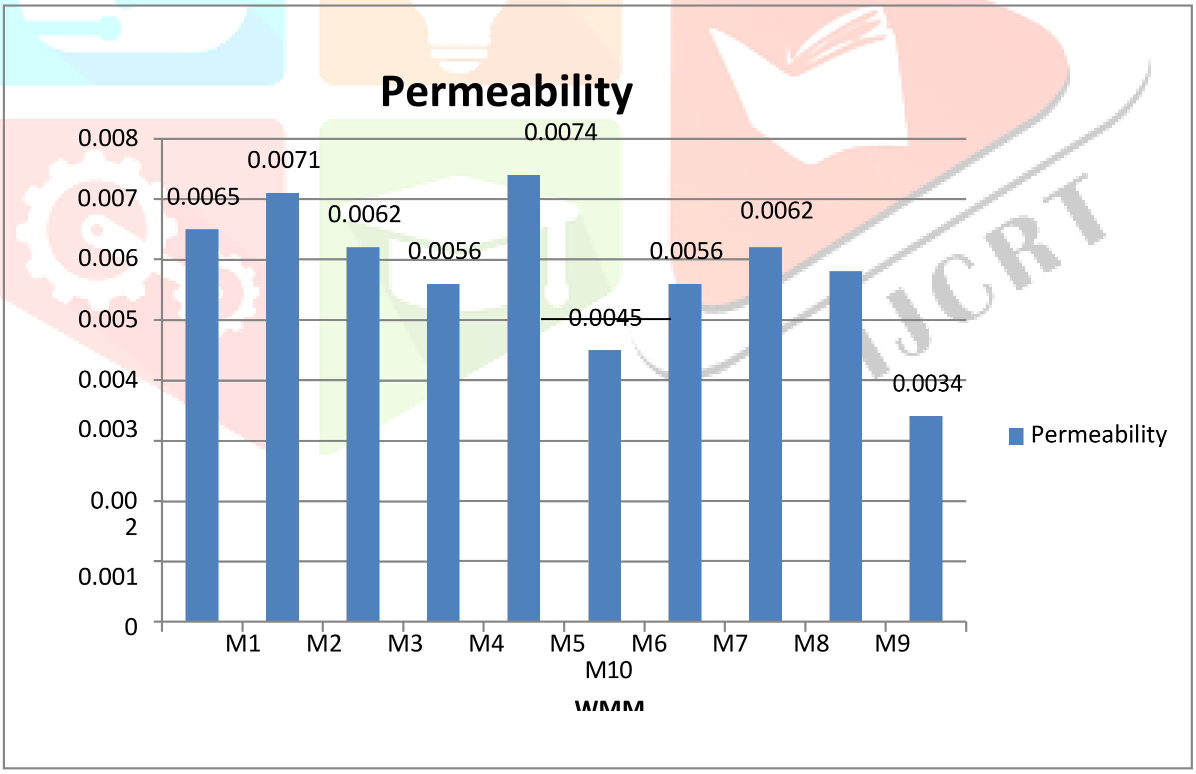


7.4Coefficient of Permeability.

The permeability test was conducted using constant head method and the results are displayed as under;

Table 7.4: Permeability of Design Mixes.

Mix Designation	Permeability (in cm/sec)
M1	6.5 x 10^{-3}
M2	7.1 x 10^{-3}
M3	6.2 x 10^{-3}
M4	5.6 x 10^{-3}
M5	7.4 x 10^{-3}
M6	4.5 x 10^{-3}
M7	5.6 x 10^{-3}
M8	6.2 x 10^{-3}
M9	5.8 x 10^{-3}
M10	3.4 x 10^{-3}

