ABSTRACT

Utilization of reused squander materials in street asphalts is these days considered not just as a positive alternative as far as supportability yet additionally, as an alluring choice in methods for giving improved execution in benefit. This is particularly valid on account of reused plastics. Thus, there is a genuine need to discover helpful applications for these developing amounts of squanders. In this examination, Waste Plastic Bags (WPB) as one type of polymers are utilized to research the potential prospects to improve asphalt blend properties. Study points incorporate concentrate the impact of including distinctive rates of granulated WPB as a total coat on the properties of black-top blend contrasting it and regular blend properties other than distinguishing the ideal percent of WPB to be added to the hot blend black-top. WPB was presented in the black-top blend in squashed shape (2 - 4.75 mm). Marshall blend plan system was utilized, first to decide the Optimum Bitumen Content (OBC) and after that further to test the altered blend properties. Altogether, 47 tests were read, 15tests were utilized to calculate the OBC and the remaining were used to examine the impacts adding different WPB rates to black-top blend. Results showed that WPB could be helpfully utilized as a modifier for black-top blends as a section of the feasible administration of plastic waste and also for the enhanced execution of black-top blend. WPB substance of 8.0 % by weight of OBC is suggested as the ideal WPB content for the change of execution of black-top blend. Black-top mix altered with 8.0 % WPB by OBC weight has roughly 24 % higher strength esteem contrasted with the ordinary black-top blend. Black-top blendaltered with higher rates of WPB show bring down mass thickness, higher stream, and higher air voids.

Keywords:Asphalt; Marshall Test; Waste Material; Plastic Bags;Aggregates

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EXPERIMENTAL INVESTIGATION OF ASPHALT MIXTURE MODIFIED WITH WASTE PLASTIC BAGS

NEU 2018

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

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In Partial Fulfilment of the Requirements for the Degree of Master of Science in Civil Engineering

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Omar Hijazi: Experimental Investigation Of Asphalt Mixture Modified With Waste Plastic Bags

Approval of Director of Graduate School of
Applied Sciences

Prof. Dr. Nadire ÇAVUŞ
Director

We certify that, this thesis is satisfactory for the award of the degree of Master of Science in Civil Engineering

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I hereby declare that all information in this document has been obtained and presented by academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I hadfully cited and referenced all material and results that are not original to this work.

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To my parents…

ABSTRACT

Utilization of reused squander materials in street asphalts is these days considered not just as a positive alternative as far as supportability yet additionally, as an alluring choice in methods for giving improved execution in benefit. This is particularly valid on account of reused plastics. Thus, there is a genuine need to discover helpful applications for these developing amounts of squanders. In this examination, Waste Plastic Bags (WPB) as one type of polymers are utilized to research the potential prospects to improve asphalt blend properties. Study points incorporate concentrate the impact of including distinctive rates of granulated WPB as a total coat on the properties of black-top blend contrasting it and regular blend properties other than distinguishing the ideal percent of WPB to be added to the hot blend black-top. WPB was presented in the black-top blend in squashed shape (2 - 4.75 mm). Marshall blend plan system was utilized, first to decide the Optimum Bitumen Content (OBC) and after that further to test the altered blend properties. Altogether, 47 tests were read, 15tests were utilized to calculate the OBC and the remaining were used to examine the impacts adding different WPB rates to black-top blend. Results showed that WPB could be helpfully utilized as a modifier for black-top blends as a section of the feasible administration of plastic waste and also for the enhanced execution of black-top blend. WPB substance of 8.0 % by weight of OBC is suggested as the ideal WPB content for the change of execution of black-top blend. Black-top mix altered with 8.0 % WPB by OBC weight has roughly 24 % higher strength esteem contrasted with the ordinary black-top blend. Black-top blendaltered with higher rates of WPB show bring down mass thickness, higher stream, and higher air voids.

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ÖZET

Sokak asfaltlarında yeniden kullanılabilir olan skrol malzemelerinin kullanılması, günümüzde sadece desteklenebilirlik açısından olumlu bir alternatif olarak değil, daha fazla fayda sağlamak amacıyla yöntemler arasında çekici bir seçenek olarak da kabul edilmektedir. Bu özellikle yeniden kullanılabilen plastikler açısından geçerlidir. Bu nedenle, gelişmekte olan skrol miktarı için faydalı uygulamaları keşfetmeye gerçek bir ihtiyaç vardır. İncelemede, asfalt harman özelliklerinin iyileştirilmesi için potansiyel olasılıkları araştırmak amacıyla bir tip polimer olarak Atık Plastik Torbalar (WPB) kullanılmıştır. Çalışma noktaları, WPB'den farklı oranların yerleştirilme etkisinin yoğunluğunu içerir, siyah-üst harman özelliklerine toplam maliyet olarak kontrast ve normal harman özellikleri WPB'nin ideal yüzdesini ayırt etmekten başka sıcak karışım siyah tepesine eklenecek. WPB, siyah-üst harmanı içinde ezilmiş şekilde (2 - 4,75 mm) sunulmuştur. Marshall harmanlama sistemi kullanıldı, ilk önce Optimum Bitüm İçeriğine (OBC) karar verildi ve sonrasında değiştirilen harmanlama özelliklerini test etmek için kullanıldı. Toplamda 47 test okundu, OBC'yi hesaplamak için 15 test kullanıldı ve geriye kalanlar siyah-üst harmana farklı WPB oranları ekleyerek etkilerini incelemek için kullanıldı. Sonuçlar gösteriyor ki, WPB'nin, plastik atıkların uygun şekilde uygulanmasında tamamlayıcı olarak siyah-üst harmanlama kullanılabilir ve ayrıca siyah-üst harmanlamanın büyütme uygulamasında kullanılabilir. Siyah-üst harmanının uygulanması için ideal WPB içeriği olarak ağırlıklı % 8.0 oranında WPB maddesi önerilmektedir. OBC ağırlığı tarafından % 8.0 WPB ile değiştirilmiş siyah-üst harman, sıradan siyah-üst harmana karşıt olarak kabaca % 24 daha yüksek mukavemet değerine sahiptir. Daha yüksek WPB gösterim oranları ile blendalize edilmiş olan siyah üst kısım; kütle kalınlığını, daha yüksek olan akışı ve daha yüksek olan hava boşluklarını azaltır.

Anahtar Kelimeler: Asfalt; Marshall testi; Atık malzeme; Plastik poşetler; Agrega

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AASHTO:	American Association of State Highway and Transportation Officials.
ASTM:	American Standard Test Method
CRM:	Crumb Rubber Modifier
HMA:	Hot-Mix Asphalt
ITS:	Initial Tensile Strength
LDPE:	Low-Density Polyethylene
OBC:	Optimum Bitumen Content
PET:	Polyethylene Terephthalate
PP:	Plastic/Polymer
SPI:	Society of the Plastics Industry
Va:	Air Voids
VFB:	Voids Filled with Bitumen
VMA:	Percent voids in Mineral Aggregates
WPPM:	Polymeric bundling material
WPS:	Waste plastic Sacks

CHAPTER 1
INTRODUCTION

1.1 Background

Because of fast mechanical development in different fields together with populace development, a conspicuous increment in squanders age rates for different kinds of waste materials is watched. Transfer of that vast measure of squanders particularly non-rotting waste materials turns into an issue of incredible worry in created and in addition to developing nations. Reusing waste into helpful items is thought to be a standout amongst the most supportable answers to this issue. So that, inquire about into new and creative employment of waste materials is widely supported.

A wide assortment of studies and research ventures have been done to discover effective uses of a portion of the waste items in thruways development talking about an extensive variety of perspectives, execution, appropriateness, fundamental concerns, and achievability of utilizing every material. These investigations endeavor to locate a sufficient blend of the requirement for sheltered and financial transfer of waste materials and the requirement for better and savvier development materials. Utilizing reused materials in road asphalts is these days considered not just as a positive choice as far as supportability yet also, as an alluring alternative in methods for giving upgraded execution in benefit.

It has been demonstrated that the expansion of certain polymer to Asphalt fastener can enhance the execution of street asphalt. The expansion of polymers normally displays more prominent protection from rutting and warm splitting. Moreover, it diminished weariness harm, stripping and enhanced temperature vulnerability. Polyetheneis widely utilized plastic material, and it has been observed to be a standout amongst the best polymer added substances (Awwad and Shabeeb, 2007; Kalantar et al., 2009).

Thin plastic sacks are for the most part made out of Low-Density Polyethylene (LDPE), and it's generally utilized for bundling. Notwithstanding, transfer of waste plastic sacks (WPB) in expansive amounts has been an issue as it's not a biodegradable material. A few investigations have been made on the conceivable utilization of waste plastic packs when all is said in done in the asphalt blend. Grouped on their structure and physical state, they have been utilized as folio modifiers or as totals coat and also, they can be used as components which somewhat substitute a segment of totals in the black-top blend. Results were empowering and display a change in the execution of the altered black-top blends (Justo and Veeraragavan, 2007; Giriftinoglu, 2007).

1.2 Problem Statement

Plastic is wherever in the present way of life, it has various applications in different parts, such as; bundling, ensuring, farming, development and notwithstanding discarding a wide range of customer merchandise. Plastic constitutes a considerable piece of city squanders in Beirut (Lebanon). It's within the scope of (11.5% - 14.50%) by weight of civil waste (Country cover solids waste Management 2014). Shockingly, plastic is a non-biodegradable material which will stay on the earth for a longtime promoting waste transfer emergency and additionally different natural concerns. Thus, there is a genuine requirement for imaginative and reasonable ways to deal with utilizing these developing amounts of squanders. One answer to this emergency is reusing waste into helpful items (Swami et al., 2012). In another side, the expansion in rush hour gridlock stacking redundancies in a blend with an inadequate level of support caused a quickened decay of the street to organize (Awwad and Shabeeb, 2007). Researchers and architects are always hunting down various strategies to enhance the execution of black-top asphalts. This examination was directed to research the conceivable utilization of waste plastic packs (WPB) as a modifier of hot-blend black-top and to survey the plausibility of fusing WPB to enhance the execution of black-top blend.

1.3 Aim and Objectives of the Research

The main aim of this research is to modify asphalt mixture using the Waste Plastic Bags (WPB), and the following objectives will be followed to achieve it.

1.3.1 Objective of the Study

- Study the impact of including distinctive rates of WPB as a total cover of the properties of asphalt blend contrasting it and customary blend properties.
- Identify the ideal percent of WPB to be added to the hot blend asphalt.

1.4 Scope of the Study

The after effects of this investigation relied upon the beginning of restrictions and criteria that were considered amid the exploratory work. These constraints include:

- Only one kind of plastics was considered as a modifier of asphalt blends properties which are squandered thin plastic packs.
- WPB is included as a total coat in the black-top blend.
- Percentages of WPB are utilized in asphalt mix within the range of 6 – 18% with 2% incremental by OBC weight.

1.5 Thesis structure

The proposition incorporates five parts. A short portrayal of the sections' substance is introduced beneath:

Chapter 1: Introduction, this part is a concise presentation, which features the idea of research. Furthermore, a proclamation of an issue, points, goals, and researchare depicted.

Chapter 2: Literature audit Brief acquaintance related with hot blend asphalt, polymers, plastic waste and its use in asphalt blend is incorporated into this part. Also, past specialists applicable to polymer adjusted asphalt blends including reused plastics are Looked into.

Chapter 3: Methodology, this part handles two points initially is the preparatory assessment of utilized materials properties, for example, aggregate, bitumen, and waste

plastics. Second is the description of exploratory work which has been done to accomplish the points.

Chapter 4: Results and data analysis the accomplished consequences of research center work are represented in this section through three phases. The principal organize handles the consequences of mixing totals to acquire black-top cover course degree bend. The second stage, Marshall Test comes about is investigated toacquire the Optimum Bitumen Content (OBC). The accompanying advance examines the impact of including different rates of WPB black-top blend properties; at last, the ideal WPB modifier content is acquired.

Chapter 5: Conclusion and recommendations conclusions got from trial come about are exhibited. Additionally, the proposals for the present investigation and other further examinations are likewise given in this part.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Different exercises like pressing expend very nearly 50-60%of the aggregate plastics fabricated. Plastics materials do not have the nature of bio-deterioration in this manner abandoning them to no alternative against being landfilled or combusted as it seems to be. Both of these procedures are unfortunate to condition, subsequently prompting sullying of air and land. There has been an enormous increment in the utilization of plastic raising from 4000 tons/annum (1990) to 4 million tons annum (2009), and it is as yet anticipated that would ascend to an exceptional level of 12 million tons/annum by 2016.

Asphalt which is regular material utilized as a part of the street development can be mostly supplanted by the waste plastic. An exploration done by (Anurag, 2015) as plastics has non-biodegradable attributes and Are additionally hurtful to human well-being along these lines transfer of waste plastic is of awesome worry to the ecological architects. The streets in Lebanon are generally adaptable write and made of bituminous cement. As bitumen is being separated from normally happening unrefined petroleum in this way has its confinement on the accessibility subsequently there is the need for an elective material. As per them by including waste plastic the property of bitumen has extended. With two for every penny of polymer blend with AC-10 bitumen can give AVC-20bitumen properties which will finally help in improving the Marshall robustness diagram life quality and other appealing property. The dark best black-top demonstrates saving in the use of bitumen as usage of waste plastic additions. The exchange of waste plastic in the bituminous black-top advancement is in this way an unchanging game plan and thusly which develop the shielded and sound condition.

