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Optimization of Asphalt Mix Improved by the Addition of Scrap Tires

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Abstract

The design of improved asphalt mix is achieved by the use of three major variables , weight of scrap tires replaced by coarse base aggregate , particles size of scrap tires finally the weight of binder used (bitumen).

The improved asphalt mix (IAM) requires a balance between rut resistance and durability to resist cracking and moisture damage (stripping) .Accordingly several factors that influence rut resistance and durability are considered during the design process:

The mix consisted of binder (3.0-6.5) %wt. , scrap tires (10-30) wt% with particle size of (1-5) cm , is achieved by the application of box-Wilson design program.

The improved mix is achieved by the use of both hot (wet) and cold (dry) processes for preparing the standard mix firstly under high temperature 168˚C with a continuous mixing for 2 hours then mould this hot mixture in standard molder found with the replacement of a coarse percent of aggregate by the different sizes of scrap tires (1-5)cm by the use of cold (dry) technique , finally a compression step is achieved with 52 hut for 20 min for both sides of molder in order to compress the prepared specimens then leaved for 24 hrs from the stability of specimens before any tests applied .

The results of selected variables are studied for prepared specimens to check different important properties (mechanical, physical, chemical, thermo-mechanical and thermo-physical properties), then applied these result properties data in analytical computer programme software to check its fitting to design model selected and calculated the optimum properties and optimum variables for improved asphalt mix.

After-ward the computerize analysis results shows that an optimum mix No.(11) reached high stability and flexibility, also gave excellent physical and chemical properties as shown in present work below.

Also described in this work the application and comparison between standard and improved optimum asphalt mix. .

Keywords: asphalt, scrap tires, preparation / properties / and application.

التصميم المثالي للخلطة الاسفلتية المحسنة بأضافة الاطارات المستهلكة

الخلاصة

ان اي عملية تصميم الخلطة الاسفلتية المحسنة قد تم باستخدام ثلاثة متغيرات رئيسية وهي(وزن الاطارات المستهلكة المستبدلة بالنسبة الوزنية لطبقة جريش الحصى الخشن

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المستخدم في الخلطة الاسفلتية القياسية، الحجم الحبيبي للاطارات المستهلكة ، وفي النهايـة وزن المادة الرابطة المستخدمة (الاسفلت الاسمنتي او (البتيومين))).

وتحتاج هذه الخلطة الاسفلتيه المحسنه تحتاج الى إجراء موازنة بين مقاومة التصدع والتكسر واطالة العمر التشغيلي لمقاومة التصدع والتلف الناتج عن الرطوبة وبناء عليه فـأن المتغيـرات التي تزيد من مقاومة التصدع والعمر التشغيلي قد تم اخذها بنظر الاعتبار في تـصميم الخلطـة وذلك بزيادة كفاءة عملية الخلط والتفاعل اضافة الى المحسنات مثل الاطارات المستهلكة لكـل من الطبقة الاساس او الطبقة الرابطة، لذلك سوف نعتمد في تقيم الخلطه النهائية المحسنة علـى اساس هذه المتطلبات وباستخدام المتغيرات المذكورة اعلاه وباسـتخدام البرنـامج التـصميمي بوكس-ولسن تم تصميم هذه التجارب ،فكانـت المتغيـرات كـالاتي(نـسبة المـادة الرابطـة (3.0-6.5) % نسبة وزنيه ، نسبة محتوى الاطارات المستهلكة المستبدلة في الخلطةالمحـسنة (10-30) % نسبة وزنيه ، الحجم الحبيبي للاطارات المستهلكه (1-5) سم).

تم تنفيذ الخلطة الاسفلتية المحسنة وعلى أساس المتطلبات والمتغيـرات الموضـحه اعـلاه باستخدام تقنيتين رئيسية في التحضير وهي الطريقة الحارة (الرطبة) وذلك في تحضير الخلطـة القياسية والمستخدمة في التبليط عند درجة حرارة عالية 168 °م لمكونات الخلطـة المـصممة (حصو ،رمل , أسمنت ، أسفلت) مع التحريك المستمر لمدة ساعتين ثم صب الخلطة الحـارة داخل القوالب المخصصة لها مع استبدال نسبة من الحصى المثبتة في الطبقة الـسميكه بنـسب وزنية من الاطارات المستهلكه (10-30% نسبة وزنية) ، والطريقـة البـاردة (الجافـة)فـي التطبيق، ثم يجري بعد ذلك كبس ورص للعينات المحضرة ومن الجهتين باستخدام جهاز الرص الخاص وبمعدل 52 ضربة لمدة 20 دقيقة وبعدها تترك العينة المحضرة لمدة 24 ساعة حتـى تستقر العينة قبل اجراء اي فحص عليها.

وفي المرحلة التالية تم تطبيق هذه المتغيرات على الخلطة التصميمية المحسنة ثم قيـاس اهـم الخـصائص التـصميمية عليهـا (الميكانيكيـة , الفيزيائيـة , والكيمياويـة،والثرمو-ميكانيكية،والثرمو-فيزياوية) ، ثم تطبيق نتائج هذه الفحوصات على البـرامج التـصميمية فـي الحاسبوب لايجادالموديل المناسب لها، وبالتالي الوصول إلـى الخلطـة المثاليـة والخـصائص التطبيقية المثالية .

أثبتت النتائج التحليلية في الحاسوب الوصول إلى الخلطة المثاليـة وكانـت الخلطـة رقـم 11،حيث أعطت هذه الخلطة المحسنة الاستقرارية والمرونة العاليـة أضـافة الـى المقاومـة الفزياوية والكيمياوية والحرارية ,وكما موضح بالتفصيل في هذا البحث.

وفي المرحلة النهائية تم اجراء التطبيق النهائي والتصميمي للخلطة القياسية والخلطة المثالية المحسنة لبيان الفروقات بين الخلطتين والموضحة نتائجها فيما بعد على متن البحث فـي جـزء النتائج والمناقشة .

Introduction

Tires are built to be tough and durable, the properties which ensure a safe ride and long service life make scrap tire disposal a difficult task. While scrap tires represent less than (2%) of total waste stream in industrialized countries, and about 5365000 tires/year in Iraq only .This dangerous problem must be associated with a disproportionate amount of attention .The hazards most commonly posed by the unsafe disposal or scrap tires (diseases, carrying rodents, mosquitoes also it caused a fire) [1, 2], The details of the above dangers problem in Iraq is shown in table (1).

Tire material is resilient, weather-proof, insulating, combustible, and bondable. Many recycling processes [3-5] can be adopted for scrap tires such as fuel source, pyrolysis, de-polymerization, in asphalt, and reclaiming [6].

A blend of reclaimed ground tire rubber reacted with asphalt cement at elevated temperature has been used as a binder in various types of bituminous construction. Rehabilitation and maintains this blend is called "asphalt–rubber". Acceptance of asphalt-rubber systems has been primarily regional, depending some what on the favorable experience gained during experimental stages of use. The information on performance of these systems has been fragmented and difficult to asses, not only has field data presented interpretation problems but evaluation of the asphalt –rubber material in the laboratory has also been fraught with difficulty [7] .

