

Research Status and Development of Plant Hot-mix RAP Technologies

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Recycling of old asphalt pavement is an important resource strategy

- Reclaimed utilization rate of old asphalt pavement is 75~100% in developed countries;
- Experience shows that performance of RAP is no less than new pavement;
- Reclaimed technologies are quite mature, there are no major technological barriers;
- RAP technology is a complete sets of technology, Dependent on the level of the milling, crushing, and mixing machines.

- ❑ In China, application experiences of reclaimed asphalt pavement technology are less, plant hot-mix reclaimed technology is similar to that of the asphalt mixtures mixing, which span small, and easy to implement;
- ❑ It's unsuitable to use hot reclaimed technology at the scene, for materials used in early asphalt pavement are uneven, and construction variability is great.
- ❑ Currently the number of the reclaimed asphalt pavement engineering is less, hot-mix reclaimed equipments at the scene are very expensive, and utilization is low. Plant hot-mix reclaimed asphalt mixtures equipments can produce general hot-mix asphalt mixtures at the same time, investment in equipments is recovery faster, and utilization is high.

Major problems

- ❑ Reclaimed equipment selection and improvement
- ❑ Performance evaluation of old asphalt pavement materials
- ❑ Composition design of reclaimed asphalt mixtures
- ❑ Performance evaluation of reclaimed asphalt mixtures
- ❑ Production quality management of reclaimed asphalt mixtures

回收料:
旧骨料
旧沥青层

新骨料
(热)

