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ASPHALT MIX DESIGN FOR BASE COURSE USING FLY ASH AS A 100% REPLACEMENT OF MINERAL FILLER

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Abstract
Asphalt mix design for base course using fly ash as a 100% replacement of mineral filler based on Marshal Stability method. Sample of Aggregate collected from hot bins from Asphalt crushing plant near Jamshoro and Fly ash collected from Lakhra coal power plant. The tests were conducted in the Highway Research laboratory of MUET. Many trials (by trial and error method for blending of aggregate) have been computed in order to achieve the desired grading and number of Marshal moulds (by Marshal stability method) have been prepared at various percentage of bitumen for optimum bitumen content. Finding of this research project have depicted the foundation of our construction industry and need to emphasis to use fly ash material in pavement construction and avoid the consequence of environmental.

INTRODUCTION

Whatever the technique and precision is being made in design by designer , if the material which is being used in the construction is not as per requirement of design then this design will not give us our desire results and targeted life of structure. Therefore, for long life of structure either we have to use the material as per design specification or we have to make the design keeping in view the properties of local available materials. The design of asphalt paving mix , as with other engineering materials designs is largely a matter of selecting and proportioning materials to obtain the desired properties in the finished construction .By the use of fly ash in asphalt mix, Paving bricks backfill etc benefits occur when consider fly ash in construction industry. It prevents human plant life. While using fly ash in construction there is no need to dump waste material as landfills. Power plant of Lakhra is very closed to Jamshoro and Lakhra power plant is only operated power plant of Pakistan. The Lakhra have largest Coal field consist large area of 250sq km. Experts believe that there is about 500 million tons deposit of Lakhra coal since twenty five years, coal is being taken from Lakhra coal mine quarry. Fly ash had been dumped in large area of power plant and its surrounding is polluted. Lot through gusts and gales blow during day and night. Also coal mining dig and transport creates environmental problem to nearest villages. This alarm researcher to consume this landfill which has great sentimental impact in the surrounding society and on agriculture fields.

AGGREGATE ITS PROPERTIES AND TEST

The amount of mineral aggregate in asphalt paving mixture is generally 90-95% by weight and 75-85% by volume. Mineral aggregate is primarily responsible for load supporting capacity of pavement; accordingly asphalt paving is heavily influenced by aggregate. Aggregate has been defined as any hard inert mineral material used for mixing in graduated particles or fragments. It includes sand, gravel, crushed, slag, rock dust or powder.

TABLE I: PROPERTIES OF AGGREGATES

Property	Definition
Toughness	To resist fracture under impact
Strength	To resist heavy compressive load
Hardness	To resist wearing or abrasive action Soundness or Durability To resist weathering action
Shape and size	Property which show Flakiness and Elongation of aggregate particles
Adhesion with bitumen	Property which show binding of aggregate with bitumen
Porosity	Property which qualifies strength of aggregate by water absorption Specific Gravity
	Property which measures quality of aggregate, stronger or weaker

TABLE II: SPECIFICATION FOR AGGREGATE GRADING FOR ASPHALT BASE COURSE FOR CLASS B

US Standard sieve size	%Passing by weight
1-1/2"(38mm)	100
1" (25mm)	75-90
¾ " (19mm)	65-80
½" (12.5mm)	55-70
3/8" (9.5mm)	45-60
No.4 (4.75mm)	30-45
No.8 (2.38mm)	15-35
No.50 (0.300mm)	5-15
No.200(0.075mm)	2-7

Quality Tests for Aggregate Gradation

Aggregate gradation is the distribution of particle sizes expressed as percent of the total weight. Gradation is determined by passing the material through a series of sieve stacked with progressively smaller openings, and weighing the material retained on each sieve.

