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Mix Design of Full Depth Reclamation with Cement

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A B S T R A C T

Good practice notes that pavement should be maintained and preserved in well condition to plying the smooth traffics & the major rehabilitation is not needed. for a various reasons, this doesn't always happen. Sometimes it is not practical to fully rehabilitate a badly deteriorated, Overall removal and replacement is not necessary, the materials of the existing pavement have valuable and can be reused in FDR. Full depth reclamation (FDR) is an efficient means of rehabilitating these damaged pavements without using new granular material. A pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the below bituminous layer materials are uniformly crushed, pulverized or blended, resulting in a stabilized base course. In its simplest form, FDR consists of in-situ pulverization of existing pavement material and underlying layers, uniform blending of pulverized material, grading, profiling and compaction. Cement, emulsion or Roadstab stabilized chemical or combinations of these materials are added to produce a strong durable base.

Keywords: Full Depth Reclamations.

Introduction

As the nation's infrastructure ages, agencies at all levels are tasked with maintaining and rehabilitating their infrastructure. While budgets are shrinking, construction costs are increasing; it is becoming more costly to completely remove and replace existing pavements. In addition, as sustainable construction practices come to the forefront, agencies want to recapitalize their investments in decades-old pavements by reusing existing materials on site in a cost-effective manner. New engineering technologies in pavement rehabilitation, such as full-depth reclamation FDR. With the use of FDR, a strong cemented stabilized layer is produced, which behaves like a semi rigid pavement. Such pavements will behave in a satisfactory manner if they are laid on a uniformly compacted and structurally sound underneath layers. Full depth reclamation in particular has great advantages in terms of savings in time, energy, materials and costs. Generally, the existing layers of deteriorated pavements including old thin bituminous layers are recycled in-place by single or multiple passes of a specialized equipment, graded (with a grader) and compacted with a pad foot/sheep foot roller and pneumatic tyred rollers and static roller. During the reclamation operation, cutting, with/without adding of additional granular material, adding of cementitious/stabilizing material at a specified rate and mixing are carried out simultaneously. The type and rate of application of the cementitious/stabilizing material and aggregates are determined through a mix design prior to the reclamation process which is governed as per existing soil/pavement materials as obtained after required testing. The key to successful FDR is maintained quality & homogeneous mixing of material. The important items include mix design, quality control and training of personnel that are involved in the recycling operation. Key mix design tests should include those for selection of type and amount of stabilizing agent to cement ratio (if any), and the volumetric of the cold mix. The guidelines should be indicated for water application, mixing, curing, compaction, achievement of desired Unconfined Compressive Strength (UCS) value and checking of riding quality of pavement.

Nomenclature
FDR: Full Depth Reclamations
RPM: Recycled Pavement Material
FSI: Free Swell Index
RAP: Recycle Asphalt Pavement
OMC: Optimum Moisture Content
MDD: Maximum Dry Density
USC: Unconfined Compressive Strength
GSB: Granular Sub Base