旧骨料 (温
度进一步提
高)
旧沥青
添加新沥青

新骨料
旧沥青
新沥青

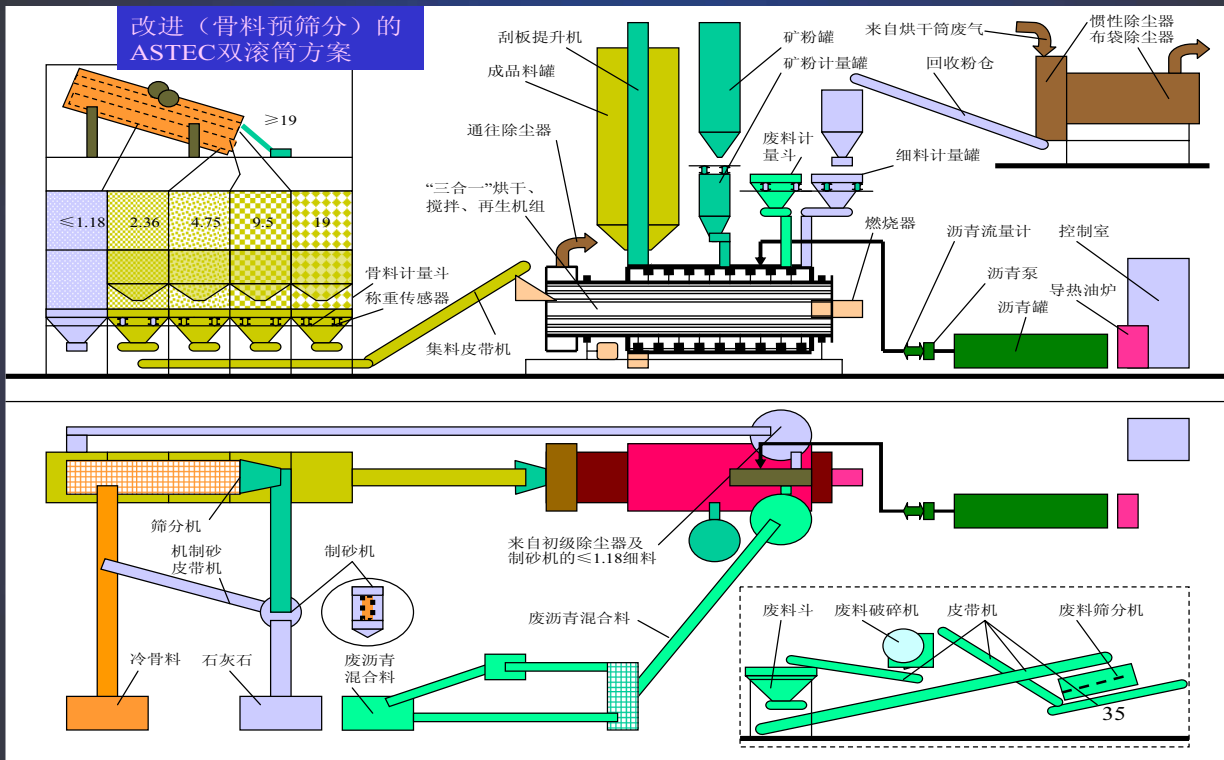
旧骨料
(温度逐
渐提高)
旧沥青开
始滴落

新骨料

旧骨料 (温
度提高到接
近新骨料)
旧沥青
新沥青
添加新矿粉

新骨料
旧沥青
新沥青

Continuous double-drum asphalt mixture mixing machine



Continuous asphalt reclaimed equipment with aggregate pre-screening

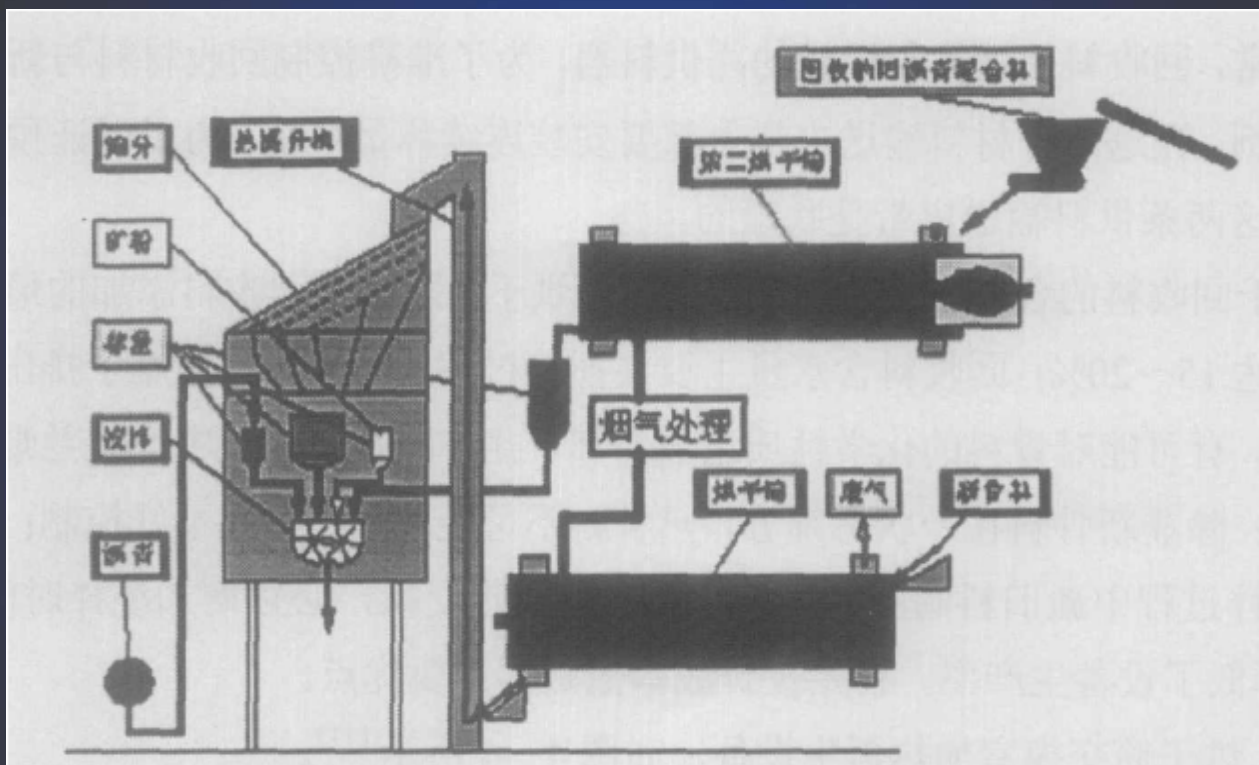
RAP stockpile sampling results

Item	Sample size	Maximum	Minimum	Mean value	Mean square deviation	Deviation coefficient (%)
4.75mm percent passing	6	20.9	19.6	19.8	1.15	5.8
0.075mm percent passing	6	6.7	5.8	6.3	0.34	5.4
Asphalt aggregate ratio (%)	6	3.77	3.99	3.88	0.07	2.0
Penetration	6	26	19	23	2.62	11.3