Chakraborty and Mehta (2017) explains that changed bitumen by polymer indicates great properties as a contrast with conventionalbitumen. Be that as it may, on the off chance that we include more per penny of plastic in bitumen the mix gets isolates on cooling. What's

more, which at last influence the properties of bitumen. In the dry procedure, the total is covered with plastic. The total covered with plastic demonstrates the enhanced restricting properties as because of an expanded territory of contact amongst bitumen and polymer. S.Rajasekaranetal (2013) explains that by covering the total with the polymer has many preferences and which at last aides in enhancing the adaptable asphalt quality it improve the asphalt quality as well as enhance the total quality. This innovation likewise helps in the transfer of waste plastic acquired from the local and modern pressing materials. The dry procedure is more profitable as it arranges the 80 % of the waste polymer in an eco-accommodating way. Also, utilization of polymer lessens the comparable bitumen amount and accordingly diminishing the development cost of the street. Gayakwad and Sasane (2000) explain that the expansion of plastic is the inventive innovation which fortifies the street development and furthermore expands the life of the street. As the plastic substance increment, the property of bitumen and total additionally builds contrasted with conventional adaptable asphalt the adaptable asphalt with the additional plastic has great outcomes. As indicated by Marshall strength test the ultimate utilization of plastic is limited to 10%.

It's demonstrated that the expansion of specific polymer added substance to asphalt blend can enhance the execution of street asphalt. The expansion of polymers commonly displays enhanced toughness, more prominent protection from lasting mishappening through rutting and warm splitting. Also, it expands firmness and diminished weariness harm. Squander plastic sacks (WPB) which is chiefly made out of Low Density Polyethylene (LDPE) has been observed to be a standout amongst the best polymer added substances which would upgrade the life of the street asphalt and furthermore take care of numerous ecological issues (Al-Hadidy and Tan, 2011; Jain et al., 2011; Kalantar et al., 2009).

Any country's advance is straightforwardly subject to the foundation. Lebanon is on the edge of a noteworthy forward push in the field of transportation foundation. In recent decades, activity volumes have expanded, requesting from asphalt engineers, more grounded and durable asphalt. New strategies for asphalt configuration are being created to enhance the execution of streets. New materials are being utilized to supplant the old ones

to enhance the solidness, quality, style, and economy. One of the promising courses is to use squander plastic packs in the bituminous street development industry. Today, the accessibility of the waste plastics pack is gigantic, as the plastic materials have moved toward becoming an integral part of a day to day life. If not reused, their immediate transfer is either via arriving filling or by burning. Both these procedures have a specific effect on the earth.

Under this circumstance, a substitute use for the waste plastic sacks is the need of extraordinary significance. In this examination of the Marshall properties of bituminous mixes have been found when plastic misuses are joined into them. Plastic in different structures is seen to be practically 5% in city enormous waste, which is risky. It is an ordinary sight in both urban and nation zones to find cleanse plastic sacks and different sorts of plastic squeezing material littering the lanes and channels. In view of its biodegradability, it makes stagnation of water and related neatness issues. With a particular true objective to beat this issue asks about has been done whether this waste plastic can be reused valuable. The experimentation at a couple of associations exhibited that the waste plastic, when added to the hot aggregate would outline a fine layer of plastic over the aggregate and such aggregate, when mixed with the folio is found to give higher quality, higher security from water and better execution over some unclear time allotment. Usage of a larger amount of plastic waste declines the need of bitumen by 10%. It similarly grows the quality and execution of the road. Plastic roads would be a haven for Lebanon's hot and incredibly moist climate, where temperatures as frequently as conceivable cross 50°C and extravagant deluges make pulverization, leaving most by far of the avenues with colossal potholes.

The use of plastic waste in adaptable asphalts would open up an answer for the transfer issues in regards to plastic squanders. Numerous exploration works have been done in the zone of utilization of plastic waste in bituminous street development. Liew et al. (2012) explored that the covering of plastics decreases the porosity, retention of dampness and enhances soundness. The polymer-covered total bitumen blend shapes better material for adaptable asphalt development as the blend demonstrates higher Marshall Stability esteem and

reasonable Marshall Coefficient. Subsequently, the utilization of waste plastics for adaptable asphalt is extraordinary compared to other strategies for simple transfer of waste plastics. The usage of plastic packs in street help from various perspectives like Easy transfer of waste, better street and counteractive action of contamination. Liew et al. (2012) expressed that the polymer bitumen mix is a superior folio contrasted with plain bitumen. The mix has expanded Softening point and diminished Penetration esteem with appropriate flexibility.

Swami et al. (2012) researched the Use of waste plastic in the development of bituminous Road. They inferred that plastic waste comprising of convey packs, containers and other used plastic could be utilized as a covering over totals and this covered stone could be utilized for Road development. Sultana et al. (2012) explored the use of waste plastic as a quality modifier in a surface course of adaptable and inflexible asphalts. They inferred that the potential utilization of waste plastic as a modifier for black-top cement and bond solid asphalt. Gawande et al. (2012) examined the "An outline on squandering plastic usage in asphalting of streets." They explored strategies to utilize plastic waste for development reason for streets and adaptable asphalts. Gawande et al. (2012) explored the "Use of peripheral materials as fixing in bituminous blends." They inferred that when plastic squanders can be utilized as added substances on bituminous asphalt. Thus, in their examination, the properties of the bituminous blend when adjusted with destroyed syringe plastic waste were explored. The work was completed by blending destroyed autoclaved plastic syringes with warmed aggregates by a dry process. Bhageerathy et al. (2014) examined the utilization of Biomedical Plastic Waste in Bituminous Road Construction. They reasoned that the Marshall strength estimation of the plastic altered blend was observed to be 51 percent more than that for the typical blend which shows an expansion in stack conveying limit.

Many investigates on PMA blend have been led for as far back as two decades. Even thoughthe option of virgin polymers to black-top to enhance the properties of black-top over a wide temperature go in clearing applications was considered a long while back, reused polymer added to black-top have likewise indicated nearly a similar bring about

enhancing the street asphalt execution when contrasted with virgin polymers. This research is an audit of the utilization of polymers in black-top asphalt. In this examination, a basic survey on the history and advantages of utilizing waste and virgin polymer in black-top is exhibited trailed by an audit of general investigations on utilizing polymers in black-top with a specific end goal to enhance the properties of pavement (Kalantar et al., 2012).

Minimization of waste material is an essential part of the cutting-edge development and improvement initiatives. Plastic is utilized as a part of different local and mechanical applications. Utilization of plastic packs and containers is exceptionally normal. The transfer of plastic waste is a significant issue due to the non-biodegradable nature of plastic. The plastic can be utilized as feedstock for ethanol like items. It can be used for street developmentand other development-related exercises. The ebb and flow survey compress the examination on the utilization of waste plastic (Shinde et al., 2015).

In the interstate establishment, a considerable number of begins materials and advances have been devised to choose their sensibility for the framework, improvement, and upkeep of these black-tops. Plastics and rubbers are one of them. Furthermore, pondering the biological approach, as a result of the unnecessary use of polythene in regular business, the pollution of the earth is tremendous. The use of plastic materials, for instance, pass on packs, mugs, et cetera is constantly growing day by day10. Since the polythene isn't biodegradable, the need of the present hour is to use the waste polythene for some profitable purposes. The usage of these materials as a road improvement shows eco-pleasing, down to earth and use of plastic gives quality in the sub-base course of the black-top (Shinde et al., 2015).

2.2 Hot Mix Asphalt

Hot-Mix Asphalt (HMA) is the most generally utilized clearing material around the globe. It's known by a wide range of names: HMA, asphaltic solid, plant blend, bituminous blend, bituminous cement, and numerous others. It is a mix of two essential fixings totals and black-top folio. Totals incorporate both coarse and fine materials, regularly a mix of various size shake and sand. The aggregates add up to roughly 95% of the aggregate blend

by weight. They are blended with around 5% black-top cover to create HMA. By volume, a run of the mill HMA blend is approximately 85% total, 10% black-top cover, and 5% air voids. Added substances are included little adds up to various HMA blends to improve their execution or workability. Since black-top solid asphalt is considerably more adaptable than Portland bond solid asphalt, black-top solid asphalts are now and again called adaptable asphalts (Transportation explore board council, 2011).

Black-top solid asphalts are built structures made out of a gathering of layers of particular materials that is situated on the in-situ soil (Sub Grade). Figure 2.1 demonstrates a vertical area of a run of the mill black-top solid asphalt structure.

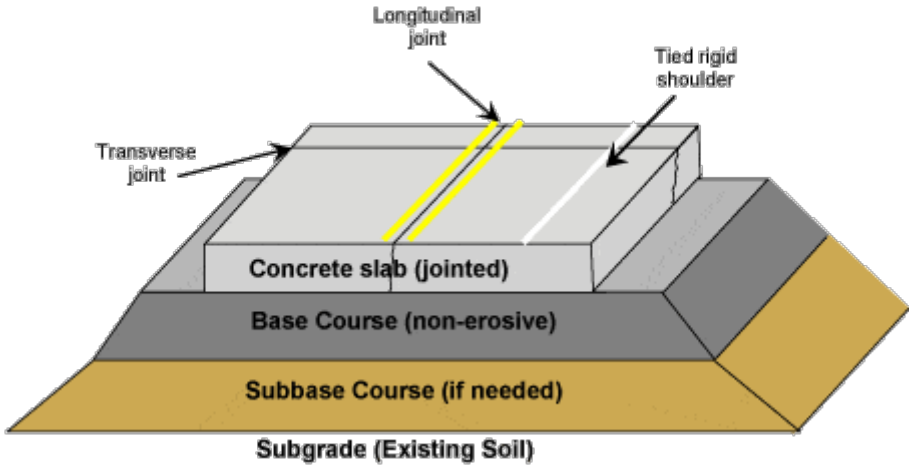

Figure 2. 1: Vertical section of asphalt concrete pavement (Oguara, 2010)

2.2.1 Basic materials in hot mix asphalt

Aggregates: Aggregate (or mineral aggregate) are hard, inert materials, for example, sand, rock, squashed shake, slag, or shake clean. Appropriately chose and evaluated totals are blended with the black-top cover to shape HMA asphalts. Aggregate is the vital load supporting parts of HMA asphalt. Since around 95% of the heaviness of thick reviewed HMA is comprised of aggregates, HMA asphalt execution is incredibly impacted by the qualities of the aggregate. Aggregate in HMA can be partitioned into three sorts as indicated by their size: coarse totals, fine aggregates, and mineral filler. Coarse aggregate is by and large characterized as those held on the 2.36-mm strainer. Fine totals are those

that go through the 2.36-mm sieve and are held on the 0.075-mm sifter. Mineral filler is characterized as that segment of the whole passing the 0.075-mm sifter. Mineral filler material - additionally alluded to as mineral clean or shake tidy - comprises of fine, idle mineral with the consistency of flour, which is added to the hot blend black-top to enhance the thickness and quality of the blend. It might be joined as a component of the consolidated total degree (Pareek et al., 2012).

Asphalt binder Black-top cover (bitumen): Asphalt fastener (bitumen) which holds aggregate together in HMA is thick, substantial deposit staying in the wake of refining raw petroleum. The black-top fastener generally comprises of carbon and hydrogen, with little measures of oxygen, sulfur, and a few metals. The physical properties of black-top cover shift significantly with temperature. At high temperatures, the black-top fastener is a liquid with a low consistency like that of oil. At room temperature, most black-top fasteners will have the consistency of delicate elastic. At below zero temperatures, the black-top fastener can turn out to be extremely weak. Numerous black-top covers contain little rates of polymer to enhance their physical properties; these materials are called polymer adjusted folios. The majority of black-top folio determination was intended to control changes in consistency with temperature (Transportation inquire about board advisory group, 2011).

2.2.2 Properties of Asphalt Mixes

Blend configuration tries to accomplish an arrangement of properties in the last HMA item. These properties are identified with a few or all factors which incorporate black-top folio content, black-top fastener attributes, level of compaction and aggregate qualities, for example, degree, surface, shape and compound synthesis. A portion of the attractive properties of black-top blends are recorded beneath with brief portrayal of each

- Resistance to changeless twisting: The blend ought not to contort or be dislodged when subjected to movement stacks particularly at high temperatures and long circumstances of stacking.

- Durability: The blend must be able to oppose weathering impacts (both air and water) and rough activity of movement. Black-top blend ought to contain adequate black-top concrete to guarantee a sufficient film thickness around the total particles
- Fatigue protection: The blend ought not to split when subjected to rehashed stacks over some undefined time frame
- Skid protection. The blend must have adequate protection from sliding, especially under wet climate conditions. Total properties, for example, surface, shape, estimate, are for the most part factors identified with slip protection.
- Workability: The blend must be fit for being put and compacted to particular thickness with sensible exertion
- Moisture harm protection: HMA ought not to corrupt significantly from dampness infiltration in with the general mish-mash
- Low clamor and great seepage properties: This property is critical for the wearing layer of the asphalt structure
- Resistance to low-temperature splitting. This blend of the property is essential in hilly areas.

2.2.3 Gradation Specifications for Asphalt Binder Course

An aggregate's molecule measure appropriation or degree is one of its most compelling qualities (Swami et al., 2012). In hot-blend black-top, degree decides relatively every essential property including solidness, soundness, strength, penetrability, workability, weakness protection, and protection from dampness harm. A sifter investigation usually estimates the degree. Table 2.1 demonstrates universal degree limits for the black-top cover course (ASTM D3515).

Table 2. 1: Gradation of Asphalt Binder Course (ASTM D5315)

Sieve No.	Sieve size (mm)	Percentage by Weight Passing	
		Min	Max
1”	25.00	100	100
¾”	19.00	90	100
1/2”	12.50	67	85
3/8”	9.50	56	80
#4	4.75	35	65
#10	2.00	23	49
#50	0.30	5	19
#100	0.15	3	14
#200	0.075	2	8

2.3 Polymer Modified Asphalt Mix

Keeping in mind the end goal to enhance the execution of black-top asphalts, various polymeric substances have been consolidated in the black-top blend as added substances in numerous structures. Polymer change of bitumen and black-top blend offers a few advantages. These incorporate upgraded weariness protection, enhanced warm breaking protection, diminish in temperature vulnerability, and enhance rutting protection (Kalantar et al., 2009). Polymers are fused in the black-top blend as fastener (bitumen) modifier. They additionally can be added to frame a total covering material. Additionally, they can be used as an incomplete substitute of a certain size of totals in the black-top blend. Properties of changed black-top blend rely upon different factors, for example, polymer attributes, blending conditions and similarity of polymer with black-top blend substance. Polymers have many writes and characterizations. Plastics are one the most generally utilized polymers these days. Impressive research has been done to decide the appropriateness of plastic squanders to be used in the black-top blend. Plastic squanders

usage in the black-top blend will be talked about, and past investigations in this field will be assessed later in this part.

