Laboratory Evaluation and Field Observation of Cold Patch Repair Mix Prepared with Coal Mix Waste Aggregate and New Binder Formulation (Bond-1, 2)

Tanuj Parmar[1] Gamit Nilam[2]
[1]Assistant Professor [2]BE Student
[1,2]Department of Civil Engineering
[1,2]Government Engineering College, Surat

Abstract— The deteriorating highway culvert infrastructure has become a major challenge for the 21st century. While more significance normally is given to highway embankments, pavements and bridge, the support of courses has ordinarily been disregarded. Cracks, Potholes, and patches are some types of road surface distresses whose assessment is essential in India. Normal and new approaches which target the medium- or long-term repair of potholes have been studied. In a catalogue of tests, evaluation methods and experiences according to existing Standards have been compiled to give road agencies an overview of the possibilities for the repair of potholes. Furthermore, the testing of techniques and the use of material types from already existing trial sites have been used to determine properties of materials and their related laboratory tests which can, or should, be used to select the correct testing of materials for this purpose. Potholes, cracks and patches are some types of road surface distresses whose assessment is essential in India (MORTH, 2004). To the motoring public, potholes are one of the most visible and annoying forms of pavement distress. Waste aggregates, which is present in coal mines. These waste aggregates can be of great use in coming future. So, our main aim is to utilize this waste into something productive and for this purpose, various tests have been carried out on Coal mixed waste aggregates, which have been taken from NTPC Thermal Power Plant.

Key words: Cold patch repair, Potholes repair, Potholes, Patch repair mix

I. Introduction

Patching potholes in asphalt pavements is an important maintenance operation for highway agencies because this activity is expensive and time-consuming. In areas with cold and wet winters, the pavement break-up makes the patching activity even more important. Potholes require immediate attention by maintenance crews to minimize further pavement damage and reduce the opportunity for vehicle damage and potential accidents. The two factors that usually cause potholes are water and traffic. A smooth surface with good skid resistance, free of alligator cracks, pumping, pushing, wheel rutting, ravelling, frost heaving, and pot holing, is desirable for safe travel by the people. But a number of factors can make a road unsuitable for further use. For example, an overlay with excess bitumen or poorly graded or inadequately fractured paving material may not have adequate particle interlock; thus pushing, rutting, and humps may develop. Poor subgrade drainage and leaching during rainy seasons can break interlocking between bitumen and aggregates and it eventually leads to cracks and potholes. Lack of proper curing leads to severe damage to newly laid pavements.

Fig. 1: Coal mix waste aggregate NTPC Badarpur New Delhi

Coal mixed aggregates are those aggregates which have been unintentionally mined from coal fields along with the coal which are supplied to various Thermal Power plants. These aggregates have very fine coal dust embedded on them, due to which it has different texture and properties than that of Natural aggregates. Also these aggregates pose a great problem in the functioning and maintenance of thermal plant and as such results in high electricity generation cost.

Fig. 2: Coal mix waste aggregate NTPC Badarpur New Delhi

II. Objective

The overall objective is to identify failure mechanisms and review current mix designs for materials developed, their performance evaluation, and field application procedures to establish design needs and criteria.

To achieve this following objectives are planned:

1) To test the physical properties of the coal mix waste aggregate for assessing their suitability for pothole and patch repair works.

2) To scientifically carry out laboratory investigation on developed new binder formulations (BOND 1, 2) by me and mix design is worked out.
3) Other test needs to be conducted like indirect tensile strength (ITS), Retain Marshall, Wet indirect tensile strength with new binder formulation (BOND 1, 2) with coal mix waste aggregate.
4) To evaluate the field performance of patch mix, also to evaluate their cost benefit analysis.

III. Scope

As pothole repair consumes hundreds of tons of natural aggregates. So, if this material turns out to be suitable for its use in patch-repair mix, then coal mixed waste aggregates can replace natural aggregates.

IV. Advantages of Use of Coal Mixed Waste Aggregates over Natural Aggregates

Coal Mixed Waste Aggregates offers many advantages if used in for construction of cold mix asphalt. Some of the common advantages associated with this are:

1) Disposal as well as Utilization of Coal Mixed Waste Aggregates from Thermal Power Plants
2) Ease of Availability
3) Cost Saving: As we are replacing the natural aggregate with the plenty available waste aggregate. The approximate saving of cost is about 40% due to reduction of quarrying cost of natural aggregate and its transportation.
4) Energy savings: One most important benefit of using coal mix waste aggregate is the reduction in the fuel consumption for quarrying of aggregates.