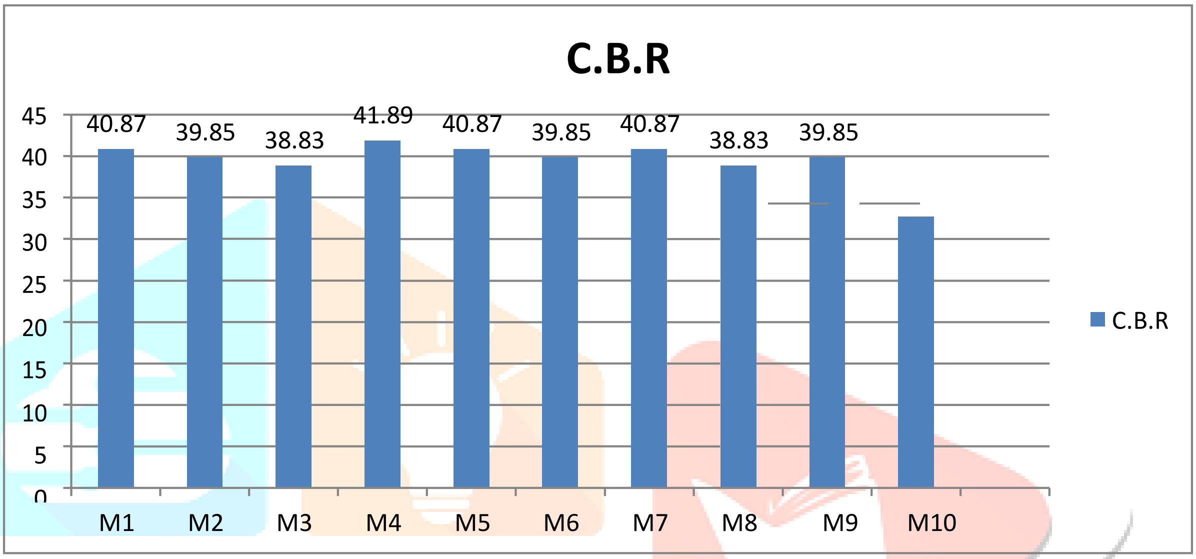


7.5C.B. R Value

The California Bearing ratio was conducted and the tests results are displayed as under

Table 7.5: CBR values of Design Mixes.

Mix Designation	CBR value
M1	56.4
M2	49.85
M3	48.83
M4	51.89
M5	50.87
M6	49.85
M7	50.87
M8	49.85
M9	53.79
M10	42.7



It is observed that C.B.R values of different mixture are approximately same except mixture M10 due to high percentage (50%) of addition of foundry sand in W.M.M mixture. Mixture M9 having maximum C.B.R value that is 53.79.

7.6Closure.

With respect to the test results we can further state that the Mix Design M9 having higher CBR value and MDD and OMC value similar to that of Conventional mix can be proposed to be used in replacement to the conventional mix design of Wet Mix macadam.

VIII COST COMPARISON

8.1Material requirement and quantity.

With respect to the recommended conventional mix (M1) and the proposed mix (M9) the material required per cum of Wet mix macadam can be tabulated as below:

Table 8.1 Material quantity per Cum.

Materials	Quantity Required for conventional design (MT)	Quantity Required for proposed design (MT)
40 mm aggregate	0.1	-
20 mm aggregate	0.28	0.1
10 mm aggregate	0.27	0.2
Stone dust	0.35	0.18
Ferromanganese slag		0.1
Foundry sand	-	0.4
Tyre chips	-	0.02
Total	1.0	1.0

8.2Cost of Referral Mix.

The Cost of referral mixes are to be divided differently for Conventional mix (M1) as well as for newly formulated mix (M9). The rates of materials are conformed with the areas and may vary accordingly. For our study the materials and the rates were collected from Butibori, Nagpur district.