The use of recycled tire did not develop as a solution environmental solid waste tire disposal problem [8, 9], but as a promising modifier for the improvement of asphalt concrete. Recycle tires (RT) can be used in hot mixes in either of two primary categories:

As a replacement of aggregate, where it is mixed with aggregate and then coated with asphalt cement binder (dry process), or as a modifier of asphalt cement binder itself, where such a modified binder is used to coat aggregate particles (wet process). There is extensive excellent literature available on both processes and technologies [8-15], but a brief description is given on wet process as it was the only one used in British Columbia.

Such modified asphalts mix can increase a high temperature stiffness, which boosts resistance to rutting, bleeding, and flushing. They reduce low temperature stiffness, which fights thermal cracking, improves fatigue resistance, also fights raveling and stripping.

The most commonly added group modifiers are the styrene/butadiene polymers (scrap tires) followed by natural rubber and crumb rubbers both virgin and recycled. The less –used plastomeric modifiers include the familiar polypropylene and polyethylene, as well as ethyl-vinyl –acetate and PVC.

The styrene/butadiene group increases stiffness, crack resistance (including low temperature thermal cracking), that improves the adhesion properties of binder. The generally addition of this component improves mixtures especially at a rate (3-6% wt) of binder depending on the PG grade of asphalt [16-19].

In the super pave mixture design system binder grade is selected based on climatic data traffic loading and traffic speed, which is soft enough at low temperatures to resist thermal cracking and stiff enough at high temperature to resist rutting [20].Also, there are some performance characteristics of asphalt concrete mixtures for which the properties of asphalt cement binder play an important role, such as durability.

Additionally they may be situations, where the properties of the aggregate portion of a particular mix can not be changed because of local conditions, economics, or frictional characteristics. In these cases an improvement in the characteristics of the mix will need to be obtained through change or improvement of asphalt binder cement or the replacement of aggregate by portion of waste tires at (10-50 %wt.) [21-24] ,the fatigue life for dry mix (cold process) is three times as long as that wet mix (hot process) , also the type of scrap tire used to make this improvement is not effect wheel tracking very much , but has a significant effect on fatigue resistance[24,25,26].

The aim of present work:

The purpose of this study is to identify and verify using all available state-of- the art sources ,how the coarse tire rubber can be utilized in asphalt concrete mixture for construction meeting standard quality performance related specifications such as more crack resistance ,lesser degree of rutting ,longer life ,decreased life cycle costs ,reduction of traffic noise ,improved resistance to permanent deformation at high temperatures , decreased pollution and ,increased environmental quality, due to improvement of thermo-mechanical properties performance.

Then a main approach is to study the effect of different operating variables (concentration of scrap tires wt. %, concentration of binder wt. %, and particle size of scrap tires) on the final operating mechanical, chemical and thermal properties of improved asphalt concrete mixtures by applying the central composite rotatable design (Box-Wilson design) to reach the optimum operating variables, with the use of both techniques hot (wet) and cold (dry) in preparation these mixes.

Also to determine the optimum coarse rubber particle size substituting aggregate in hot and cold mix ,the concentration of this coarse aggregate substitute ,and finally the optimum concentration of binder used to gave excellent performance and durability in characteristic and application properties.

Experiment

Preparations of improvement asphalt mix samples:

A flow chart of experimental mix system is shown in figures (1&2).Weigh in to separate pans the amount of each size fraction required to prepare a batch standard design asphalt mix (aggregate(fine & coarse) , cement(filler) ,and asphalt cement(binder)) at the classification of each component shown in table (2). The pan of a batch mix was put on a hot plate (0-250˚C) with continuous mechanical mixing (950 cycle/min) until the temperature of standard aggregate asphalt mixture reaching 168˚C (hot wet process step). The second step is to form a crater in the hot mix asphalt concrete mixture in order to replace percent of scrap tire particles about (10-30) %wt and (1-5) cm diameter of particles size due to Central Composite Rotatable Design experimental program [27] (CCRD) with the aggregate (dry & cold process) ,then mold these prepared mix in to a clean ,hot and crease molder assembly then face the compaction hammer (Germany comp. in asphalt lab ,ring No. 11142) after place appear toweling cut to size in the bottom of mold then place the mold assembly on the compaction pedestal in to mold holder apply 52 blows with compaction hammer prepaid circularly to the base of mold , remove the base plate and collar then reverse and reassemble the mold with the application of same no. blows , after compaction remove the base plate and leaving specimen in atmosphere field for 24 hrs. Before any test applied, then applied the final characteristic tests mechanical, chemical, and thermal properties in order to reach the optimum improvement mix conditions for concentration of scrap tires and concentration of binder [20, 21].

Different particle size of scrap tires of 50 mm and smaller than it was collected manually from the local street of Baghdad. And the designed of experiments were carried out according to the Central Composite Rotatable Design CCRD [27] for three variables in fifteen experiments for preparing improved asphalt mix as follow:

X_1= concentration of scrap tires replacement in asphalt mix (coarse aggregate) = (10-30%wt).

X_2= particle size of scrap tires replacement in asphalt mix= (1-5) cm (thickness).

X_3= concentration of binder used in asphalt mix = (3-6.5) %wt

The response of experiments conducted according to Box-Wilson method was fitted to a second order poly-nominal (mathematical model from which the optimum response was calculated as shown in table (3).

Material in experimental programme:

Different particle size of scrap tires of 50 mm and smaller than it was collected manually from the local street of Baghdad.

The asphalt binder is brought from the middle spot of Iraq in Al-Durra refinery factory. Where this type of binder is tested (at the asphalt lab / university of technology) and then gave passing properties to use it as a binder in the improvement of asphalt mix as shown table (4).

Testing of standard and improvement asphalt mix:

Physical properties:

- Bulk unit weight (γ):

This type of design factor is determined for both standard and improvement samples by clamping and weigh samples in both air and water, then recorded the weight in both cases, this factor is calculated by the use of equation below:

$\gamma = W_A/V = W_A/W_A\text{-}W_W$

Where:

W_A= weight of sample in air (gm).

V= volume of sample = volume of displacement water (cm^3).

W_w= weight of sample in water (gm).

- Theoretical unit weight (ψ):

This type of test is determined by the use of stable prepared sample to calculate the percent of air void depending on weight of samples and weight of all component used (aggregate ,filler , binder , scrap tires) , and use the equation below :

$$\Psi\ (gm/cm3) = W_A/\ (Wb/G_b) + (Wc/G_c) + (W_f\ /G_f) + (\ W_{mf}/G_{mf})$$

Where:

W_b, G_b= volume (cm^3), weight (gm) and specific gravity of binder (gm/cm^3)

W_c, G_c= volume (cm^3), weight (gm) and specific gravity of coarse aggregate (gm/cm^3)

W_f, G_f= volume (cm^3), weight (gm) and specific gravity of filler (gm/cm^3)

W_{mf}, G_{mf}= volume (cm^3), weight (gm) and specific gravity of mineral filler (gm/cm^3).

- Wet and dry density:

This type of test is determined by the exposure of prepared sample to air (dry) and water (wet) then applied the general density equation.

