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A Move Towards Warm Mix Asphalt with RAP

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Abstract: **All the research and development being carried out in the field of roads in India is getting empowered from the potential of public infrastructure growth in the country. But the adoption and application of modern methods of construction and its actual success in implementation in real time construction projects is an area which is still open to a huge analysis. The paper is thus targeting this void between industrial and technological fields by presenting a case study of a company Ashoka Buildcon Ltd. which is one of the pioneers of new technologies in road construction in India. It also serves as a model for other companies in the country by successfully implementing them. Analysis of this advancement which marks the shift from conventional hot mix asphalt (HMA) method towards adoption of warm mix asphalt (WMA) technology, after successful incorporation of reclaimed asphalt pavement (RAP).**

1. INTRODUCTION

The advent of new technology has revolutionized the Indian Road Construction Industry. The three 20 year road plans so far have been very successful in connecting the far corners of this country. But at the dawn of 21st century as the environment became a rising concern this industry also underwent a change in its structure. All the new development started happening in order to protect environment. But it was only when technology provided environmental protection along-with economic incentive, did the industries start adopting the upcoming technologies. Ashoka Buildcon possess this vision to generate a win-win situation for all by adopting the new techniques and also benefiting from its successful implementation.

The company spotted the potential of milling technology in 2009 during Bhandara-Durg project and decided to employ milling machines to their upcoming projects. The first note-worthy implementation of milling and recycling of milled material as RAP in bituminous mix happened in Sambalpur-Bargarh Road Project (NH6). It is an 88.2km four lane (18m) road project. Incorporation of RAP reclaimed from milling in this project led to substantial savings in terms of time and cost.

After milling technology, the upcoming warm mix technology also was tested for its potential. Warm mix technology enables mixing, transporting and paving of bituminous mix at temperature lower than the conventional hot mix process and thereby leads to conservation of fuel and environment. Various warm mix additives such as Thiopave, Evotherm, etc. were considered. An admixture named Evotherm J1 was tested in May 2013 on DHK-KHP project site and its analysis was conducted.

This paper accounts for all these developments till date and produces the actual cost analysis for the same. Also a new approach of testing a warm mix additive along with a mixture of RAP and aggregates is pursued and analysed in this paper. Cost projections for this type of construction process are also made and its environmental benefits are specified.

Keywords**:** Hot mix Asphalt, Milling and Recycling, Profile Correction, Warm Mix Asphalt (WMA), Costing.

2. CONVENTIONAL HOT MIX ASPHALT PROCESS:

In conventional bituminous paving in order to achieve proper workability, the hot mix plants produces bituminous mix at temperatures more than 150 degree Celsius. Such high temperature require heavy fuel consumption and generate substantial emissions. Irrespective of its drawbacks, HMA is still the dominant process for road construction.

As Sambalpur-Bargarh project is our case of study; all the analysis is done on the basis of four lane road project itself. The effectiveness of each step towards modernisation in the construction process is determined on the basis of its economical as well as environmental impact.

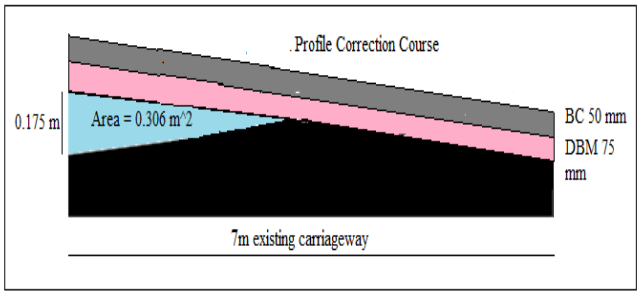


Fig 1: Method of construction by conventional process.

In the Sambalpur-Bargarh road project (NH6) as per conventional method the existing road surface of 7m was to be overlayed with DBM and BC layers along with camber correction and widening to 9.0 m. (As shown in the figure 1).

This type of construction is only permitted where no reconstruction is necessary. Over the stretch of this project the alignment of new road coincided with the existing road over a total stretch of 65.2 km. In the subsequent sections of this paper the methods that are analysed only affect the top two layers of highway pavement and those are Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC), hence quantitative details of only these layers (LHS or RHS) are taken in consideration.

