FUNCTIONAL METHOD OF USING THE NANO LIME IN THE PROPERTIES OF RECYCLED COLD ASPHALT MIXTURE WITH BITUMEN EMULSION

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ABSTRACT

The additives that are in micro dimensions have been mostly used so far in the preparation of emulsion asphalt in Iran. The use of nanoparticles has been less examined in asphaltic mixtures. The urgent need to prepare asphalt from recycled materials can be felt due to limited resources of the materials required for the production of asphalt. On the other hand, the use of cold asphalt with bitumen emulsion has been more considered in recent decades because of high price of fuel and decrease of the amount of environmental pollutants and energy resources limitation. We should inevitably use additives to enhance the quality, durability and strength of the prepared mixture because of applying recycled materials and bitumen emulsion in the preparation of cold asphaltic mixtures. The possibility of using lime nanoparticles in the prepared mixture of emulsion asphalt were examined in this research according to the results of a research laboratorial work and use of Marshall modified design method.

KEY WORDS
cold recycling, bitumen emulsion, nano lime, asphalt mixture

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INTRODUCTION

Roads network constitutes a significant part of the national wealth of each country. Road plays a major role in the field of communications that are tool of economic, cultural and social development of human societies. Building and construction of new roads, as well as repairing and maintaining the existing roads allocates significant amounts of cost to itself every year. The topics of study, design, implementation, control and maintenance of roads pavement has a particular importance in advanced industry of road-construction. If each of above factors are not considered appropriately pavement will be quickly damaged against atmospheric factors and loading caused by traffic. It will cause on the one hand a depreciation of the initial investment. It will increase the repair and maintenance costs and on the other hand decrease of safety and driving comfort and imposition of additional costs because of the vehicles depreciation. So some measures should be always considered to increase the durability, quality and life of pavement and prevent early failures. Asphaltic mixtures of the final layer of pavements are flexible and under the direct influence of destructive effects of atmospheric conditions and stresses caused by traffic loads etc. Therefore, the use of factors to improve the mechanical and functional properties of asphaltic mixtures, as well as reducing the cost of building and maintaining them seems logical affair. Today, the use of nano materials in asphaltic mixtures to increase their strength and durability against atmospheric conditions and loading conditions in developed countries for optimal use of resources and national capitals is a customary affair.

Increase of durability and improvement of the function of asphaltic mixtures because of significant costs that annually are spent from the country's construction budget to repair and maintain the existing roads is essential affair according to the above cases. For this purpose, examination of strategies that can lead to improvement of function of asphaltic mixtures and increase of their durability, reusing the existing old surfaces and modifying their bitumen can greatly help to solve the problem. Also, the creation of permanent deformations on the route of the wheels passing that is terminologically called groove is also of the common destruction in asphalt pavements. This causes problems for road users and reduces quality of road and quality of driving, and also causes the accumulation of water in them and creation of hydroplaning phenomenon and reduction of the level of road safety.

So if the existing asphaltic surfaces that have been destroyed can be recycled and improve the final resistance of asphaltic mixture by using additives, we have highly helped to improvement of quality of the existing surfaces, increase of safety and saving in construction costs and preservation of the existing resources It has been tried in this research to evaluate the role of nano lime substance and bitumen emulsion in improving Marshall Resistance of recycled asphaltic mixtures, and thus improving its function against destructions by using Marshall Resistance measurement device.

Objectives and definitions

The aim of this research is to find a strategy for preparation of asphaltic mixtures with better function and longer useful life by using additives that firstly are produced domestically and secondly are consistent with the asphaltic mixture. If nano lime effect is positive on improving function of asphaltic mixture, it can be used as an option for recycling and reconstructing asphaltic pavement layers in areas with heavy traffic loading cause early destructions in asphaltic surface layers or for the areas that there is no access to suitable stony materials for reconstruction of the existing surfaces.