Deviation coefficients of asphalt aggregate ratio, penetration, 0.075mm percent passing and 4.75mm percent passing separately reduced from 10.1 to 2.0, 33 to 11.3, 26 to 5.4 and 10.7 to 5.8.



Reclaimed asphalt mixture mixing factory

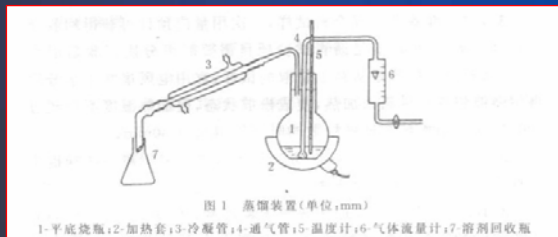


Methods selection:

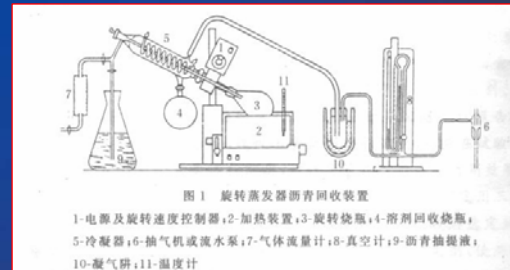
Rotary evaporation reclaimed asphalt variation coefficient of blank asphalt is between 5~20%, and reclaimed asphalt variation coefficient is between 38~69%.

Solvent selection:

Trichlorethylene, Dichloromethane, toluene, mixed solution of toluene and ethanol (20% ethanol)



Abson method



Rotary evaporation method

a) Black aggregates

When old asphalt content in the RAP is low, and aging degree is severe, old RAP material just as re-broken aggregates used in reclaimed asphalt mixtures. Performance and content of old asphalt can be not considered into materials design.

b) Part mixed

When RAP content is less, or old asphalt content in RAP is low and aging degree is severe, old asphalt performance effect on mixing asphalt performance can be neglected. In materials design, technical performance requirements of new asphalt should be main considered in addition to add the amount of old asphalt, use new asphalt technology performance control the design and construction of reclaimed mixtures.

c) Complete mixed

When RAP content is high, ratio of old and new asphalt is close in mixing asphalt of reclaimed mixtures, old asphalt performance in asphalt mixing plays an important role and affect mixing asphalt performance. Old asphalt and screening aggregates extracted from new asphalt, aggregates and RAP should be used as raw materials to design and produce reclaimed mixtures.

$$\lg P = a \lg A + (1 - a) \lg B$$

In the formula:

P—Harmonic asphalt penetration, 1/10mm;

A—Soft asphalt penetration, 1/10mm;

B—Hard asphalt penetration, 1/10mm;

a—Harmonic ratio, for soft asphalt quality percentage in the harmonic asphalt, %.

RAP content less than 40%

For high content of RAP, mixing formula may be shown by non-linear characteristics, it should be pay attention with application of linear mixing formula and charts.

