Impact Of Aggregate And Fly Ash Filler Types On Asphalt And Control Mix Designs

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Abstract: Asphalt is a pavement material that is brittle and hard in cold environments and soft at elevated temperatures. It has been historically employed as the most popular paving material for roadways & wastes of Coal Combustion Products are used in the pavement .in these mainly two types of mix materials are used in the pavement materials used like Asphalt mix and Control Mix for road construction. Which used different materials or binder to make strength of pavement and properties which make its strength like coating of aggregate, binder replacement , use of binder ,its workability (compaction) and TSR (Tensile strength ratio) ratio and aging also. In this we have study on Asphalt and control mix designs to compare the material properties by made the laboratory test on it. Test which is used to find out the best material from both of them. In which Asphalt mix has 4.95% binder & Control mix has 5.50% binder in the mix. In which the asphalt mixture had the four type's type-1, type-2, type -3, and type-4 and compare with the control mix to find out the best material for pavement. By doing the laboratory test on both material to observe the best material from them by performing test like Moisture Content, Indirect tensile strength test, Aging test, workability test and aggregate coating on them. We found that the asphalt mix has better effect over control mix.in the following type-1 has greater binder replacement of 10%. In IDT test asphalt found effective than control mix asphalt had better TSR ratio than the control mix.

Index Terms: Asphalt mix, Control mix, Workability, Aging resistance, Moisture damage etc.

1 INTRODUCTION

Transportation research circular entitled Asphalt Emulsion Technology has provided detailed information regarding Asphalt emulsion. An emulsion is a dispersion of small droplets of one liquid in another liquid. Emulsions can be formed by any two immiscible liquids but in most emulsions one of the phases is water. Asphalt emulsion is a liquid product in which a substantial amount of Asphalt is suspended in a finely divided form in water in presence of emulsifiers. The Asphalt droplets range from 0.1 to 20 micron in diameter [1].

DESIGN OF COLD MIX

Properties of cold mixes are varied by many parameters like; source of aggregate, curing condition and curing time, etc. Hence there is no universally accepted mix design method for cold mixes. But Marshall Method is popularly used to design emulsified mixes. Marshall Method for emulsified asphalt aggregate design is based on the research conducted at the University of Illinois. This method is applicable to base course mixture for low volume traffic load. Cold mix is used in surface course also for low to medium traffic volume road. The cold mix design is carried out to optimize water and emulsion content for aggregate in the mix [2] [11].

Aggregates Selection

In India aggregates should conform the physical requirement laid by MoRTH specification (2001). Testing of aggregate like sieve analysis, specific gravity, aggregate impact value and soundness is necessary.

Emulsion Selection

Selection of emulsion depends on aggregate type and aggregate gradation and ability of emulsion to coat the aggregate. According IS 8887:2004 specifications, five grade of emulsion; RS-1, RS-2, MS, SS-1 and SS-2 are used to prepare cold mix. Quality tests should be carried out on the selected emulsion according to IS 8887:2004 [8].

Determination of Initial Emulsion Content

Centrifuge Kerosene Equivalent test (C.K.E) is used to estimate initial residual bitumen content. If C.K.E equipment is not available, emulsified asphalt content designated as P can be estimated using the Asphalt Institute empirical formula given below (Asphalt Institute, 1989).

$P = (0.05A + 0.1B + 0.5C) \times 0.7$

Where,

P is % Initial residual bitumen content by mass of total mixture, A is % of aggregate retained on sieve 2.36 mm, B is % of aggregate passing sieve 2.36 mm and retained on 0.075 mm, C is % of aggregate passing 0.075 mm.

The initial emulsion content value can be obtained by dividing P by the percentage of bitumen content in the emulsion.

Coating Test

Using trial emulsion content coating test is to be carried out by using all of the batches of aggregates and filler, rewetted with water. Coating test will be carried out at a range of water content. For example, coating test will be started using slow setting emulsion at about 3 percent added water. Sixty seconds of mixing time is sufficient when aggregate is mixed with water. The bitumen emulsion is added afterwards and then mixed for about 1 minute until even coating is obtained.

