Cold-in-Situ Rehabilitation of Reclaimed Asphalt Pavement (RAP)

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ABSTRACT

Cold Recycling Technology (CRT) of worn out bituminous pavement is a relatively new technology which has important application in the road surface treatment and paving towards green highway. Due to economic and environmental constraints like reduction in construction cost, preservation of aggregate and binder, etc, more attention is turning towards recycling of bituminous surface as an alternative to conventional pavement rehabilitation. The objective of this paper is to analyze flexible pavement with insitu cold recycling technique using Reclaimed Asphalt Pavement Material (RAP) and Emulsion/Foam Bitumen. As a case study, pilot project Bilgram-Unnao-Allahabad section (SH 38) where cold recycling technique using reclaimed material and Emulsion/foam bitumen was used as a part of rehabilitation of flexible pavement instead of conventional overlay in order to achieve economy and executing within limited time period.

Reclaimed Asphalt Pavement (RAP) is the term given to removed and or / processed materials containing asphalt and aggregate. These materials are generated when asphalt pavements are removed for construction, resurfacing, or to obtain access to buried utilities. Recycling asphalt pavement makes both environmental and economic sense. The use of recycled asphalt pavement has grown widely, reducing the use of virgin materials. When properly crushed and screened, RAP consists of high quality, well-graded aggregate coated by asphalt cement.

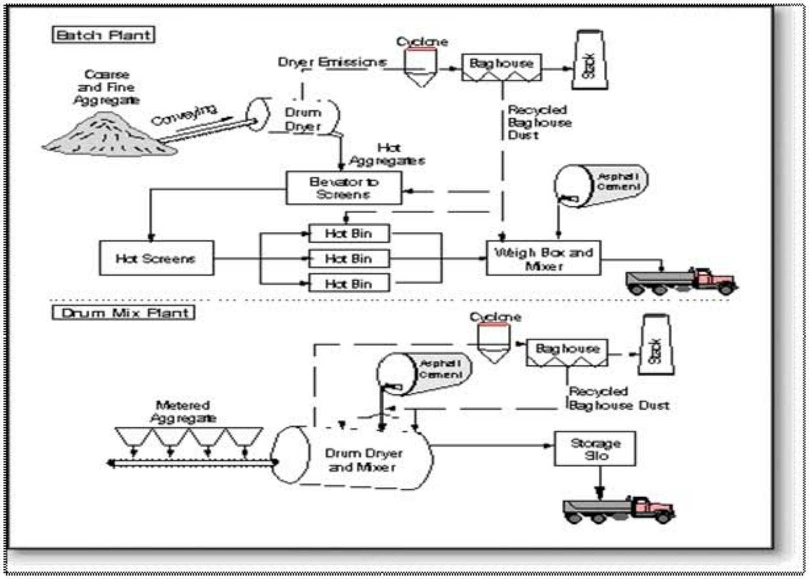
Reclaimed Asphalt Materials

Recycling of Reclaimed Asphalt, Pavements (RAP) is required to be used for technical, economical, and environmental reasons. The use of RAP also decreases the amount of waste produced and helps to resolve the disposal problems of highway construction materials.

Several recycling techniques, such as hot mix plant recycling, hot in-place recycling, cold mix plant recycling, cold in place recycling, and full depth reclamation, have evolved over the years. In-place recycling not only reduces the use of new materials but also reduces emissions, traffic and energy associated with the transport and production of these materials.

Hot Mix Recycling

It involves combining RAP with new or "virgin" aggregate, new asphalt binder, and recycling agents in a central hot mix plant to produce a recycled mix.

