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Comparative study on the materials of resistance to spall in the asphalt pavement

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ABSTRACT
Water damage phenomenon is widespread in our country, especially in southern rainy regions. This article adopts the method of indoor experimental comparison to study on road performance of a variety of spalling resistance material, like cement、quick lime、hydrated lime、amine、no-amine. The results found that: the comprehensive performance of quick lime as the spalling resistance material is better than other materials on the performance of overall road.
KEY WORDS- water damage, adhesion, the material of resistance to spalling, contrast test, road performance.

I. Introduction

Now whether ordinary or high grade asphalt pavement of asphalt pavement, water damage problems are common, especially southern rainy area and the frozen north in our country. Loosely peeling pumping pulp pit slot are common phenomenons of water damage [1]. Water seepage caused by voids of asphalt pavement is a key cause of the pavement water damage, however, if the adhesion of asphalt and aggregate very well, the road will not appear loose flaking phenomenon even if seepage. In 2005, 20% (more than 400 km of roads)of the asphalt highway 1100 km built in France was designed a big void fraction of drainage asphalt concrete pavement, but did not find the large-scale water damage phenomenon because of large voids.

According to the study that permeable capacity of asphalt treated drainage layer material by Hongbin Xie, Zukang Yao [2] have found: When water enters the interior of asphalt pavement, internal road will be a long time in a wet state, no matter how good drainage capacity of treated permeable pavement it is, peeling will loose inevitable if asphalt and aggregate have bad adhesion. Though damage caused by water seepage road is an important reason, not the root cause, the root cause of asphalt and aggregate adhesion is not strong. So as to prevent or mitigate water damage of asphalt pavement, the most effective method is to increase the asphalt and aggregate adhesion[3]. Mix the admixture in the asphalt (including foreign chemistry admixture or cement or lime admixture) is the most effective measure to improve the adhesion of the asphalt and the aggregate [4].

II. The raw materials

2.1 Asphalt

AH-70 asphalt is used for the asphalt test in this paper, namely heavy traffic volume label 70 road asphalt, about its performance indicators are as follows:

Project	Unit	Technical provision	Test result
Penetration（25℃,100g,5s）	1/10mm	60～80	69.8
Softening point Not less than	℃	46	47
Ductility （10℃） Not less than	cm	20	72.8
Dynamic viscosity (60℃) Not less than	Pa · s	180	250
Solubility （trichloroethylene ）Not less than	%	99.5	99.98

2.2 Aggregate

Aggregate use pebbles, the paper test uses 0~2.36mm, 2.36mm~4.75mm, 4.75mm ~ 9.5mm, 9.5mm ~ 19.0mm, 19.0 ~ 26.5mm five different particle aggregates, now its physical and mechanical indicators are listed below:

Particle size range	0～2.36mm	2.36mm～4.75mm	4.75mm～9.5mm	9.5mm～19.0mm	19.0～26.5mm
Apparent density	2.652	2.731	2.744	2.758	2.789
Natural packing	0.95	1.399	1.401	1.409	1.415
Water absorption/%	/	2.03	1.47	0.86	0.76
Flakiness content /%	/	/	4.2	4.1	3.7
Crushing value /%	/	/	/	10.2	/
Abrasion volume by Los Angeles rattler /%	/	4.0	5.4	/	6.5

2.3 Mineral powder

Mineral powder used in this paper is alkaline, it has milky white color and better gloss, its physical and mechanical properties are as follows:

Specific surface area，m2/kg	Density，g/cm3	Loss on ignition，%	Hydrophilic coefficient	Water content，%	Mobility ratio，%	Activity index，%	
						3d	28d
429	2.85	1.12	0.76	0.50	98	92	115

2.4 Antistripping material

2.4.1 Carlo amine（amines and non-amines）

"Carlo amine" are common materials used as antistripping special additives, which are mainly non-ionic surfactants, dark brown and a faint smell of sticky paste.