Old asphalt A and AH-90 content performance indicators

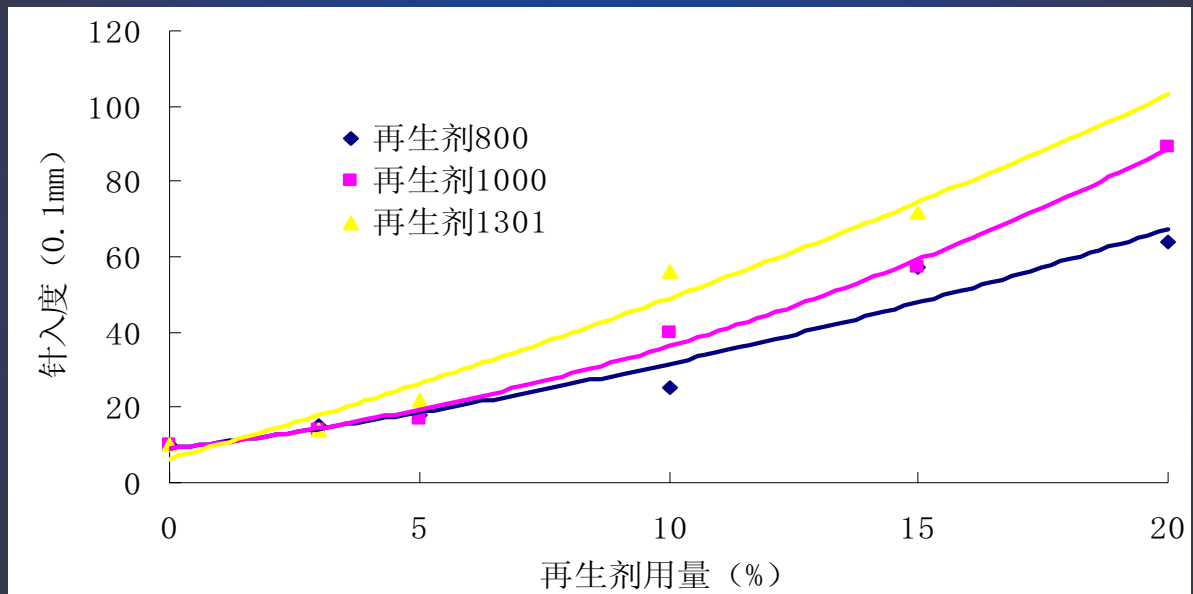
Old asphalt ratio	0%	9.86	20.7	40.3	80.0	100%
Performance indicators						
Penetration, 25°C, 0.1mm	85	65	48	33	14	9
Softening point, °C	44.1	45.5	47.5	55.4	67.2	76.5
Softening point, 15°C, cm	>100	>100	>100	>100	40	12
Harmonic calculation penetration	85	68	53	34	14	9
Harmonic calculation soften point	44.1	47.3	50.8	57.1	70.0	76.5

Reclaimed old asphalt PG performance compared

Evaluation index	Old asphalt	New asphalt	Mixing
Penetration, 0.1mm	33	61	53
Soften point, °C	57.0	47.8	50.0
15°C ductility, cm	13.9	>100	>100
60°C viscosity, pa.s	634	186	258
64°C before RTFOT	4.08	1.37	1.75
64°C after RTFOT	5.76	2.27	2.60
BBR m-value (-12°C)	0.347	0.349	0.340
BBR S-value (-12°C)	140	160	162
Remark:	accordance with PG64-22 standards		

Asphalt selection in reclaimed asphalt mixture

New asphalt suggestion grade	RAP content		
	Reclaimed asphalt grade		
	P ≥ 30	P=20~30	P=10~20
No change for asphalt selection	<20%	<15%	<10%
Select a new grade by half a grade level above normal, that is, penetration 10(0.1mm)	20~30%	15~25%	10~15%
Determine according to asphalt mixing harmonic principle	>30%	>25%	>15%



Reclaimed agent and asphalt A component

Testing materials	Saturated hydrocarbon	Aromatic hydrocarbon	Colloid	Asphaltene
800# reclaimed agent	8.06	86.14	4.10	1.70
1000# reclaimed agent	6.30	87.16	4.62	1.92
Old asphalt A	8.44	42.10	45.31	4.15

Reclaimed agent short-term aging performance

Asphalt content	Testing items	Before RTFOT	After RTFOT	Changes in percentage
Old 20%, 800#	Penetration	64	37	42%
	Ductility	>100	36.3	64%
Old 16%, 1000#	Penetration	61	39	36%
	Ductility	82.3	14.5	82%

Marshall method and Superpave method main design process:

1. Confirm mineral aggregate gradation of reclaimed mixtures;
2. Confirm RAP materials content;
3. Confirm each shelf new aggregate adding proportion according to RAP content and gradation;
4. Estimate mixing asphalt content according to RAP content and asphalt content, confirm adding new asphalt content;
5. Make different asphalt content samples according to estimation asphalt amount;
6. Carry out Marshall test or rotating compaction test;
7. Confirm optimum asphalt content, and check volume parameters of asphalt mixtures;
8. Validate high-temperature stability and water damage resistance ability of asphalt mixtures;
9. If necessary, evaluate the fatigue performance, low-temperature performance and aging resistance ability of asphalt mixtures.