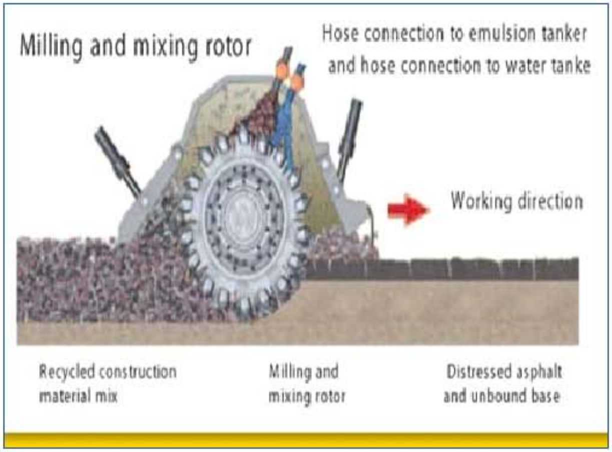


HMP

Cold Mix Recycling

Cold Mix Recycling is a method of recycling where RAP, new aggregate (if needed), and emulsified bitumen or foamed bitumen without the need of heat are mixed in a centrally located cold mix plant. Many old road alignment having thick bituminous layers are being abandoned in four and six laning projects and the entire RAP and aggregate can be salvaged by milling machine and reused in new construction.

CMP & Milling



Cold recycling also involves rehabilitation of the existing asphalt or granular road surface. The existing road surface is pulverized and the material is mixed on the site with foamed bitumen or bitumen emulsion. The process of in-situ recycling of distressed pavement using cold-mix technology is referred to as Cold In-Place recycling (CIPR). CIPR thus is a pavement rehabilitation measure that typically consists of the following operations:

1. Milling the existing pavement layers upto a depth of 300 mm.
2. Treatment with bitumen emulsion or foamed bitumen often in combination with addition of crusher dust, fresh aggregates if required, and a small percentage of active filler such as cement.
3. Adding water for compaction
4. Repaving the mix.
5. Compaction.

In a CIPR process, the top bituminous layer (Reclaimed asphalt pavement) as well as a part or whole of the granular or stabilized base layer are recycled. The residual binder contend added to the mineral aggregates in the process of CIPR is generally lower (< 4 percent) in comparison to hot bituminous mixtures. The recycled product is not used as final surfacing layer but used as base or sub-base layer.

Gradations of Aggregates

The aggregates from RAP may not have the required gradation and its CBR may be as low as 30 compare to fresh close graded aggregate having CBR as high as 200. Addition of crusher dust containing particle size from 6 mm to 0.075 mm and fines passing 0.075 mm (15 to 30 percent) and 1 percent cement or lime or both by weight of dry aggregates helps in dispersion of the bitumen emulsion in the mix. Lime modifies the clay that may have contaminated the RAP.

Gradation of RAP Mixes

Sieve size mm	Percentage passing
45	100
37.5	87 -100
26.6	77 -100
19	96 -99
13.2	61 -87
4.74	33 -50
2.36	25 -47
0.60	12 -27
0.30	8 -21
0.75	2-9

Bitumen Emulsion Type

Since the blend of RAP and crusher dust consists of plenty of fine particles, only slow setting emulsion (SS2) with minimum residual bitumen content of 60 percent is used. Foamed bitumen is produced by injecting water into hot bitumen resulting in instantaneous foaming.

Case Study

Bilgram-Unnao-Allahabad (SH-58) Ch. 71.00 to 85.00 in district Unnao of Uttar Pradesh was in very bad condition. Wide spread cracks were visible on the pavement. This project was selected for rehabilitation with Cold in Place Recycling (CIPR). Existing bituminous crust of pavement was 40mm. Total 75mm depth of pavement was recycled. Some stretch of road was reclaimed with bitumen emulsion and some stretch was reclaimed with Foamed bitumen.

Design

CBR	=	6%
MSA	=	20
Existing Granular Crust	=	395mm
Existing Bituminous Crust	=	40mm

Treated RAP	=	75mm
BC	=	40mm

Construction

The top bituminous layer was replaced by 75mm in situ cold mix recycled layer. The cold recycle mix consists of RAP material with addition of 1% cement, 15-20% fresh aggregate and 3.5% emulsion . The cold recycled mix was then compacted using heavy compactor to achieve required density. Finally wearing coat of 40mm BC was laid on top of cold recycled layer.