Variation of Residual Asphalt Content

A set of test specimens are prepared over a range of residual asphalt content. Test mixtures are prepared in increments of residual asphalt contents; using the previously determined optimum water content for mixing and compaction. Specimen can be prepared referring the guidelines given for emulsion content in MoRTH specification (2001). Specimens are cured in mold for 1 day at room temperature and 1 day out of the mold in oven at 38°C. Specimens are soaked with water using vacuum apparatus and then tested for soaked stability. Bulk specific gravity, Marshall Stability and flow of dry specimen and soaked stability and flow of wet specimen are determined from the test specimen using Marshall Test apparatus. Optimum residual asphalt content is determined from the plot of dry stability and soaked stability versus residual asphalt content. The optimum residual asphalt content is chosen that provides maximum soaked stability. The other Marshall

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parameter like total voids, stability loss and absorbed moisture content should be taken into consideration during selection of optimum residual asphalt content.

2 LITERATURE REVIEW

Ghafoori, N., Nyknahad, D., & Wang, L. (2013) [7] found the results of the laboratory and field investigations of the selected PCC/FBC composites to be encouraging. The strength and stiffness of the PCC/FBC mixtures are suitable and in most cases surpass the engineering requirements for low-volume county and other secondary roads. The field and laboratory results were influenced by similar parameters and the engineering indices (results) of the field cores were higher than those of the laboratory specimens. This behaviour may be attributed to the excellent field compaction and favourable curing environment provided by the 51-mm asphalt surface course. Argiz, C., Menéndez, E., Moragues, A., & Ángel, M. (2014) [1] studied the correlation between the compressive strength of coal ash mortars and their corresponding flexural strengths seems to fit adequately, independently of the type of ash used (bottom or fly). Based on the investigations, a relation is proposed to be valid for both ashes. Summing up, it can be concluded that bottom ash mixed with fly ash in percentages from 0% to 100% does not affect significantly neither the mechanical or durable performance of the blended mortars studied in this research program. Saride, S., Avirneni, D., Javvadi, S. C. P., Puppala, A. J., & Hoyos, L. R. (2015) [10] prepared the fly ash treated RAP mixes using both replacement and addition methods and the results in terms of unconfined compressive strength and resilient modulus were compared. Samples were prepared with different dosages of fly ash (10, 20, 30 and 40 %) and were cured at 1, 7 and 28 days to test their strength and stiffness properties. Díaz, R. O., Montañez, A., & Cuentas, J. (2016) [5] researched the optimal percentage to stabilize the granular-base material is 3% in weight. It was determined that one of the main improvements of stabilizing base material with coal tar is expansion, achieving an 80% reduction for which the expansion percentage is 0.02. The expansion percentage found in the material is considered low or non-critical according to the specifications of INVIAS, in which the minimum percentage of a material is 2%. Saha, R., Malloy, K., Bautista, E., & Sobolev, K. (2017) [9] researched the Atomic Force Microscope can be used to reveal the structure of bitumen with fly ash additives. The micelle structures were isolated and analyzed with the help of Gwyddion software. The peak height and the surface area of the micelle structures were measured. Juntao Lin et al. (2018) [8] investigate the development mechanism of early-stage strength for cold recycled asphalt mixture using emulsion asphalt. The influence parameters of early-stage strength development for cold recycled mixture by emulsion and cement (CRME) is firstly studied, and then the direct tensile test is used to determine the early-stage strength development law of emulsion asphalt–cement mortar. The results indicate that the cement plays the predominant role in strength of CRME in first 3 days, while emulsion asphalt plays the predominant role in both early-stage and final strength. Edeh, J. E., Joel, M., & Abubakar, A. (2019) [6] studied the use of local waste materials of SCBA and RAP mixes generated and disposed in large quantities resulting in environmental problems. The maximum CBR of 28% (unsoaked) and 14% (soaked) was recorded for 50% RAP + 50% SCBA mix and can be used as subgrade material in road construction. Cold Asphalt Mixture (CAM) is a complex visco - elastic-plastic material that may be used for avenue creation at the ambient temperature. This is viable due the usage of bitumen emulsions, which contain mainly emulsified bitumen and water. In addition some properly, i.e. Flexibility, make CAM specifically appealing for low/medium site visitors roads, wherein the poorer great of the sub grades has a tendency to supply higher deflections under visitor's masses, becoming particularly essential that asphalt layers adapt to such deformations without cracking. In order to increase all the strength of CAM, the emulsion wishes to interrupt, which generally happens in the course of blending or compaction, and the interstitial water wishes to evaporate, which might also take from 2 to 24 months. It is vital to reduce the time to open the road after production. This is the principal motivation for the present research, which aims to investigate the aging of the Cold asphalt mixture by performing test on the material like Moisture test, Sieve analysis, and workability test on the Coal Combustion Products (CCPs) that to find out the which is better between asphalt & control mix by using short term aging analyze the test report of laboratory test on both of materials to find out the suitable material.

