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MIX DESIGN OF HMA AND CMA FOR POTHOLE REPAIRS

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Abstract **- Development of potholes on flexible pavements is very common phenomena during monsoon and after monsoon in India. Problems of road distresses, especially problems of potholes on flexible pavements are becoming more dangerous for users. Potholes are not only cause for road accidents but also they are creating discomfort to passengers. Generally hot mix is used by government for patch work of potholes. But in rainy season hot mix plants are closed, so hot bituminous mix is not available for filling of potholes. Also considering heating temperature required for hot mix which is around 180^{0}C, there is a big problem of environmental pollution. Generally people use conventional methods like murum filling or aggregate filling etc, but these methods provide temporary convenience for passengers and after some time again potholes are formed. Various readymade patching materials are also available in market for patching works, but considering costs, they are uneconomical. In this study the approach is made towards new cold mix which can be used in rainy season also for patching works. The aim of the study is to prepare a economical cold patching mix which can be used for patching works at normal temperatures. Road survey is carried out for classification of potholes based on their actual dimensions to decide upon sizes of precast Hot Mix Asphalt blocks.**

Keywords: Hot Mix Asphalt (HMA), Cold Mix Asphalt (CMA), Potholes, Cutback Bitumen, Asphalt Concrete (AC)

I. INTRODUCTION

Development of potholes on pavements is very common phenomena during monsoon and after monsoon. Theoretically Potholes should be filled using Hot Mix produced in Hot Mix Plants (HMA), but generally in India HMA plants are shut down during monsoons and there for the hot bituminous mix is not available fore filling of potholes. So many times potholes are repaired by using some local techniques like Murum filling etc.[4]

There are various manufacturer who provide material for patching of potholes like Makhalt (Mak Premix), RIPSTAR BT9 A.K. instant Patch Premix, Hinkol Roadbond, etc. but considering economy, these materials are having high costs (300Rs to 400 Rs. Per 25 Kg. Bag) which make their use in limited conditions. Also there are various mixes available like HMA, Warm Mix Asphalt (WMA), Cold Mix Asphalt (CMA) by using which we can repair Potholes on the roads.. In case of repairs of Potholes, Hot Mix is not economical because, during transportation hot mix cools down and therefore cannot be compacted appropriately to provide a durable patch.

Considering HMA, during their production in hot mix plants, large amount of pollutant gases are emitted into the environment due to high temperatures which may be up to 180^{0}C. To avoid this environment pollution there is a concept called Warm Mix Asphalt (WMA) [1] in which the temperature is lower than HMA by 30^{0}C – 40^{0}C.Ultimately pollution will be reduced and also costs of fuel. So WMA can be used for repairing potholes. Similarly, there is a new concept of use of Cold Mix Asphalt [5] in which the temperature is very low as compared to HMA and WMA. Temperature of CMA is about 60^{0}C while mixing and 30^{0}C to 40^{0}C while using on site.

The project deals with developing a new innovative technique for repairing potholes on roads which will be very simple to use and take less time. For that purpose, an approach is made to use combination of CMA and HMA which can be prepared in labs or in plants and then we can use this for pothole repairs. So the objective of this project is to develop an innovative method for pothole repairs.

II. PROBLEMS OF CURRENT POTHOLE PATCHING METHODS

Following are major problems regarding actual patching works,

1. Trimming of pothole – while carrying out patchwork, no pothole is trimmed into square or rectangular shape. As per IS guidelines, potholes should be cut into Square or Rectangular Shape.
2. Cleaning – no pothole get cleaned properly. Generally brush is used for cleaning, so dust and fine material remains as it is in the pothole. This causes poor bonding between new material and old material. So after sometime pothole takes place at the same location.
3. Mix Design – Proper mix design should be used while making patching material.
4. Filling of potholes is done as whole. i.e. the whole potholes is filled by mix at the same time which should be in proper layers.
5. Rough surface – in some cases, after filling of pothole, wearing course is not applied causing roughness of top layer and discomfort to passengers. Sometimes open graded carpet (OGC) is used for pothole patchworks which makes road surface rough.
6. Waste of material – i. After filling of potholes the remaining material is kept as it on the site as the cost of collecting and transporting the remaining material may higher than the

material. ii. After filling pothole with HMA, generally grit is applied on the pothole, but while applying grit layer, large amount of wastage takes place.