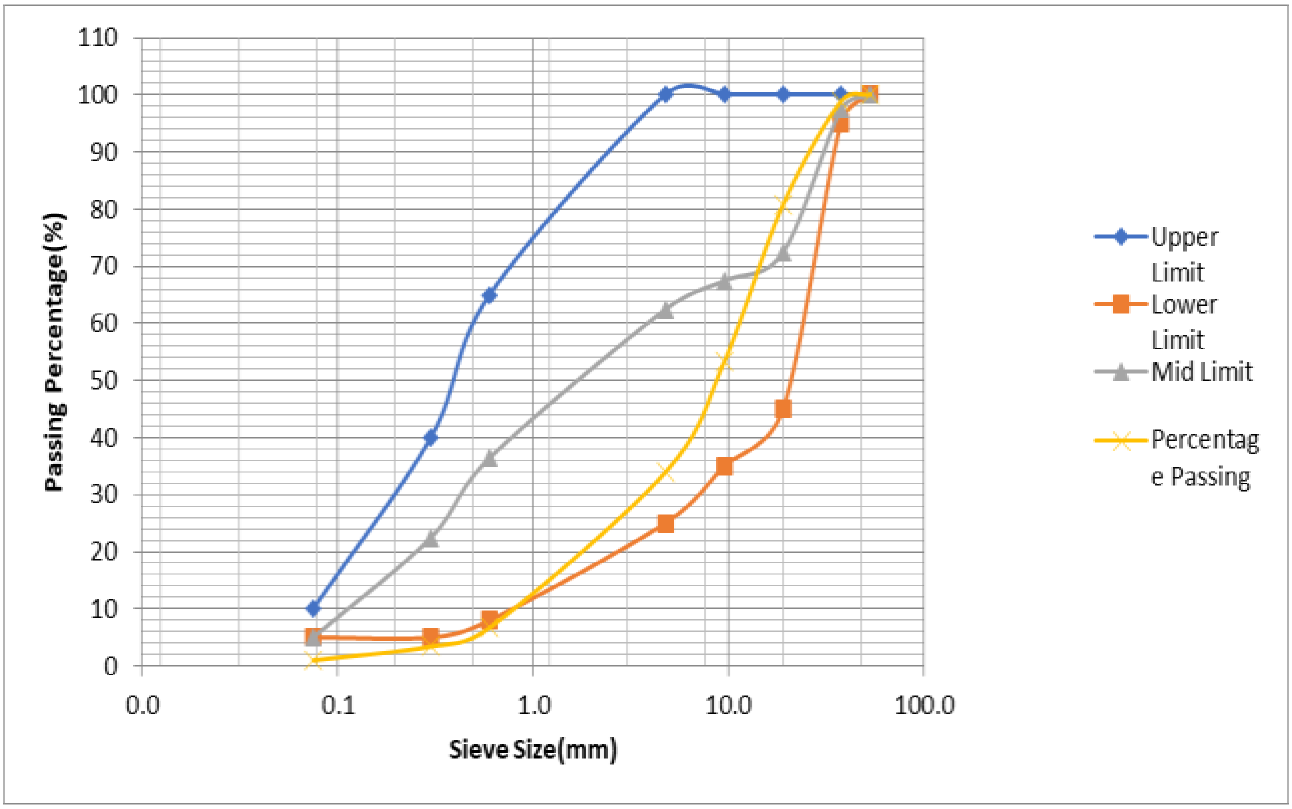
FDR Mix DESIGN With Cement

Full depth reclamation of bituminous asphalt pavement, also known as FDR, it is a rehabilitation method that involves recycling & reuse of an existing asphalt pavement and its base and sub base layers into a new base layer. The FDR process begins with using a road reclaimer to pulverize an existing bituminous asphalt pavement and a portion of the its base, sub base and subgrade. Generally, the pulverized material is uniformly blended with an additional stabilizing material as such Portland cement to provide an upgraded, homogeneous mixing of material. Finally, the stabilized material is compacted in place with sheep foot rollers & Static roller. The result is that a stiff, stabilized base that is ready to laying new rigid or flexible surface course.

Mix Design of FDR with OPC 43 Grade Cement

Sieve Analysis of Existing material:

Sample Weight (gm)		14858 (gm)		
IS Sieve Size (mm)	**Weight Retained (gm)**	**Cum. Weight Retained (gm)**	**Cum. % Weight Retained (gm)**	**Percentage Passing**
53.0	0	0	0.00	100.00
37.5	172	172	1.16	98.84
19.0	2680	2852	19.20	80.80
9.5	4080	6932	46.66	53.34
4.75	2872	9804	65.98	34.02
0.600	4035	13839	93.14	6.86
0.300	493	14332	96.46	3.54
0.075	358	14690	98.87	1.13



Free Swell Index of soil as per IS: 2720 (Part XL) – 1977

The test was conducted as procedure stated in IS:2720 (part XL) -1977, results are as following:

No.	Sample	FSI		
		Kerosene	Distilled water	Roadstab + Distilled water
1	Insite Material	0 %	10 %	0%

Modified Proctor Test

The test was conducted as procedure stated in IS 2720 (PART 8 results are as following

Bulk density is taken out by the following formula:

Yw = (m2 – m1) / Vm

m1 = Weight of mould with the base plate.

m2 = Weight of mould with the compacted soil.