2.4.2 Cement

P.C32.5 cement is used in the paper, it contains 28% of slag addition, the indicators are as follows:

Project		China National Standard	Actual test results
SO3（%）		≤3.5	1.99
MgO（%）		≤6.0	1.80
CL-（%）		≤0.06	0.023
Fineness（%）		≤10.0	2.1
Setting Time （%）	Initial setting	≥45	281
	Final setting	≤600	336
3d	Flexural strength（Mpa）	≥2.5	3.8
	Compressive strength（Mpa）	≥10.0	17.9
28d	Flexural strength（Mpa）	≥5.5	7.3
	Compressive strength（Mpa）	≥32.5	33.4

2.4.3 Quicklime

Calcium quicklime is used in the test of this paper and it is premium grade, MgO content of 4.2%, effective CaO and MgO content of 80.0%, effective CaO of 75.8%, free water is 0.4% to 2%, 0.125mm sieve residue≤3%.

2.4.4 Hydrated lime

Effective CaO and MgO content of 70% hydrated lime, water content is 1% and its degree of fineness is good, 0.125mm accumulated retained percentage is 7%, first grade.

III. Proportioning of test scheme

The grade used in texts that involved in this paper is high-grade pavement beneath layers commonly used grade: AC-25C, the nominal maximum particle size of coarse asphalt concrete is 25cm, belongs to the suspended dense structure.

Test scheme is improved respcectively by 0.2%, 0.3%, 0.4%, 0.5%, 0.6% content of amines and non-amine anti-stripping agent, but by 1%, 1.5%, 2.0%, 2.5%, 3.0% content of cement and lime. Note: the percentage of mineral powder, quicklime, cement, hydrated lime is the proportion of mineral aggregate; volume proportion of non-amines and amine anti-stripping agent = The amount of anti-stripping agent/ The amount of asphalt.

Material / Program name	Quicklime	Hydrated lime	Cement	Amines	Non-amines
Improvement scheme 1	Asphalt +1.0% Quicklime +4.0% Mineral powder	Asphalt +1.0% hydrated lime +4.0% Mineral powder	Asphalt +1.0% Cement +4.0% Mineral powder	Asphalt +0.2% amines +5.0% Mineral powder	Asphalt +0.2% non-amines +5.0% Mineral powder
Improvement	Asphalt +1.5%	Asphalt +1.5%	Asphalt +1.5%	Asphalt +0.3%	Asphalt +0.3%