2.3.1 Polymers structure and classification

Polymer altered black-top bonds have been utilized as a part of endeavors to moderate both activity and ecologically incited asphalt troubles. Polymers need to use to diminish rutting caused by activity loads amid warm climate conditions. The most popular reasons given for enhanced rutting protection are an expansion inconsistency because of the added substance as well as the development of an elastomeric arrange which enables oppose to activity incited stresses. Polymers have likewise been utilized to diminish warm splitting caused by the constriction of the asphalt as temperatures decrease. These added substances are thought to build split: protection because the consideration of finely scattered polymer particles obstructs break spread; this system is alluded to as split sticking. Another way to deal with decreasing warm breaking is to utilize a milder than a regular review of black-top concrete. Polymer added substances are then used to moderate potential warm temperature rutting issues caused by using the lower consistency black-top concrete. This last approach expects that the cold temperature properties of the folio are represented by the black-top bond while the warm temperature properties are fundamentally a component of the: polymer expansion.

While polymers have been utilized for over three decades, their capacity to take care of asphalt trouble issues has demonstrated blended in-benefit comes about. Changes found in research center arranged and assessed blends have not reliably converted into enhanced asphalt execution. A few explanations behind these blended outcomes can be credited to the altered fastener and incorporate a failure to precisely characterize the capacity of the polymer inside the black-top, contrariness to a certain polymer and black-top concrete mixes, and no particular strategy for characterizing an ideal convergence of polymer. Different purposes behind the factors achievement of polymer altered folios can be the aftereffects of blend issues, for example, unseemly aggregates degree determinations, and absence of essential research facility tests which can be identified with asphalt execution. Development issue, for example, mixing times, blending temperatures, and field

compaction will likewise have a vast part in the achievement or disappointment of a task. Polymers can be delegated elastomers or plastomers. Elastomers (rubbers) allude to elastomeric which endorse the capacity of a material to come back to its unique shape when a heap is evacuated. Elastomers normally incorporate copolymers of styrene and butadiene. They likewise incorporate characteristic and engineered rubbers (e.g., Morsel Rubber Modifier CRM) (El-Saikaly, 20l3; Awwad and Shabeeb, 2007). Elastomeric and Plastomeric polymers are more named either thermoset or thermoplastic. At the point when at first warmed, thermoset polymers build up a mind-boggling structure, which is held after cooling, however, which can't be turned around when warmed. Interestingly, thermoplastic polymers likewise build up a very much characterized, connected structure when cooled, yet the resultant structure can be turned around with warming (King and Johnston, 2012).

2.4 Plastic Polymers

Plastics are principally natural polymers of high atomic mass. The crude materials for plastics generation are characteristic items, for example, cellulose, coal, gaseous petrol, salt and raw petroleum. Diverse plastics have unique polymer chain structures which decide a considerable lot of their physical attributes. By far most of these polymers depend on chains of carbon iotas alone or with oxygen, sulfur, or nitrogen too (Giriftinoglu, 2007).

2.4.1 Types of plastics

The Society of the Plastics Industry (SPI) built up an uncommon numbered coding framework in 1988 to enable customers and recyclers to legitimately recognize the sort of pitch that was utilized as a part of assembling an item. Makers take a coding framework and place an SPI code, or number, on every plastic item, which is normally formed into the base (Giriftinoglu, 2007).

2.4.2 Plastics waste problem

Because of fast mechanical development in different fields together with populace development, a conspicuous increment in squanders age rates for different sorts of waste materials is watched. A large number of the squanders delivered today non-biodegradable,

for example, impact heater slag, fly cinder, steel slag, scrap tires, plastics, and so on that will stay in nature for many years promoting waste transfer emergency and also different ecological concerns. Plastics industry have numerous significant advancements over the most recent two decades came about because of the expanded use of plastics in different segments. Bundling, ensuring, structures, agribusiness, cutting edge, and water administration and so forth. Plastics now are all over and have incalculable employments. Utilization of this non-biodegradable item is developing quickly, in a similar time plastic squanders is likewise developing step by step, and the issue is the means by which to manage these squanders (Jain et al., 2011). A standout amongst the most widely recognized utilized plastics is the thin plastic sacks which utilized as a rule for bundling. However, the transfer of the waste plastic sacks in huge amounts constitutes a genuine ecological issue, because of their concoction idleness. Consequently, there is a genuine need to discover helpful applications for these developing amounts of squanders. Reusing waste into useful items is viewed as a standout amongst the most straightforward answers for this emergency with the goal that exploration into new and imaginative employment of waste materials is persistently progressing (Justo and Veeraragavan, 2002).

2.4.3 Plastic Wastes utilization in asphalt mixtures

Squander plastic as one kind of plastomer polymers can be used in black-top solid blend through three distinct procedures in particular dry process, wet process and the third procedure incorporates utilizing waste plastic as a fractional substitute of a certain size of aggregate (Khan et al., 2009). The dry process incorporates fusing plastic polymer which is mixed with hot totals to shape a total covering layer more often than not by plastic melting over the total hot surface before including bitumen. This covering layer would upgrade be holding and building properties of totals prompting the change in the strength of black-top blends relying upon plastic qualities and blending conditions. The dry process is relevant just for plastic polymers (Awwad and Shabeeb, 2007; Gawande et al., 2012). The wet process includes synchronous mixing of bitumen and waste plastic. Polymer change of bitumen including the plastic polymer is a typical technique to enhance the nature of bitumen by altering its rheological properties through mixing with manufactured polymers

(Gawande et al., 2012). Bitumen change through including polymer offers numerous upgrades for black-top blends that may incorporate enhancements in rutting protection, warm splitting, weariness harm, stripping and temperature vulnerability. These enhancements drove polymer adjusted bitumen to be a substitute for standard bitumen in various clearing and support applications. Properties of changed bitumen rely upon different factors, for example, polymer - bitumen attributes, blending conditions and similarity of polymer with bitumen. Polymers are joined in bitumen with two strategies, first is the expansion of latex polymer to bitumen which offers a moderately simple scattering of a polymer. Second is the expansion of strong polymers to bitumen which ordinarily requires a high shear blender to acquire consistently scattered blend (Domingos et al., 2015). Another technique to join plastics in a black-top blend is to supplant a segment of mineral totals of an equivalent size of polymer which is fundamentally used to consolidate squander plastic and devours a more prominent extent of plastic in a black-top blend.

2.4.4 Using plastics for binder modification

Kalantar et al. (2009) examined the likelihood of utilizing waste PET as polymer added substances for cover in a black-top blend. Squander PET is powdered and blended in extents 2, 4, 6, 8 and 10 % (by the heaviness of OBC) with bitumen at temperature 150 C. PET altered cover brought about higher protection from changeless disfigurement and higher protection from rutting because of their higher softening moment that contrasted with regular folios. Reduction inconsistency and increment in the protection from a stream and temperature changes likewise shows up in PET adjusted folio (Barad 2014).

As indicated by (Pareek et al., 2013) Recycled Polyethylene (PET) might be valuable in black-top asphalts, bringing about diminished lasting twisting through rutting of the asphalt surfacing. PET is generally utilized as a part of water and soda jugs, and it's ordinarily reused. Examination point was to assess the groove protection of PET as polymer added substances to black-top blend. The study incorporates deciding the greatest level of PET as bitumen modifier and examination the PET altered black-top blend with the traditional blend in term of trench protection. The tests incorporate the assurance of

infiltration record, Marshall Test, and three-wheel inundation following test which used to assess trench protection. The most extreme plastic substance was 7.5%, and the ideal bitumen content (OBC) for common blend was 5.3% while the OBC for PET changed blend was 5.2%. Concentrate inferred that PET changed black-top covers give better protection against lasting mis happenings because of the coupling property of plastic in PET adjusted black-top blend which exhibited in greater sturdiness and lower trench profundity contrasted with a regularblend.

2.4.5 Using plastics as an aggregate coat

Jain et al. (2011) revealed that the consolidation of waste polymeric bundling material (WPPM) in the bituminous blends upgrade asphalt execution and also ensure nature. The study incorporates reusing milk sacks and other HDPE based convey packs as added substances in bituminous blends. Results uncovered that the ideal dosage of WPPM is 0.3% to 0.4% by weight of the black-top mixture. Higher measurements prompt unfortunately higher solidness of blend. It's discovered that utilizing of WPPM in bituminous blends significantly enhancing execution properties which incorporate diminishment in rutting and misshapening esteems. Creators support utilizing of WPPM in street development as a feasible alternative for transfer of non-degradable plastic waste (Khan andGundaliya2012).

Manju et al. (2017) looked at properties of bituminous blends containing plastic/polymer (PP) (8% and 15% by weight of bitumen) with customary bituminous blends. Squander PP modifier was utilized as a part of a destroyed shape (Particle estimate, diam 2-3 mm), reviewed totals were warmed at 150-160C in a stove and waste PP modifier was included into hot totals previously blending OBC. Marshall Specimens for regular and altered blends were tried. Results demonstrate that Marshall steadiness of changed blends was 1.21 and 1.18 times higher than ordinary blends for modifier extents 8 and 15% separately. ITS and rutting protection was likewise enhanced in altered blends. Roundabout Tensile Strength (ITS) for customary blend was 6.42 kg/cm 2 while these where 10.7 and 8.2

kg/cm2 for changed blends 8 and 15% individually, rutting for regular blend was (7 mm) while these were 2.7mm and 3.7mm for altered blends 8 and 15%.

2.5 Conclusion

In the wake of checking on the past examinations identified with use of plastics and plastics squanders in the black-top blend as a modifier there are unique structures for expansion of plastics to black-top blend which can enhance black-top blend properties. Properties of the adjusted black-top blendare identified with numerous viewpoints, for example, plastic composes, usage frame and level of included plastic. In this investigation, one kind of plastics which is thin waste plastic sacks will be used in the black-top blend as a total coat. The impact of including WPB in the range 6-18% with 2% incremental by the heaviness of OBC will be considered. Locally available bitumen and totals will be utilized as a part of this examination.

CHAPTER 3
METHODOLOGY

3.1 Introduction

The principal goal of this investigation is to assess the properties of asphalt altered with plastic sacks. Process and methodology on how this examination is done will be clarified in detail.

This section manages two subjects. To start with is to assess utilized materials properties, for example, aggregates, bitumen and waste plastics. Second, is to portray how exploratory work has been done to accomplish ponder goals.

3.2 Materials

3.2.1 Asphalt mixture

Asphalt road aim is to support the loads induced by traffic and to distribute these loads in such a way that the transmitted stresses do not exceed the capacity of the sub-grade. The asphalt mix with the used plastic bags has been subjected,and the mechanical properties of the asphalt are listedin Table 3.1.

Table 3.1: Main and local sources of used materials

Material	**Source**	
	Main	Local
Aggregates	Crushed rocks (Beirut)	ARACO Lebanese Asphalt SAL
Bitumen	Lebanon	ARACO Lebanese Asphalt SAL
Milled waste plastic bags	Local waste plastic bags	Spinneys supermarket

- Specification (ASTM C 136)
- Table 3.2 and Figures 3.1 - 3.2 show aggregates sieve analysis results.