Vm = Volume of mould in cm3

Dry density Yd in g/cm3 from the equation are as follows:

Yd = Yw / (1+W/100)

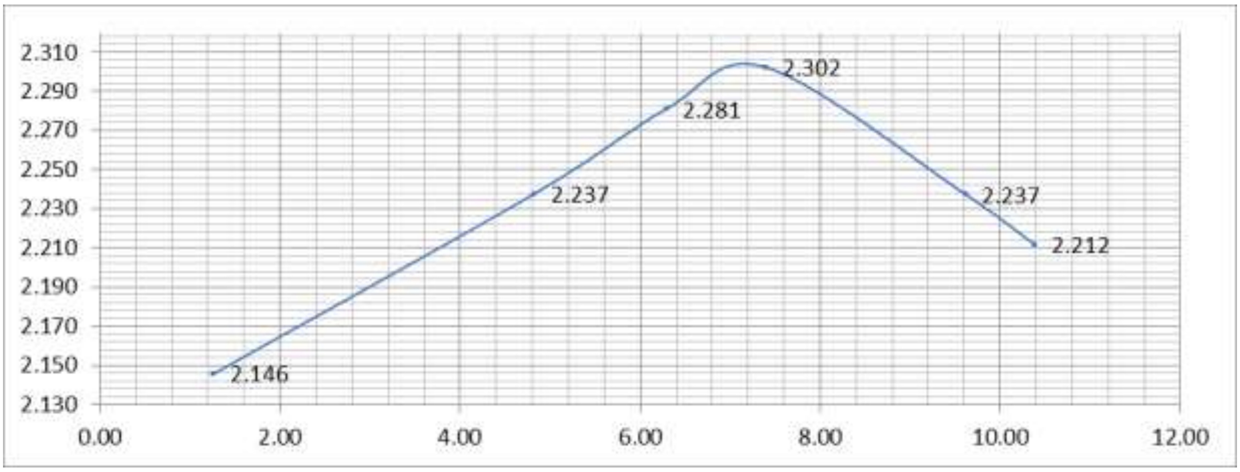
Yw = Bulk density

W = % of moisture content

After this a graph is plotted placing Dry density in Y axis, and moisture contents in X axis, and a smooth curve line is formed. The peak of the curve is registered and Maximum dry density at that specific moisture content is considered as optimal moisture contents.

PROCTOR COMPACTION TEST						
{IS 2720 (PART 8)}						
Type of Material	RPM		Date of sampling		11/10/2022	
Source	SITE		Sampled by		Jointly	
Location	292+430 (RHS)		Date of Testing		01/10/2022	
Proposed use	FDR		Tested by		Jointly	
Mould No.	Wt. of mould (A) (gm)		**6317**	Volume of Mould (v) (cc)		**2250**
Trial No.	1	2	3	4	6	
% of water added	1.00	4.00	5.50	7.00	8.50	10.00
wt. of wet RPM + mould(gm) (B)	**11206**	**11594**	**11772**	**11880**	**11835**	**11810**
wt. of wet RPM (C= B-A)	4889	5277	5455	5563	5518	5493
wet density of RPM gm/cc (ϒwet = C/V)	2.173	2.345	2.424	2.472	2.452	2.441
Container No	**1**	**2**	**3**	**4**	**5**	**6**
Weight of Container in (gm) (D)	**111.21**	**135.71**	**149.04**	**106.93**	**108.27**	**107.17**
Wt. of Wet RPM + Container (gm) (E)	**191.21**	**263.10**	**240.4**	**212.8**	**237.19**	**248.21**
Wt. of dry RPM + Container (gm) (F)	**190.21**	**257.24**	**234.99**	**205.51**	**225.88**	**234.94**
Wt. of Water (G=E-F)	1.00	5.86	5.41	7.29	11.31	13.27
Wt. of Dry RPM (gm) (H=F-D)	79	121.53	85.95	98.58	117.61	127.77
water content %(W=G*100/H)	1.27	4.82	6.29	7.40	9.62	10.39
Dry density (g/cc) ϒdry=((ϒwet*100)/(100+W)	2.146	2.237	2.281	2.302	2.237	2.212

Result:



No	Material	MDD in gm/cc	OMC in %
1	Existing material	2.305	7.20

Atterberg's Limit:

Liquid Limit

Designed Material sample of 150 gm was taken which passed through 425µ IS sieve. Required quantity of distilled water was taken, mixed with thes required ratio of chemical additive, and kept for 10 minutes. Then both mixes were mixed to form a homogeneous mix. This homogeneous mix was then transferred to the cup of Cone Penetrometer Apparatus, considering that no air was trapped the mix in the cup. This cup is then levelled by knife to the top. After placement of Designed Material mix with chemical additive to the cup, was shifted to and placed in base of Cone Penetrometer Apparatus.