2.1 Quantitative analysis for 9.0 m width of road by Conventional method

Average per meter quantity of aggregate required for DBM and BC layers conventionally					
Layer	**Thickness**	**Aggregate**	**Net density of layer**	**Quantity of aggregate**	**Quantity of Bitumen**
	(mm)	%	MT/cum	MT	MT
DBM @4.5%	75	95.5	2.45	1.579	0.074
BC @ 5.0%	50	95	2.5	1.0687	0.0562
			Net Total	2.647	0.1302

2.2 Profile correction Course (PCC) by BM (i.e. Bituminous Macadam) @ 3.5% bitumen.

Average per meter quantity and cost of filling by conventional method					
Filling type	**Area**	**Aggregate**	**Net Density**	**Quantity of Aggregate**	**Quantity of Bitumen**
	m^2	%	MT/cum	MT	MT
BM @3.5%	0.306	96.5	2.35	0.694	0.025

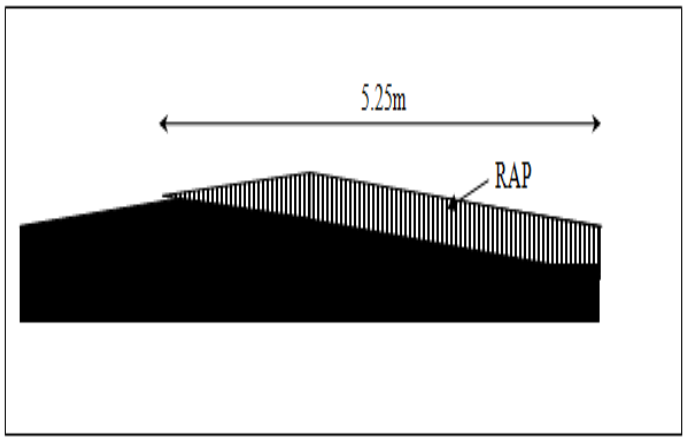
2.3 Cost Analysis:

Different cost arising per meter construction of four lane road without milling					
Cost incurred	**Rate**	**BC**	**DBM**	**BM**	**Total cost**
	Rs./MT				Rs.
Production cost	700.00	787.43	1151.50	503.30	2442.23
Transportation cost for 15 km lead @Rs 5 per km	75.00	84.38	123.38	53.93	261.68
Laying cost	125.00	140.63	205.63	89.88	436.13
Aggregate cost	325.00	347.33	510.58	225.55	1083.45
Bitumen cost	50000.00	2810.00	3700.00	1250.00	7760.00
Total Quantity		4169.76	5691.08	2122.65	11983.48

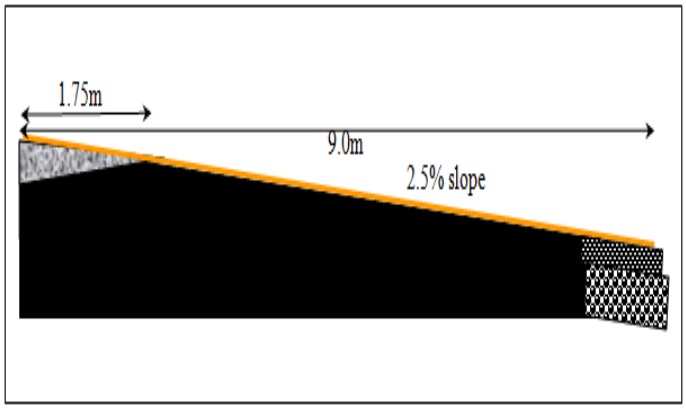
Cost per Rmt for existing road by Conventional method – Rs. 11983.48

3. OVERLAY BY MILLING AND RECYCLING:

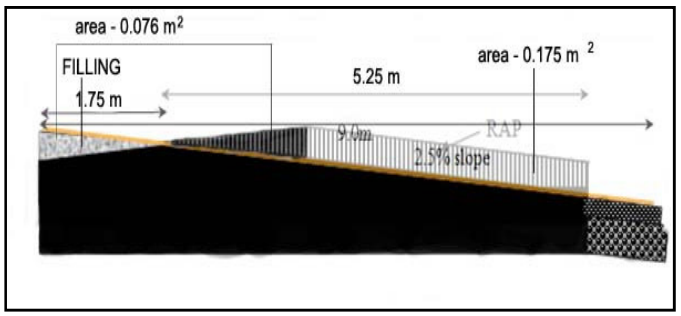
- The removing of existing road pavements to a desired depths without affecting the pavement is called a milling. The milling machine grinds road surface and generates milling material known as Recycled Asphalt Pavement (RAP).
- Milling technology is adopted for repairing, recycling and profile correction of road surfaces during maintenance and widening operations.
- Milling used for profile correction is as illustrated below :
  - Partial milling of existing road surface at 2.5% camber:



- New profile corrective coarse:



- Comparative cross section



- This leads to considerable saving of materials as well as energy consumptions leading to cheaper production costs and cleaner environment.
- Along with it the procured aggregate is also utilized in various percentages in different layers and consumed 100% minimising the requirement of virgin aggregate even further.
- With the modernisation in machineries, a next generation Hot Mix Plant are now available to incorporate RAP to produce Hot Mix Asphalt with incorporation of RAP.
- After milling the requirement of thickness of overlays is also reduced as the surface is well furrowed and in Sambalpur-Bargarh Project structurally it is possible to optimize the DBM layer thickness which further cuts down on production costs.

The detailed analysis of this technology incorporation in terms of costing is explained as below:

3.1 Quantitative Details:

Average per meter quantity of aggregate required for DBM and BC layers conventionally					
Layer	**Thickness**	**Aggregate**	**Net density of layer**	**Quantity of aggregate**	**Quantity of Bitumen**
	(mm)	%	MT/cum	MT	MT
DBM @4.5%	75	95.5	2.45	1.579	0.074
BC @ 5.0%	50	95.0	2.5	1.068	0.0562
			Net Total	2.647	0.1302

3.2 Profile correction course for milled area:

Average per meter quantity and cost of filling after employing milling.					
Filling type	**Area**	**Aggregate**	**Net Density**	**Quantity of Aggregate**	**Quantity of Bitumen**
	m^2	%	MT/cum	MT	MT
BM @3.5%	0.076	96.5	2.35	0.172	0.0062

3.3 Cost analysis:

Different cost arising per meter construction of four lane road with milling (which reduces profile correction quantity)					
Cost incurred	**Rate**	**BC**	**DBM**	**BM**	**Total cost**
	Rs./MT				Rs.
Production cost	700.00	787.43	1151.50	124.74	2063.67
Transportation cost for 15 km lead @Rs 5 per km	75.00	84.38	123.38	53.93	261.68
Laying cost	125.00	140.63	205.63	89.88	436.13
Aggregate cost	325.00	347.33	510.58	55.90	913.80
Bitumen cost	50000.00	2810.00	3700.00	310.00	6820.00
Total Quantity		4169.76	5691.08	634.44	10495.27

3.4 Cost incurred for milling :

Cost incurred	Rate per sq. MT	Quantity	Total amount
Cost of milling operation	55	5.25	288.75

3.5 Milling material Reclaimed per meter

Cross section area	Net Density	Net Quantity	Quantity of aggregate reclaimed	Quantity of bitumen reclaimed	Amount of Aggregate reclaimed	Amount of bitumen reclaimed
m^2	MT/cum	MT	@ 98 %	@ 2%	Rs	Rs.
0.251	2.45	0.615	0.602	0.0123	210.7	615

3.6 Cost of transporting the milling material

Cost incurred	Rate	Quantity	Total amount
Transportation charges for 15 km lead @ Rs 4 per km	600	0.615	36.9

3.7 Total cost per meter for milling and recycling method

Cost	Total amount
Cost for construction	10495.
Cost of milling operation	(+) 289
Cost of transportation of milling material	(+) 37
Cost of Bitumen Reclaimed	(-) 615
Cost of Aggregate reclaimed	(-) 211
Total amount for milling and recycling method	9995
Difference in cost as compared conventional method	1988.48

Net saving in material = 16.6%
Thus over the stretch of one kilometre net savings: 19, 88, 480.
Therefore approx. savings over 65.2 km of milled stretch of Sambalpur-Bargarh project: 12, 96, 48, 896.

4. WARM MIX ASPHALT

Warm mix asphalt (WMA) is a technology of preparation of paving mixes at temperature lower than that of conventional hot mix plants. The drop in the temperature ranges from 25 to 30 degrees. This drop reduces the fuel consumptions and also the greenhouse emissions caused due to both fuel burning and emissions from hot mixes prepared. The challenge is to facilitate proper binder coating over the aggregate at the targeted low temperatures. For this the viscosity of binder must be reduced by using external additives or specialised mechanical processes.

