ARTICLE

INVESTIGATING THE EFFECT OF NANO-LIME COLD RECYCLED ASPHALT MIXTURE PROPERTIES IN PLACE WITH BITUMEN EMULSION

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ABSTRACT

Urgent need to produce asphalt from recycled materials is felt due to the limited resources needed of materials for the production of asphalt. On the other hand, the use of cold asphalt of bitumen emulsion in recent decades had been more considered due to high fuel price and reduces a number of environmental pollutants and limitation of energy resources. We should use inevitably additives in order to improve the quality; durability and strength of prepared mixture due to the use of recycled materials and bitumen emulsion in the preparation the cold asphalt mixtures. In Iran, so far in the preparation of emulsified asphalt, the additives are used that are used in micro dimensions and the usage of nanoparticles in asphalt mixture is less. According to a research laboratory and modified Marshall Design method, the usage possibility of nanoparticles and lime and its effect on the properties of asphalt emulsion have been studied in this study. Comparison of recycled asphalt samples that have nanoparticles lime properties has been shown that strength properties of recycled asphalt bitumen emulsion are without nanoparticles improves the samples lime in about 5%.

KEY WORDS
Cold recycling, asphalt emulsions, Nano-lime,

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INTRODUCTION

One method of recycling, which today has more acceptance because of its advantages is cold recycling with the use of asphalt emulsion. In this way, due to the variety of materials, and procedures, as well as organizations and institutions according to previous experiences, Marshall Method is modified. In Iran, the most common design approach is Marshall Method that is used in recycled asphalt mixtures with bitumen emulsion. In this study, with the use of modified Marshall method has been tried to investigate the role of Nano material, lime and bitumen emulsion to improve the strength of recycled asphalt mixture Marshall and thus improve its performance against failure by Marshall Resistance meter(1).

MATERIALS AND METHODS

Modified Marshall Method

Modified Marshall Method is used for bitumen cold recycling project with bitumen emulsion in accordance with ASTM-D1559 or AASHTO T245 that is different with hot asphalt design method. The limited scope of this directive is limited to mixtures that bitumen emulsion or young making emulsions are consumed to prepare them with comply with the specifications of ASTM-D5505, materials of RAP (Reclaimed Asphalt Pavement) and, if necessary, new stone materials are consumed (2).

Building RAP (Reclaimed Asphalt Pavement) and, if necessary, new stone materials are used. In this way mixed design are done in a way that the total amount of moisture does not exceed to 3% (% Water emulsion, water content in the crushed asphalt and the percentage of water is added to the mixture) (3). The specimens are dense with 50 hammers Marshall. Compacted samples for 6 hours at 60 ° C and then are cured for 12 hours in the lab and then Marshall Resistance and psychological test's action is applied for determining the specific gravity. Optimization is calculated for maximum weight percent bitumen emulsion set and empty space percentages are calculated for different amounts of bitumen emulsion.

Design method proposed in this study

In this study, a modified Marshall Method is used that in asphalt pavement milling machine of gradation, moisture percent, bitumen percent and asphalt carved stone material properties were determined after sampling. Then, in accordance with the existing guidelines, asphalt samples weighing 1150 g was developed with bitumen emulsion of 2, 2.5, 3, 3.5 and 4 percent and Nano-lime of 1, 2 and 3% and then water, bitumen emulsion and additive (Nano-lime) added and mix together for about 3 minutes so that to be obtained a completely homogeneous mixture (4).
The four samples compacted by Marshall (Three samples to measure their mental strength and Marshall and a measure of weight in water samples) and a sample was created to measure the specific gravity of the sample. Samples prepared by application of 50 hammer Marshall and after curing for 6 hours at 60 ° C, for 24 hours are put it in ambient temperature, respectively (5). Then were removed from the Marshall molds and were tested at the same resistance and softness temperature. The crushed sample was weighted at first and then the sample was put in water about 5 minutes the sample weight was measured in water and also immediately achieved after drying the surface of the sample weight saturation. The actual weight of the sample is calculated by having this data. as well as the weight of the container filled

with water without aggregates asphalt mixture of asphalt maximum theoretical density was calculated by weighing samples of uncrushed asphalt mixture and by getting uncrushed sample weight in the water (6).