3 MATERIALS USED IN RESEARCH

Asphalt Binder

Asphalt binder selection was based on environmental conditions as well as traffic conditions. The feasibility study used an unmodified PG60-30 (performance grading) asphalt binder. In this research, the asphalt binder that was used was also an unmodified PG60-30. Again, this means that the binder in this study possessed adequate physical properties up to at least $60^{o}C$. This is the high pavement temperature that this binder can serve at. The second number refers to the low temperature grade which means that the binder used in this study could be used down to at least - $30^{o}C$. Figure 1 shows a representative bucket of PG60-30 binder that was used for this research.

Figure 1: *PG60-30Asphalt binder*

Aggregates

There were five different types of aggregates used in this blend: 12.5 mm (material retained on 12.5 mm sieve), 9.5 mm (material retained on 9.5 mm sieve), 4.75 mm (material retained on 4.75 mm sieve), Manufactured (MFG'D) Sand, and Natural (N) Sand. The maximum aggregate size is defined as 19.0 mm, and the nominal maximum aggregate size is 12.5 mm. The 12.5 mm, 9.75 mm, and 4.75 mm aggregates were separated by using larger sieves and manually shaking since this reduced sieving time by quite a bit.

Coal Combustion Products (CCPs)

In this research there were four types of representative Coal Combustion Products (CCPs) that were used: Type-1, Type-2, Type-3, and TYPE-4 (Spray Dryer Absorber). These materials were evaluated based on physical and chemical properties which are important when differentiating them. it was followed to determine the specific gravity by using the Helium Pycno meter , it was followed to determine the particle size distribution, surface area, and fineness

Mixing of Materials

Once all the materials were weighed out, the aggregates were then mixed thoroughly, and then put in the oven to warm up to the designated temperature. As a reminder, for the Asphalt mixtures, the fly ash was added to the mixed aggregates prior to being placed in the oven. All Control mixes were mixed at 150^{o}C and then compacted at 140^{o}C, whereas all mixes with fly ash were mixed at 150^{o}C and then compacted at 150^{o}C.

4 RESULTS AND DISCUSSIONS

AGGREGATE COATING

Asphalt film thickness was used to evaluate proper aggregate coating for both Control and Asphalt mixtures. This parameter was important to calculate since the Asphalt had 10% (by mass) binder replacement with fly ash and this means less binder is available to coat the aggregates. Asphalt film thickness is not directly considered as a design requirement, however evaluating aggregate coating is critical. It has been found that average values for asphalt film thickness should typically be between 6 to 8 μm. This thickness range has been found to establish a thick enough coating around the aggregate particles which will prevent rapid oxidation, and even prevent moisture damage. After the film thickness was calculated it was also important to visually inspect the coating of the aggregates. During the mixing process, there were no problems observed in terms of aggregate coating. The asphalt binder seemed to coat the aggregates at the same rate for both the Control mixtures and Asphalt mixtures.

WORKABILITY

Workability was evaluated by comparing the densification curves of the Control mixtures and Asphalt mixtures. All compaction comparisons for workability were evaluated for short-term aged materials because this demonstrates the physical condition in which the material is mixed, placed, and compacted. For all evaluations, the Control mixtures were compacted at 140oC and the Asphalt mixtures were compacted at 150oC. As seen by the preliminary study results, the Asphalt mixtures required more compaction effort. To eliminate these differences, temperature was increased (making the material less viscous) to allow for improved compaction efforts.

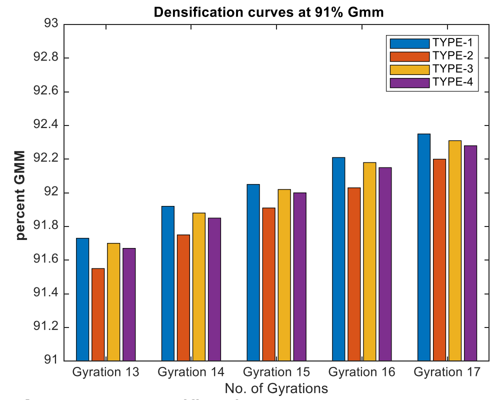

Figure 2: *Densification curves at 91% Gmm*

The compaction volumetric was evaluated to understand the differences between the Control and Asphalt mixtures. Above figur shows the difference in mixture volumetric for all mixture types. From this, it can be seen that the maximum specific gravity (Gmm) increased due to the addition of CCPs. The reason for this increase is because the specific gravity of the CCPs (TYPE-1 C, 2.71; TYPE-2 F, 2.62; TYPE-3 F, 2.50; TYPE-4, 2.33) was higher than the specific gravity of asphalt binder. Since 10% of binder was being replaced with fly ash (by weight), the bulk and max specific gravities increased due to the proportional increase in the aggregate quantities. The results also demonstrate higher maximum specific gravities for the fly ashes with higher specific gravities such as TYPE-1 and TYPE-2 (F).