Reading of Penetrometer is adjusted to zero and was adjusted that the tip of the cone is just above the Designed Material surface and then vertical clamp was allowed to free fall with its own standard weight. After 5 seconds depth of the penetration of this cone in Designed Material is registered. Again, this process is repeated till we get 4 figures between 14 to 28 mm. Portion Designed Material mix of each Designed Material is collected in small containers and kept in oven for 24 hours to allow moisture to evaporate and determine moisture contents in the Designed Material. After gathering the required no of data, a graph is plotted considering the penetration at specific moisture content. The moisture content corresponding to cone penetration of 20 mm was taken as the liquid limit of the Designed Material and was expressed to the nearest first decimal place.

Plastic Limit

Designed Material sample of 20 gm was taken which passed through 425µIS sieve. When both the liquid limit and the plastic limit of a Designed Material are to be determined, a quantity of Designed Material sufficient for both the tests is taken for preparation of the Designed Material. At a stage in the process of mixing of Designed Material and water at which the mass becomes plastic enough to be easily shaped into a ball, a portion of the Designed Material sample in the plastic state is taken for the plastic limit test. A ball is formed with about 8 g of this plastic Designed Material mass, rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling is between 80 to 90 strokes per minute. Counting a stroke as one complete motion of the hand forward and back to the starting position again.

The rolling is done till the threads are of 3 mm diameter. The Designed Material then be kneaded together to a uniform mass and rolled again. This process of alternate rolling and kneading is continued until the thread starts crumbling under pressure required for rolling and the Designed Material can no longer be rolled into a thread. This considered a satisfactory end point. The pieces of crumbled Designed Material thread collected in the air tight container and the moisture content determined by oven dry method.

Test Results:

No	Description	Sample	Atterberg's limit
			Distilled water
1	Liquid limit %	Existing Material	21.00
2	Plastic limit %		NP
3	Plastic index %		NP

Unconfined compressive strength:

Procedure: IS 4332 Part-5

Molds were casted size 150x150x150, at OMC and MDD with following composition of mixed material.

Test results summary:

Material	Existing material
Dosage Cement content	5%
Dosage Roadstab compound	0.00581%, 134 gm per cum

Cube ID	Age of Cube days	UCS Value (MPa)
1	7	4.44
2	7	4.67
3	7	4.44
Average value		**4.52**

4	28	4.89
5	28	4.89
6	28	5.56
Average value		**5.11**

Durability Test:

Test Procedures: IS Code IS: 4332 (Part IV) moulds were casted size 150x150x150, at OMC and MDD with following composition of mixed material.

Material	**Existing material**
Dosage Cement content	5%
Dosage Chemical Additive	0.00581%, 134 gm per cum

Test results summary:

No	**Weight**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**	**Loss %**	**Avg. Loss%**
1	7728	18	20	21	19	23	25	21	22	23	24	25	11	252	3.26	3.18%
2	7760	17	20	22	17	20	18	22	17	23	24	25	16	241	3.10	

Design Test Results Summary

Test	**Result**
FSI	10%
MDD	2.305 gm/cc
OMC	7.2%
Liquid Limit	21%
UCS 7 Days	4.52 MPa
UCS 28 Days	5.11 MPa
Durability loss	3.18 %

Conclusion

In this mix 5% OPC 43 Grade cement and 0.00581% of chemical additive was mixed and a homogeneous mix was prepared 150x150x150 mm moulds were created for UCS and Durability.

Free swell Index of the soil is 10% with water and after mixing with Roadstab chemical the FSI of soil is 0%.

UCS moulds curing of 7 days shown results avg. 4.52 MPa and 28 days curing results were 5.11 MPa. Both of these results qualify the minimum requirement i.e., 4.5 MPa.

Durability test shown 3.18% loss of material after 12 wet and dry cycle, which qualifies the permitted loss of 14%.

As per recommendation of codal provision IRC 37-2018, it is required to provide Crack Relief layer over the Stabilized Layer. For Crack relief layer recommend to use GEO Grid minimum of 100 KN over Stabilized Layer.

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