RESULTS AND DISCUSSION

Technical specifications of cold recycled asphalt mixtures test results without additives
Five series of Marshall Samples with values of 2, 2.5, 3, 3.5 and 4% bitumen emulsion without any additive made from crushed asphalt that technical specifications have been shown as below [Table 1].

Table 1: Technical specifications for asphalt mixtures with bitumen emulsion 2%

Sample weight in the air (g)	1160	Uncrushed sample weight in the air (g)	1175
Sample weight in the water (g)	672	Weight of full of water dish (g)	2637
Saturated sample weight (g)	1202.5	Weight of the container filled with water and containing the sample (g)	3300
Real gravity (gr/cm3)	2.12	The maximum sample density (gr / cm3)	2.21
Marshall Resistance (kg)	730	Softness (mm)	2.6

Table 2: Technical specifications for asphalt mixtures with bitumen emulsion 2.5%

Sample weight in the air (g)	1168	Uncrushed sample weight in the air (g)	1185
Sample weight in the water (g)	675	Weight of full of water dish (g)	2637
Saturated sample weight (g)	1208	Weight of the container filled with water and containing the sample (g)	3320
Real gravity (gr/cm3)	2.15	The maximum sample density (gr / cm3)	2.23
Marshall Resistance (kg)	755	Softness (mm)	2.85

Table 3: Technical specifications for asphalt mixtures with bitumen emulsion 3%

Sample weight in the air (g)	1164	Uncrushed sample weight in the air (g)	1180
Sample weight in the water (g)	664	Weight of full of water dish (g)	2637
Saturated sample weight (g)	1198	Weight of the container filled with water and containing the sample (g)	3315
Real gravity (gr/cm3)	2.19	The maximum sample density (gr / cm3)	2.31
Marshall Resistance	785	Softness (mm)	3.3

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(kg)			

Table 4: Technical specifications for asphalt mixtures with bitumen emulsion 3.5%

Sample weight in the air (g)	1177	Uncrushed sample weight in the air (g)	1175
Sample weight in the water (g)	672	Weight of full of water dish (g)	2637
Saturated sample weight (g)	1210	Weight of the container filled with water and containing the sample (g)	3300
Real gravity (gr/cm3)	2.18	The maximum sample density (gr / cm3)	2.28
Marshall Resistance (kg)	755	Softness (mm)	3

Table 5: Technical specifications for asphalt mixtures with bitumen emulsion 4%

Sample weight in the air (g)	1183	Uncrushed sample weight in the air (g)	1192
Sample weight in the water (g)	661	Weight of full of water dish (g)	2637
Saturated sample weight (g)	1205	Weight of the container filled with water and containing the sample (g)	3320
Real gravity (gr/cm3)	2.17	The maximum sample density (gr / cm3)	2.27
Marshall resistance (kg)	705	Softness (mm)	2.5

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As well as Marshall Resistance changes, real specific gravity, the maximum theoretical specific gravity, softness and percentage of void space than the percentage of bitumen emulsion used have been shown in [Fig [1 to 5]. According to [Fig. 1] can be seen that, Marshall Resistance increases with the percentage of bitumen for asphalt mixtures, this increase was pitch of 3.2 and then Marshall Resistance reduces with decreasing the bitumen emulsion sample. Thus, according to this figure and [Fig. 2 to 5] percent of optimum bitumen emulsion, is 3.2% by weight of stone materials (7).