Reclaimed mixtures road performance evaluation

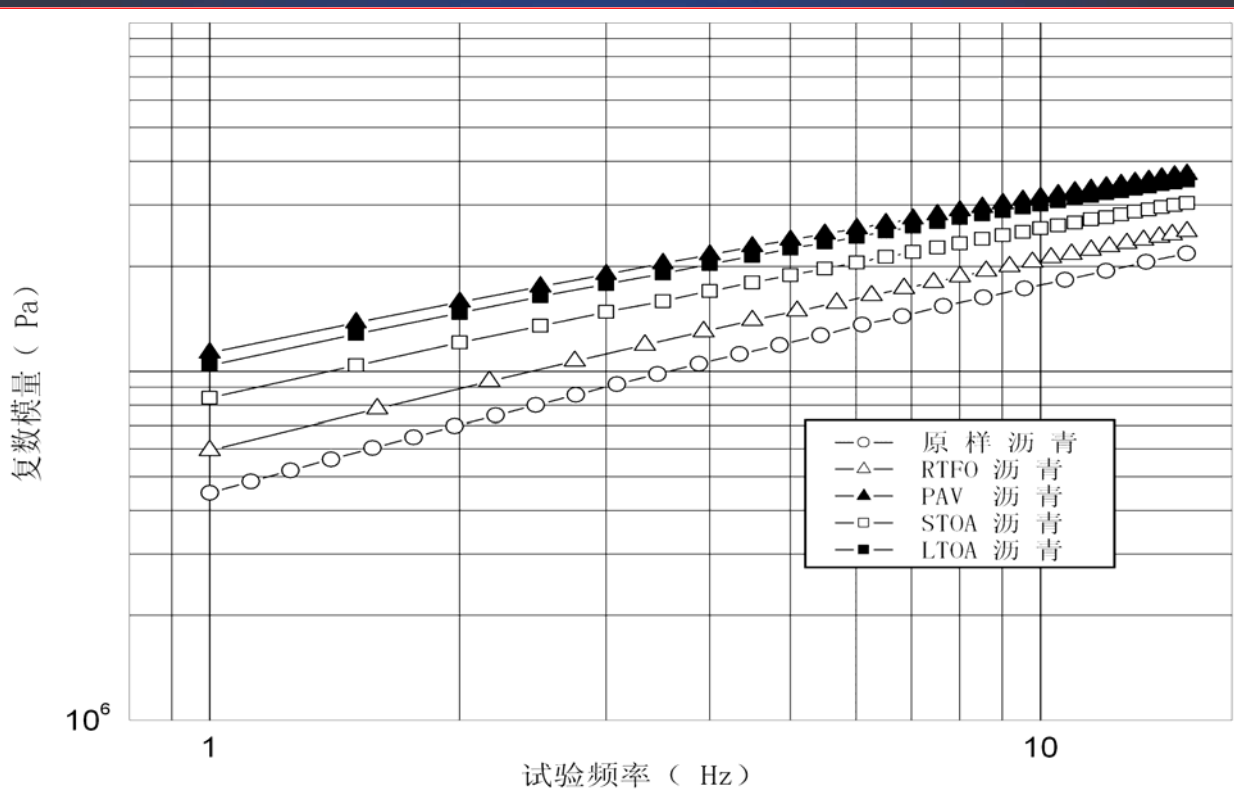
RAP content	0%	10%	20%	40%
Dynamic stability (time/mm)	1677.5	2251.0	2400.0	4864.5
Fatigue life (myriad time)	13.5	13.1	12.4	10.2
Low temperature stiffness (MPa)	2420	2509	2459	2694
Residual marshall stability (%)	73.94	72.05	71.75	74.34