Table 3. 2: Aggregates sieve analysis results

Sieve size (mm)	Sieve No	Sample passing percentage				
		Coarse Agg Type I	Coarse Agg Type II	Coarse Agg Type III	Coarse Agg Type IV	Sand
19	¾”	100.0	100.0	100.0	100.0	100.0
12.5	½”	1.2	72.2	100.0	100.0	100.0
9.5	3/8”	0.5	30.2	99.50	100.0	100.0
4.75	#4	0.5	4.6	41.18	97.0	100.0
2.00	#10	0.5	2.2	6.09	68.4	100.0
1.18	#16	0.5	1.9	5.04	49.7	100.0
0.6	#30	0.5	1.6	5.02	35.3	99.0
0.425	#40	0.5	1.5	5.02	30.1	68.2
0.3	#50	0.5	1.3	3.01	28.6	19.1
0.15	#100	0.4	0.9	2.05	21.4	0.2
0.075	#200	0.2	0.3	1.02	18.4	0.0
Pan	Pan	0.0	0.0	0.0	0.0	0.0

3.2.1.1 Binder

One customary usually utilized bituminous folio, in particular, VG 30 bitumen was being used as a part of this examination to set up the examples. Regular examinations were accomplished in order to verify/decide the substantial properties of the current fasteners. The substantial properties in this way got are compressed in Table 3.3

Table 3. 3: Physical Properties of binder (ASTM D6847-02)

Property	Value
Penetration at 25^0 C (mm)	67.7
Softening Point (^{0}C)	48.5
Specific Gravity	1.03

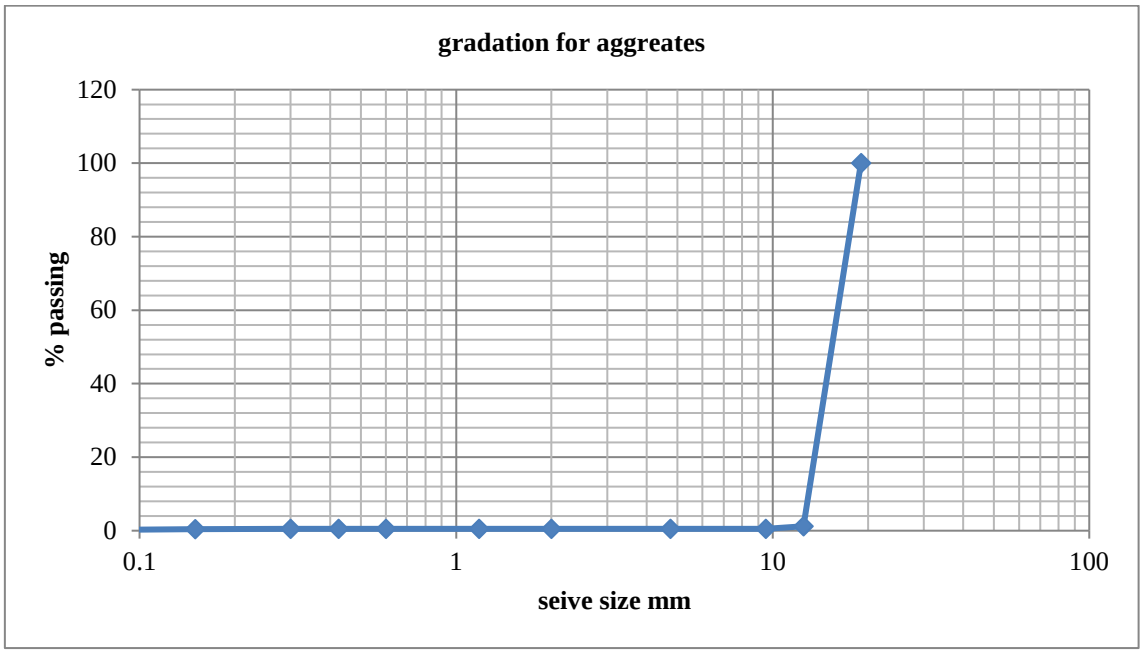

Figure 3. 1: Gradation curve (Coarse Agg Type I 19.0)

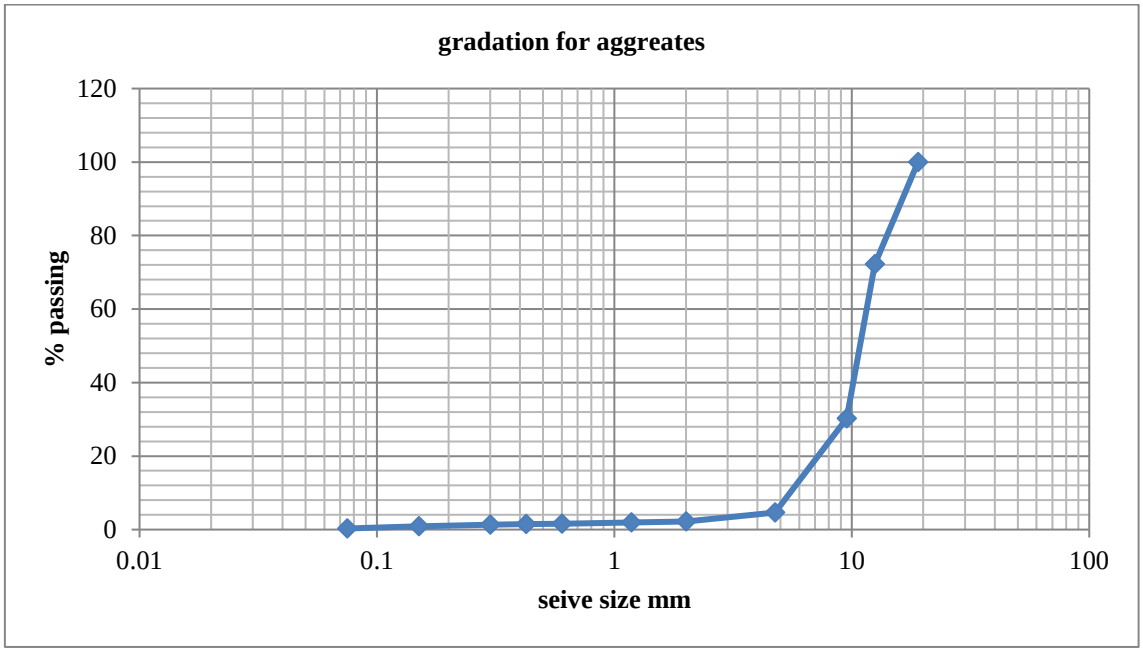

Figure 3. 2: Gradation curve (Coarse Agg Type II 12.5)

3.2.1.2 Stiffness

The firmness modulus being noteworthy execution marker for black-top blends particularly the cover and base layers. The flexible solidness in asphalt is a measure of the material's capacity to spread the activity stacking over a zone. A blend with high flexible firmness spreads the heap over a more extensive region which lessens the level of strain experienced drop down in the asphalt structure, subordinate to the temperature and recurrence of stacking. The firmness of the bituminous material can be utilized as a part of the estimation of required layer thickness in asphalt outline. The solidness parameter is by and large assessed as the proportion between the greatest pressure and the most extreme strain.

$$E = \frac{\sigma}{\varepsilon} \qquad (1)$$

Where, E = elastic stiffness (MPa), Σ = applied stress (N/ mm^2), E = resultant strain

In spite of the fact that the pressure strain reaction of the bituminous material is viscoelastic, this has been discovered reasonably for configuration purposes gave that some limit conditions are connected. There are diverse strategies accessible to decide the firmness modulus of the bituminous blends.

- Asphalt folio 70/80 was utilized as a part of this examination. To assess the bitumen properties number of lab tests has been performed, for illustration, specific gravity, malleability, streak point, fire point, softening point and infiltration. Test specification: ASTM D5-95this test method determins the penetration of semi-solid and solid bituminous materials.

3.2.1.3 Fatigue

Weakness can be characterized as the marvel of crack under rehashed or fluctuating pressure having a most extreme esteem by and large not as much as the rigidity of the material. It comprises of two principal stages, split commencement and break proliferation, and is caused by malleable strains produced in the asphalt by movement stacking as well as temperature varieties and development hones.

The fatigue characteristics of asphalt mixtures are usually represented regarding initial stress or strain and the number of load repetitions to failure and can be expressed approximately as follows:

$$Nf = A\left(\frac{1}{\varepsilon t}\right) b\left(\frac{1}{Smix}\right) c \qquad (2)$$

Where;

Nf = number of load application to failure

et = Tensile strength

S_{mix} = mixture stiffness

A B C = experimentally determined coefficients

3.2.2 Waste Plastic Bag

Balancing out added substances were utilized as a part of the blend to give better restricting property. Presently a day's polypropylene, polyester, mineral, and cellulose are generally used as strands. The current examination, polyethylene is utilized as balancing out added substance to enhance execution attributes of asphalt.

For planning of bituminous blends stone matrix asphalt (SMA) aggregate has been subjected, according to MORTH evaluating as given in Table 3.4, a specific sort of fastener and polyethylene in required amounts were blended according to Marshall Procedure. Specific gravity and substantial properties of aggregates are demonstrated in Table 3.5 & Table 3.6.

Table 3.4: Gradation of aggregates for SMA

Sieve Size (mm)	Percentage Passing
19	100
13.2	93
9.5	61
4.75	27
2.36	23
1.18	20
0.6	17
0.3	15
0.075	10

Table 3.5: Specific Gravity of aggregates for SMA

Types of aggregates	Specific gravity
Coarse	2.75
Fine (Stone)	2.6
Fine (Slag)	2.45
Filler (Stone dust)	2.7

Table 3.6: Physical Properties of Coarse aggregates for SMA

Property	Test Result
Aggregate Impact Value (%)	14.3
Aggregate Crushing Value (%)	13.02
Los Angeles Abrasion	18
Flakiness Index (%)	18.83
Elongation Index (%)	21.5
Water Absorption (%)	0.1

In introducing contemplate polyethylene is utilized as settling added substance "Spinneys" from the nearby general store in Lebanon used for conveying the products which were bought. These polyethylene packs were gathered; it was rinse by placing them in boiling water for 3 hours later it was dried. Table 3.7 and 3.8 shows the properties of WPB. The desiccated polyethylene bundles were chopped into thin bits of size then tied up as shown in Figure 3.3, after that it will be placed in the oven over 170 degrees to get hard plastic like aggregates. At the point when the polyethylene is included with bitumen and aggregate, it is to be guaranteed that the blending will be appropriate. Particular Gravity of polythene was found as 0.905.

Figure 3. 3: Spinneys waste plastic bags

Table 3.7: Physical Properties of waste plastic bags

Properties	Results
Specific gravity	0.905
Softening point	54.22^0 C
Young Modulus	109.75 Mpa
Strain at break	1351%
Strain at peak	1271.5%
Displacement at break	135.15 mm
Displacement at peak	127.15 mm
Stress at peak	14.59 Mpa

Table 3.8: Waste plastics properties

Property	Detail
Plastic type	Waste thin plastic packaging bags
Plastic material	Low-density Polyethylene (LDPE)
Size (mm)	2.00 - 4.70
Density (g/cm3)	0.90
Melting Point (^{0}C)	110

3.2.3 Aggregates and Mix Design

There are different kinds of mineral aggregates worn to make bituminous blends be able to be gotten from various regular basis, for example, frosty stores or mines and can be utilized with or without additional handling. The aggregates can be additionally handled and completed to accomplish great execution attributes. Mechanical results, for example, steel slag, impact heater slag, fly fiery remains and so forth now and then utilized by supplanting normal aggregates to upgrade the execution attributes of the blend. Aggregate give up to 90-95 % of the blend weight and adds to the vast majority of the heap bearing and quality attributes of the blend. Consequently, the quality and substantial properties of the totals ought to be proscribed to guarantee decent asphalt while the aggregates are of 3 composes;

Coarse aggregates: held on 4.75 mm sifter are know to be coarse aggregates. Coarse aggregates ought to be monitor pulverized shake, rakish fit as a fiddle, free from clean particles, earth, vegetation and fundamental issues which tenders a compressive and shear quality and shows great interlocking properties. In display think about, boulder chips are utilized as coarse aggregate with particular gravity 2.75

Fine aggregates: ought to be perfect monitored excavation cleans and ought to be complimentary from dirt, soil, foliage or fundamental issue. Fine totals, comprising of

boulder pounder cleans were gathered from a neighborhood pounder with divisions passing 4.75 mm and held on 0.075 mm ASTM sifter. Fills the voids in the coarse aggregate and solidifies the cover. In this examination, fine stones and slag are utilized as fine aggregate whose particular gravity has been observed to be 2.6 and 2.45.

Filler: Aggregate going from side to side 0.075 mm strainer is known as filler. Fills the voids, solidifies the cover and offers penetrability. The present examination, stone and fly fiery remains are utilized as filler whose particular gravity has exist observed being 2.7 and 2.3.

There is a wide range of techniques for the use of waste plastic materials in the black-top blend. In this investigation; the point of including waste plastic packs (WPB) to black-top blend is to give a total covering material and not to upgrade bitumen properties as bitumen modifier. In the wake of getting OBC, 32 tests were set up at OBC to assess the impact of adding WPB to black-top blend tests by thinking about eight extents of WPB (0, 6, 8, 10, 12, 14, 16 and 18% by the heaviness of OBC)

The technique of joining WPB in the black-top blend can be compressed as takes after :

- WPB must be heated at 170 degrees for 50mins then sieved to have a granular size (2.00 – 4.75 mm) as shown in Figure 3.4
- An important measure of heated WPB is blended with course totals (Coarse Agg Type I (0/19), Corse Agg Type II (0/12.5) and Coarse III (0/9.5)). WPB and course totals blend is warmed at (185-190 °C) for around (2.5) hours as shown in Figure (3.5). The warming temperature and term of totals were pickedgiven numerous exploratory trials to be sufficiently hot to soften WPB that it would adhere to the total surfaces and leave the finished surface with great attachment between covered totals.
- Fine totals are warmed at an equal temperature for a similar period from to some extent yet in a separate skillet. Trial trials demonstrate that it's smarter to isolate fine totals from blend to some degree when warming since they would shape a

protecting layer covering dissolved plastic which may debilitate grip between course totals and softened plastics.

- An important measure of bitumen is warmed to the point that it achieves 150^0C.
- WPB and course totals are blended with finetotals took after by expansion of hot bitumen at OBC. All fixings are blended overwhelmingly to shape a homogeneous black-top blend.

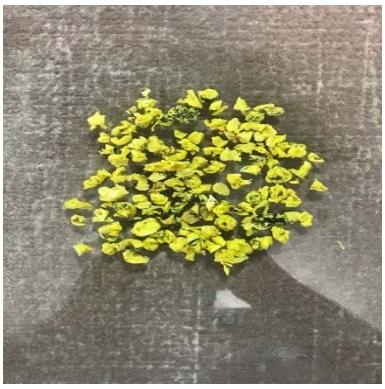

Figure 3. 4: WPB heated at 170 degrees

After getting a ready changed black-top blend, examples are arranged, compacted, and tried by standard 75-blow Marshall Method assigned as (ASTM D 1559-89).

Figure 3. 5: Adding WPB to aggregates before heating

3.3 Laboratory Test Procedures

This investigation depends on research center testing as the principle technique to accomplish contemplates objectives. All the testing is directed byutilizing gears and gadgets accessible in the research facilities from the city Beirut.

Research center tests are partitioned into a few phases, start with an assessment of the properties of utilized materials like bitumen, aggregates and plastics. Strainer examination is done for each aggregate sort to get the reviewing of total sizes took after by totals mixing to get fastener course degree bend used to get the ready black-top blend. From that point onward, Asphalt blends with various bitumen substance are arranged, and Marshall test is directed to acquire ideal bitumen content. The estimation of the ideal bitumen is utilized to get ready black-top blends altered with different rates of waste plastic sacks. Marshall Test will be used to assess the properties of these altered blends. At long last, research center tests come about are gotten and broke down. Figure 3.6 demonstrates the stream diagram of research center testing strategy. The material required for the present investigation is the constituents of hot blend black-top and Waste plastic packs as fundamental and nearby wellsprings of these materials.