- Void of total mix (V.T.M):

This type of design factor is calculated by the use of equation below:

$$V.T.M\ (\%) = (\Psi - \gamma / \Psi) * 100.$$

Chemical properties:

This type of test is determined by the preparation of different concentration of chemical solutions (100% H2O , 5% H2SO4 (acidic sol.), and 5% NaOH (alkali sol.)), then all prepared standard (table 2) and improvement samples as conditions in (table 3) is soaked for 7 days at 50°c after ward recorded the change in weight every 24 hrs to check which of samples is more chemically stable than others (optimum one).

2.2.3 Mechanical properties:

This type of test is determined by the use of Marshall Machine tester in asphalt lab / of building eng. Depart.) due to (ASTM D155982 - Marshall apparatus) stability and dynamically measurement , where put the prepared sample horizontally in the center of this tester then exposure it to sever load until failure occurs and this factor is called flow and record the failure of stable sample only after load stable occur then called stable value .

Results and Discussion

The statistical analysis system (SAS) soft ware is used for estimating mathematical model representing the second order response surface fitted to the design points and responses (table 5) [27].

The non-linear estimation order is made for a defined function model. The coefficients of this model are estimated and the second order response mathematical model can be written as follows:

$Y_{u.w.m}$= 1.91+0.073 X1+0.012 X2 +0.11 X3 +0.008996 $X1^2$ +0.00338 $X2^2$+0.039998 $X3^2$+0.00835 X1X2+0.020348 X2X3+0.2018 X1X3 .

$Y_{T.w.m=}$ 1.93999+0.079987 X1 + 0.046816 X2+0.12265 X3 + 0.015419 $X1^2$ +0.035085 $X2^2$+ 0.060755 $X3^2$ + 0.047178 X1X2 +0.0828 X2X3 +0.16 X1X3 .

Y stability = 4.89+0.2285 X1 – 0.2439 X2 +1.534 X3 -0.0719 $X1^2$+ 0.4836 $X2^2$ +0.43646 $X3^2$ -1.61 X1X2 +0.71769 X2X3 + 2.72 X1X3.

Y flow= -4.3+0.30777 X1-0.3432 X2 +1.89777 X3 + 0.08822$X1^2$+ 1.4549 $X2^2$ + 0.8216 $X3^2$ + 0.4 X1X2- 1.93866 X2X3-0.00113 X1X3 .

YV.T.M= 4.1+0.1555 X1+0.71 X2 +2.026 X3 + 0.37077 $X1^2$ +1.137 X2 + 0.0707 $X3^2$- 0.8613 X1X2 + 1.3613 X2X3 + 0.5864 X1X3 .

Yp.D= 1.99-0.1 X1 – 0.045 X2 + 0.0494 X3 + 0.01487 $X1^2$ + 0.0432 $X2^2$ + 0.0982 $X3^2$ – 0.0623 X1X2 – 0.0.087 X2X3 – 0.07022 X1X3.

Yp.w= 1.02- 0.03 X1-0.001955 X2 - 0.0585 X3 + 0.04 $X1^2$ + 0.01669 $X2^2$ + 0.01469 $X3^2$ + 0.0434 X1X2 – 0.043 X2X3 – 0.0239 X1X3.

From this model the optimum operating variables and optimum excellent properties were determined and graphical correlations of these characteristics properties (unit wt of mix, Theo. Wt of mix, stability, flow,pd, and pw) with each variable are constructed over the range used in forming the model.

The evaluation of the optimum operating conditions for improvement asphalt mix was performed by using a computer program namely (optimization techniques. The results of optimization are:

X1= concentration of scrap tires (wt %) = 20 gm.

X2= particle size of scrap tires (cm) = 3.0.

X3= concentration of binder asphalt (wt %) 6.482.

The effect of operating conditions on the characteristic properties of final improved asphalt mix:

Effect of scrap tire concentration on the properties of asphalt mix.

Physical properties:

Figs. (3,4) shows the effect of set concentrations of scrap tires on the physical properties of improved asphalt mix (bulk unit weight, theoretical unit weight, wet and dry density ,V.T.M) under optimum particle size (3 cm).

It appears that both bulk unit weight and theoretical unit weight of improved mix are increased with increasing the concentration of scrap tires with preference of optimum mix (No.11, 20 % wt S.T, 6.482 % of B, and 3 cm P.Z) of 1.865 gm/cm^3 and 2.47 for theoretical one. These values of density are decreasing with increasing concentration of scrap tire then become constant at optimum mix. Conditions (No.11, 20%wtS.T , 6.482% wt B, 3 cm P.Z) due to the properties of scrap tires [7, 8], see Fig. (5), but shows an increasing for wet density with increasing of S.T concentration reached higher wet density for optimum mix (No.11) of 1.23 gm/cm^3 due to the characteristic properties of aggregate a shown in Fig. (6).

Fig. (7) Shows the effect of set concentration of scrap tires on the V.T.M (void of total mix) at optimum particle size (3 cm), which is decreased for increasing the concentration of scrap tires due to the randomly shape of scrap tire particles with preference of optimum one (No.11) of (8.2) V.T.M ,which agreement with standard one of (8) only .

Chemical properties

Figs. (8, 9, and 10) show the effect of different chemical solutions (100% H_2O, 5% H_2SO_4, 5% NaOH) on final improved asphalt mixtures, where the change in weight is increased with increasing time of aging until reach constant values. All improved samples have excellent chemical resistance than standard asphalt mix with constant and preference stability in weight(due to the change in weight observations) for optimum mix (No. 11) due to the chemical resistance of scrap tires[7,8].

Mechanical properties

Figs. (11, 12) show effect of set concentrations of scrap tires on the mechanical properties of final improved mix (stability (KN), flow modulus of elasticity (mm)).

It appears that all stability values of improved mix are decreased with increasing concentrations of scrap tires with preference for optimum one No.11 of 7.99 KN than standard of 7.8 KN. Also this improved mix give high modulus of elasticity and less distortion with increasing concentration of scrap tires for optimum mix No.11 at 7.8 mm flow than other standard one distorted at (8 mm) due to the characteristic properties of tires[7,8].

Effect of concentrations for binder (asphalt) on the final improved asphalt mix.

Physical properties

Figs. (13, 14, 15, 16, and 17) show the effect of set concentrations of binder on the physical properties of final asphalt mix (bulk unit weight, theoretical unit weight, V.T.M, dry and wet density at optimum particle size (3cm).

It appears that the weight of bulk unit is increased at increasing weight of binder with preference for optimum one (No.11) of (1.866

gm/cm^3) than standard one of (1.86 gm/cm^3), also the theoretical unit weight is increased with increasing concentration of binder with preference of optimum one at (2.47) ratio than other standard at (2.46) ratio.

And Fig. (15) Shows the decreasing concentration of binder to reach (8) V.T.M like standard mix applied due to the characteristic properties of tires [7, 8].It also appears that a dry density of final mix is decreased with increasing concentration of binder then reached (2.22) gm/cm^{3}for both optimum and standard mix. And increasing wet density for final mix caused by increasing concentration of binder with preference for optimum one at (1.23 gm/cm$^{3)}$ than standard one at (1.24 gm/cm^3) due to the characteristic properties of tires[7,8

Mechanical properties

Figs. (18 and 19) show the effect of set concentrations of binder on the mechanical properties of final mix (stability, and flow) at optimum particle size (3cm).