Other Problems,

1. Machinery requirement on site – machines like roller, HMA tankers, and boilers. Etc required on site for patching works.
2. Labors – labors for handling material, cleaning, filling potholes, tamping, etc. are required.
3. Raw material – prior to patching, there is need to bring the raw material like aggregates, binder barrels, etc on site.
4. Traffic Problems – while patching any pothole, traffic should be stopped or diverted for long time.
5. Conventional methods – if potholes do not get filled immediately, then people from the residing area use conventional methods like, filling potholes by Murum, aggregates, Brocken bricks, or any suitable waste material etc. such things gives temporary comfort for passengers after some time again pothole takes place.

III. Road Survey

First of all, road survey is carried out for measurements of potholes. Length, Width, Depth and Radius of Potholes were measured on actual sites. While carrying out road survey, actual problems regarding Pothole formation and regarding pothole patchworks were found.

In this study two State Highways (SH) and two Major District Roads (MDR) were selected as the scope of project is limited for SH and MDR. A 40 KM patch of every road was selected for survey. Further the patch was divided into 8 sections, each of 5Km. After that potholes in 1 KM length of road in each section were measured. The 1 Km from the section was selected randomly to get fair results considering material variations, workmanship variations.

After carrying out road survey, following data is collected regarding pothole sizes,

TABLE 1 – Statistics of Miraj - Pandharpur Road

		Length	Width	Depth	Radius
N	Valid	26	26	26	26
	Missing	47	47	47	47
Mean		126.58	85.38	5.04	63.23
Median		105.00	68.50	5.00	52.50
Mode		110	60	6	55

TABLE 2 – Statistics of Sangli to Vita Road

		Length	Width	Depth	Radius
N	Valid	42	42	42	42
	Missing	0	0	0	0
Mean		102.86	65.48	4.88	51.43
Median		90.00	60.00	5.00	45.00
Mode		80	50	4	40

TABLE 3 – Statistics of Sangli to Bagni Road

		Length	Width	Depth	Radius
N	Valid	20	20	20	20
	Missing	1	1	1	1
Mean		133.00	82.00	4.90	66.50
Median		115.00	80.00	5.00	57.50
Mode		120[a]	80	5	60[a]

a. Multiple modes exist. The smallest value is shown

TABLE 4 – Statistics of Tasgaon to Kundal Road

		Length	Width	Depth	Radius
N	Valid	42	42	41	42
	Missing	0	0	1	0
Mean		139.76	105.48	8.83	69.88
Median		135.00	100.00	8.00	67.50
Mode		120	90	6	60

*Note – All Units for tables are in Centimeter.

After measuring pothole dimensions (Length, width, depth, radius), SPSS analysis was carried out to get average dimensions of potholes. From this, average dimensions of potholes were found as, 1.3 x 0.9 x 0.05 m. Then, potholes are divided into two sizes, small and medium. Then precast HMA blocks using two materials, Asphalt Concrete (AC) blocks and Open Graded Carpet (OGC) blocks were casted.

IV. PRECAST HMA BLOCKS

For casting HMA blocks of small size, AC (Asphalt Concrete)/ BC (Bituminous Concrete) was used, which is generally used as a impervious carpet layer (Dense graded). The gradation of AC was aggregate size below 10mm and binder content was 5%. Temperature of the mix was 160 ^{0}C.

Specially prepared moulds were used for casting HMA blocks. Using the same, HMA blocks were casted. These precast blocks will be used for filling of potholes. As the blocks are casted on plants, quality of mix is maintained so a durable patching mix having known properties will be available. Following picture shows a precast bituminous block.

Image 1 – Precast Bituminous Block

Image 2 – HMA Blocks of various sizes

Gradation of AC material was as follows,

TABLE 5. Gradation of aggregates for HMA blocks

Sieve Size (mm)	Percent Passing
13.2	92.06
9.5	86.62
4.75	68.41
2.36	50.06
1.18	41.55
0.6	35.36
0.3	22.71
0.15	19.02
0.075	5.52

V. COLD MIX

In this study, a cold patching mix was prepared, which can be used during rainy season also for patchworks. A cold mix is a mixture prepared using a special type of bitumen called CUTBACK Bitumen.

a. Cutback bitumen

In cutback bitumen suitable solvent is used to lower the viscosity of the bitumen. The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate. Cutback bitumen is used for cold weather bituminous road construction and maintenance. The distillates used for preparation of cutback bitumen are naphtha, kerosene, diesel oil, and furnace oil. There are different types of cutback bitumen like rapid curing (RC), medium curing (MC), and slow curing (SC). RC is recommended for surface dressing and patchwork. MC is recommended for premix with less quantity of fine aggregates. SC is used for premix with appreciable quantity of fine aggregates.

b. Aggregates

Coarse aggregates shall consist of crushed rock or crushed gravel which should be retained on 2.36 mm sieve. Aggregates shall be clean, hard, durable, and cubical in shape, free from dust and soft organic and other deleterious substances.