Table 8.2 Cost of Conventional mix (M1)

Material	Qty (MT)	Rate (Rs. /MT)	Total (Rs.)
40 mm Aggregate	0.1	600	60
20 mm aggregate	0.28	650	182
10 mm aggregate	0.27	475	128.25
Stone dust	0.35	525	183.75
		Total	**554/MT**

Table 8.3 Cost of Newly Formulated mix (M9)

Material	Qty (MT)	Rate (Rs. /MT)	Total (Rs.)
20 mm aggregate	0.1	650	65
10 mm aggregate	0.2	475	95
Stone dust	0.18	525	94.5
Ferromanganese slag	0.1	75	7.5
Foundry Sand	0.4	110	44
Tyre Chips	0.02		0
		Total	**306/MT**

Use of Ferromanganese slag, Foundry sand and Shredded tyre chips in replacement to the conventional materials (fine aggregate) in WMM results in saving cost of WMM is Rs. 248 per MT. Thus, replacement of conventional materials by industrial waste results in 44.77% saving in cost.

IX. Conclusion

- The report intends to improve the Basic Properties of Wet Mix Macadam by use of Industrial waste by studying the basic material properties of Wet Mix Macadam and the Industrial wastes including Foundry Sand, Tyre Chips and Ferromanganese slag. Test result shows successful and feasible application of industrial waste.

- Test taken on various mix proportions shows that proportion with 10% Ferromanganese slag, 40% foundry sand and 2% tyre chips i.e. design mix (M9) fulfills the structural requirements in comparison to the conventional design mix (M1).

- **52% use of industrial waste** saves similar quantity of natural resources as shown in Table 8.1 hereby reducing the impact of the waste on Environment and encouraging the eco disposable measures.

- Cost comparison in reference to Table 8.2 and Table 8.3 shows **44.77%** (10% Ferromanganese slag + 40% Foundry Sand +2% tyre chips) **saving over conventional method** and material.

X Acknowledgment

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XI References

[1] G.D. Ransinchung R.N., Praveen Kumar, Brind Kumar, Aditya Kumar Anupam and Arun Prakash Chauhan (April 2014), “Laboratory Evaluation for the Use of Moorum and Ganga Sand in Wet Mix Macadam Unbound Base Course” INDIAN HIGHWAYS, Vol. 42-No. 4

[2] O. Yazoghli-Marzouk, N. Vulcano-greullet, L. Cantegrit, L. Friteyre and A. Jullien (2014), “Recycling foundry sand in road construction–field assessment”, Construction and Building Materials, 61, 69–78.

[3] Robin L. Schroeder (1994), “The Use of Recycled Materials in Highway Construction”, Public Roads Magazine, Vol. 58-No. 2

[4] Sagar B. Patil and Prof. Dhananjay S. Patil (September-2013), “Evaluation of Cost-Effective Material for Maintenance of Flexible Pavement”, International Journal of Scientific & Engineering Research, Volume 4”

[5] C.N.V. Satyanarayana Reddy and K. Durga Ran (Oct 2013), “Potential of Shredded Scrap Tyres in Flexible Pavement Construction”, Indian Highways, Vol.41-No.-10”

[6] Krishna R. Reddy, Ph.D., P.E. and Aravind Marella (October 2001) “PROPERTIES OF DIFFERENT SIZE SCRAP TIRE SHREDS”, The Seventeenth International Conference on Solid Waste Technology and Management, Philadelphia, PA, USA.”

[7] Ratnasamy Muniandy, et al. (November 2011) “The effect of type and particle size of industrial wastes filler on Indirect Tensile Stiffness and Fatigue performance of Stone Mastic Asphalt Mixtures” Australian Journal of Basic and Applied Sciences 5(11):297-308

[8] D.S.V. Prasad and G. V. R. Prasada Raju (AUGUST 2009) “PERFORMANCE OF WASTE TYRE RUBBER ON MODEL FLEXIBLE PAVEMENT”, ARPN Journal of Engineering and Applied Sciences VOL. 4, NO. 6.