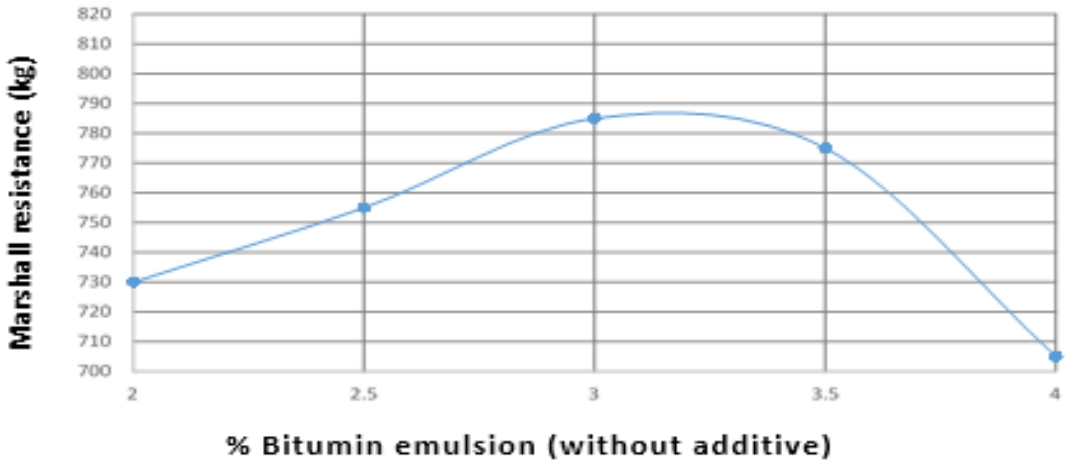

Fig. 1: Marshall Resistance changes - the percentage of bitumen emulsion (without additives).

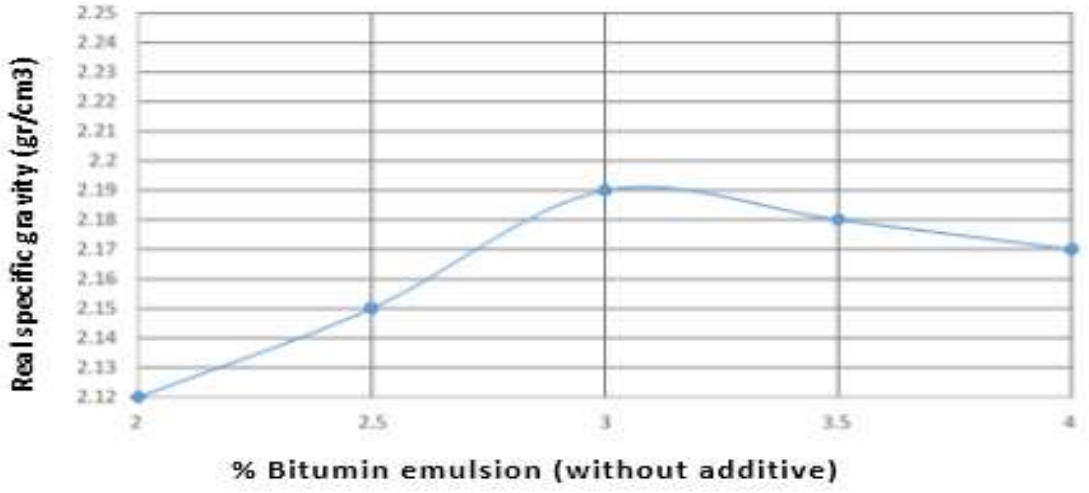

Fig.2: Real specific gravity changes - the percentage of bitumen emulsion (without additives).

According to [Fig. 2], that show the real specific gravity changes with the addition of different samples of the bitumen emulsion, production samples can be seen on real gravity that with the percentage of bitumen in the asphalt mix up the real gravity of samples and a denser and denser object is reached mixed performance improves (8). However, the results also showed that after adding 3% bitumen emulsion increase the real specific gravity was stopped cold asphalt mix and then decreased with increasing bitumen virtually real specific gravity.