It appears that the stability values are decreased with increasing concentration of binder with preference of optimum mix (No.11) that have high stability at (7.7 KN) than other standard one of (7.5 KN) , and less distortion of final mix at (8.0 mm) than other standard mix of (8.1mm) as shown in Fig. (18) Due to the characteristic properties of tires to absorb any noise and give good performance durability [7, 8].

Effect of particle size of scrap tires on the final characteristic properties of improved asphalt mix.

Physical properties

Figs. (20, 21, 22, and 23) show the effect of set particles size on the physical properties of improved mix (theoretical unit weight, V.T.M, dry and wet density) at optimum concentration of scrap tires of 20% wt. It appears that the values of two bulk unit weight and theoretical unit weight are increased with increasing particle size with preference for optimum mix (No.11) of (2.472 gm/cm^3) than other standard one of (2.45 gm/cm^3) due to the characteristic properties of tires[7,8]. Also V.T.M values are decreased with increasing particle size with preference of optimum mix (8.25 V.T.M) than other standard one of (8 V.T.M) due to the characteristic properties of scrap tires [7,8] see fig.(22) due to the characteristic properties of tires[7,8].

And figs. (23, 24) shows the effect of particle size of waste tires on the density of final improved mix where, values of dry density are decreased with increasing particle size due to characteristic properties of scrap tires with preference for optimum mix of (2.20 gm/cm^3) than standard one of (2.24 gm/cm^3) .The values of wet density are increased with increasing particle size until reach (1.23 gm/cm^3) for optimum mix No.11 like standard one due to the characteristic properties of aggregate.

Mechanical properties

Figs. (25 and 26) show the effect of set particles size on the mechanical properties (stability, flow) of final improved asphalt mix at optimum concentration of scrap tires 20%wt. It appears that values of stability are decreased with increasing particle size with preference of optimum mix of (7.89 KN) due to the characteristic properties of tires [7, 8].

Thermo- Mechanical properties

The thermo-mechanical properties (stability, and flow) were studied at sever conditions (60˚ C and

4˚C) for both optimum improved asphalt mix (No.11, 20 %wt S.T, 6.482 wt %B, 3cm P.Z) and standard asphalt mix. It appears that the stability of optimum asphalt mix is higher than standard one with less distortion ,also give excellent performance properties (more crack resistance, lesser degree of rutting, longer life,decreassed life cycle costs, and improve the resistance to permanent deformation at high temperature) [7, 8] as shown in table (6).

Thermo-Physical properties

The thermo-physical properties (unit bulk weight, theoretical unit weight, V.T.M, dry and wet density) were studied at severs conditions (60˚C, 4˚C) for both optimum improved mixes (20% wt.S.T, 6.482wt% B, 3cm P.Z). It appears that both bulk and theoretical unit weight have excellent results than standard one ,also both wet and dry density for optimum mix is less than standard one with preference of optimum one which is reduction all traffic noise (see table 7) [7,8].

Conclusions:

Based on the present work the following conclusions can be drawn regarding the improvement of asphalt mixture that will be used in the local street paving by the use of scrap tires waste:

1. The optimum conditions which give excellent characteristics and performance properties in (thermo-mechanical, thermo-physical, and chemical) properties are: 20%wt of scrap tires, 3 cm particle size, and 6.482 wt% of binder (asphalt).
2. Quantitative relationships could be obtained between the experimental variables and the final excellent performance of optimum improved asphalt mix.
3. The dry density measured is related to the characteristic properties of scrap tires applied but the wet density measured is related to the characteristic properties binder concentrations applied.
4. All chemical resistance measured are higher than standard mix of asphalt with preference of optimum one of higher stability and no change in weight in different chemical solutions (100% H_2O, 5% NaOH, 5% H_2SO_4).
5. The values of V.T.M between optimum and standard one is little difference with preference of optimum one that like standard one.
6. The final optimum mix (No.11) have high performance in thermo-physical properties (unit bulk weight, Theo. unit , dry and wet density .V.T.M) that gave excellent stability to noise ,rutting also best thermo –mechanical properties under sever condition (4, and 60˚C) for (stability distortion and elasticity) then it improved the final performance properties "more crack resistance lesser degree of rutting, long life, decreased life cycle costs , reduction of traffic noise, improved resistance to permanent deformation at high temperatures, decreased

pollution, increased environmental quality".

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Table (1) shows the details data for scrap tires in Iraq *

	Volume of m^3tire per year	Average weight for tire (ton/yr)	The area m^2 filled by S.T /year	No. of S.T/year
Baghdad	**275000**	**102000**	**31000**	**2200000**
All Iraq	**1400000**	**270000**	**100000**	**5365000**

***** This details supplied by both general traffic office and amanat Baghdad /solid waste office for small and large cars.

Table (2) show the classification of standard improved asphalt mix *

Sieve size (mm)	Passing (%)	Retained (%)	B.C (%wt.) 3.018	B.C (%wt.) 3.75	B.C (%wt.) 4.75	B.C (% wt.) 5.75	B.C (% wt.) 6.482
25-50	0	14	164	178	191	154	144
19	15	6.0	73	50	25	50	52
12.5	77	13	160	160	160	160	160
9.5	88	13	160	160	160	160	160
4.75	35	15	180	180	180	180	180
2.36 (No.8)	38	12	140	140	140	140	140
0.3 (No.50)	88	15	180	180	180	180	180
0.075 (No.200)	10	5	50	50	50	50	50
Pan		4	57	57	57	57	57
Wt of cement		3	36	45	57	69	77
Tot. mix			1200	1200	1200	1200	1200

* details the design of base component (B.C) supplied from the general building laboratory center / properties of building materials (asphalt , cement , coarse , sand) for standard base asphalt mix .

Table (3) results of experiments planned according to CCRD real variables.

Exp.No.	X_1(%wt)S.T	X_2(Cm) S.T	X_3(%wt)
1	26	42	5.75
2	14	42	5.75
3	26	19	5.75
4	26	42	3.752
5	14	19	5.75
6	14	42	3.75
7	26	19	3.75
8	14	19	3.75
9	30	30	4.75
10	20	50	4.75
11	20	30	6.482
12	10	30	4.75
13	20	10	4.75
14	20	30	3.018
15	20	30	4.75

Table (4) the characteristic properties of asphalt used.

type of property	Temperature (˚ C)	Values
Ductility (m)	25	1.0
Fluidity (˚C)	50-51	50-51
Penetration (mm)	0	8 10 11
	25	15 32 40
	48	180 210 225

Table (5) the results of statistical analysis for preparing improved asphalt mix.