Three types of methods are mainly used for achieving this drop in viscosity:

- By adding organic additives to the binder
- By adding chemical additives to the binder
- By bitumen foaming technologies

A new approach of mixing WMA additive with RAP and virgin aggregate is tested with the help of Ashoka Highway Research Centre. An effort is made to incorporate RAP in DBM II layer. Mix design is performed as per Asphalt Institute Manual Series 2. The Marshall samples are casted and volumetric analysis is done to find out the properties and optimum binder content.

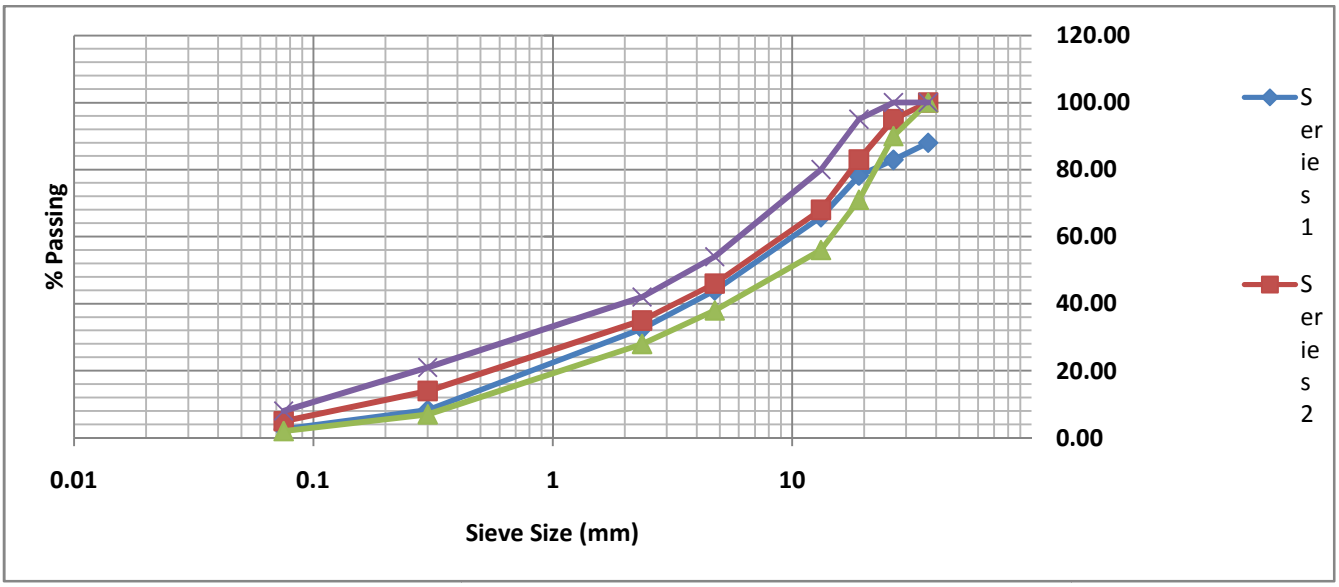
Job Mix Formulation for DBM Grade 2.

Following is the report of the RAP Gradation and Blending done for incorporation of 12% RAP.

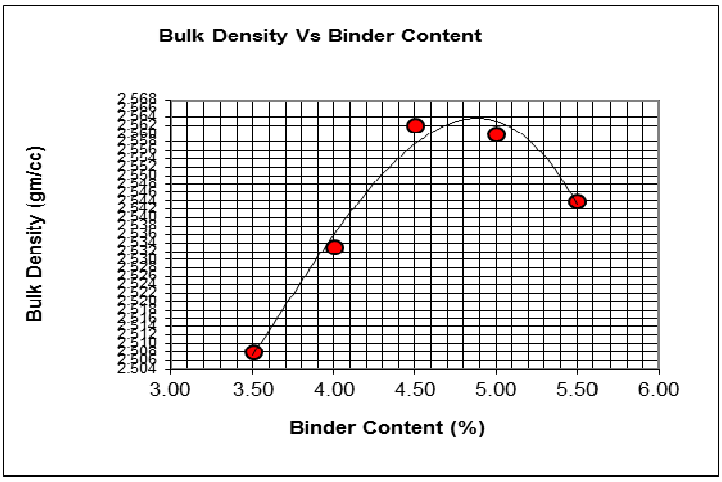
Percentage passing					
Sieve Size	**37.5mm pass - 22.5mm ret**	**22.5mm pass - 14mm ret**	**14mm pass -5mm ret**	**5mm Down**	**RAP**
37	100	100	100	100	100.00
26.5	36.47	100	100	100	95.18
19	2.17	90	100	100	83.10
13.2	0.34	28.96	100	100	58.17
4.75	0.24	0.47	19.33	99.8	24.31
2.36	0	0.38	2.03	80.04	12.77
0.3	0	0	0	20.61	3.76
0.075	0	0	0	6.37	1.43