Also, adding lime to asphalt nano if it has positive effect can be economical in terms of cost of roads repair and maintenance and also be effective in preserving the country's natural resources that are non-renewable resources given that the costs of roads repair and maintenance have a high figure in most

countries. The main objective of this research is to evaluate the effect of two independent variables: bitumen emulsion and nano lime on the function of the dependent variables of recycled cold asphalt mixtures.

Bitumen emulsion

Bitumen emulsion is obtained by mixing bitumen and water with an emulsifier substance. Bitumen is floating in the water in this mixture with dimensions of 1 to 10 microns. Water constitutes the continuous phase and bitumen constitutes the suspended and discontinuous phase of this mixture. Bitumen emulsifiers create an electric charge (positive or negative) in the surface of bitumen particles. The repulsive force resulting from namesake charge prevents interconnection of bitumen particles in bitumen emulsion.
The amount of bitumen in bitumen emulsions is from 55 to 65%; amount of water from 35 to 45%, and bitumen emulsifiers constitutes maximum 0.7% of bitumen emulsion weight. Bitumen emulsions can be used for the preparation of a variety of hot and cold factory asphalt and / or mixture in place, superficial asphalt, bituminous coatings, crack filling and sealing asphaltic surfaces, soil and sand stabilization, dusting, etc.
It does not usually need to heat bitumen emulsions for using them, so they are superior to other types of bitumen in terms of economy and safety. Bitumen emulsions mixing with wet aggregates and / or spreading bitumen emulsion on wet sandy and / or asphaltic bottom of road does not have a negative effect on bitumen emulsions' function. Bitumen emulsions are considered the best and most economical alternative for dissolved bitumen environmentally and economically, because:

* Energy consumption for heating them is far less than the dissolved bitumen.
* Only water evaporates in bitumen emulsions instead of evaporation and sublimation of petroleum solvents existing in dissolved bitumen and their dissemination in the environment that cause severe pollution.
* Cost about 20 to 50% weight of petroleum solvents existing in dissolved bitumen is far greater than the cost of emulsifier substance in bitumen emulsions in the current situation of energy crisis.

Bitumen emulsions are divided into two main groups and other sub-groups as follows according to the particles created in the surface of bitumen floating particles:
The bitumen particles' surface is negatively charged by using emulsifiers of organic acids' alkaline salts type. These bitumen emulsions are called anionic. They are divided into four types of fast setting, rapid setting, medium setting, and slow setting as following [Table 1] that each has subdivisions:

Table 1: Subgroups of anionic bituminous emulsions

Rapid setting (RS)	Medium setting (MS)	Slow setting (SS)
RS-1	MS-1	SS-1
RS-2	MS-2	SS-1h
HFRS-2	MS-2h	
	HFMS-1	
	HFMS-2	
	HFMS-2h	
	HFMS-2s	

The above suffixes and prefixes have the following meanings:
(A) HF prefix represents the bituminous coating with greater thickness on aggregates.
(B) Suffixes 1 and 2 represent the percentage of less and more pure bitumen in bitumen emulsions, respectively.
(C) H suffix represents the use of harder pure bitumen (less penetration grade) in bitumen emulsions.
(D) S suffix in HFMS-2s medium setting bitumen emulsion is the indication of diluted pure bitumen with a minimum penetration grade of 200 in bitumen emulsion.

MATERIALS AND METHODS

Marshall modified method is used according to ASTM-D1559 or AASHTO T245 that is different from hot asphalt design method for cold recycling asphalt plan with bitumen emulsion. The scope of using this guideline is limited to the mixtures that bitumen emulsion or rejuvenating emulsions conforming to ASTM-D5505 specifications, RAP materials (Reclaimed Asphalt Pavement) and, if necessary, new stony materials are used for preparing them.
The amount of emulsion used in this method ranges usually from 1% to 2% and rejuvenating emulsions from 0.5% to 1.25% compared to bituminous mixture weight. The greater values are for the mixtures that the percentage of its crushed stony materials is high and the amount of bitumen existing in it is less. The low percentages are used for the mixtures with high amount of fine grain and round-corner.
The rejuvenating emulsions are not used while the percentage of bitumen emulsion should be increased when new stony materials are added to RAP.