TABLE III: GRADATION OF COARSE AND FINE AGGREGATE AASHTO T-72 AND AASHTO C-136

US Standard sieve size	% Passing bin 01	% Passing bin 02	% Passing bin 03	%Passing bin 04
1-1/2"(38mm)	100	100	100	100
1" (25mm)	58.65	95.14	100	100
¾ " (19mm)	44.41	59.45	100	100
½" (12.5mm)	33.21	29.68	100	100
3/8" (9.5mm)	18.12	8.16	90.51	100
No.4 (4.75mm)	-	-	61.32	54.04
No.8 (2.38mm)	-	-	20.27	4.9

No.50 (0.300mm)	-	-	6.62	0.63
No.200(0.075mm)	-	-	3.41	-

Specific Gravity and Water Absorption Coarse and Fine Aggregate Test Results (AASHTO T-85 and AASHTO-84)

Specific gravity of an aggregate is the ratio of the weight of unit volume of material to the weight of same volume of water at 20-25 centigrade. Water absorption gives an idea of strength of rock. It is accepted as a measure of its aggregate porosity and sometime this value is even considered as a moisture of its resistance to frost action though this has not yet been confirmed by adequate research. Stone having more water absorption are generally considered unsuitable unless they are found to be acceptable based on strength impact and hardness tests.

TABLE IV: AVERAGE SPECIFIC GRAVITY AND WATER ABSORPTION OF COARSE AGGREGATE

Sieve Size	1-1/2"	1"	¾"	½"
Bulk Specific gravity (Oven dry)	2.7	2.67	2.67	2.75
Bulk Specific gravity (SSD)	2.75	2.70	2.72	2.85
Bulk Specific gravity (Apparent)	2.71	2.69	2.71	2.84
Water Absorption %	0.58	0.67	0.52	1.15

TABLE V: AVERAGE SPECIFIC GRAVITY AND WATER ABSORPTION OF FINE AGGREGATE SIEVE SIZE #4

Name of test	Result
Bulk Specific gravity (Oven dry)	2.63
Bulk Specific gravity (SSD)	2.67
Bulk Specific gravity (Apparent)	2.79
Water Absorption %	2.55

Abrasion Test AASHTO T-96

Due to the movement of traffic the road stones used in the surfacing course are subjected to wearing action at the top. When fast moving vehicles with rubber tires moves on the road and steel types of animal drawn vehicles rub they cause abrasion of stones on the road surface.

TABLE VI: LOSS ANGELES ABRASION TEST

Name of test	Result
Percentage wear of material of grading A	25.2%
Percentage wear of material of grading B	27.3%
Percentage wear of material of grading C	27.5%
Percentage wear of material of grading D	31.8%

Soundness Test

This test is intended to study the resistance of aggregate to weathering action. In order to quicken the effect weathering due to the alternate wet dry and or freeze thaw cycles in the laboratory, the resistance to disintegration of aggregate is determine by soaking the aggregate specimen in saturated solution of sodium sulphate or magnesium sulphate. In this research we found the result of Soundness value is equal to 8.6%.

Stripping Value of Road aggregate Test

Bitumen and tar adhere well to all normal types of aggregates provided that they are dry and not exceptionally dusty. If a pavement is to be strong and durable the binder must adhere firmly to the aggregate particles. In this research striping value of aggregate is equal to 95%.

Flakiness and Elongation Test

For Base course the presence of flaky and elongated particle are considered undesirable as they may cause inherent weakness with possibility of breaking under heavy loads. Angular shape of particles is desirable for base course due to increased stability derived from the better interlocking. Thus evaluation of shape of particles, particularly with reference to flakiness and elongation is necessary.

TABLE VII: FLAKINESS AND ELONGATION TEST RESULT

Name of test	Result
Flaky particle contained in aggregate	6.27%
Elongated particle contained in aggregate	1.27%

FLY ASH

The sample of fly ash was collected from Lakhra coal firepower Sindh Pakistan which is running through coal as a fuel . This power plant is about 35 km away from Mehran university of Engineering Technology Jamshoro Sindh. Fly ash created from Lakhra power plant is very fine powder recover from gases create by coal fire electric power generated.