RAP content	0%	10%	20%	40%
Fatigue life (myriad time)	13.5	13.1	12.4	10.2
Compared with new mixtures	—	-3.0%	-8.4%	-26.6%
Stiffness (Mpa)	12480	13677	15054	16907
Compared with new mixtures	—	9.6%	18.8%	29.4%

Original asphalt and original mixtures	Original asphalt is asphalt without any laboratory aging measures, and original asphalt mixtures are mixing mixtures without any asphalt mixture aging measures.
RTFO asphalt and RTFO mixtures	RTFO asphalt is original asphalt after short-term aging in the rotating thin film oven (Standard asphalt PG grade short-term aging method), RTFO mixtures are RTFO asphalt mixing mixtures without any asphalt mixture aging measures.
PAV asphalt and PAV mixtures	PAV asphalt is RTFO asphalt after long-term aging in the pressure aging vessel (Standard asphalt PG grade long-term aging method), PAV mixtures are PAV asphalt mixing mixtures without any asphalt mixture aging measures.
STOA asphalt and STOA mixtures	STOA mixtures are original mixtures forming after short-term heat oven aging, STOA asphalt is asphalt reclaimed from STOA mixtures by Abson method (Standard test methods of asphalt and asphalt mixtures T 0726-1993).
LTOA asphalt and LTOA mixtures	LTOA mixtures are mixtures from STOA mixtures forming after long-term heat oven aging, LTOA asphalt is asphalt reclaimed from LTOA mixtures by Abson method (Standard test methods of asphalt and asphalt mixtures T 0726-1993).

Asphalt type	Original asphalt	RTFO asphalt	PAV asphalt	STOA reclaimed asphalt	LTOA reclaimed asphalt
Penetration (0.1mm)	66	46	28	40	30
Penetration ratio to original asphalt	1	0.70	0.42	0.61	0.45



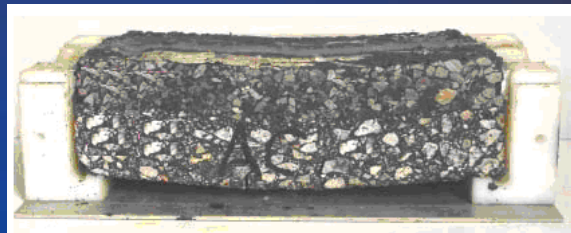
Aging reclaimed asphalt mixtures performance evaluation

Testing points	Rutting before aging (mm)	Rutting after aging (mm)
Reclaimed LSM-25	7.55	6.33
Reclaimed AC-25I	7.41	4.67
New mixtures LSM-25	7.06	6.66
New mixtures AC-25I	6.55	5.70



Re-aging track detection at the scene

Grouping		A	B	C	D	E	F
Construction time		03.5.10	03.11.29	03.4.19	03.11.21	03.7.3	03.11.27
New asphalt penetration		77	64	68	64	75	64
Reclaimed asphalt penetration		15	21	22	19	--	--
Calculation penetration		55.5	51.2	54.3	44.5	--	--
Calculation construction penetration		42.2	38.9	41.3	33.8	54.0	46.1
1st testing	Time	04.5.30	04.5.30	04.5.30	04.5.30	04.5.30	04.5.30
	Penetration	39	40	--	30	40	42
2nd testing	Time	05.7.10	05.7.10	05.7.10	05.7.10	05.7.10	05.7.10
	Penetration	29	55	34	33	30	40



Testing points	Fatigue life before aging	Fatigue life after aging
Reclaimed LSM-25	33552	57994
Reclaimed AC-25I	23424	114464
New mixtures LSM-25	16946	-----
New mixtures AC-25I	26185	109957

Plant hot-mix reclaimed technology popularized strategies

- ❑ Make clearly that plant hot-mix reclaimed is the main industrial policy
- ❑ Policy supports asphalt mixtures reclaimed
- ❑ Expand production scale of plant hot-mix reclaimed asphalt mixtures
- ❑ Improve production quality management level of reclaimed asphalt mixtures

Guangfo highway after overhaul