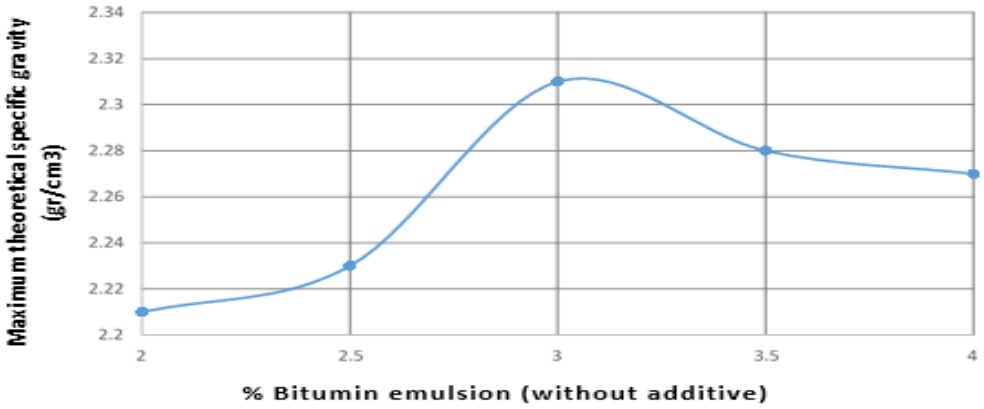

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Fig.3: Maximum theoretical specific gravity changes - the percentage of bitumen emulsion (without additives).

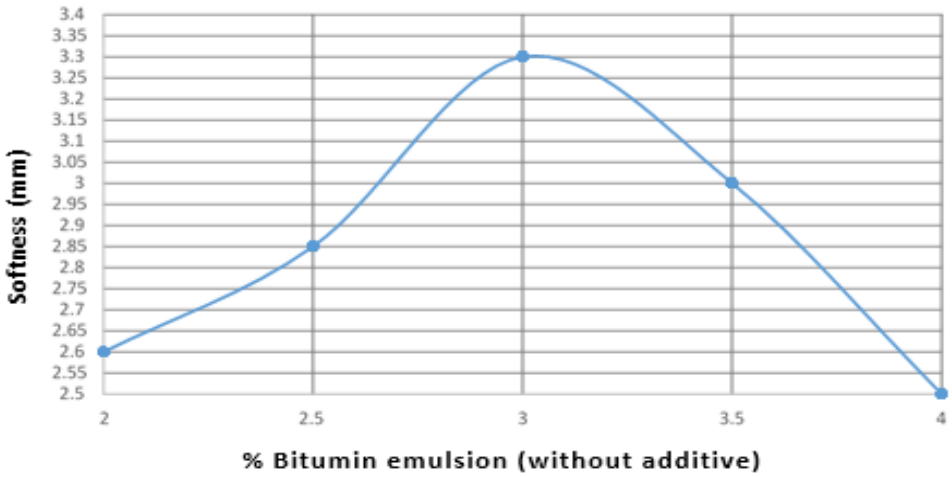

Fig. 4: The softness changes - the percentage of bitumen emulsion (without additives).

About the maximum theoretical specific gravity of the samples can be said with respect to [Fig. 3] by increasing the percentage of bitumen in the asphalt mixture, Asphalt maximum theoretical specific gravity increases. The reason for increasing specific gravity can search in fine-grained clamps with the coarse aggregate and more continuous granulation was blended (9). This is an increase of about 3.1% of bitumen emulsion stopped and then increase the amount of bitumen emulsion mixture has backfired and reduces the theoretical maximum specific gravity of the samples.