V. Test and Evaluation Methods for Use in Laboratory and Field.

The tests and evaluation methods used to select pothole repair materials and techniques. From these results, it was found that pothole repair materials and techniques need to be assessed by a certification procedure prior to use because the size of works makes compliance checking impractical.

VI. Laboratory Tests On Aggregates

Aggregates were sieved as per the requirement of Impact, Stripping, Soundness, Water absorption test procedures. These test were performed as per procedures described in relevant IS codes. The tests performed are as follows;

1) Impact Value Test and Wet Impact Value Test, IS:2386 (Part 4)-1963
2) Water absorption and Specific Gravity Test, IS: 2386 (Part 3)-1963
3) Soundness Test, IS: 2386 (Part 5)-1963
4) Stripping Value Test, IS:6241-1974

Sr. No	Name of experiment	Experiment value	Limits as per morth 2013
1	Impact value test	21.9%	24% max
2	Wet Impact value test	24.1% (Difference Dry-Wet=2.2%)	Difference b/w dry and wet impact should not >10%
3	Water Absorption	1.9% (10mm)	2% max
4	Specific Gravity	2.54	2-3
5	Soundness in Sodium Sulphate	4.43% (4.75mm-10mm)	12% max

Table 1: Experimental value of natural aggregate

VII. Composition of Mixtures

When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading shall fall within the limits shown in Table 2. As far as possible an aggregate with water absorption of 1.0 or less shall be used.

Sieve size mm	Natural aggregate percentage of passing through sieve size	Specified limits IRC 116
9.5	100	100
4.75	75	100-40
2.36	54	40-10
1.18	26	10-0
0.075	18	2-0

Table 2: Grading of natural aggregate for patch repair

VIII. New Binder Formulation (Bond 1, 2)

"New binder formulation-BOND (Liquid Bitumen) is Bitumen that is dissolved in a solvent. Typical solvents include Naphtha, gasoline and kerosene, white spirit etc. The type of solvent controls the curing time while the amount determines the viscosity of the BOND".

IX. New Binder Formulation (Bond 1, 2) Properties

Cut-backs are bitumen preparations in which the viscosity of the binder has been reduced by the addition of a volatile solvent, normally derived from petroleum. Typically the solvents used are white spirit and kerosene. Cut-back products are typically used for spraying and some mixing applications.

Sr no.	Material	Material	Content
1	Vg-10 bitumen	Vg-30 bitumen	85%
2	Anti-stripping agent	Anti-stripping agent	1%
3	Solvent	Solvent	14%

Table 3: Properties of new binder formulation (BOND 1, 2)

X. Results of Tests on New Binder Formulation (Bond 1, 2)

Sr no.	Characterises	Test result bond 1 (vg-10)	Test result bond 2 (vg-30)	Limits
1	Residue from distillation up to 360ºc percent volume by difference	85%	85%	85-100
2	Test on residue (a) Viscosity	856	1027	300-

	(b) Ductility at 27ºc,cm (c) Solubility in trichloroethylene	110 100%	116 100%	1200 100 100
3	Water content percent by mass	0.2%	0.2%	0.2%

XI. Design of Patch-Repair Mix

Optimization of the mix design of materials takes place not only in terms of volumetric and compaction characteristics, but also requires the consideration of engineering properties of the mix, durability and long term performance. At the same instance, economic point of view also remains high lightened in the selection of mix designs.

In the view of mix design it is always a difficult task to address its performance. It is because of a number of diversities including:

1) The variety of ways in which the performance of material can be calculated for example durability, fatigue life etc.
2) Problems in finding the mode of failure of material and mechanism for it.
3) The different types of mix properties and material properties that can affect performance e.g. binder content, material solidity, gradation of aggregate etc.
4) External factors as climate, traffic frequencies, loading intensity etc.

XII. Mix Requirement for Designed Cold Mix

Apart from conformity with the grading and quality requirements for individual ingredients, the mix shall meet the requirements set out in below table.