TABLE VIII: CHEMICAL ANALYSIS OF FLY ASH

Constituent	Chemical analysis
SiO3	21.53
Al2O3	15.45
Fe2O3	32.09
SO3	9.98
CaO	6.9
MgO	3.7
Na2O	1.79
K2O	0.16
LOI	8.34

TABLE IX: GRADATION OF FLY ASH

US Standard sieve size	%Passing
1-1/2"(38mm)	100
1" (25mm)	100
¾ " (19mm)	100

½" (12.5mm)	100
3/8" (9.5mm)	100
No.4 (4.75mm)	100
No.8 (2.38mm)	100
No.50 (0.300mm)	69.25
No.200(0.075mm)	24.85

BITUMEN

It is a mixture of hydrocarbons of natural or pyrogenous origin , or a combination of both frequently accompanied by non metallic parameters which may be gaseous liquid semi solid and which are completely soluble in carbon disulfide.

TABLE X: PROPERTIES OF BITUMEN

Property	Definition
Hardness	Property which gives the degree of hardness
Ductility	Property which forms thin film around aggregate
Viscosity	Property which define fluidity of bitumen
Density	Property which show strength i.e Specific gravity
Solubility	Property which shows solubility of binder insolvent
Water content	Property which shows water content in binder
Softness	Temperature where bitumen attains particular degree of softness.

TABLE XI: BITUMEN TEST RESULTS

Name of Test	Results
The Penetration of the given bitumen @25 ^{0}C	83
Ductility of bitumen @25 ^{0}C	115cm
The Softening of the given bitumen	46 ^{0}C
Specific gravity of the given bitumen	1.05 g/cc
Flash point of the given bitumen	317 ^{0}C
Fire point of the given bitumen	365 ^{0}C

BLENDING OF AGGREGATE

In this project trial and error method have been adopted for blending of aggregate. The simplest method of determining proportions is generally the trial and error method. The individual aggregate gradations are examined and certain percentage of each aggregate is chosen.

TABLE XII: TRIAL BLENDING OF AGGREGATE ASPHALT BASE COURSE

%Used	1-1/2"	1"	¾"	1/2"	3/8"	No.4	No.8	No.50	No.200

Fraction	Average gradation of aggregate fractions								
1-1/2”		100	58.63	44.4	33.2	18.1	-	-	-
1”		100	95.14	59.4	29.6	8.16	-	-	-
1/2”		100	100	100	100	100	90.5	61.3	20.2
No.4		100	100	100	100	100	54.0	4.95	0.63
Fly ash		100	100	100	100	100	100	100	69.2
						Combine gradation for blend			
1-1/2”	30	30	17.5	13.3	9.96	5.43	-	-	-
1”	18	18	17.1	10.7	5.34	1.46	-	-	-
1/2”	15	15	15	15	15	15	13.5	9.19	3.04
No.4	29	29	29	29	29	29	15.67	1.43	0.18
Fly ash	08	08	08	08	08	08	08	08	5.4
Blend grading	100	100	86.7	76.0	67.3	58.8	37.2	18.6	8.1
Job mix		100	87	76	67	59	37	19	9
Specification		100	75-90	65-80	55-70	45-60	30-45	15-35	5-15

requirement specification

ASPHALT MIX DESIGN

Asphalt mix is normally termed as HMA (Hot Mix Asphalt) which is consisted combination of uniformly aggregate mix and coat with asphalt cement. To dry the aggregate and obtained sufficient fluidity of asphalt cement for proper workability and mixing both the asphalt and aggregates must heat to mix the term hot mix.