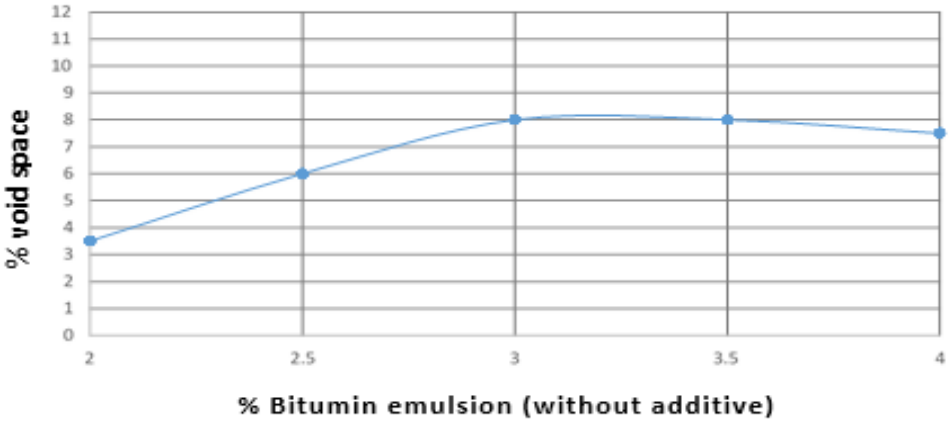

Fig. 5: void space changes - the percentage of bitumen emulsion (without additives)

Test results of Technical Specification mix asphalt with Nano asphalt

After determining the optimal amount of emulsion and with regard to kind of additive (Nano asphalt) that has a positive surface charge the anionic emulsion breaker used and to determine the optimal amount of Nano-lime accordance with previous practice, three sets of samples with values 1, 2 and 3 percent by weight of materials, Nano added lime made and tested the results of which are as the following [Table 6]:

Table 6: Technical specifications for asphalt mixtures with bitumen emulsion and Nano-lime of 1%

Sample weight in the air (g)	1210	Uncrushed sample weight in the air (g)	1250
Sample weight in the water (g)	667	Weight of full of water dish (g)	2620
Saturated sample weight (g)	1215	Weight of the container filled with water and containing the sample (g)	3265
Real gravity (gr/cm3)	2.17	The maximum sample density (gr / cm3)	2.25
Marshall resistance (kg)	745	Softness (mm)	2.3

Table 7: Technical specifications for asphalt mixtures with bitumen emulsion and Nano-lime of 2%

Sample weight in the air (g)	1229	Uncrushed sample weight in the air (g)	1278
Sample weight in the water (g)	776	Weight of full of water dish (g)	2620
Saturated sample weight (g)	1265	Weight of the container filled with water and containing the sample (g)	3344
Real gravity (gr/cm3)	2.26	The maximum sample density (gr / cm3)	2.38
Marshall resistance (kg)	826	Softness (mm)	3.4

Table 8: Technical specifications for asphalt mixtures with bitumen emulsion and Nano-lime of 3%

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Sample weight in the air (g)	1208	Uncrushed sample weight in the air (g)	1255
Sample weight in the water (g)	684	Weight of full of water dish (g)	2620
Saturated sample weight (g)	1258	Weight of the container filled with water and containing the sample (g)	3226
Real gravity (gr/cm3)	2.5	The maximum sample density (gr / cm3)	2.36
Marshall resistance (kg)	810	Softness (mm)	2.1

According to [Fig. 6] can be seen that adding Nano lime increases resistance to cold asphalt mixture Marshall samples compared to if the samples were used without additives (Nano-lime) . Nano additives also increase the percentage of lime in asphalt mixture to about 2.2 percent by weight of asphalt mixtures, Marshall also increases the resistance of samples then the amount of Nano-lime Marshall resistance is reduced (10). Thus, according to this figure and [Fig. 7 to 10] percentage of improved Nano lime to add to the mix is 2.2% by weight of the asphalt mixture.