Parameters	Cutback
Minimum stability	2.2 KN at 25ºC for maintenance 3.3 at 25ºC for paving
Percent Maximum stability loss on soaking	25
Minimum flow (mm)	2
Compaction level (Numbers of blows)	75
Per cent air voids	3-5
Percent minimum coating	-

Table 5: Mix requirements for Design cold Mix as per Morth table 500-45 2013

XIII. Marshall Mix Design

The first purpose of Marshall Samples is the determination of optimum bitumen content for any mix. Here, we designed marshal molds with New Binder formulation (BOND 1, 2) so, their optimum bitumen contents are described in the text below.

XIV. New Binder Formulation (Bond-1)

New binder formulation (bond-1) Percentage (%)	Density	Stability	Flow
5	1.81	8.79	0.82
6	1.98	9.49	0.98
7	1.86	10.83	0.87

Table 6: new binder formulation 1 density, stability and flow

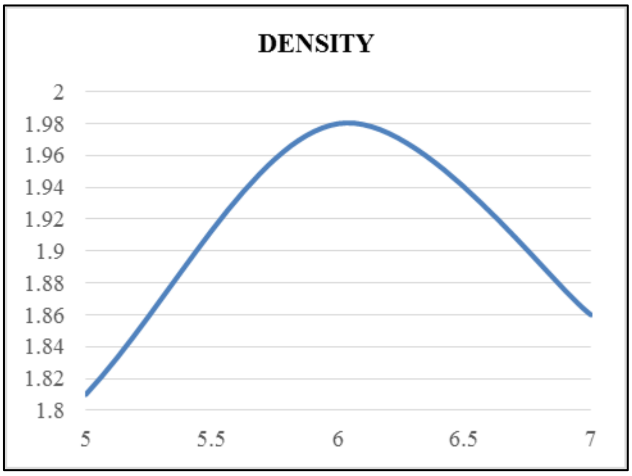

Fig. 3: Relationship between binder content and density

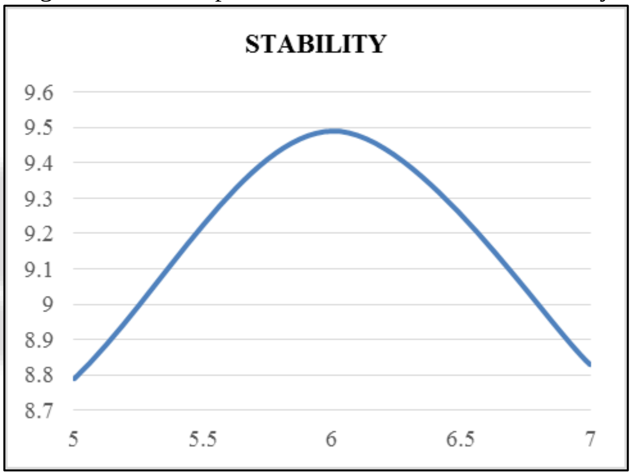

Fig. 4: Relationship between binder content and stability

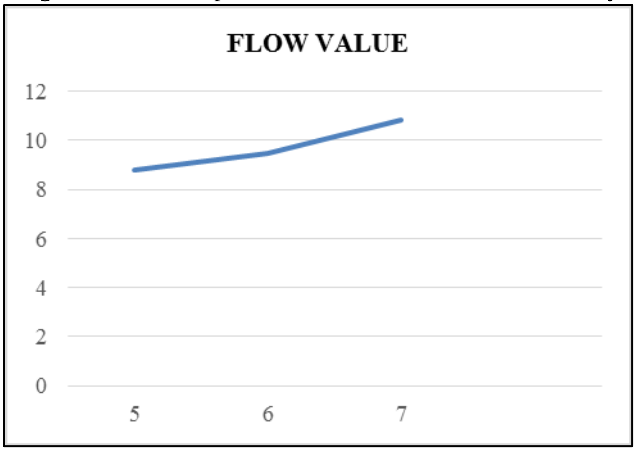

Fig. 5: Relationship between binder content and flow value

XV. New Binder Formulation (Bond-2)

New binder formulation (bond-1) Percentage (%)	Density	Stability	Flow

5	1.87	9.11	0.94
6	2.21	10.42	1.09
7	1.98	12.74	1.85

Table 7: new binder formulation 2 density, stability and flow

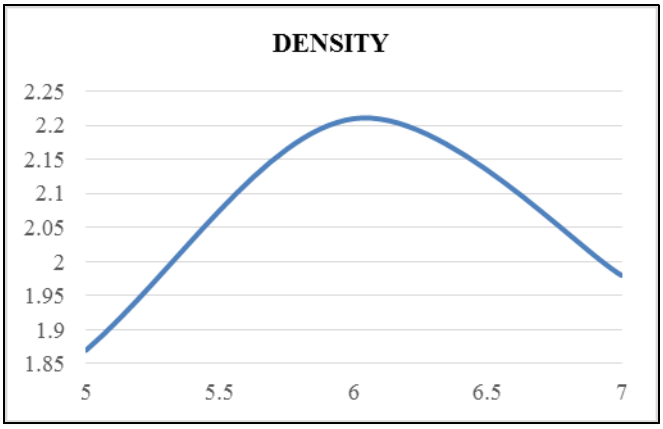