Marshall Test

(A) Samples are placed in an electric furnace and with temperature heat test of 25 degrees for 2 hours. Avoid placing the samples in bath water.

(B) Marshall resistance of the samples is measured according to the relevant clauses in ASTM-D1559 and / or AASHTO T245.

(C) Maximum weight specific for recycling mixture designed by using AASHTO-T209 method is measured for each of the percentages of bitumen emulsions and / or rejuvenating emulsion and / or ASTM-D2041 and the samples' empty space is calculated.

(D) Four series with three samples, each series with a total amount of water of 2, 2.5, 3, 3.5, 4% follow as equal calculation in row (C) of sub clause (3-4-4) are prepared in optimum bitumen percentage. Then the empty space is calculated follow as the above row (C). Thereby optimum water percentage is obtained in optimum bitumen percentage.

(E) Sensitivity test of the designed mixture against moisture in optimum bitumen and optimum mix water is performed according to AASHTO-T283 method. Ratio of saturation resistance to dry resistance is calculated.

Stony materials and bitumen emulsion tests used in research

The used tests of gradation, technical specifications, percentage of bitumen and bitumen emulsion that are needed for designing recycled asphaltic mixture were performed on bit-asphalt samples obtained from milling machine as well as MS1 medium setting anionic bitumen emulsion.

Tests conducted on RAP materials include

- Sand Equivalent Test was conducted by using standard AASHTO- T176. The result of this test was obtained 70%.

- Determination of fracture percentage was done by considering at least two broken aspects of grains remained on sieve of $\frac{3}{8}$ inch. The used RAP materials had fracture of 76%.

- Los Angeles abrasion test was conducted in 500 rounds according to ISO AASHTO- T96 to determine estimation of aggregates' resistance against abrasion. The level of grains' abrasion in 500 rounds is 31%.

- Materials water absorption test was conducted in AASHTO-T104 method. The amount of water absorption of materials was obtained 2.15%.

- Weight loss test with sodium sulfate in 5 cycles that its amount was obtained 3.4% for the used materials.

- It was specified that these material do not have plastic properties to determine the plasticity indication of the used materials according to standard AASHTO-T89 and AASHTO-T90.

RESULTS AND DISCUSSION

Results of the tests conducted on RAP materials have been summarized in the following [Table 2].

Table 2: Test results of technical specifications of lathed asphalt

Test	Specifications-Percentage	Results obtained from lathed asphalt
Sand Equivalent	Minimum 35	70%
Abrasion with Los-Angeles test in 500 rounds	Maximum 40	31%
Fracture	Minimum 50	76%
Water absorption	Maximum 3	2.15%
Weight loss with sodium sulfate in 5 cycles	Maximum 12	3.4%

RAP materials gradation was done by using AASHTO-T27 after washing. Its results are as the following [Table 3].

Table 3: Results of lathed asphalt gradation test

Sieves	Bit-asphalt materials	Allowed tolerance according to Table (3-4)
38 mm	100	100
25 mm	100	
19 mm	97.5	
12.5 mm	96	
9.5 mm	92.6	
4.75 mm	81.5	25 – 85
2.36 mm	54.5	
1.18 mm	36.3	
0.3 mm	15.5	
0.15 mm	12	
0.075 mm	7	3 – 15

Table 4: Test results of bitumen extracted from lathed asphalt

Test	Implementation method	RESULTS
Penetration grade bitumen at 25 ° C (0.1 mm)	AASHTO T 49	10
Softening point (C)	AASHTO T 53	71
Bitumen viscosity (cm Stax)	AASHTO T 201	7.5