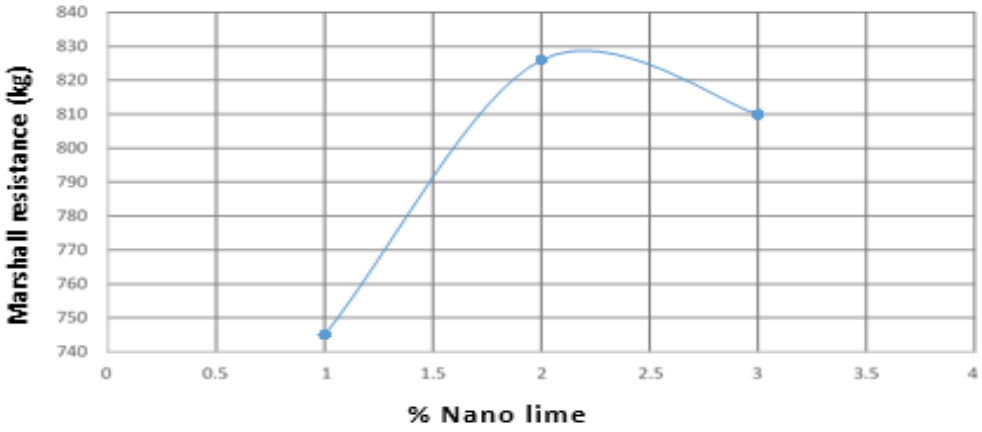

Fig.6: Marshall Resistance changes - the percentage of Nano Lime

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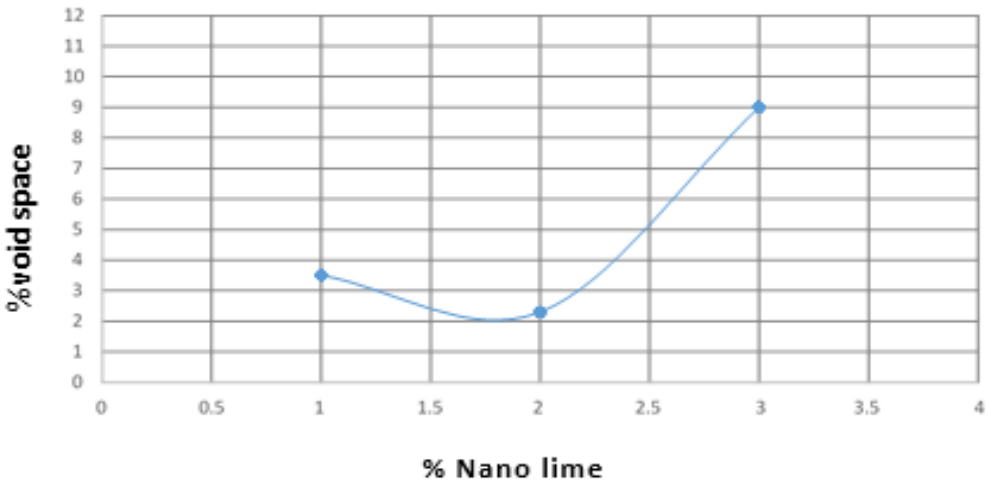

Fig.7: Void space changes - the percentage of Nano Lime.

According to [Fig. 7], percentage of void space of the samples decrease compared to no additives with adding Nano lime to cold asphalt mix, and offers denser and more compact body that can be greater due to the use of filler content (additives) that fill porous limestone aggregates used by the Nano-filled Bath and gives more and more impenetrable seal body (11). This reduction of the amount of void space up to about 1.8 percent of Nano-lime and then the decreasing trend has been reversed the void space and void space asphalt mixture increases by increase the amount of Nano-lime to 3%.