Fine aggregate shall consist of crushed mineral material which is passing through 2.36 mm sieve and retained on 75-micron sieve. It shall be clean, hard, durable, and free from dust and soft organic and other deleterious substances. Natural sand should not be used.

TABLE 6. Gradation of Aggregates [5]

Sieve Size (mm)	Percent Passing
9.5	100
4.75	40-100
2.36	10-40
1.18	0-10
0.075	0-2

c. Cold Mix Preparation

Samples of Cold Mix using cutback bitumen were prepared. Cutback bitumen having grade MC800 was used. Procedure for preparation of cold mix is as follows,

1. Binder content used in cold mix depends upon water absorption of aggregates, so calculate water absorption of aggregates.
2. Select binder content as 4.5%, 5%, 5.5% etc. depending upon water absorption of aggregates. 4.5 % binder content is used as water absorption of aggregates was 1.1%.
3. Increase binder content if water absorption is more. For Example, for water absorption of 1.5 % use binder content 5%.
4. Aggregates gradation for cold mix is aggregates passing through sieve 9.5mm.
5. Prior mixing aggregates and binder, aggregates were heated to 60ºC and binder was heated at 90ºC.
6. Then the mixture can be stockpiled.

Image 3 - Cold mix sample

VI. NEW PROCEDURE FOR POTHOLE REPAIRING

Following procedure should be adopted for pothole filling during rainy season.

1. Carry out visual inspection of pothole to decide size of precast block from available sizes. Size of precast block should be large enough to cover whole pothole. If pothole size is more than available block

sizes, then carry out actual measurements of pothole and decide no of blocks to be used for one pothole patching.
2. Carry out marking around the pothole considering the selected precast block size in step one.
3. Cut the pothole with respect to markings made in step no 2 so that the block size selected in step 1 should be fit into it.
4. If the pothole is having less depth, then make it deeper so that the precast block will fit into it.
5. Clean the pothole; remove loose material, debris, etc.
6. Now if the depth of pothole is more than required then, level the bottom of pothole by using cold patching mix prepared.
7. Carry out hand tamping by any tamping tool so that levelled surface will be prepared.
8. Apply tack coat to all sides of pothole.
9. After placing precast block into pothole, all sides of potholes should be sealed using bitumen binder.
10. Apply seal coat on the patched surface area if required.
11. Prior mixing aggregates and binder, aggregates were heated to 60ºC and binder was heated at 90ºC.
12. Then the mixture can be stockpiled.

VII. CONCLUSION

1. Precast HMA blocks were prepared using two materials as mentioned above. But due to less binder content (3.5%) in OGC material, there was poor bonding between aggregates and binder. So these OGC blocks were damaged while lifting.
2. AC material was having binder content of 5% so there was proper binding between aggregates. So precast AC block were casted. Weight of AC block having size (0.45 x 0.30 x 0.05)m was around 15Kg, while weight of block having size (0.6 x 0.45 x 0.05) m was around 30Kg.
3. Cold mix was prepared using binder content of 4.5% as water absorption of aggregates used was 1.1%.
4. Method mentioned above for pothole filling during rainy season is effective because, we are using cold patching mix into pothole which performs well in rainy season. Without waiting for HMA material, we can use the cold mix for repairing potholes.
5. Sometimes there may be only few potholes on any road of long patch. In such cases, bringing all material, equipments, etc. for repairing potholes becomes tedious work. In such situation method mentioned above can be used. Just bring required no of precast blocks, bags of cold mix and cutting tools and carry out pothole repair work within less time.
6. If wearing course of road is damaged to irregular size having very less depth say 10mm to 20mm, in such cases, just apply cold mix on the surface and carry out normal compaction.
7. For large size precast bituminous blocks, mesh can be used as reinforcement so that it will become stronger and can be handled without damaging.

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