AGING RESISTANCE

The aging resistance was evaluated by comparing the aging index of all the mixtures. The aging index is the ratio of the number of gyrations to reach 91% Gmm for short-term aged materials. The short-term aging procedure used in this research mimics the aging due to mixing, placing, and compacting.

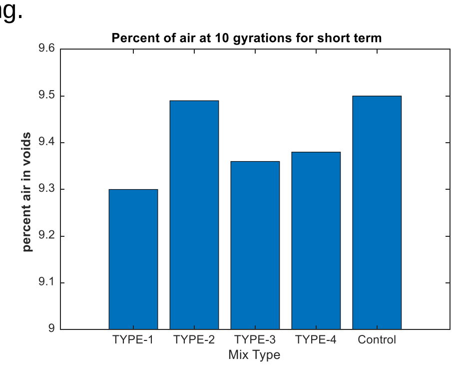

Figure 3: *Percent air at 10 gyrations for short term*

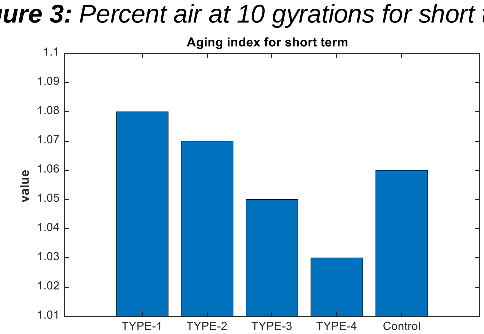

Figure 4: *Aging index for control and asphalt mixtures*

MOISTURE DAMAGE

Moisture damage was used as a parameter to evaluate the durability of asphalt pavements. Asphalt specimens were tested under different conditions to understand the effects of moisture damage. The samples that were tested were dry, saturated, and conditioned. The dry samples were placed into a leak-proof plastic bag and then placed in a water bath at 25 ± 0.5oC for 2 hr ± 10 min and then tested with the IDT. The saturated and conditioned specimens were both vacuum-saturated to a degree of saturation of 70 to 80%. The saturated specimens were then placed into a water bath at 25 ± 0.5oC for 2 hr ± 10 min and then tested with the IDT. The conditioned samples were placed in a water bath at 60 ± 1oC for 24 ± 1 h, then placed in a water bath at 25 ± 0.5oC for 2 hr ± 10 min and then tested with the IDT.

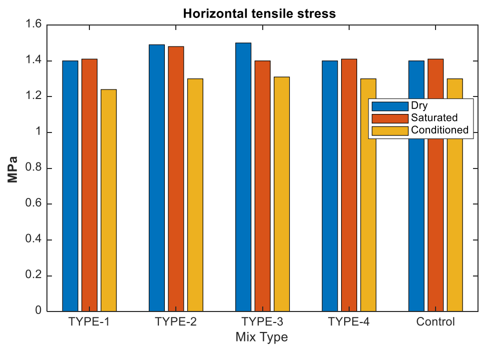

***Figure 5:** Horizontal tensile stress at center specimen*

Table 1 shows the tensile strain at failure for the Asphalt and Control specimens. This table demonstrates the effects of moisture damage on the ability for asphalt pavements to deform. For conditioned specimens the strain at failure is reduced in all cases. It is interesting to see that the ultimate strain (related to flow) increase for the saturated TYPE-2 (F) and Control specimens. The TYPE- (4) mixtures experienced the highest strain at failure of 0.0693 mm/mm for the dry samples and TYPE-1 experienced the lowest strain at failure of 0.0613 mm/mm for the dry samples.