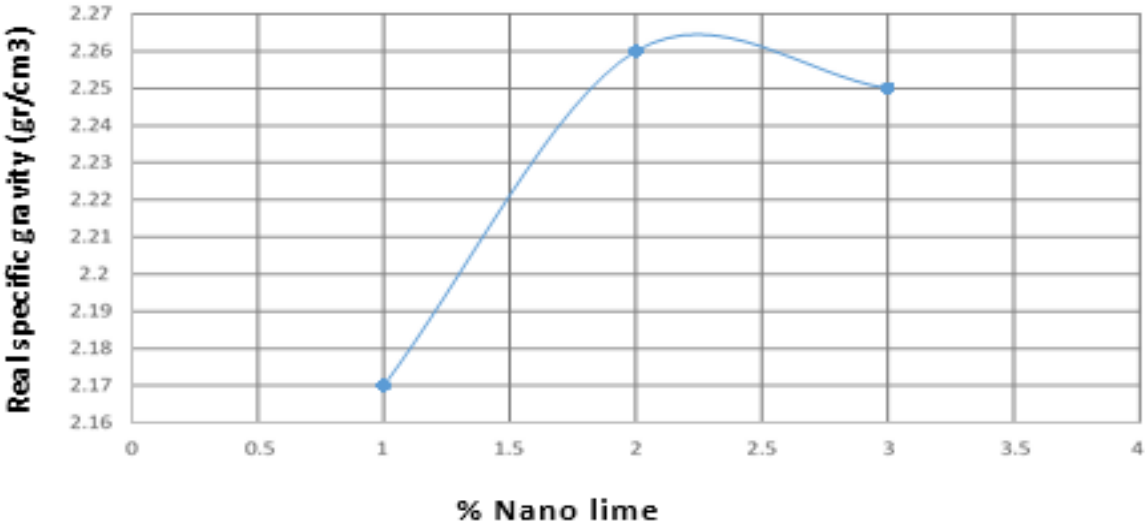

Fig. 8. Real specific gravity - Nano-lime percent.

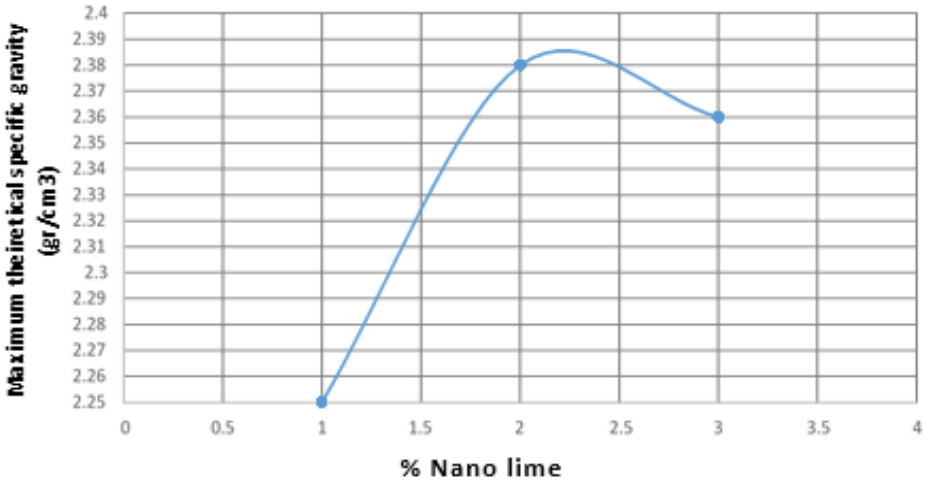

Fig. 9: Maximum theoretical specific gravity changes - Nano Lime.

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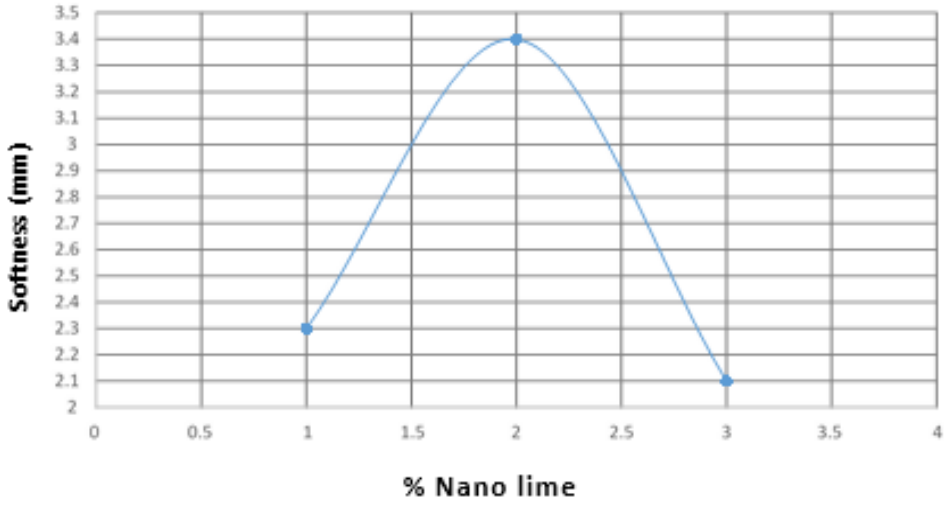

Fig.10: Softness changes - Nano Lime.