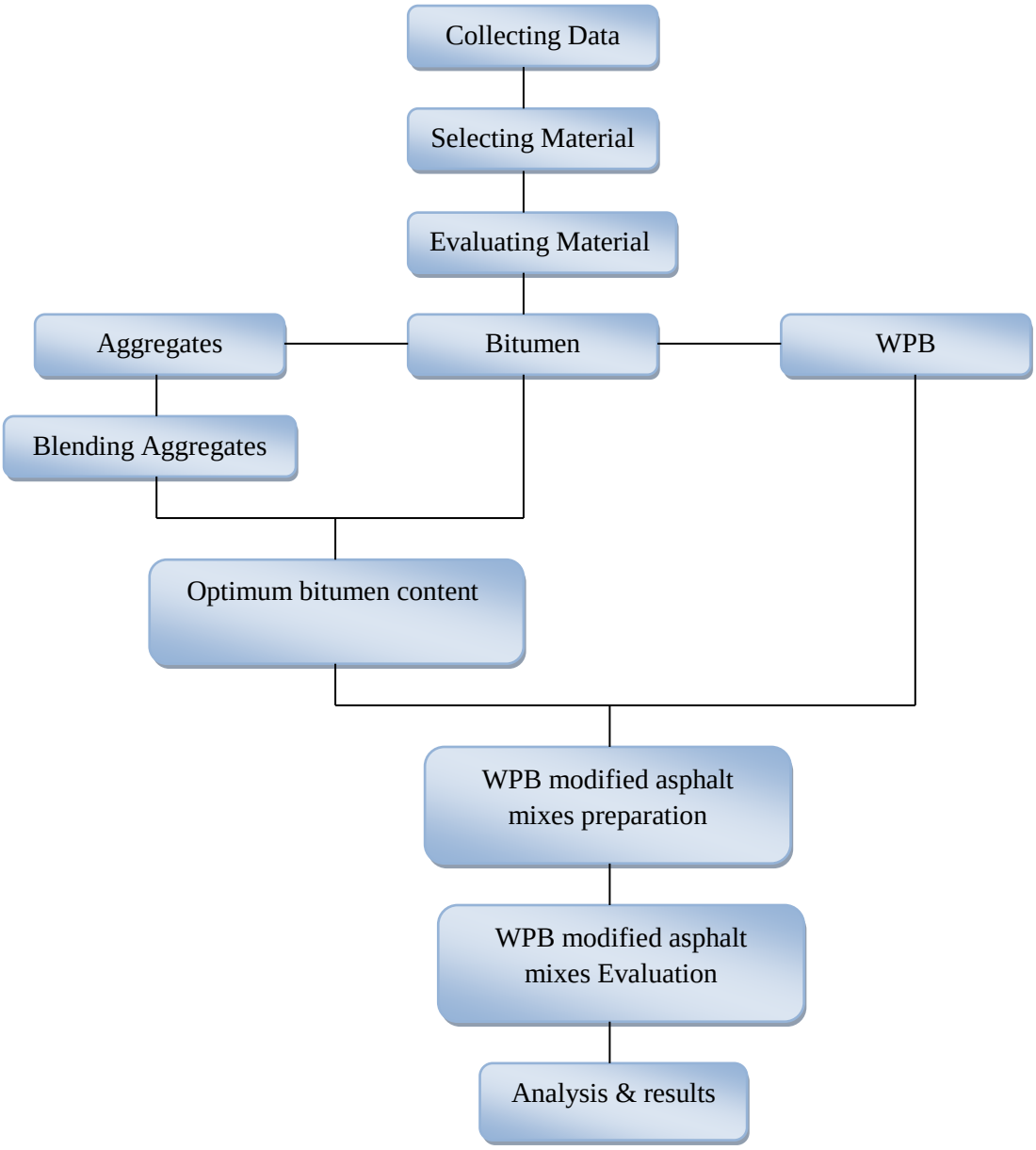

Figure 3. 6: Flowchart of Experimental Design

3.3.1 Blending of Aggregates

Black-top blend requires the joining of at least two aggregates, having distinctive degrees, to create a total mix that meets degree details for a specific black-top blend. Accessible aggregate materials 19, 12.5, 9.5, 4.75 and sand are coordinated to get the correct degree

inside as far as possible as indicated by ASTM particulars utilizing the numerical trial technique as shown in Figure 3.7. This strategy relies on proposing different trial extents for total materials from an entire degree. The level of each size of aggregates is to be processed and contrasted with detail limits. On the off chance that the computed degree is inside as far as possible, no further changes should be made; if not, a modification in the extents must be made and the computations rehashed. The trials are preceded until the point when the level of each size of aggregates is inside permissible cutoff points. Aggregates mixing comes about are exhibited in the up and coming section.

Figure 3. 7: The sieved aggregates

3.3.2 Marshall Test

Marshall Method for planning hot black-top blends is utilized to decide the ideal bitumen substance to be added to a particular aggregate mix coming about a blend where the coveted properties of quality and toughness are met, as shown in Figure 3.8. As per standard 75-blow Marshall plan strategy assigned as (ASTM D 1559-89) various 15 tests every one of 1200 gm in weight were readied utilizing five distinctive bitumen substance (from 4 - 6% with 0.5 % incremental). Three examples were utilized to get a ready black-top blend with one bitumen substance to have a normal estimation of Marshall Stability, mass thickness, and stream. Figure 3.9 demonstrate Marshall Specimens for various bitumen rates.

Figure 3. 8: The Marshall test

Marshall Properties of the black-top blend, for example, soundness, stream, thickness, air voids in the idealblend, and voids loaded withbitumen rate are acquired for different bitumen substance. Accompanying charts are then plotted:

A. Bitumen Content vs Stability;
B. Bitumen Content vs Flow;
C. Bitumen Content vs Bulk Specific Gravity;
D. Bitumen Content vs Air voids (Va);
E. Bitumen Content vs Voids Filled with Bitumen (VFB);

Figure 3. 9: Marshall Specimens for different bitumen percentages

3.3.2.1 Determination of optimum bitumen content (OBC)

The ideal bitumen content (OBC) for the proposed blend is the normal of three estimations of bitumen content, which include:

- Bitumen content at the highest stability (*% mb*) *Stability*
- Bitumen content at the highest value of bulk density (*% mb*) *bulk density*
- Bitumen content at the median of allowed percentages of air voids (Va = 3-5%) (*% mb*) *Va*

Marshall graphs are utilized to obtain the three values below.

Optimum bitumen content (OBC) %= (%mb) Stability (%mb) bulk density (%mb) Va / 3

Properties of the black-top blend utilizing ideal bitumen substance, for example, steadiness, stream, Va, mass thickness and VMA are acquired and checked against particulars.

3.3.3 Penetration Test

- Test specification: ASTM D5-95this examination process wrap the fortitude of the penetration with in semi-solid and solid bituminous materials as shown in Figure 3.10.
- Container dimension: 75 mm x 55mm

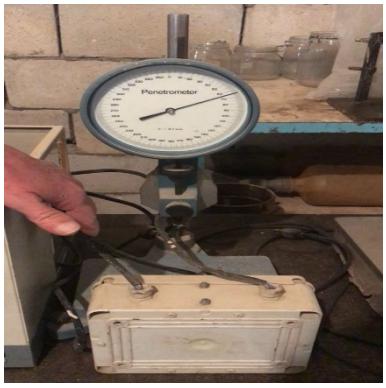

Figure 3. 10: Penetration test

3.3.4 Ductility Test

- Test specification: ASTM D113-86 the ductility of bituminous material is measured by the distance to which it will elongate before breaking when two ends of a briquette specimen of the material, are pulled apart as shown in Figure 3.11 at a specified speed and a specified temperature.

Figure 3. 11: Representing the Ductility test performed in the laboratory

3.3.5 Softening Point

- Test specification: ASTMD36-2002 the Automatic Softening Point Apparatus features a microprocessor-based controller, an automatic load ball applicator, two optical detectors, and two test positions for measuring the softening point of bitumen's, waxes, and other solid to semi-solid products.
- Figure 3.12 show softening point test for bitumen samples.

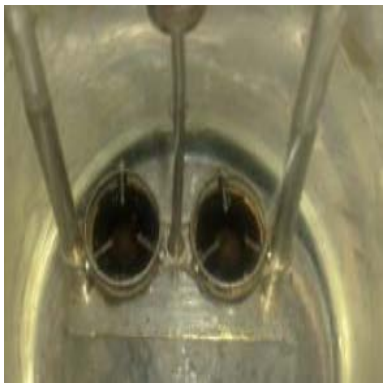

Figure 3. 12: Softening point test for bitumen samples

3.4 Summary

Perform essential research facility tests on black-top blends to describe the mechanical properties, for example, firmness modulus, weariness, and protection from perpetual distortion. Some black-top blends will be delivered with different waste plastic portions in the blends and the blends at that point subjected to different here and now molding administrations previously compaction to assess the impact of bitumen cooperation on its properties.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Introduction

Consequences of research center work had been acquired and broke down to accomplish ponder destinations which incorporate concentrate the impact of including different rates of WPB the mechanical properties of the black-top blend and recognize the ideal percent of WPB to be added to hot blend black-top. Research center work comes about are displayed in this part in three phases. In the first place, handle the consequences of mixing totals to get black-top folio course degree bend. The second stage, Marshall Test is completed with various rates of bitumen which are (4.0, 4.5, 5.0, 5.5 and 6.0%) and the outcomes are broke down keeping in mind the end goal to get the ideal bitumen content (OBC). In the wake of getting OBC, the accompanying advance is to ponder the impact of including distinctive rates of WPB black-top blend properties which are (6, 8, 10, 12, 14, 16 and 18%) by the heaviness of OBC. Marshall test comes about for adjusted black-top blends are breaking down lastly the ideal WPB modifier content is gotten.

4.2 Blending of Aggregates

The last extent of each aggregate material in black-top fastener course appears in Table 4.1. The proposed totals degree bend is observed to fulfill ASTM detail for black-top fastener course degree. The degree of the last aggregate blend considered ASTM degree maximum value is introduced in Figure 4.1 & Table 4.2.

Table 4. 1: Proportion of each aggregate material from a proposed mix

Type of Aggregate	Size (mm)	Proportion from a proposedmix (%)
Type I Coarse Aggregate	19	14.0
Type II Coarse Aggregate	12.5	19.0
Type III Coarse Aggregate	9.5	27.0
Type IV Coarse Aggregate	4.75	34.0
Sand	0.6	6.0
Sum		100

Table 4. 2: Gradation of the proposed mix with ASTM specifications limits

Sieves Size (mm)	Percentage Passing	ASTM D5315 Specification limits (%)	
		Minimum	Maximum
25	100.00	100	100
19	99.93	90	100
12.5	80.76	67	85
9.5	72.65	56	80
4.75	50.47	35	65
2.36	31.04	23	49
1.18	24.59	15	37
0.6	19.21	8	26
0.425	15.38	6	22
0.3	10.75	5	19
0.15	7.74	3	14
0.075	6.24	2	8

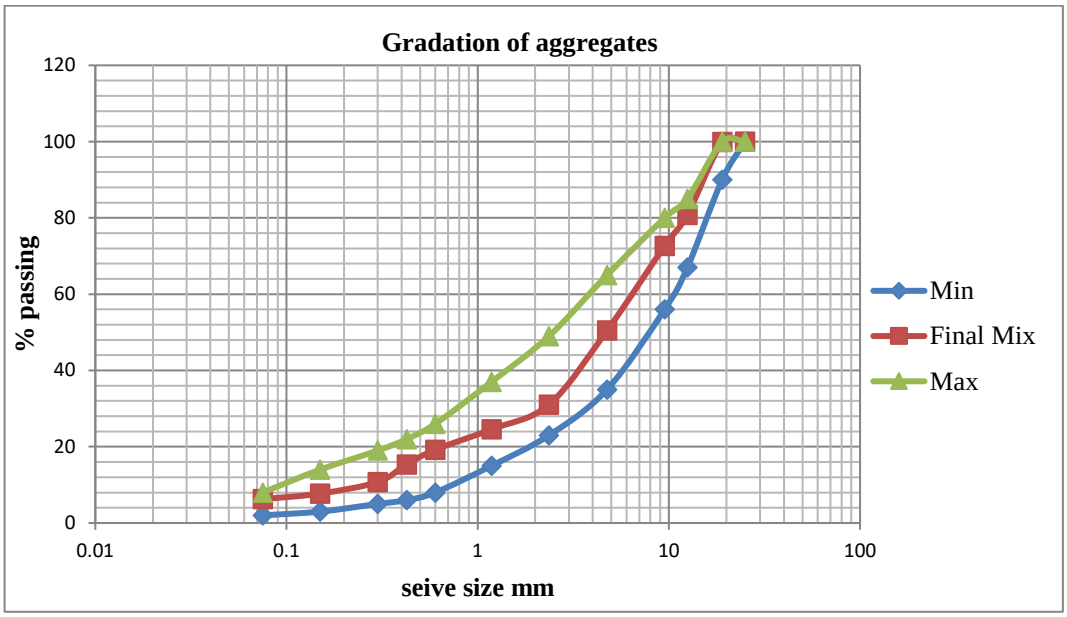

Figure 4. 1: Gradation of final aggregates mix with ASTM specification range

4.3 Bitumen Penetration Test

The test was being performed under the specification of ASTM D5, and bearing in mind the container dimension about 75mm x 55m in size was consider to experiment therefore the test results have been derived below in Table 4.3.