Property	Correlation coefficient %	Estimate .standard of deviation	Average absolute error %
Unit weight of mix (gm)	93.587	0.99725	0.5
Theo. weight of mix (gm)	94.892	0.9482	0.75
Stability (KN)	97.286	0.944	0.7
Flow (mm)	96.16	0.923	2
V.T.M	95.871	0.9243	0.45
ρW (gm/cm^3)	98.17	0.9817	2.5
ρD (gm/cm^3)	96.855	0.98415	2

Table (6) Thermo-mechanical properties of optimum and standard mix at sever condition

Asphalt mix type	Sever condition (˚C)	Thermo-mechanical properties Stability (KN)	flow (mm)
S.A.M	40	4.70	2.2
	60	3.67	3.2
I.A.M	4	6.02	1.2
	60	3.73	2.2

Table (7) Thermo-physical properties of optimum and standard mix at sever conditions

Asphalt mix type	Sever conditions	Thermo-physical properties Bulk unit wt.	theo.unit.wt	ρw	ρD	V.T.M
S.A.M	4 °C	2.419	1.159	1.69	2.88	10
	60 °C	2.419	1.159	1.69	2.88	10
I.A.M	4 °C	1.88	2.04	1.0	1.93	7.8
	60 °C	1.88	2.04	1.0	1.93	7.8

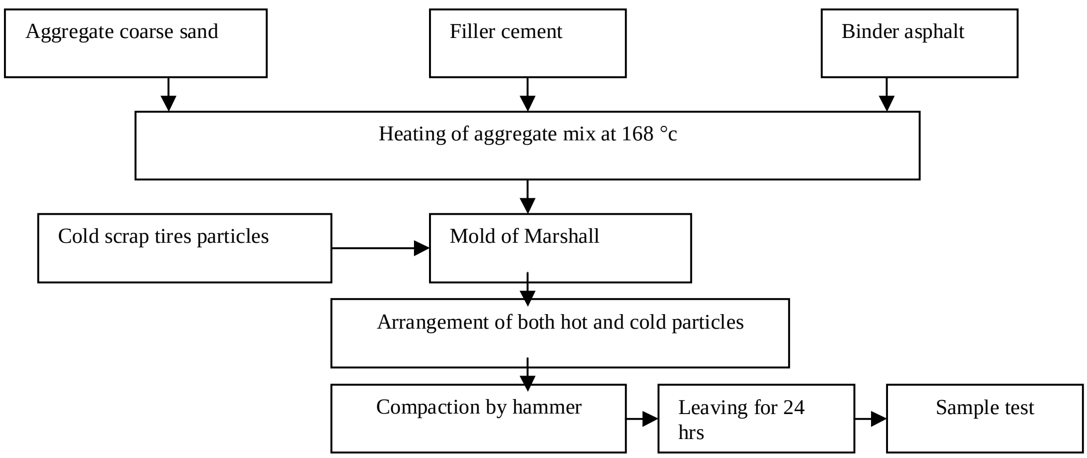

Figure (1) shows the preparation of improvement asphalt sample

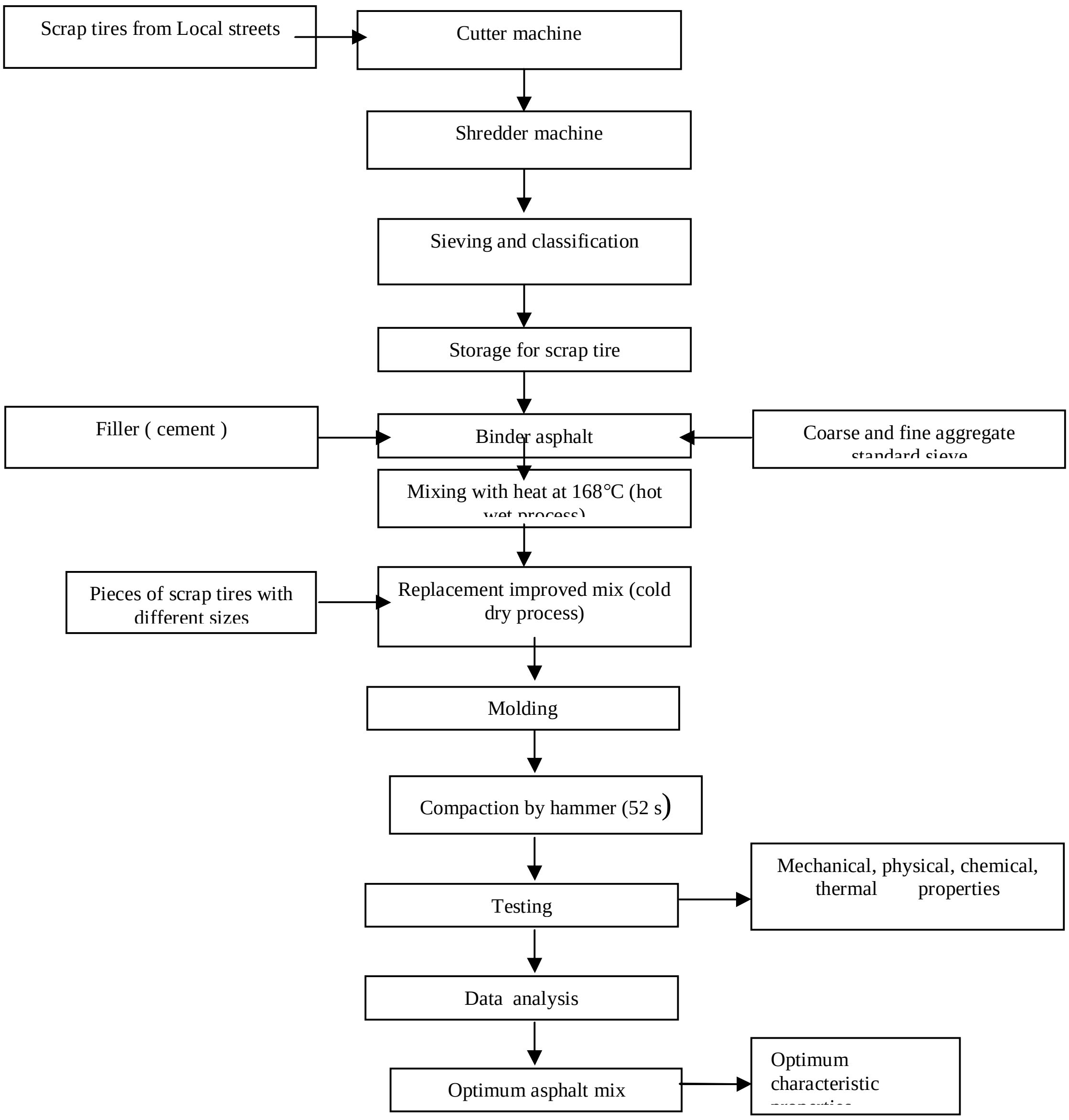

Figure (2) flow chart of asphalt improvement process

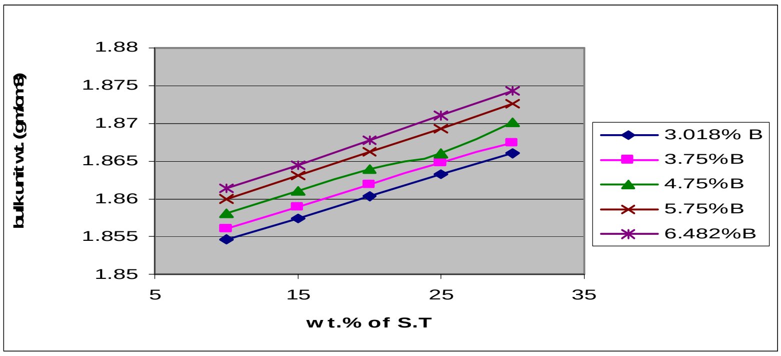

Figure (3) shows the bulk unit vs. weight ratio of scrap tires.