Distressed Pavement before rehabilitation

Distressed Pavement before rehabilitation

Construction work in progress

Road after completion of work

Significant Cost and material savings

Traditional removal and replacement of pavement ("mill & pave") involves pulverizing a significant portion of the old pavement and hauling it off-site, followed by replacement with new materials and asphalt. The costs of trucking and time to haul away the tons of old material, dumping fees to dispose it off and the cost of obtaining new aggregates and producing new hot-mix asphalt represent major costs for project. RAP reduces these costs significantly. On average, project can expect 15-25% cost savings compared with traditional pavement removal and replacement:

A comparative study based on this project shows a significant savings of 15% & 25% respectively, in material and cost, in comparison to conventional method of rehabilitation as depicted in graph.

Evaluation of Constructed Pavement

Construction of road work was completed in May, 2015. Inspections of road were carried out frequently to evaluate the condition and after construction performance. Road was found in good condition. No cracks were appeared in the pavement.

During the last inspection of road in October 2017, Deflections were calculated using Falling Weight Deflectometer. Layer moduli were calculated using KGPBACK programme. Using these, moduli strains were calculated at the bottom of bituminous layer and at the top of sub grade using IIT Pave. The results are as follows.

Field Deflection in micron mm

S. No	0	230	600	900	1080	1360	Pav.Temp	Season	Layer thickness in mm	
									Bit	Granular
1	343.47	146.76	52.22	28.21	23.88	20.20	33.20	winter	40	395
2	330.97	149.55	51.77	28.65	22.96	19.69	33.20	winter	40	395
3	333.39	149.52	52.85	28.61	24.49	18.24	33.14	winter	40	395
4	356.32	192.36	94.56	53.06	45.54	34.87	32.96	winter	40	395
5	353.52	189.88	93.21	51.59	43.96	32.23	32.28	winter	40	395
6	344.60	188.61	93.86	51.64	44.42	33.80	33.02	winter	40	395

Falling weight = 45 in KN

Normalised Deflection in mm

S. No	0	230	600	900	1080	1360	Pav.Temp	Season	Layer thickness in mm	
									Bit	Granular
1	0.305	0.130	0.046	0.025	0.021	0.018	33.20	winter	40	395
2	0.294	0.133	0.046	0.025	0.020	0.018	33.20	winter	40	395
3	0.296	0.133	0.047	0.025	0.022	0.016	33.14	winter	40	395
4	0.317	0.171	0.084	0.047	0.040	0.031	32.96	winter	40	395
5	0.314	0.169	0.083	0.046	0.039	0.029	32.28	winter	40	395
6	0.306	0.168	0.083	0.046	0.039	0.030	33.02	winter	40	395

Moduli Value(MPa)

S.No	Moduli Value from KGPBACK Program			Moduli Value after (Temp and seasonal correction)		
	Bit	GB	Sub	Bit	GB	Sub
1	1957.00	581.40	100.0	1809.2	446.4	86.7
2	1980.4	593.6	100.0	1830.8	453.7	86.7
3	1990.2	583.9	100.0	1835.2	447.9	86.7
4	1977.5	589.7	100.0	1809.4	451.4	86.7
5	1972.6	598.0	100.0	1753.2	456.3	86.7
6	1953.1	593.2	100.0	1791.7	453.5	86.7
15th Percentile moduli				**1782.0**	**447.5**	**86.7**

Strain as per IIT Pave

CBR =	6	E_t=	128.8	x 10^{-6}	Fatigue Life =	161.4 msa
MSA =	20	E_V=	421.0	x 10^{-6}	Rutting Life =	28.4 msa

Conclusion

RAP provides a higher strength parameter in terms of modulus of resilience & in turn it leads to saving in aggregate and saving in cost. This technique is environment friendly also as it consumes less aggregate, less energy & saves the natural resources.

It was observed that even after passage of 2 years, pavement was in good condition with no cracks anywhere and fatigue & rutting life were 242 MSA & 28.4 MSA respectively for 90% reliability against the designed traffic of 20 MSA, which implies that against the remaining period of 13 years of original design, the life of pavement even now since Oct 17 is 19 years.