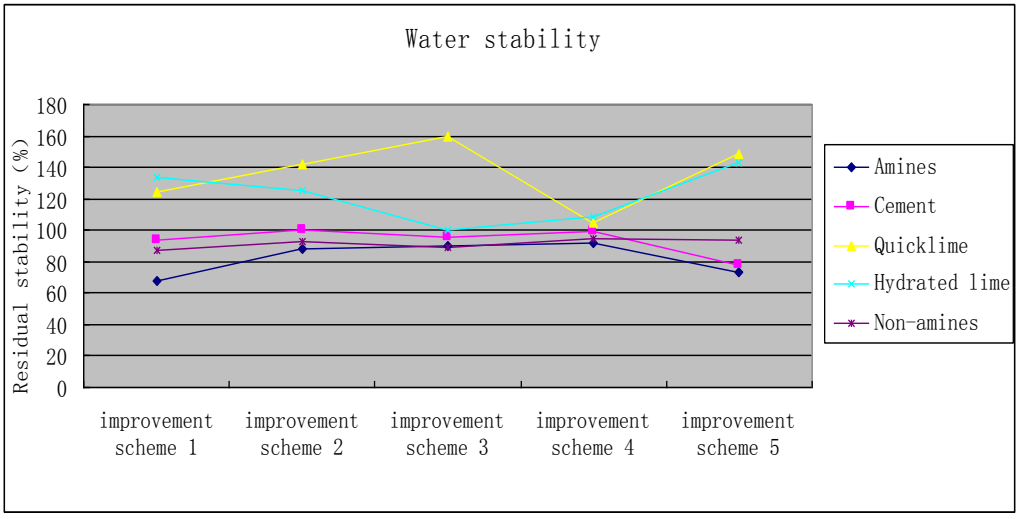
scheme 2	Quicklime +3.5% Mineral powder	hydrated lime +3.5% Mineral powder	Cement +3.5% Mineral powder	amines +5.0% Mineral powder	non-amines +5.0% Mineral powder
Improvement scheme 3	Asphalt +2.0% Quicklime +3.0% Mineral powder	Asphalt +2.0% hydrated lime +3.0% Mineral powder	Asphalt +2.0% Cement +3.0% Mineral powder	Asphalt +0.4% amines +5.0% Mineral powder	Asphalt +0.4% non-amines +5.0% Mineral powder
Improvement scheme 4	Asphalt +2.5% Quicklime +2.5% Mineral powder	Asphalt +2.5% hydrated lime +2.5% Mineral powder	Asphalt +2.5% Cement +2.5% Mineral powder	Asphalt +0.5% amines +5.0% Mineral powder	Asphalt +0.5% non-amines +5.0% Mineral powder
Improvement scheme 5	Asphalt +3.0% Quicklime +2.0% Mineral powder	Asphalt +3.0% hydrated lime +2.0% Mineral powder	Asphalt +3.0% Cement +2.0% Mineral powder	Asphalt +0.6% amines +5.0% Mineral powder	Asphalt +0.6% non-amines +5.0% Mineral powder

IV. Experimental study on pavement performance

Anti-stripping agent to improve the adhesion properties of asphalt and aggregate is well known, but all kinds of anti-stripping agent to enhance the adhesion of asphalt and aggregate comparison that how good or bad, as well as anti-stripping agent after adding other road performance changes like: high temperature stability, low temperature cracking resistance, fatigue resistance, need to explore and research.

4.1 Water stability

Water stability: This problem is solved by setting the Marshall stability test to calculate the stability of its residual flooding to evaluate the ability of asphalt mixture spalling resistance when subject to water damage, draw relevant graphics based on the data obtained are as follows:

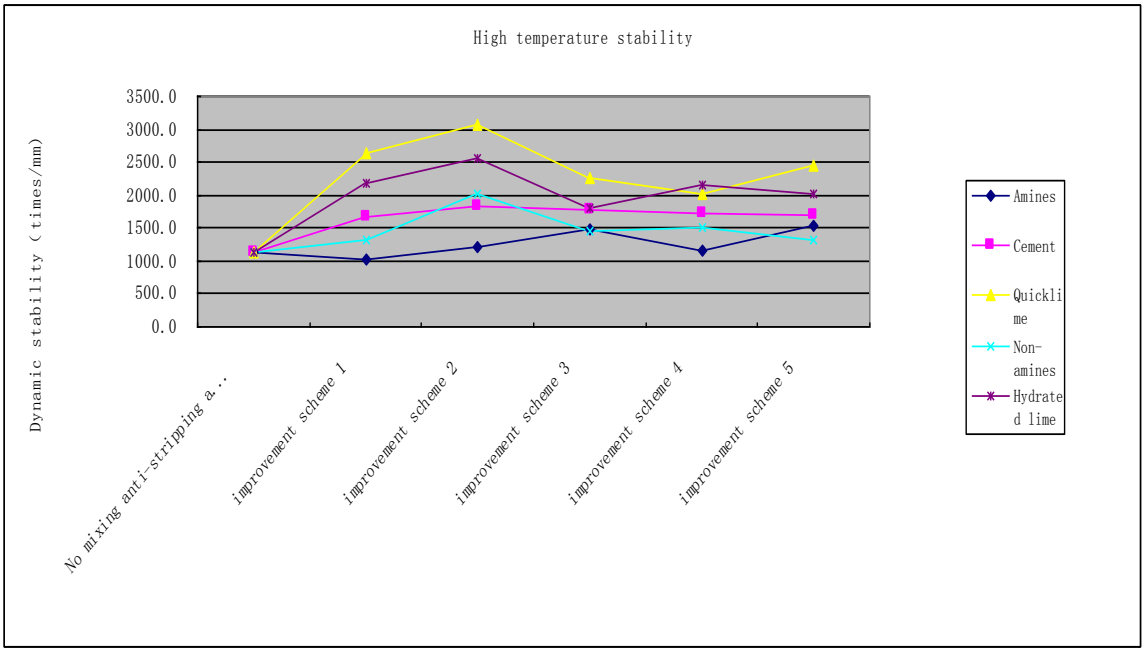


Relevant data from the residual stability can be seen: Overall, the water stability of quicklime is the best, followed by hydrated lime, water stability of cement is the third, chemical class-specific anti-stripping agent Carlo amine (amines and non-amines) are inferior to the above three

anti-stripping material in this respect, non-amine anti-stripping agent is better than amines; when quicklime uses the improvement scheme 3 that uses 2% instead of 2% of the mineral powder(quicklime and mineral powder's total dosage are 5%),it has the highest value of the residual stability; the graphic shows that 2% of quicklime instead of 2% of mineral powder is the best program of all kinds that anti-stripping agents to enhance water stability program which recommended in the actual construction process.

4.2 High temperature stability

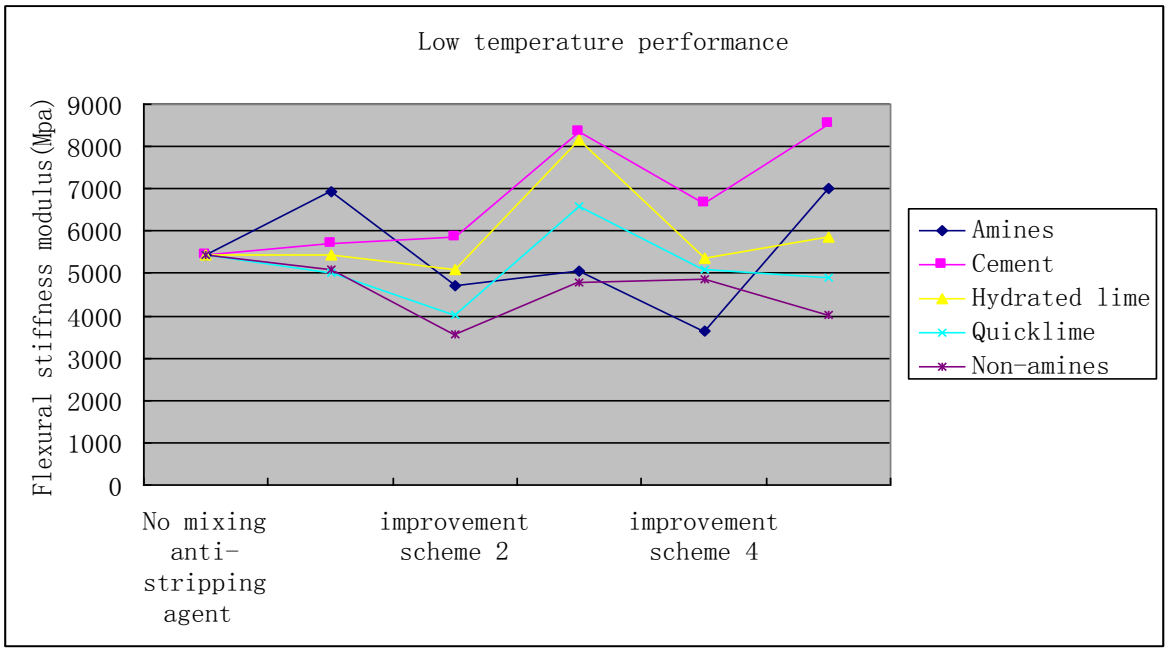
By setting rutting test, dynamic stability index is getted to assess the asphalt mixture's high-temperature rut resistance, to measure different anti-stripping programs' high temperature stability of asphalt mixture, a line chart below based on the relevant data:



From the above charts and graphics can be concluded that: 1, after adding anti-stripping agent, high temperature stability of asphalt mixture has been improved significantly than that of no mixing anti-stripping agent; 2, in general, the effect of high-temperature stability aspect, quicklime> hydrated lime> cement> Non-amines> amine; 3, by analyze five fold trend curve found that each class of anti-stripping agent have adopted respective programs 2 will to obtain optimal results, when use Carlo amine as anti-stripping agent, 0.3% of the content will be able to achieve the best performance at high temperature stability, when use cement as an anti-stripping agent, with 1.5% of cement instead of 1.5% of mineral powder (the total dosage of cement and mineral powder is 5%) to ensure high temperature performance of asphalt mixture to achieve the best, when use lime as an anti-stripping agent, with 1.5% of lime instead of 1.5% of mineral powder (the total dosage of lime and mineral powder is 5%), high-temperature performance of asphalt mixture would to achieve the best.

4.3 Low temperature performance

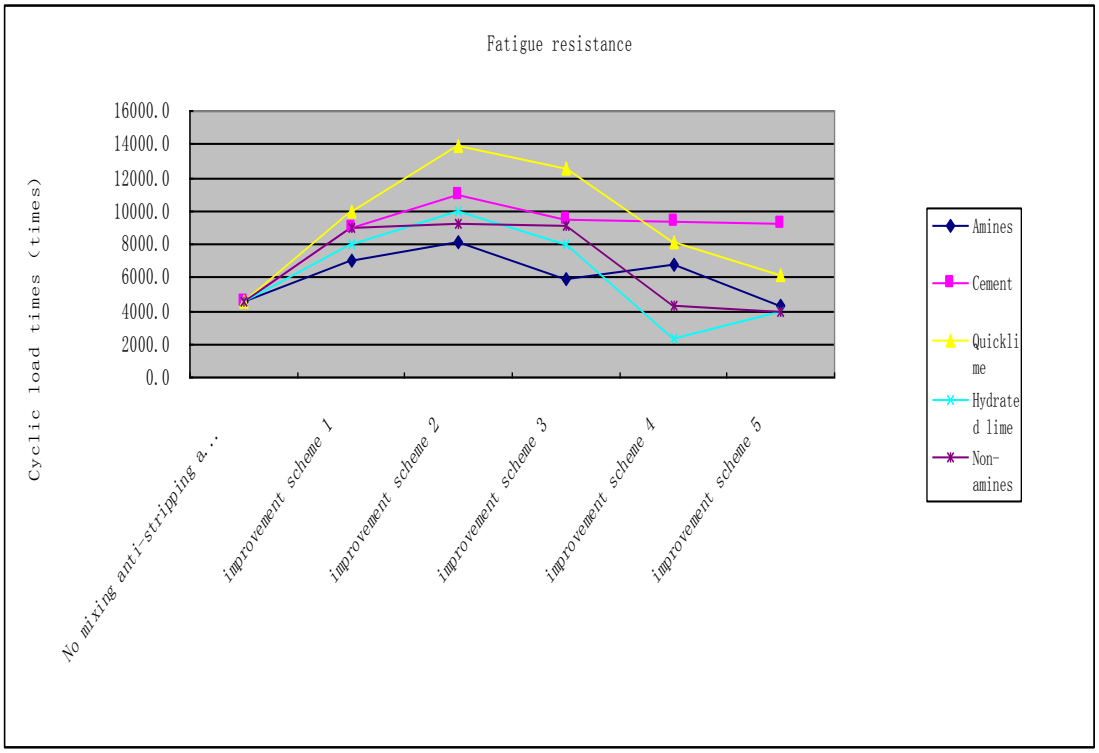
Flexural stiffness modulus is the most important indicator of performance that evaluation of asphalt mix at low temperature, by setting low temperature test to evaluate the performance of low temperature cracking of asphalt mixture. The obtained experimental results will generate a line chart below:



Generally believed that the flexural stiffness modulus of asphalt mixture Sb smaller shows that the low temperature crack resistance better, so from the above chart data can draw the following conclusions: 1, mixing cement or hydrated lime in asphalt does not improve low temperature performance, it will lead to deterioration of the low temperature performance; 2, but in the asphalt mixture mix quicklime or amine anti-stripping agent, whether it can improve the performance of low temperature cracking depends on the specific allocation scheme, such as the incorporation of 1.5% of lime or incorporated 0.5% of amine anti-stripping agent in the material, will significantly improve the low temperature performance of asphalt mixture; 3, for the non-amine anti-stripping agent, no matter what kind of blending program will improve the low temperature performance of asphalt mixture, especially when incorporate 0.3% of non-amine anti-stripping agent in it, the low temperature cracking performance greatly enhanced. Thus paving asphalt pavement at high altitudes or high cold regions, non-amine anti-stripping agent is preferable, the most suitable is 0.3%.

4.4 Fatigue resistance

Stress control is adopted to study fatigue resistance of asphalt mixture in this paper, UTM machine has been using to conduct dynamic creep test, pressure conditions for unidirectional lateral pressure, mold using clamps of splitting test, test specimens using standard Marshall compaction specimen, but need to replace parameters of creep test: Height of 101.6mm,diameter of 113.4mm, squeeze time test is 1 min, pre-pressure of test is 10KPa, test temperature is 15℃, stress ratio of 0.4, applied load is sine electromagnetic wave pulse , the pulse time is 0.1S, interval 0.9s.In the test, the stress due to the use of a controlled manner, a great linear relationship between strain and fatigue damage, and the strain increases with the increase of the number of loading cycles, so the fatigue damage will also increase with the number of loading cycles increasing ,when they reach a certain number of times, the specimen will be broken, but this time the number of cycles can be regarded as the fatigue life of the material. The result data is made below the line chart:



It can be seen from this figure: 1, overall fatigue performance comparison, quicklime> cement> hydrated lime> Non-amine> amines; 2, no matter what kind of anti-stripping agent, what kind of scheme, fatigue resistance of asphalt mixture performance can be enhanced to a certain extent (in addition to improvement scheme 4 of non-amine anti-stripping agent); 3, when using improvement program 2 of quicklime (1.5% instead of 1.5% of mineral powder used as an anti-stripping agent), the asphalt mixture's fatigue performance will reach a maximum.

V. conclusion

As can be seen by the above test, can find that antistripping agents not only enhance the stability of asphalt mixture of water, and some anti-stripping agents can significantly improve other road performance of asphalt mixture, such as high temperature stability and low temperature performance. Based on the above results can be seen: the overall road performance, quicklime is better than hydrated lime, hydrated lime is better than cement, the cement is superior to non-amine anti-stripping agent, and amine anti-stripping agent to be inferior to the combined effect of the above four materials; when the paved road in the rain-fed areas improvement scheme 3 of quicklime is the best choice(with 2.0% of quicklime instead of 2.0% of mineral powder used as an anti-stripping agent), when the pavement in a larger temperature difference region, recommended to adopt improvement scheme2 of quicklime (with 1.5% of quicklime instead of 1.5% mineral powder used as an anti-stripping agent).

It should be noted that anti-stripping agents also has some rock compatibility, in the actual construction select the optimal blending solution which should consider various factors like climate, geology, cost and so on.

References

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