Table 4. 3: Penetration of bitumen

	Section A			**Section B**		
Trial	1	2	3	1	2	3
Initial	0	0	0	0	0	0
Final (0.1 mm)	68	64	66	65	68	69
Penetration value (0.1 mm)	68	64	66	65	68	69
Average		66.0			67.3	
			66.65			

4.4 Ductility Test

The present ductility test was being performed under the specification ASTM D113-86, and the results havebeen listed in Table 4.4.

Table 4. 4: Ductility of Bitumen

Section	Ductility (cm)
A	138
B	146
C	143
Average	144.33

4.5 Softening Point Test

The present softening point test has been carried out under specification ASTMD36-2002, and the result has been enlisted in Table 4.5.

Table 4. 5: Softening point test

Section	Softening point (°C)
A	47.1
B	47.2
Average	47.15

4.6 Flash and Fire Point Tests

The flash point test has been carried out under the specification ASTM D92-90, and the test results are enlisted in Table 4.6. For Flash point test the lowest temperature at which the application of test flame causes the vapors from the bitumen to momentarily catch fire in the form of flash, where the lowest temperature at which the application of test flame causes the bitumen to fire and burn at least for 5 secs.

Table 4. 6: Fire point & Bitumen flash test results

Flash point (C^0)	270
Fire Point (C^0)	282

4.7 Marshall Test

As talked about in Chapter 3 various 15 tests every one of 1200 gm in weight was readied utilizing five different bitumen substance from 4 - 6% with 0.5 % incremental keeping in mind the end goal to get the ideal bitumen content (OBC). Table 4.7demonstrates a synopsis of Marshall Test comes about. Additionally, subtle elements are displayedin.

Table 4. 7: Marshall Test

Bitumen content (%wt.)	No. Of Sample	Corr. Stability (Kg)	Flow (mm)	ρA (g/cm3)	Air voids Va (%)	Voids with bitumen (%)	Voids Mineral Aggregate (%)	VFB (%)
	1	1518.69	3.45	2.39	7.77	9.12	16.58	54.98
	2	1421.74	3.36	2.35	8.15	8.89	17.65	50.81
4	3	1379.31	2.45	2.40	7.45	9.11	16.22	54.78
	Average	1439.91	3.08	2.38	7.79	9.04	16.81	53.52
	1	1551.78	3.45	2.31	5.50	9.11	14.12	62.22
4.5	2	1383.19	2.68	2.28	6.27	9.02	15.25	57.98
	3	1438.76	2.47	2.22	5.68	8.87	13.65	59.68
	Average	1457.91	2.86	2.27	5.81	9.0	14.34	59.96

	1	1451.91	2.89	2.37	4.37	9.08	13.46	66.61
	2	1516.86	3.12	2.29	4.68	9.11	13.89	64.89
5	3	1528.53	3.08	2.38	4.22	9.21	13.92	67.12
	Average	1499.10	3.03	2.34	4.42	9.13	13.75	66.20
	1	1611.10	3.41	2.32	4.01	9.11	13.21	69.52
5.5	2	1365.89	3.49	2.40	3.61	9.22	12.89	72.02
	3	1263.56	2.89	2.42	2.45	9.14	13.87	65.89
	Average	1403.51	3.26	2.38	3.35	9.15	13.32	69.14
	1	1561.23	4.31	2.65	3.89	9.18	12.97	70.32
	2	1351.95	4.11	2.45	3.78	9.13	12.89	70.89
6	3	1289.66	4.22	2.65	3.92	9.11	13.11	69.51
	Average	1400.94	4.21	2.58	3.86	9.14	12.99	70.24

4.7.1 Stability bitumen content relationship

Stability being the highest freight essential to deliver disappointment of the sampling when a stack is connected next to a steady rate of 50 mm/min. Figure 4.2 solidness comes about for various bitumen substances are spoken to dependability of black-top blend increments as the bitumen content increment till it achieves the top at bitumen content 5% then it began to decay bit by bit at higher bitumen content.

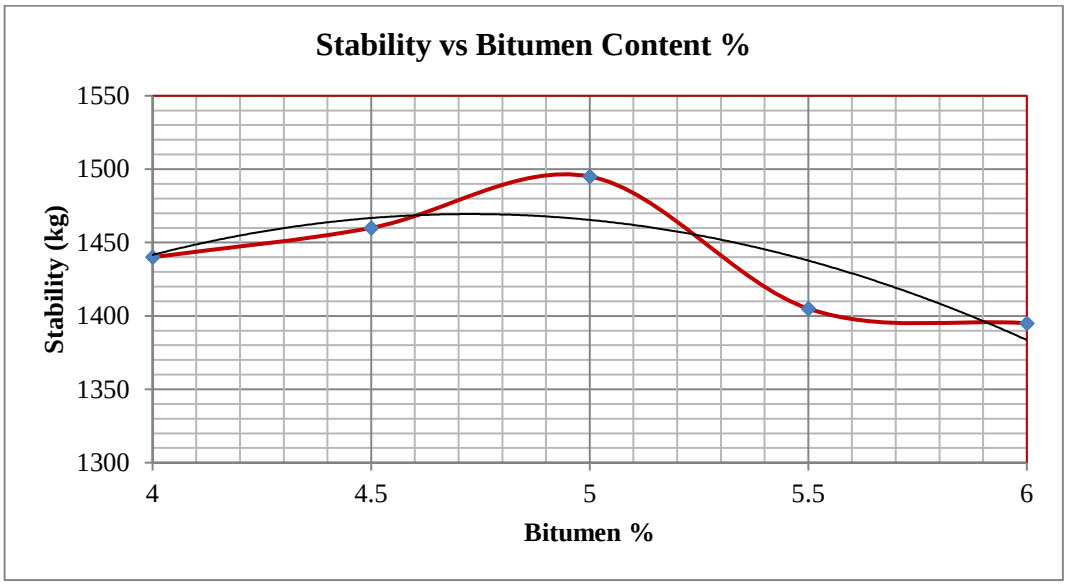

Figure 4. 2: Bitumen content vs Stability

4.7.2 Flow bitumen content relationship

The stream is the aggregate sum of misshapen which happens at most extreme load. Figure 4.3 Flow comes about for various bitumen substances are spoken to a stream of black-top blend increments as the bitumen content increment till it achieves the crest at the maximum bitumen content 6 %.

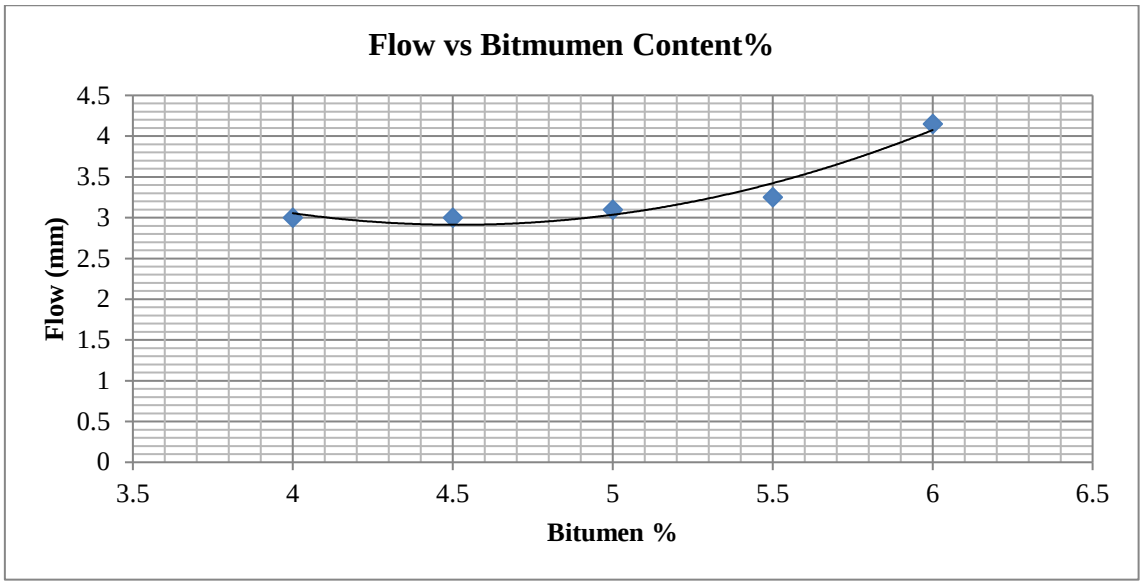

Figure 4. 3: Bitumen content vs Flow

4.7.3 Bulk density – bitumen content relationship

Mass thickness (Bulk density) being the real thickness of the firmed blend. In Figure 4.4 Bulk thickness comes about for various bitumen substances are spoken to mass thickness of black-top blend increments as the bitumen content increment till it achieves the pinnacle (2.35 g/cm3) at bitumen content 5 % then it began to decay continuously at higher bitumen content.

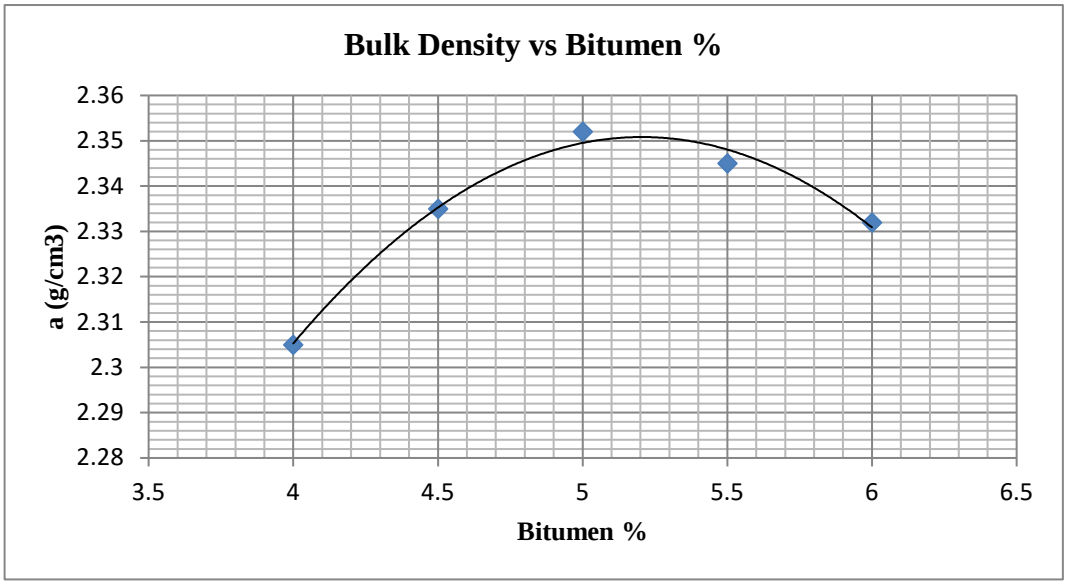

Figure 4. 4: Bitumen content Bulk vs Density

4.7.4 Va and Bitumen content relationship

Va % is the level of air voids by volume in the example or compacted black-top blend. In Figure 4.5 Va% comes about for various bitumen substance are spoken to most extreme air voids content esteem is at the least bitumen rate 4%, Va% diminish continuously as bitumen content increment because of the expansion of voids rate loaded with bitumen in the black-top blend.

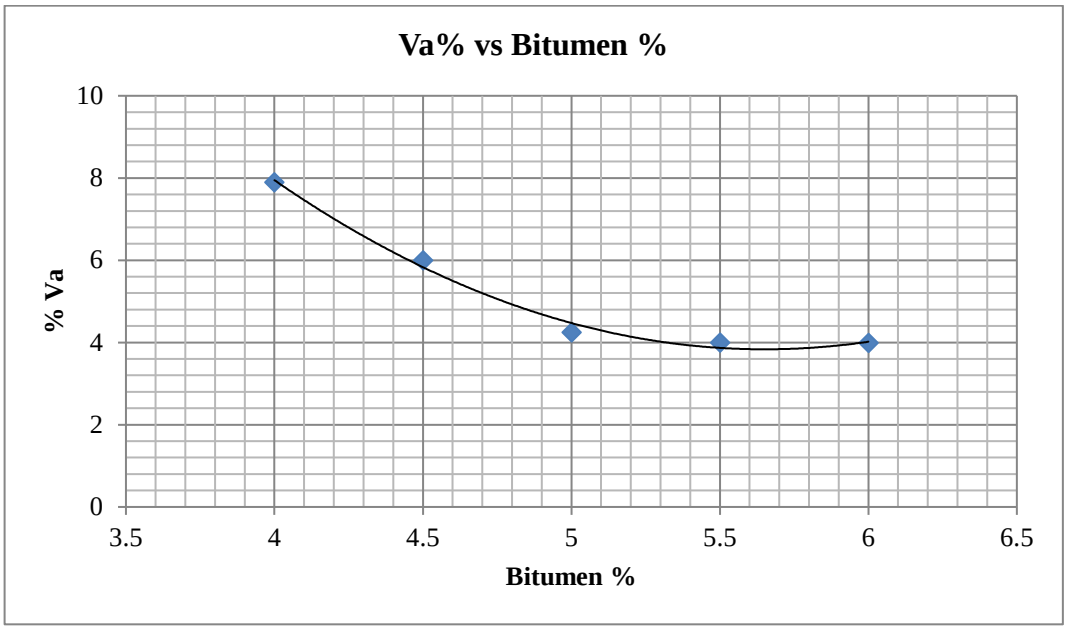

Figure 4. 5: Bitumen content vs Mix air voids proportion

4.7.5 VFB% and Bitumen content relationship

Annulled seal with Bitumen being the level of voids in mineral aggregate loaded with bitumen. In Figure 4.6 VFB% comes about for various bitumen substances are spoken to. Least VFB content esteem is at the most reduced bitumen rate 4%, VFB% expansion bit by bit as bitumen content increment because of the expansion of voids rate loaded with bitumen in the black-top blend.