Table 5: Test results of MS1 medium setting anionic bitumen sample

Test		Standard	Results
Bitumen remained from distillation (percentage)		ASTM D6697	72.3
Gradation Test (percentage)		ASTM D6933	0.07
Coating capability of dry stony materials (visual description)		ASTM D244	Average
Coating durability of dry stony materials coated against water (visual description)		ASTM D244	Average
Coating capability of wet stony materials (visual description)		ASTM D244	Average
Coating durability of wet stony materials coated against water (visual description)		ASTM D244	Average
Molecular charge determination test		ASTM D244	Negative
Stability against sedimentation at 24 hours (percentage)		ASTM D6930	1.6
Viscosity test at 50 ° C (second)		ASTM D244	265
Test on bitumen remained from distillation	Bitumen insoluble materials determination test (solubility) (percentage)	ASTM D2042	99.9
	Bitumen ductility determination test (plasticity) (cm)	ASTM D133	20<
	Bitumen penetration grade determination test (0.1 mm)	ASTM D5	91

In this research, the plan of recycled cold asphalt mixture was extracted with emulsion bitumen. Asphaltic samples with different percentages of additives were made and tested according to the existing guidelines; so that the optimum percentages to be obtained for each additive including water, bitumen emulsion and nano lime. Since the type of the produced asphalt is cold and with bitumen emulsion, therefore, this type of pavement has low initial resistance and Marshall Resistance. So, the additives must be used inevitably to be able to provide Marshall Resistance of the produced asphalt. Therefore, the use of additives that can be effective in improving cold asphalt resistance is inevitable. Nano lime has been used in this research.

Medium setting was chosen because of the use of nano lime of anionic bitumen emulsion type and having enough time for proper mixing. Samples of 1150 g were prepared with bitumen emulsion of 2, 2.5, 3, 3.5 and 4 percentage and nano lime of 1, 2, and 3 percentages. 3 grinded samples and 1 non-grinded sample were prepared for each selected amount to determine the maximum special weight. The optimum bitumen emulsion percentage was determined based on Marshall Resistance in this method.

It can be also stated about theoretical maximum special weight of samples that theoretical maximum special weight of asphalt increases with the increase of bitumen emulsion percentage in cold asphalt mixture. The reason for this increase of special weight can be searched in more connection of fine grains with the coarse stony materials and mixture gradation becoming more connected.

The effect of use of nano lime on resistance of recycled cold asphalt mixtures that had been prepared with bitumen emulsion was evaluated by conducting Marshall Test according to standard ASTM- D1559 in this research. it was tried that the best method to be performed for proper mixing and avoidance of conglobating the substances despite the problem of uniform distribution of lime nanoparticles in the mixture in a way that mixing time does not last more than two minutes.

Since the type of the produced asphalt is cold and with bitumen emulsion, therefore, this type of pavement has low initial resistance and Marshall Resistance according to the type of research and the conducted work of "Effect of nano-lime in properties of cold recycled asphalt mixture with bitumen emulsion".
So, the additives must be used inevitably to be able to provide Marshall Resistance of the produced asphaltin the initial ages and / or higher ages. Therefore, the use of additives that can be effective in improving resistance of cold asphalt is inevitable.

As mentioned above, in the preparation of emulsified asphalts are from the additives that have been used in micro dimensions and before this study, in Iran the possibility of using nanoparticles in a mixture of emulsified asphalt have been less studied.Based on problem assumptions in case of using nano-lime instead of active filler In cold recycled asphalt mixture Marshall Stability sample should be improved and percentage of empty space of the mixture reduced so be able to reach an Impermeable layer. It is anticipated that the use of nanoparticles instead of active filler improves the efficiency of mixture and causes the homogenization of asphalt mixture. In this way and due to being indigent of laboratory that is available, the samples were built and were tested by using Marshall method in accordance with AASHTO and ASTM and to obtain percentage of empty space and specific gravity samples the aforementioned values were calculated and analyzed by using standards of AASHTO and ASTM.

CONFLICT OF INTEREST
There is no conflict of interest.

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FINANCIAL DISCLOSURE
None

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