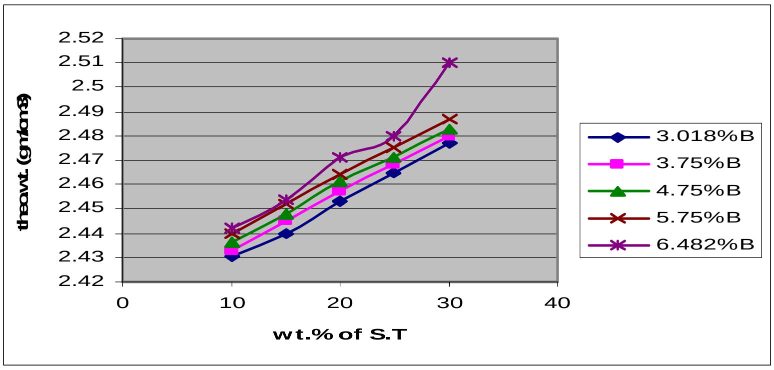

Figure (4) shows the effect of scrap tires content Vs theoretical unit weight.

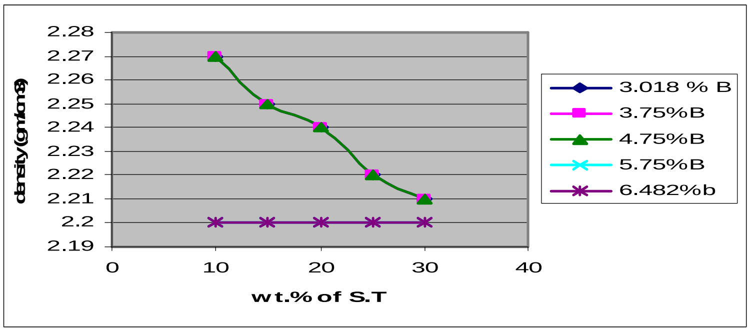

Figure (5) shows the effect of scrap tires on density of mix.

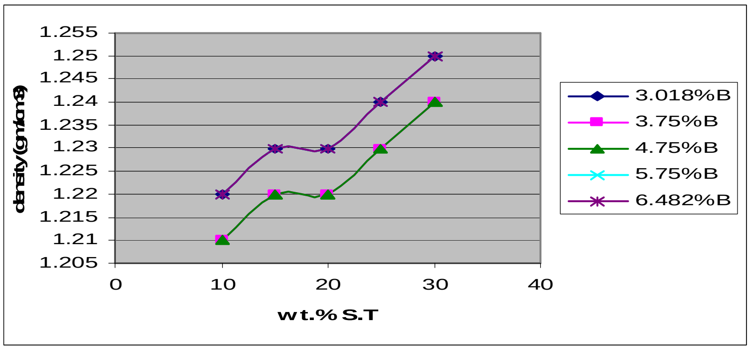

Figure (6) shows the effect of scrap tires on wet density of mix.

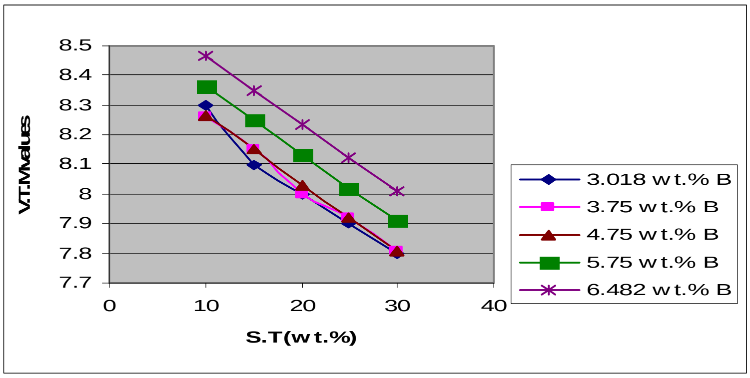

Figure (7) shows the effect of S.T. % on V.T.M values of final mix.

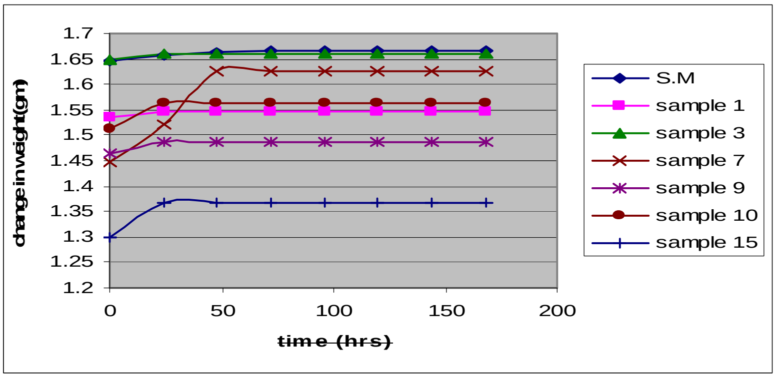

Figure (8) shows the chemical properties of final mixes in (100% H_2O)

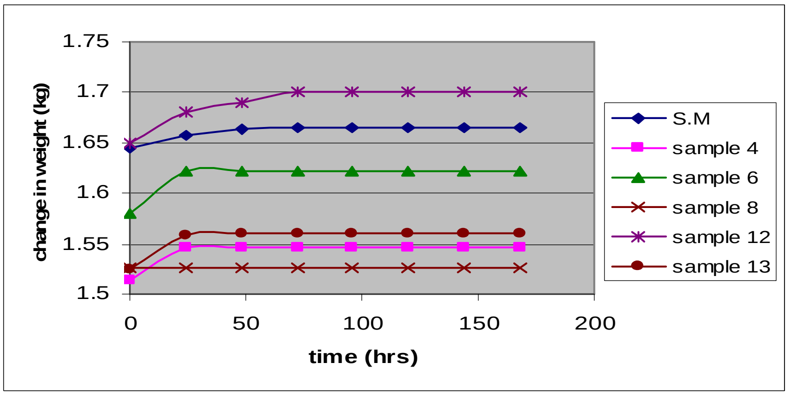

Figure (9) shows the chemical properties of final mixes in (5% H2SO4).

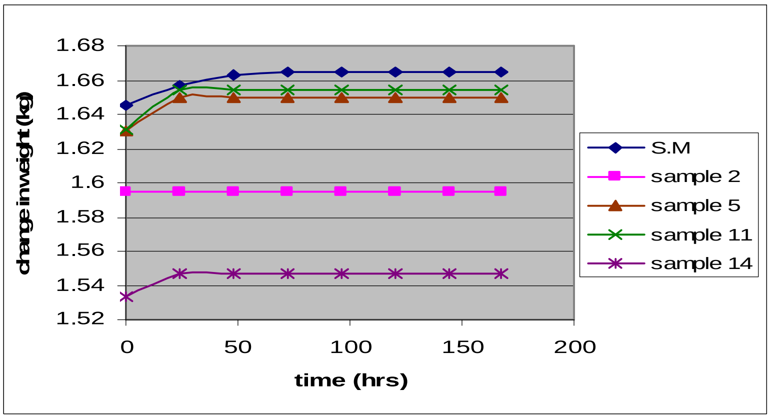

Figure (10) shows the chemical properties of final mixes in (5% NaOH).