COMPARISON OF SAMPLE RESULTS

A comparison of the various parameters asphalt additives and without Nano asphalt is as below.

Table 9: Effect of Adding Nano lime on asphalt parameters

Type of parameter	Marshal stability	Real gravity	Voids	Softness	The maximum specific gravity theory
Without additives	785	2.19	8	3.3	2.31
With Nano-lime	826	2.26	3.5	3.4	2.38

CONCLUSION

1. Adding lime cause to increase the resistance of Nano Marshall Asphalt samples compare to lacking Nano lime sample. Based on experiments carried out in optimized weight of Nano-lime is 2.2% by weight of a mixture of asphalt. The optimum weight of the percent of increasing resistance with Nano Marshall Samples in compared with samples without lime is about 5 percent.
2. According to the results recycled cold asphalt mix design with extraction bitumen emulsion and in accordance with available instructions, asphalt samples were tested with different percentages of additives to obtain the optimal amounts and percentages for each additive, including water, bitumen emulsion and nono-lime. Since the type of produced asphalt is of cold kind and with bitumen emulsion, so this type of pavement has the initial resistance and low Marshall Resistance. So it is necessary to use additives to be able determine produced asphalt Marshall Resistance. Therefore, the use of additives that can be effective in improving the cold asphalt resistance is inevitably that Nano-lime has been used in this study.
3. As the test results show voids of the sample reduce by adding Nano lime to the cold asphalt mix and offers denser body. Thus it can be said that the use of Nano-lime offers more non-influential and a better seal body. Furnish led to the non-permeable seal of the top layer of pavement eventually that this causes the water to penetrate the pavement and the road is one of the causes of damage become less. So with limited infiltration of water from the body surface of the pavement and by considering the proper drainage arrangements in the lower layers of pavement can use the obtained feature by additives win maximum. On the other hand, due to the use of more filler content (Additives) used aggregate pores are filled with the finer material that this is resulted by increasing efficiency and strengthening of the mixture and skeleton of the mix. Finally, the effect of these cases appears with the increases the resistance Marshall and increases the fatigue swing in cold asphalt mix by considering the positive impact of all factors mentioned above.
4. Since the publication specialized in recycled asphalt doesn't mention any restrictions by mental recycled asphalt, therefore, this parameter is not very important for this type of pavement. But, it was observed for

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smooth asphalt layers Binder and Topeka according to instructions such as Asphalt Institute that the samples made with soft Nano-lime in the acceptable range. Binder and Topeka are for both classes. As mentioned regulations softness have been mentioned at the acceptable range for Binder cortex and cortex Topeka between 2 and 3.5, after more carefully at the results achieved by the softness of (mental) samples can be said that this type of pavement are run as potential in both the cortex Binder and Topeka.

5. It can be stated about the maximum specific theory weight of samples that asphalt maximum specific theory weight of asphalt increases with increasing the percentage of bitumen emulsion in cold asphalt mixture. The reason for this weight increasing can be more searched in locking and clamps of fine-grained with large stone materials and become joined the mixed granulation.

6. The real gravity is 3.3% with regard to testing asphalt content optimization of Marshall by weight of asphalt is mixed due to the cold recycling operation that maintenance limit of RAP is less in the diversity of materials used and with no repetition of tests, it is extended to the whole piece. In this case, laboratory maintenance costs and given the relatively low cost of testing methods modified Marshall are also reduced.

CONFLICT OF INTEREST
There is no conflict of interest.

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None

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None

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