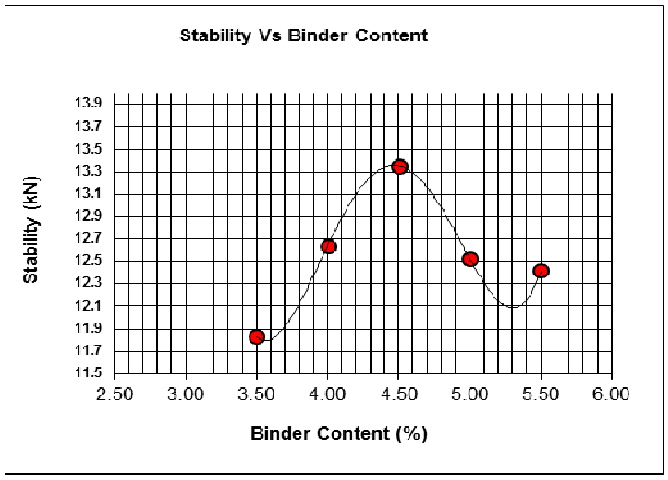
Blending								
37.5mm pass - 22.5mm ret	**22.5mm pass - 14mm ret**	**14mm pass - 5mm ret**	**5mm Down**	**RAP**	**Average**	**Mid limit**	**Lower limit**	**Upper limit**
8.00	20.00	20.00	40	12.00				
8.00	20.00	20.00	40.00	12.00	88.00	100.00	100	100
2.92	20.00	20.00	40.00	11.42	82.92	95.00	90	100
0.17	18.00	20.00	40.00	9.97	78.17	83.00	71	95
0.03	5.79	20.00	40.00	6.98	65.82	68.00	56	80
0.02	0.09	3.87	39.92	2.92	43.90	46.00	38	54
0.00	0.08	0.41	32.02	1.53	32.50	35.00	28	42
0.00	0.00	0.00	8.24	0.45	8.24	14.00	7	21
0.00	0.00	0.00	2.55	0.17	2.55	5.00	2	8

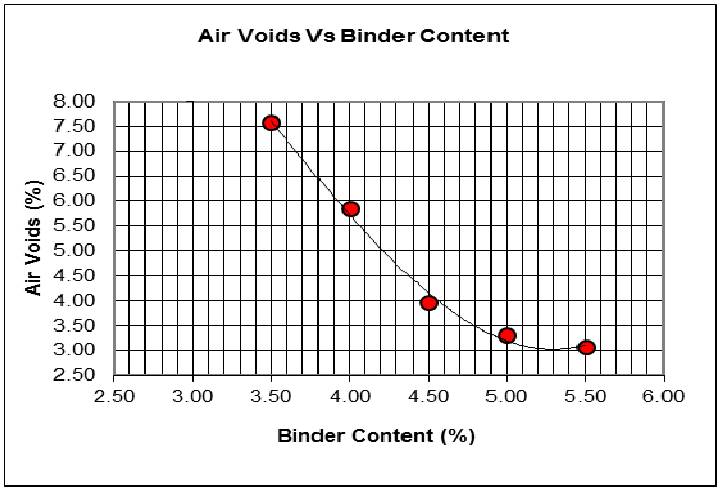
Gradation curve:

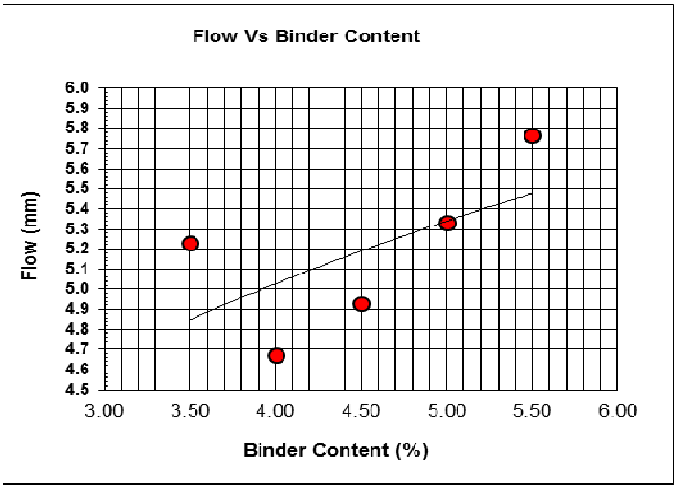


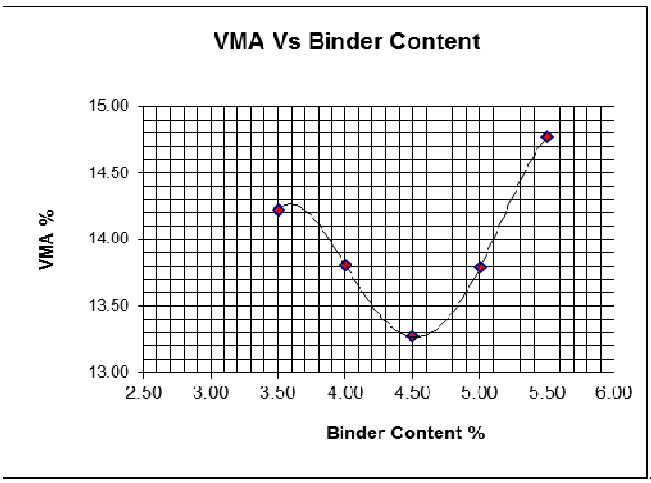
Marshall Stability Curves:

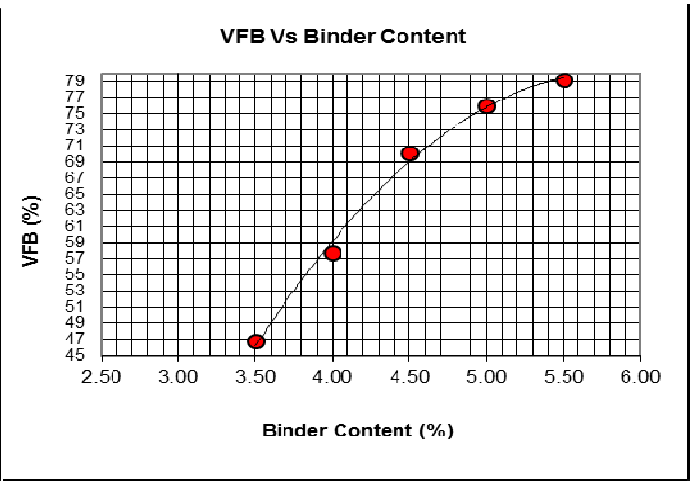












Optimum binder content – 4.5 %

Following is the report of moulds tested without using WMA additive and by using 0.5% WMA additive:

Mix Properties	DBM II with 0.5% WMA additive
Mixing Temp deg C	125
VG 30 Binder Content (%)	4.5
Average Bulk Density (g/cc)	2.567
Air voids (%)	4.22
VMA (%)	13.1
VFB (%)	67.81
Stability (kg)	16.34
Flow (mm)	4.27

Suitability of Warm Mix along with RAP can be concluded from the volumetric analysis

Apart from the material saving, there is saving in fuel consumption of about 10 to 15 % due to reduction in production temperature by 25 degrees using WMA additive. So if the above process is employed for any conventional road widening project, an approximate saving of about **20 %** can be achieved.

CONCLUSION

After analysing the processes thoroughly and taking into account all its benefits we may come to a set of conclusions;

- Significant cost saving in terms of energy, fuel consumption, material consumption.
- Incorporation of RAP helps in Borrow area conservation and reduction in dependency on virgin aggregates since huge quantity can be aggregates can be saved.
- It also mitigates the problem of disposal of bituminous mix generated through Milling.
- The adoption of above mentioned technologies targets the benefit of concessionaire as well as environment.
- All the three R's of conservation that are Reduce, Reuse and Recycle are followed to the fullest so it is in total an ideal process.
- India being a developing country, more and more roads will be subjected to widening in years to come and hence such it will be best to apply the above mentioned practices for all Highway as well as District Road widening projects.

5. ACKNOWLEDGEMENTS

I like to thank Ashoka Buildcon for giving me the opportunity to study the entire road construction process in detail and for all the co-operation of the staff. Also thanks to Ashoka Highway Research Centre for helping me in conducting the tests. My special thanks to my mentor Mr. Sanjay Londhe, CEO Ashoka Buildcon for his expert guidance throughout the entire process of this analysis and learning.

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