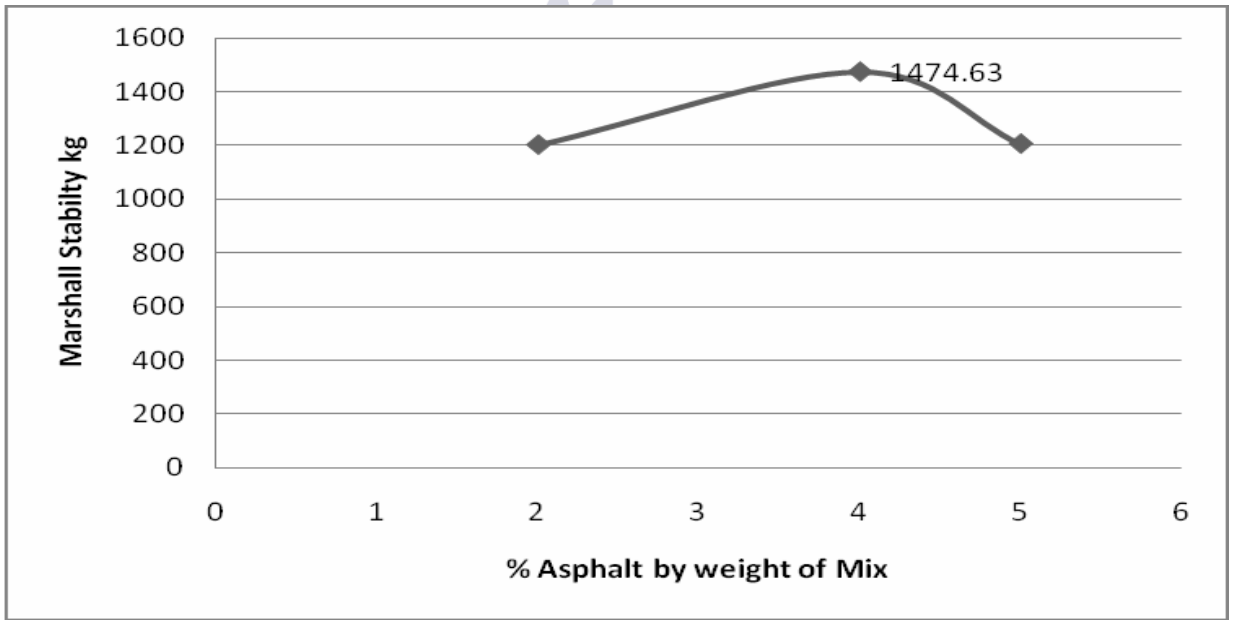

Fig. 1. Marshall stability vs % Asphalt by weight of mix using fly ash

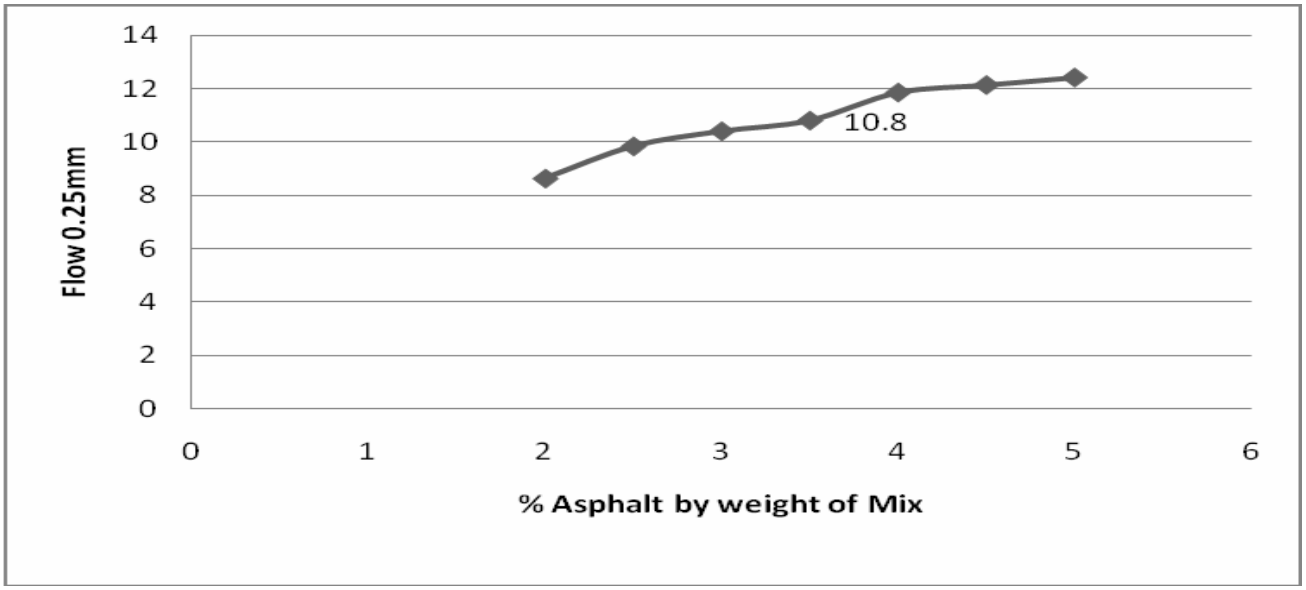

Fig. 2. Flow vs % Asphalt by weight of mix using fly ash

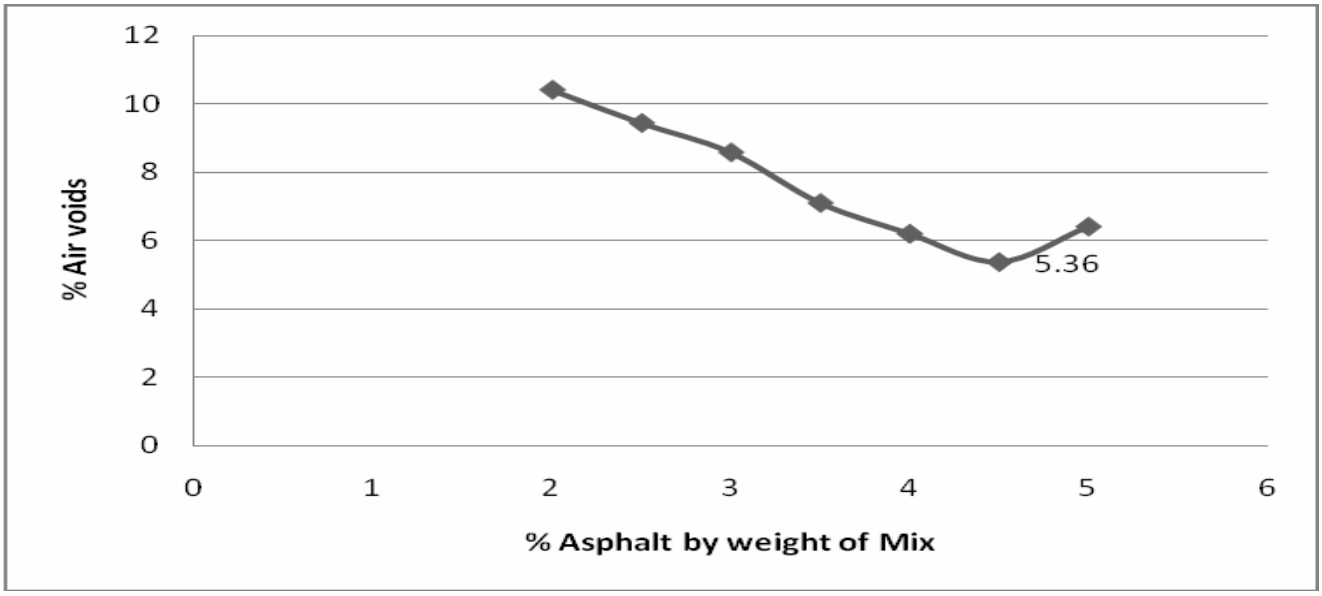

Fig. 4. Voids filled vs % Asphalt by weight of mix using fly ash

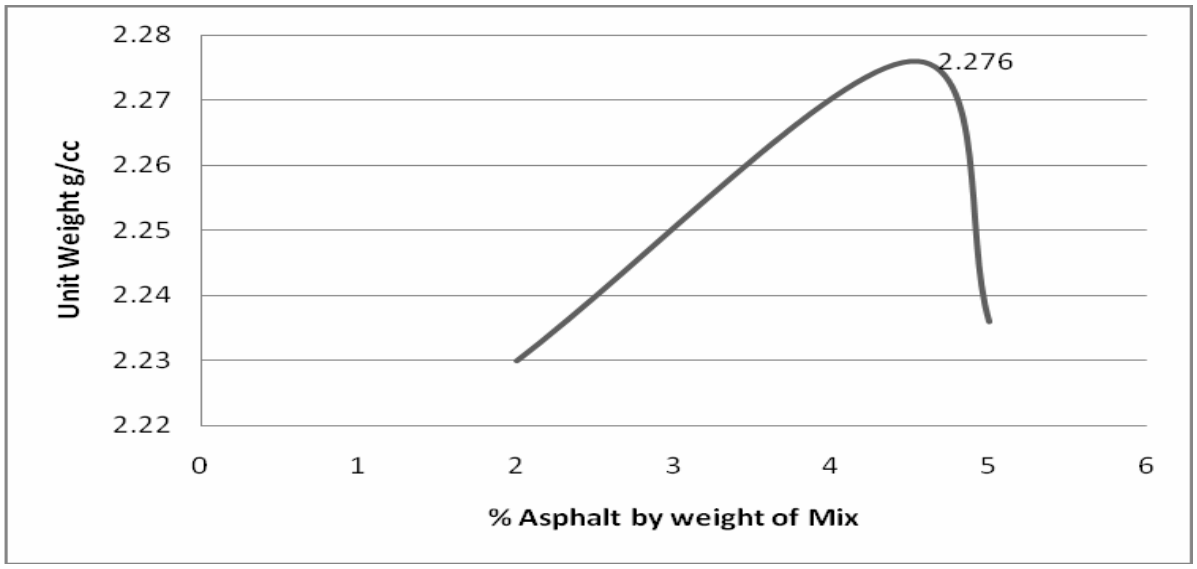

Fig. 5. Unit weight vs % Asphalt by weight of mix using fly ash

TABLE XIII: MARSHAL STABILITY ASPHALT MIX DESIGN SUMMARY TEST RESULTS

Asphalt content % Properties	2.0	2.5	3	3.5	4.0	4.5	5.0
Bulk Sp. Gravity	2.23	2.37	2.24				
	2.264	2.267		2.276	2.236		
Max Sp Gr. Paving mix							
Absorbed asphalt % wt total aggregate							
Effective asphalt content %							
Voids in mineral aggregate							
Air voids in comp. min%							
% Voids filled	2.489	2.47	2.45	2.43	2.42	2.405	2.236
	0.56	0.56	0.56	0.56	0.56	0.56	0.56
	1.45	1.954	2.457	2.95	3.46	3.97	4.468
	13.45	13.62	13.95	13.47	13.79	13.91	15.87
	10.4	9.43	8.57	7.09	6.19	5.36	6.4
	22.67	30.76	38.5	47.36	55.11	61.46	59.67
Stability in kg	1201.24	1250.5	1283.1	1340.2	1474.6	1222.07	1205.10
Flow (0.25mm)	8.64	9.84	10.4	10.8	11.84	12.12	12.4

CONCLUSION

So from above discussion it is cleared from experimental study that we can use the fly ash in pavement construction as a 100% replacement of mineral filler. Every one desire for two things economy and save of time therefore if any road constructed near where huge fly ash is available we can use the fly ash as 100% replacement of filler. We have loss of only about 8.81% stability.

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