Fig. 6: Relationship between binder content and density

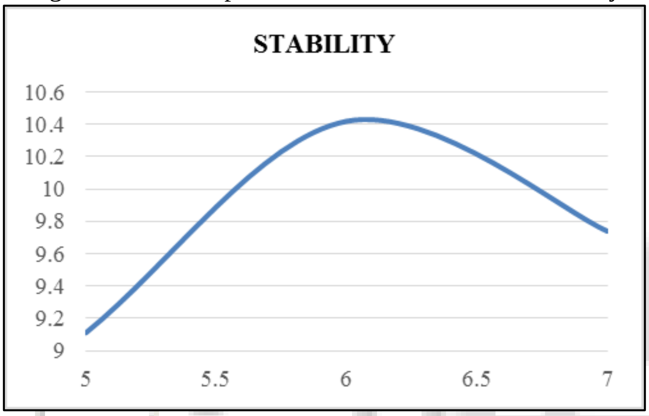

Figure 7: Relationship between binder content and stability

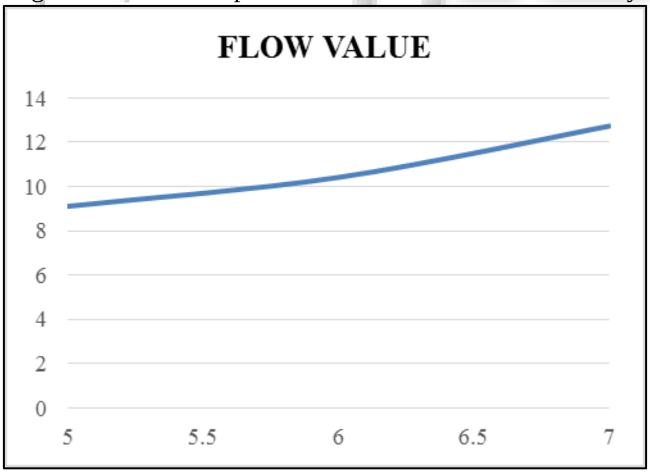

Figure 8: Relationship between binder content and flow value

XVI. RETAIN MARSHALL STABILITY

New binder formulation-1 (BOND-1)	Stability	Flow	New binder formulation-2 (BOND-2)	Stability	Flow
6%	5.93	3.04	6%	6.21	3.32

Table 8: Retain Marshall Stability

XVII. INDIRECT TENSILE STRINGTH

This test method determines the tensile strength of compacted bituminous mixtures. The tensile properties of bituminous mixtures are of interest to pavement engineers because of the problems associated with cracking. The tensile characteristics of bituminous mixtures are evaluated by loading the Marshall specimen along a diametric plane with a compressive load at a constant rate acting parallel to and along the vertical diametrical plane of the specimen through two opposite loading strips. The values of indirect tensile strength may be used to evaluate the relative quality of bituminous mixtures in conjunction with laboratory mix design, testing and for estimating the resistance to cracking. The results can also be used to determine the resistance to field pavement moisture when results are obtained on both water conditioned and unconditioned specimens.