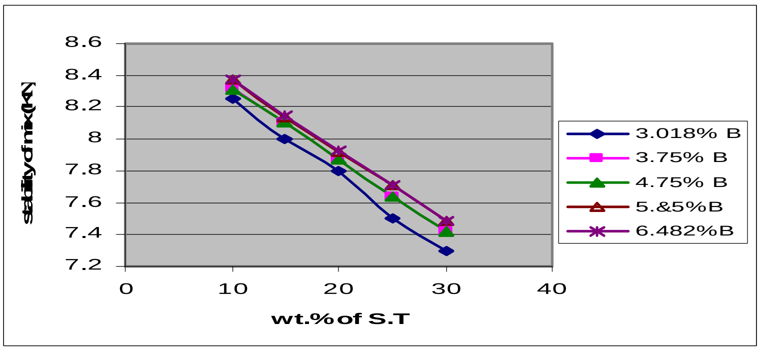

Figure (11) shows the effect of scrap tires on stability of final mixes.

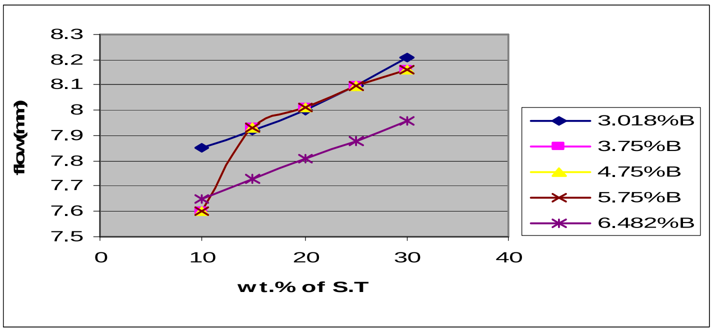

Figure (12) shows the effect of scrap tires on the flow of final mixes.

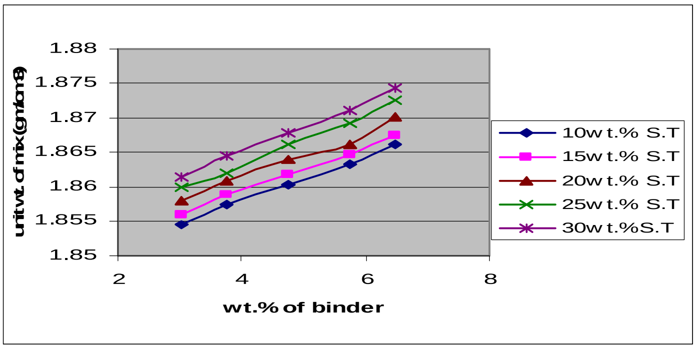

Figure (13) shows the effect of binder (% wt.) on the unit weight of final mixes.

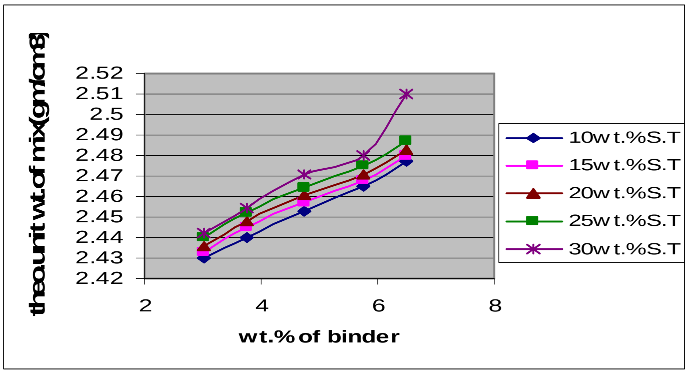

Figure (14) shows the effect of binder on the theoretical unit weight of final mixes

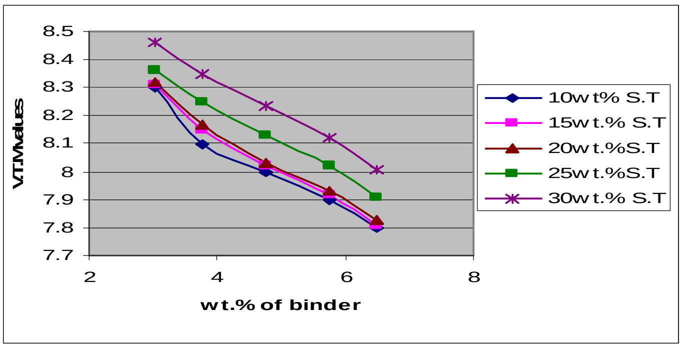

Figure (15) shows the effect of binder (% wt.) on the V.T.M value of final mixes.

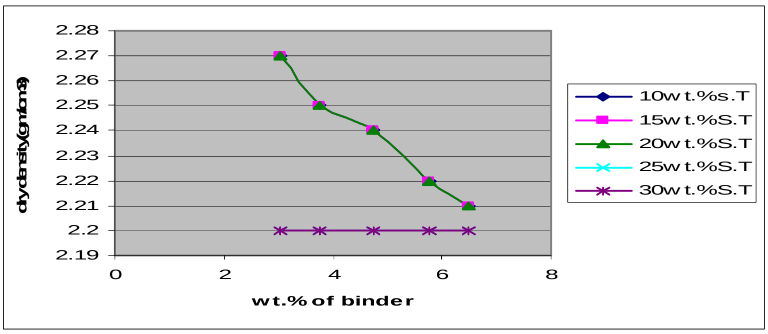

Figure (16) shows the effect of binder (%wt.) on the dry density of final mixes.

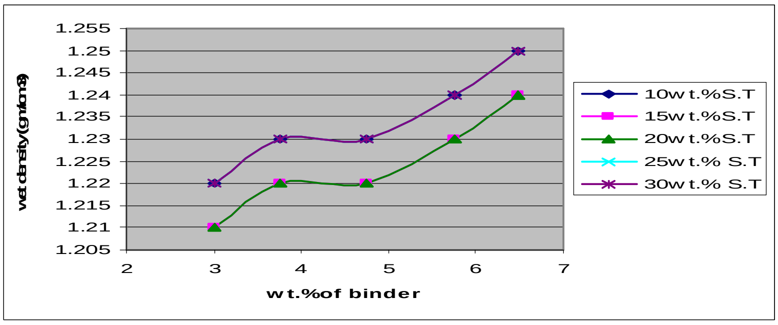

Figure (17) shows the effect of binder (%wt.) on the wet density of final mixes.

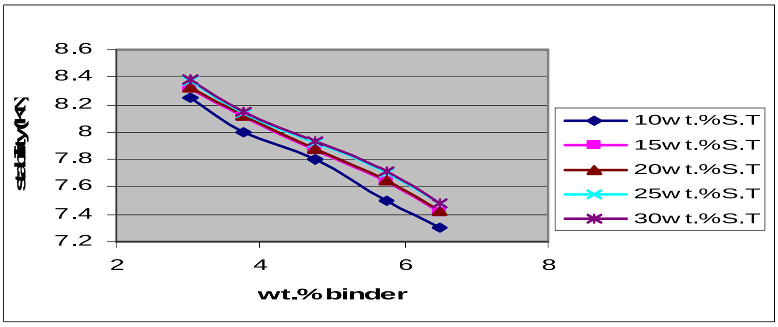

Figure (18) shows the effect of binder (% wt.) on the stability of final mixes.