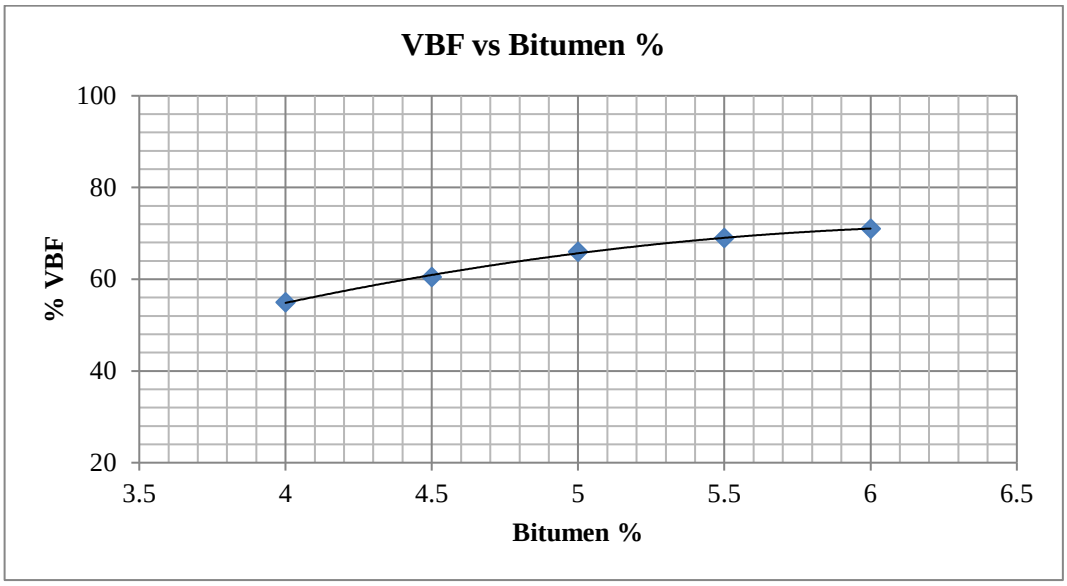

Figure 4. 6: Bitumen content vs voids filled bitumen proportion

4.7.6 Determination of optimum bitumen content (OBC)

Figures 4.2, 4.4 and 4.5 are used to discover three qualities separately.

- OBC at the highest stability (% mb) permanence = 5%
- OBC at the highest bulk density (% mb) = 5%
- OBC at the medium of allowed percentages of air annulled (*% mb*) *Va* =5%

Optimum bitumen content (OBC) = 5 + 5 + 5/3 = 5%

All results of asphalt mix with OBC satisfy Municipality of Lebanon and Asphalt Institute specifications requirements as shown in Table 4.8.

Table 4.8: Properties of the asphalt mix using optimum bitumen content

Property	Value	Local Specification		International Specification (Asphalt Institute, 1998)	
		Minimum	Maximum	Minimum	Maximum
Stability (kg)	1472	900	-	817	-
Flow (mm)	3.1	2	4	2	3.5
Void in Mineral aggregate (VMA)%	13.8	13.5	-	13	-
Air Void (Va)%	4.3	3	7	3	5
Bulk density (gm/cm^3)	2.35	2.3	-	2.3	-

4.8 Effect of adding WPB on the mechanical properties of asphalt mix

4.8.1 Phase (I): Conventional asphalt mix

The mechanical properties of the asphalt mix prepared with OBC (5.10 %) without the addition of WPB are shown in Table 4.9.

Table 4. 9: Mechanical properties of asphalt mix without the addition of WPB

Sample	**Bitumen % (By total weight)**	**Corr. Stability**	**Flow (mm)**	**ρA (g/cm3)**	**Va (%)**	**Vb (%)**	**VMA (%)**	**VFB (%)**
1	5	1506.01	2.78	2.34	3.68	11.45	15.66	75.32
2	5	1524.85	2.89	2.32	4.53	11.63	16.21	71.21
3	5	1523.63	2.98	2.33	3.85	11.71	15.62	74.68
Average	5	1518.16	2.88	2.33	4.02	11.59	15.83	73.73

4.8.2 Phase (II): Asphalt mix with (WPB)

As indicated by the system beforehand delineated in chapter 3 tests were set up at OBC to assess the impact of adding WPB to black-top blend tests by thinking about seven extents of WPB (6, 8, 10, 12, 14, 16 and 18% by the heaviness of OBC). Table4.10 demonstrates the mechanical properties of black-top blend utilizing various rates of WPB (By weight of OBC).

Table 4. 10: Mechanical properties of asphalt mix with WPB

WPB % (By weight of OBC)	Sample No	Bitumen % (By total weight)	Corr-Stability (Kg)	Flow (mm)	ρA (g/cm3)	Voids (Va) (%)	Voids with bitumen Vb (%)	Voids in mineral aggregate VMA (%)	VFB (%)
6	1	5	1687.5	3.17	2.41	4.47	11.71	16.18	72.3
	2	5	1668.1	2.87	2.39	4.57	11.68	16.38	70.8
	3	5	1941.2	3.29	2.37	3.79	11.81	15.57	75.8
	Average	5	1765.6	3.11	2.39	3.27	11.73	16.04	73.0
8	1	5	2001.6	3.36	2.36	4.45	11.56	16.14	72.3
	2	5	1851.6	3.14	2.37	4.71	11.59	16.31	71.4
	3	5	2405.7	2.98	2.41	4.11	11.68	15.81	74.1
	Average	5	2100.3	3.16	2.38	4.42	11.61	16.08	72.6
10	1	5	2011.1	2.87	2.36	4.54	11.71	16.18	72.4
	2	5	2074.0	3.16	2.37	4.48	11.67	51.89	73.3
	3	5	1840.8	3.70	2.37	4.41	11.67	16.07	73.0
	Average	5	1975.3	3.24	2.36	4.47	11.68	28.04	72.9
12	1	5	1916.6	3.22	2.39	4.36	11.73	16.12	73.0
	2	5	1941.0	3.61	2.37	4.16	11.75	15.89	74.4
	3	5	2103.2	3.73	2.39	5.21	11.75	16.06	73.0

	Average	5	1986.9	3.52	2.38	4.57	11.74	16.02	73.5
	1	5	1986.1	3.29	2.35	4.95	11.67	16.61	70.2
	2	5	2071.2	3.24	2.36	4.59	11.59	16.37	71.0
14	3	5	2051.3	3.74	2.36	4.59	11.62	16.76	69.3
	Average	5	2036.2	3.42	2.35	4.71	11.62	16.58	70.1
	1	5	1926.0	3.89	2.30	5.07	11.61	16.19	71.5
	2	5	2061.1	4.31	2.38	5.13	11.53	16.57	69.7
16	3	5	1815.0	3.41	2.36	4.56	11.61	16.12	71.8
	Average	5	1934.0	3.87	2.34	4.92	11.58	16.29	71.0
	1	5	1889.0	3.82	2.63	4.52	11.63	16.12	72.3
	2	5	1662.0	3.31	2.38	5.05	11.56	16.45	69.7
18	3	5	1654.4	5.15	2.38	5.09	11.56	16.45	69.8
	Average	5	1735.1	4.09	2.32	4.88	11.58	16.34	70.6

4.8.2.1 Stability – WPB content relationship

By and large, the steadiness of the changed black-top blends is higher than the regular black-top blend (1522.2 kg). Every one of the estimations of steadiness for various modifier rates is higher than solidness of ordinary blend. The greatest dependability esteem is discovered about (2200.3 kg) at WPB content around (8%). Figure 4.7 and Figure 4.8 demonstrates that the strength of adjusted black-top blend increments as the WPB content increments till it achieves the crest at 8 % WPB content then it began to decay steeply at higher WPB content.

The change of soundness in WPB altered black-top blends can be clarified because of the better attachment created amongst bitumen and WPB covered aggregate because of intermolecular holding, these intermolecular attractions improved quality of black-top blend, which like this helps to upgrade sturdiness and solidness of the black-top blend (Manjuet al., 2017)

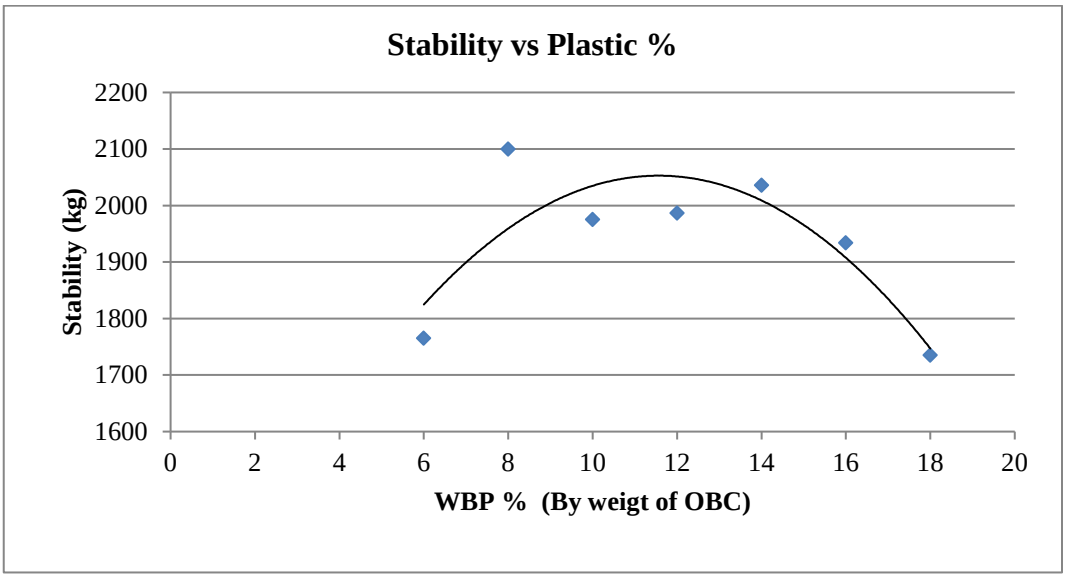

Figure 4. 7: WPB content and stability relationship

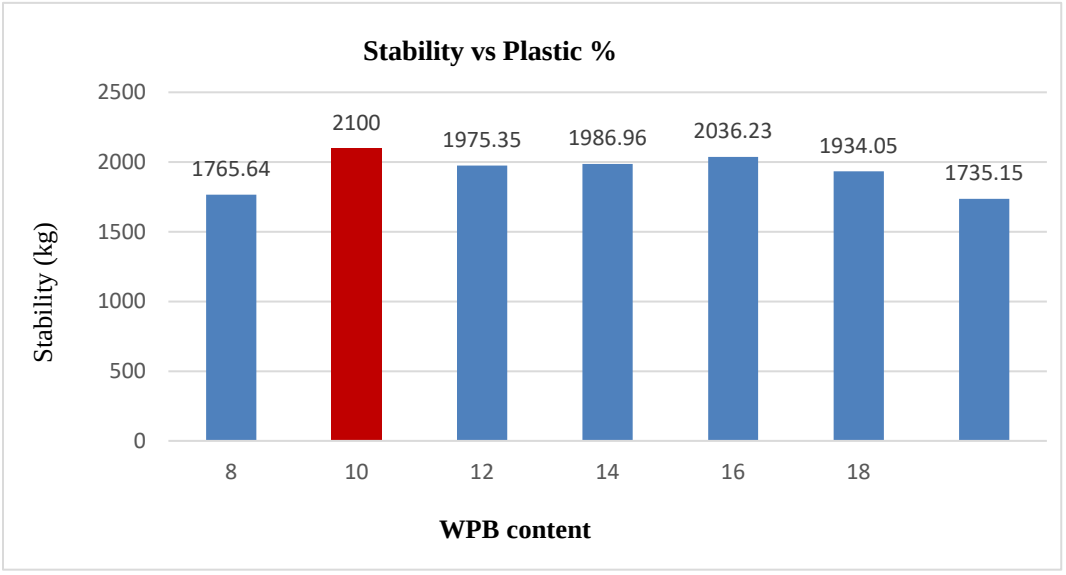

Figure 4. 8: Best WPB % compared with base asphalt for stability

4.8.2.2 WPB content and Flow relationship

For the most part, the stream of the changed black-top blend is higher than the traditional black-top blend (2.97 mm). Figure 4.9 demonstrates that the stream increments consistently as the WPB modifier content increment. The stream esteem stretches out from 3mm till it achieves (4mm) at WPB content (18%).

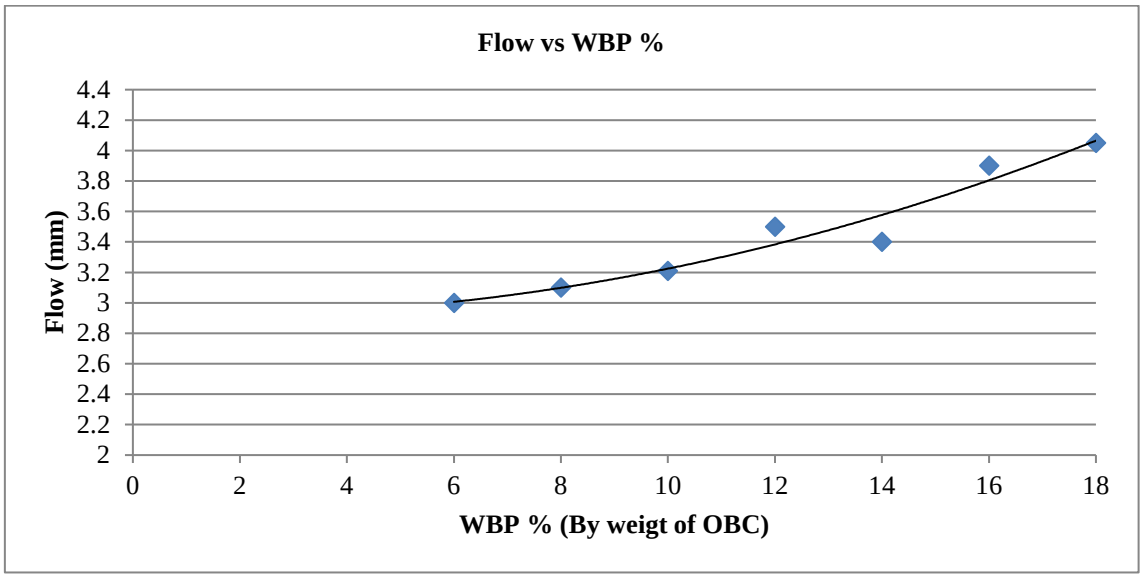

Figure 4. 9: WPB content and asphalt mix flow relationship

4.8.2.3 WPB content and Bulk density relationship

The mass thickness of WPB adjusted black-top blend is lower than the customary black-top blend (2.36 g/cm3). The general pattern demonstrates that the massthickness diminishes as the WPB content increment. The most extreme mass thickness is (2.35 g/cm3) at WPB content (6%), and the base mass thickness is (2.313 g/cm3) at WPB 18%. This decline of massthickness can be disclosed to be because of the low thickness of an additional plastic material. Figure 4.10 and Figure 4.11 demonstrate the bend which speaks to black-top blend mass thickness – WPB content relationship.