XVIII. NEW BINDER FORMULATION (BOND-1)

New binder formulation-1 Percentage (%)	Loading (KGF)	Dia. Of mould (cm)	Height of mould (cm)	ITS value kg/cm^2
5	119	10.0	7.9	0.959
6	144	10.0	7.6	1.20
7	128	10.0	7.4	1.10

Table 9: New binder formulation 1 ITS value

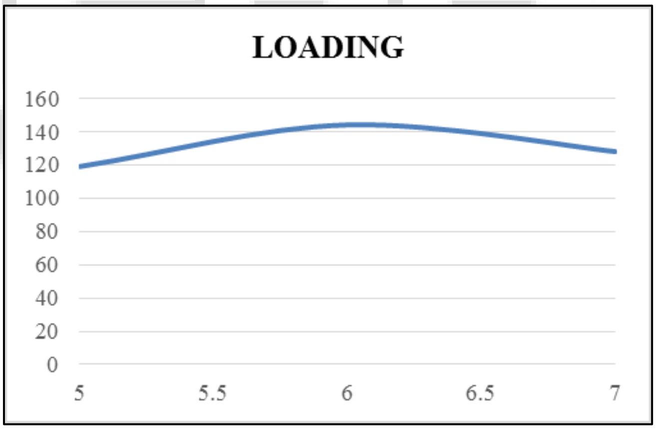

Fig. 9: Relationship between binder content and loading

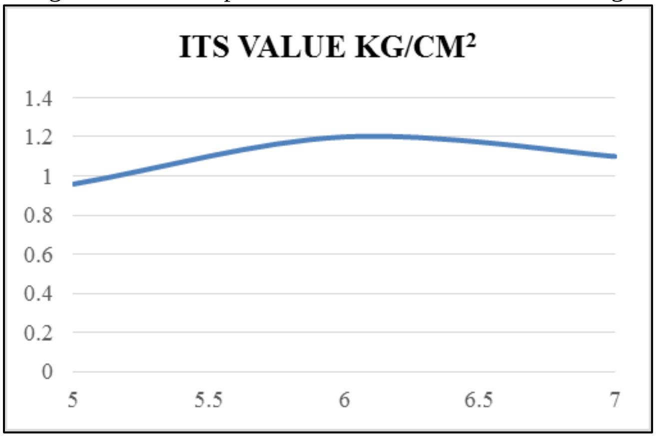

Fig. 10: Relationship between binder content and ITS value

XIX. New Binder Formulation (Bond-2)

New binder formulation-1 Percentage (%)	Loading (KGF)	Dia. Of mould (cm)	Height of mould (cm)	ITS value kg/cm^2
5	124	10.0	7.7	1.02
6	168	10.0	7.4	1.44
7	153	10.0	7.6	1.28

Table 10: New binder formulation 2 ITS value

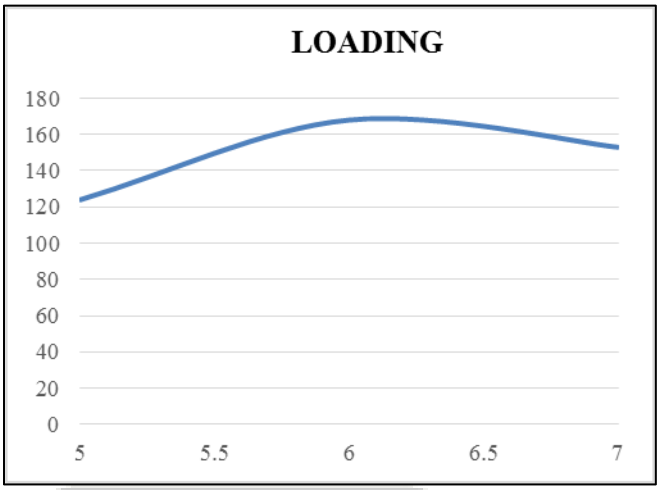

Fig. 11: Relationship between binder content and loading

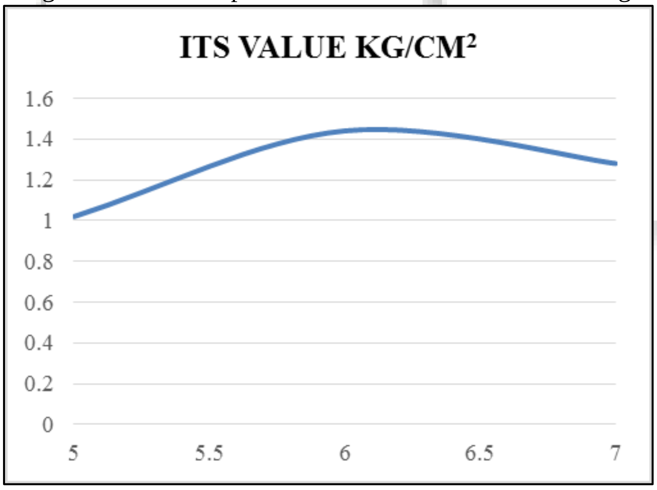

Fig. 12: Relationship between binder content and loading

XX. Wet Indirect Tensile Strigth

Bond-1	Loading	Dia of mould (cm)	Height of mould (cm)	ITS value kg/cm^2	Bond-2	Loading	Dia of mould (cm)	Height of mould (cm)	ITS value Kg/cm^2
6 %	126	10.0	7.7	1.04	6 %	144	10.0	7.6	1.20