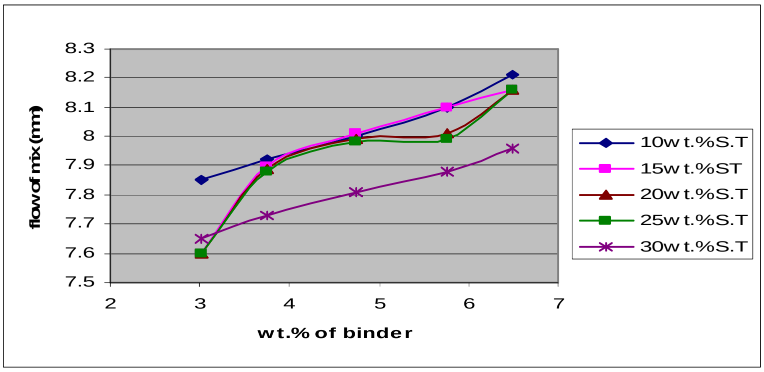

Figure (19) shows the effect of binder (% wt.) on the flow of final mixes.

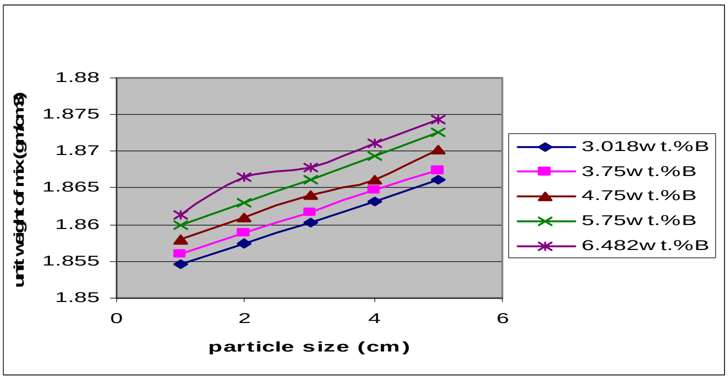

Figure (20) shows the effect of particle size of S.T on the unit weight of final mixes.

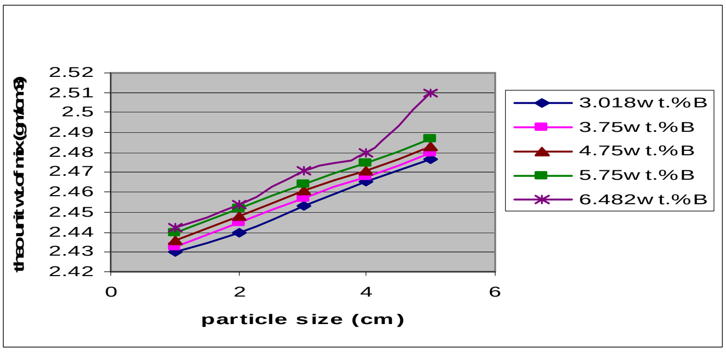

Figure (21) shows the effect of particle size of S.T on the theoretical unit weight of final mixes.

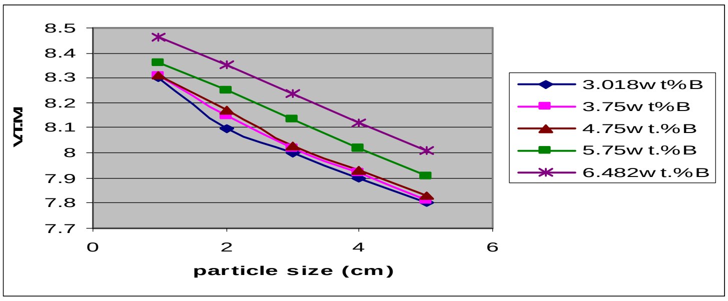

Figure (22) shows the effect of particle size of S.T on the V.T.M value for final mixes.

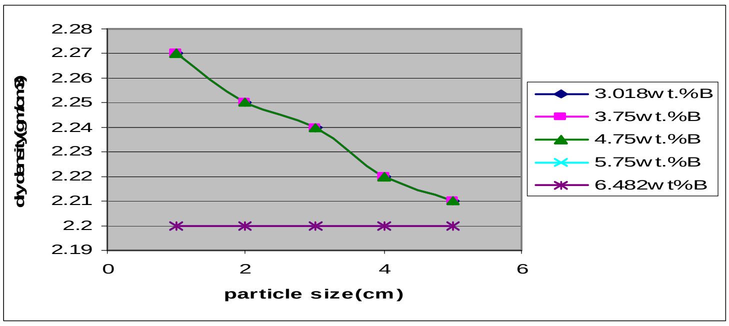

Figure (23) shows the effect of particle size of S.T on the dry density of final mixes.

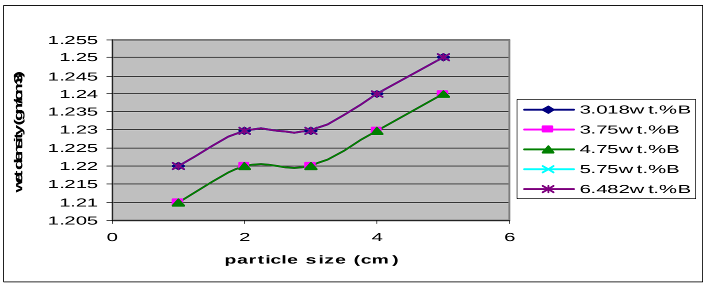

Figure (24) shows the effect of particle size of S.T on the wet density of final mixes.

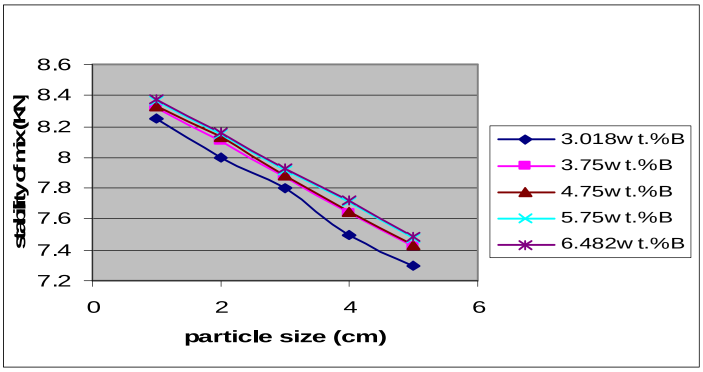

Figure (25) shows the effect of particle size on the stability of final mixes.

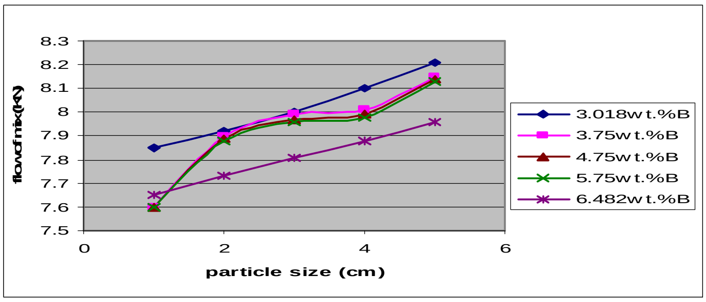

Figure (26) shows the effect of particle size of S.T on the flow of final mixes.