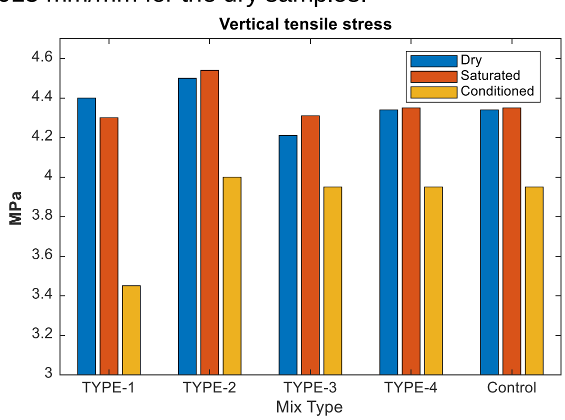

***Figure 6:** Vertical compressive stresses at center of specimen*

***Table 1:** Tensile strain at Failure*

Tensile strain at Faiilure in mm/mm					
	TYPE-1 C 10%	TYPE-2 F 10%	YPE-3 F 10%	TYPE- 4 10%	CONT ROL 10%
Dry	0.0613	0.0618	0.0651	0.0693	.0659
Saturated	0.0601	0.0671	0.0600	0.0659	.0745
Conditioned	0.0580	0.0564	0.0592	.0643	.0654

The Tensile Strength Ratio (TSR) was calculated and compared for conditioned and dry samples (Table 2), as well as for conditioned and saturated samples (Table 3). The TSR values are required to be at or above 80%; the results demonstrate that all mixtures fulfilled this requirement. Higher values of TSR are desired as this indicates a better performance in terms of moisture damage resistance. It can be observed that all Asphalt mixtures enhanced the moisture damage resistance when compared to the Control mixture. When comparing the conditioned samples with the dry samples, TYPE-3 (F) performed the best since the TSR was 0.922 and the Control performed the worst with a TSR of 0.828. When comparing the conditioned samples with the saturated samples TYPE-3 (F) also performed the best with a TSR of 0.911 and the Control samples performed the worst with a TSR of 0.852.

***Table 2:** TSR conditioned samples compared with dry samples*

TSR conditioned samples compared with dry samples					
	TYPE-1 C 10%	TYPE-2 F 10%	TYPE-3 F 10%	TYPE-4 10%	CONTROL 10%
TSR	0.860	0.891	0.922	0.918	0.828

***Table 3:** TSR Conditioned samples compared with saturated samples*

TSR Conditioned samples compared with saturated samples					
	TYPE-1 C 10%	TYPE-2 F 10%	TYPE-3 F 10%	TYPE-4 10%	CONTROL 10%
TSR	0.875	0.895	0.913	0.904	0.849

In terms of moisture damage resistance it can be concluded that Asphalt mixtures resisted the effects of moisture damage better than the Control mixtures. The results proved that adding CCPs to asphalt mixtures enhanced the moisture damage resistance. The Asphalt mixtures also demonstrated higher strengths in IDT which is an important parameter.

CONCLUSION

Asphalt film thickness, which is an important characteristic associated with binder coating, was higher for the Control mixtures (9.03 μm) as compared to the Asphalt mixtures (7.66 μm). However, there had been no predominant differences found for aggregate coating satisfactory or blending performance. Preliminary study outcomes demonstrated a want for better compaction attempt for Asphalt combinations than Control mixtures when compacted on the equal 140oC temperature. The Asphalt combos within the initial examine had TYPE-1 fly ash at 10% (by mass) binder replacement and this proved to increase stiffness when you consider that compaction effort was greater.The workability becomes used to assess the differences in compaction efforts for Asphalt (compacted at 150oC) and Control mixtures (compacted at 140oC). The increase via 5oC for Asphalt mixtures decreased the compaction efforts, so TYPE-1(C), TYPE-3(F), and TYPE-(4) combos had validated less compaction attempt than the Control combination. The TYPE-2 (F) mix discovered the equal densification profile because the Control combination due to a higher mastic viscosity. The research effects proved that the use of fly ash in asphalt can appreciably improve the ageing resistance. For instance, TYPE- (4) combos carried out the great in terms of getting old resistance seeing that this combination had the lowest getting old index of one.04 whilst as compared to the Control aggregate which had an growing old index of 1.07.TYPE-three (F) also produced incredible consequences because it yielded an getting old index of one.06. 127. It was proven that each one Asphalt samples produced better closing strengths in dry Indirect Tensile Testing (IDT) than the Control samples. The TYPE-1 and TYPE-2 (F) combos developed the best strengths of 11.90 kN and 12.20 kN. The Control combos only produced strengths of 11.50 kN. The TYPE-four ( ) established the very best closing deformation at failure of 3.37 mm.The studies consequences established that each one Asphalt combinations had progressed moisture-harm resistance based totally on the Tensile Strength Ratio (TSR) parameter in comparison to the Control mixtures. The TYPE-3 (F) mixture had the best TSR of 0.913 and the Control combination had the bottom TSR of 0.849.

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