Table 11: Wet ITS of BOND 1 and BOND 2

XXI. Experience for Trial Section

The issued was later supplemented with a secondary one which focused on experience gained by dedicated trial sections for the durability of various pothole repair materials. Detailed description of conditions at the trial sites, selection criteria and other accessible material data can be found. From the various trial sections the generic types could be evaluated according to their estimated durability.

Fig. 13: Pothole in NTPC badarpur

Fig. 14: Pothole repair in NTPC badarpur with coal mix waste aggregate

Fig. 15: potholes in CSIR-CRRI Campus

Fig. 16: potholes repair in CSIR-CRRI Campus with coal mix waste aggregate

There is need to implement a simple and effective method of repairing potholes not only during the monsoon but also throughout the year. This can be achieved by using the latest cold mix asphalt technology for producing and stockpiling readymade bituminous potholes patching mix. The generic cold patching mix meeting the specimen was produced on limited scale in New Delhi CSIR-CRRI during 2015 in winter. Potholes on NTPC Badarpur, New Delhi and some main streets of Delhi were patched with this mix.

Performance factor	Condition of patch repair works					
	7 days	15 days	21 days	1 month	3 month	6 month
Appearance	Very good	Very good	Very good	Very good	satisfactory	satisfactory
settlement	Nil	Nil	Nil	Nil	Nil	Nil
Raveling	Nil	Nil	Nil	Negligible	Negligible	Negligible
stripping	Nil	Nil	Nil	Nil	Negligible	Negligible
Bleeding	Nil	Nil	Nil	Nil	Nil	Nil
Unevenness	Nil	Nil	Negligible	Negligible	Negligible	Negligible
displacement	Nil	Nil	Nil	Nil	Nil	Nil

Table 12: Performance factor and condition of patch repair work

XXII. Conclusion

1) Physical properties of the coal mixed waste aggregates were found at par with natural aggregates. This indicated their suitability for road construction and maintenance of bituminous road works.
2) Mechanical properties such as Marshall's stability, indirect tensile strength, Retain Marshall stability, Wet indirect tensile strength, New binder formulation (BOND 1, 2) with coal mixed waste aggregates has to be satisfied according to MoRth 5th revision 2013.
3) Based on the above results and conclusions, the coal mixed waste aggregates are recommended for field trials to check their performance under traffic and weather conditions

Reference

[1] The Economic Times report dated 3 April 2013, "Stones in coal cost NTPC over Rs 11,000 crore per year"(http://articles.economictimes.indiatimes.com/2013-04 03/news/38248567_1_coal-india-ltd-gross-calorific-value-domestic-coal)
[2] Kandhal P.S. (2008), "Asimple and Effective Method of Repairing Potholes in India", IRC Journal.
[3] Anderson, D.A., et al. 1988. More Effective Cold, Wet-Weather Patching Materials for Asphalt Pavements, Federal Highway Administration, Report No. FHWA-RD-88-001.
[4] Carpenter, S.H. and T.P. Wilson. 1991. Evaluations of Improved Cold-Mix Binders—Field Operations Plan, Federal Highway Administration, Contract No. DTFH61-90-00021.
[5] Bitumen institute, a basic bitumen emulsion manual, 3rd edition, USA
[6] Arnold J. Hoiberg, Bituminous materials Volume II, John Wiley & sons Inc., New York 1965
[7] Paterson W D O. 1987. Road Deterioration and Maintenance Effects. Models for planning and Management. John Hopkins Press, Baltimore, USA.
[8] Robert F L. 1996. Hot mix Bitumen Materials, Mixture Design and Construction. National Bitumen Pavement Association. 2nd Edition.
[9] Federal Highway Administration (FHWA). 2003. Distress Identification Manual for the Long term Pavement Performance Program.
[10] Dr. Fixit Pothole Repair, Ready mix Water based Cold Bituminous Pothole Repair System, pidilite industries ltd., Andheri (E) Mumbai 400059, India.