[9] R.M. Subramanian and S.P. Jeyapriya (2009), “STUDY ON EFFECT OF WASTE TYRES IN FLEXIBLE PAVEMENT SYSTEM”, IGC, Guntur, INDIA

[10] D. Satish Chandra, Arjun Chhetri, Sonam Wangchen, Sri. Harsha Yadagani, March - April (2013), “DESIGN AND ESTIMATION OF RURAL ROAD IN VADDESWARAM”, International Journal of Civil Engineering and Technology (IJCIET), Volume 4.

[11] Mohd Rosli Hainin, et al. (January 2011) “The Influence of Steel Slag as Alternative Aggregate in Permeable Concrete Pavement” IOP Conference Series Materials Science and Engineering 712:012011

[12] Krishna R. Reddy and Aravind Marella (January 2010) “Characterization and Performance Assessment of Shredded Scrap tyres as Leachate drainage material in landfills” Practice Periodical of Hazardous Toxic and Radioactive Waste Management 14(1)

[13] Kamyar C. Mahboub, and Phillip R. Massie (January 1996) “Use of Scrap Tire Chips in Asphaltic Membrane” Transportation Research Record Journal of the Transportation Research Board 1530(1):59-63.

[14] W. Chebbi, O. Yazoghli-Marzouk, M. Dauvergne, L. Lumiere, A. Jullien (February 2016)” Environmental Assessment of Eaf Slag in Different "End Of 2nd Life" International Journal of Advances in Mechanical and Civil Engineering, ISSN: 2394-2827 Volume-3, Issue-1, Feb.-2016

[15] Krishna R. Reddy and Richard E Saichek (January 2002) “Properties of Different Size Scrap Tire Shreds: Implications on Using as Drainage Material in Landfill Cover Systems” M.S. Thesis, University of Illinois at Chicago, Chicago, IL.

[16] Yucel Guney, Ahmet H. Aydilek, M. Melih Demirkan (August 2005) “Geo-environmental behaviour of foundry sand amended mixtures for highway subbases” Science direct Volume 26 Issue 9, 2006.

[17] R. A. Khan and A. Shalaby (1995) “Performance of A Road Base Constructed with Shredded Rubber Tires” Environmental Report No.95-2, University of Wisconsin, Madison

[18] Bant Singh and Srijit Biswas “Effect of e-Quality control on Tolerance limits in WMM and DBM in highway construction - A Case Study” Global Advanced Research Journal of Engineering, Technology and Innovation (ISSN: 2315-5124) Vol. 2(3) pp. 158-166, June 2013

[19] Sofi Aanesah, Ar. Sukhmanjit “A Review Study on Use of Industrial Waste in Bituminous Mixes” International Journal of Latest Research in Engineering and Computing (IJLREC) Volume 5, Issue 3, Page No. 41-43 May-June 2017

[20] Deng and Tikalsky “Usability of waste foundry sand in concrete” Geotechnical and leaching properties of flowable fill incorporating waste foundry sand,” Waste Management, vol. 28, no. 11, pp. 2161–2170, 2008.

[21] Siddique and Noumowe “Utilization of spent foundry sand in controlled low-strength materials and concrete,” Resources, Conservation and Recycling, vol. 53, no. 1-2, pp. 27–35, 2008.

[22] R. Siddique, Y. Aggarwal, P. Aggarwal “Strength, durability, and micro-structural properties of concrete made with used-foundry sand (UFS)” Construction and Building Materials, vol. 23, no. 2, pp. 976–980, 2009.

[23] Y. Guney, Y. D. Sari, M. Yalçın, A. Tuncan, and S. Dönmez. “Re-usage of waste foundry sand in high-strength concrete” Waste Management, vol. 30, no. 8-9, pp. 1705–1713, 2010.

[24] G. Singh and R.Siddique. “Effect of waste foundry sand (WFS) as partial replacement of sand on the strength, ultrasonic pulse velocity and permeability of concrete” Construction and Building Materials, vol. 26, no. 1, pp. 416–422, 2012.