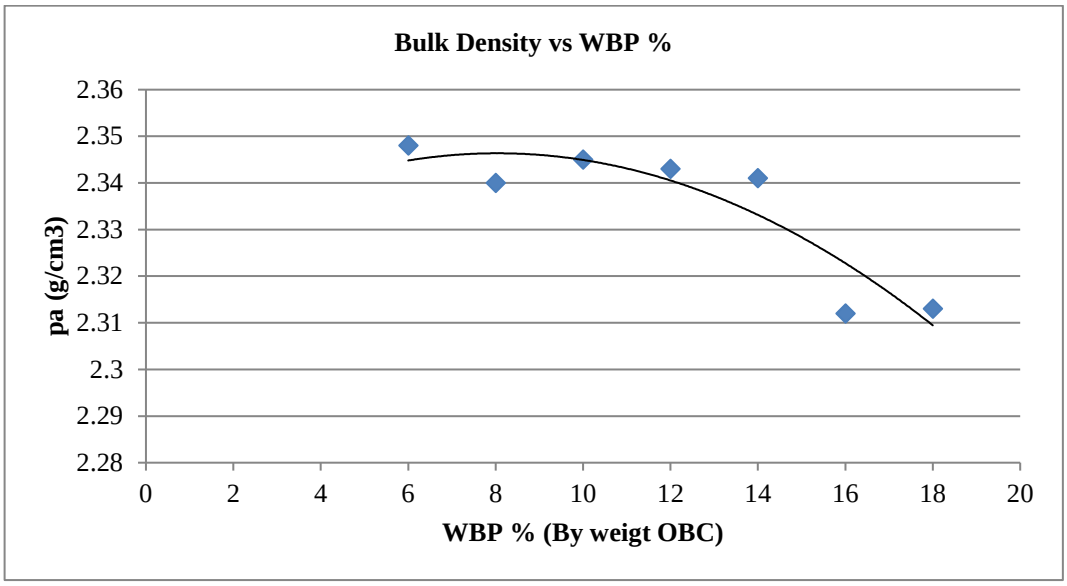

Figure 4. 10: WPB content and asphalt mix bulk density relationship

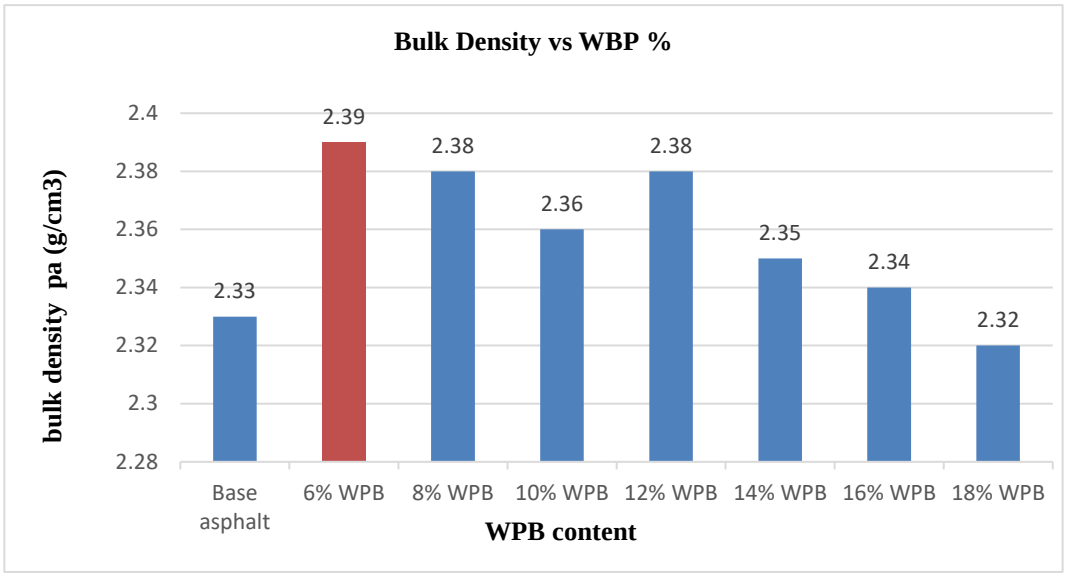

Figure 4. 11: Best WPB % compared with base asphalt for bulk density

4.8.2.4 WPB content and Air voids (Va) relationship

The air voids extent of changed black-top blends is more significant than ordinary black-top blend 4.15 %. Va % of changed black-top blends increments step by step as the WPB content increment till it comes to the most elevated Va% esteem at 18% WPB. For the most part, adjusted black-top blends have Va% content inside particulars extend. Figure

4.12 and Figure 4.13 demonstrates the bend which speaks to black-top blend air voids – WPB content relationship.

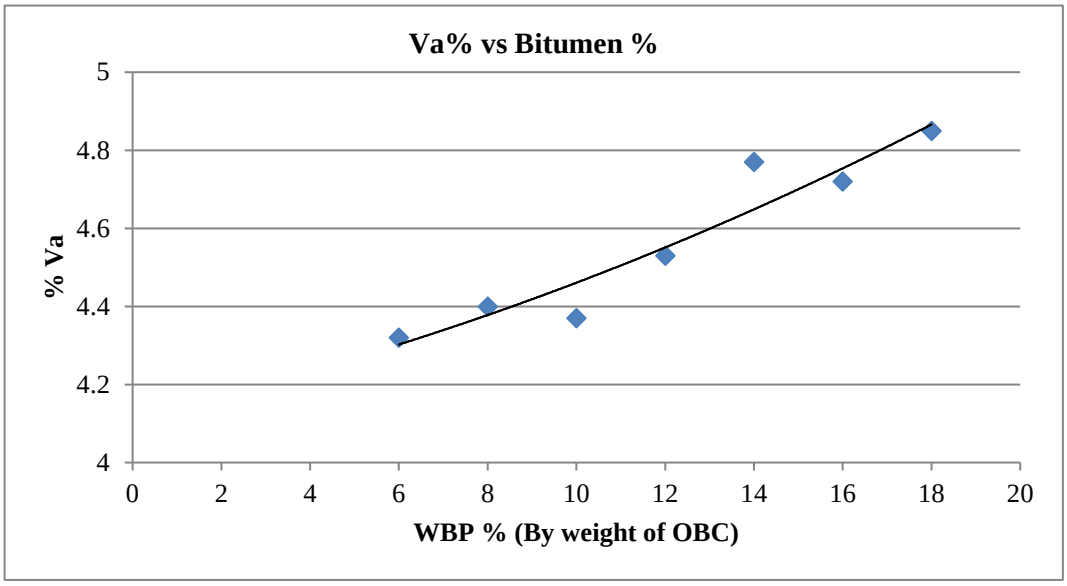

Figure 4. 12: WPB content and asphalt mix air voids relationship

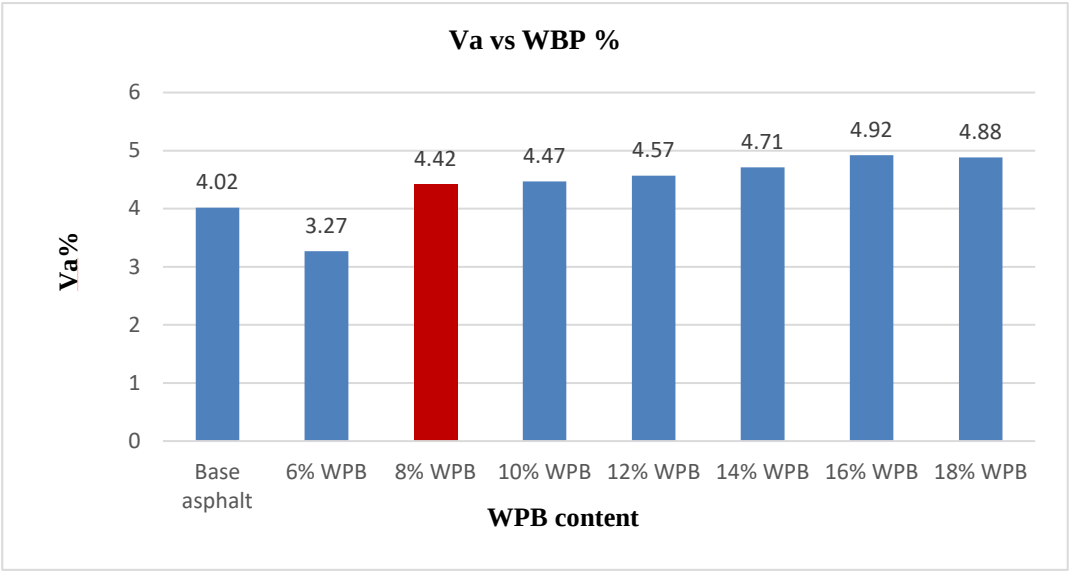

Figure 4. 13: Best WPB % compared with base asphalt for air voids

4.8.2.5 WPB content and voids in mineral aggregates (VMA) relationship

The voids in mineral totals rate VMA% for the black-top blend is influenced via air voids in black-top blend Va and voids loaded with bitumen Vb. VMA% of changed black-top blends is for the most part higher than ordinary black-top blend 15.94 %. VMA % of altered black-top blends increments as the WPB content increment, it achieves 16.38% at WPB content 18%. Figure 4.14 demonstrates the bend which speaks to black-top blend VMA% – WPB content relationship.

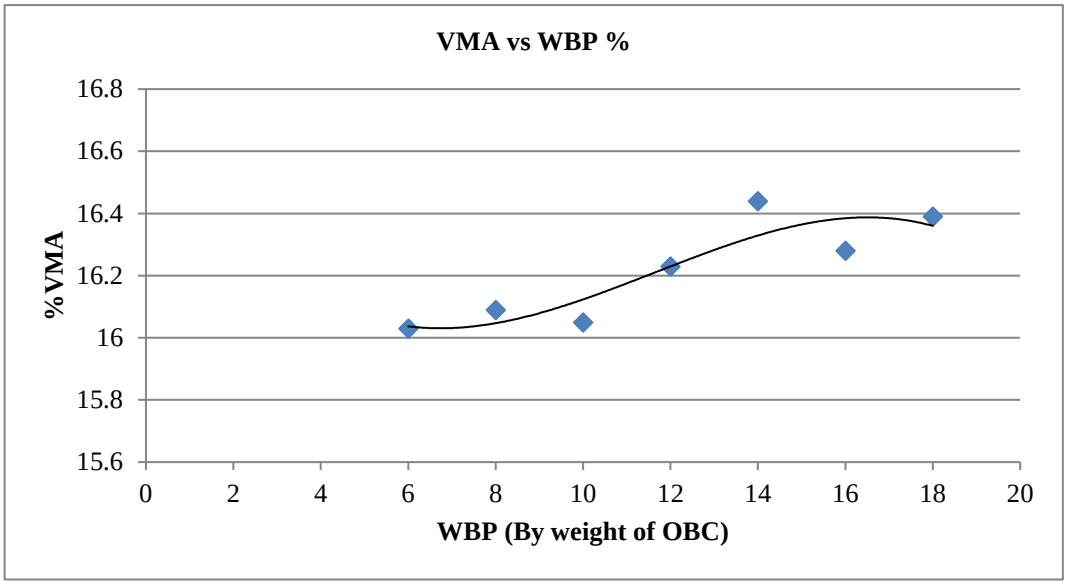

Figure 4. 14: WPB content and asphalt mix voids of mineral aggregates relationship

4.8.3 Optimum modifier content

An arrangement of controls is prescribed to get the ideal modifier content that creates a black-top blend with the best mechanical properties. Black-top blend with ideal modifier content fulfills the accompanying:

- Maximum stability
- Maximum bulk density
- Va % within the allowed range of specifications.

Figures 4.7, 4.9 and 4.10 are used to find WPB percentages which satisfy these three controls. The WPB percentages which satisfy controlsare summarized in Table 4.11.

Table 4. 11 Summary of controls to obtain optimum modifier content

Property	WPB (By OBC weight)
Maximum stability	8%
Maximum bulk density	6%
Va% within the allowed range of specifications	8%

The maximum WPB content is the average of the previous five WPB contents.

Optimum WPB content (By OBC weight) = (14 + 6 +8)/3 = 8%

4.8.4 Required WPB quantity

To imagine how much WPB will be required for a section of road when using WPB modified asphalt mix. The following example would be useful.

Example: Road section with the following parameters

- Width = 10 m
- Length = 1 km
- Asphalt binder course layer with 6 cm depth
- Density of modified asphalt mix = 2.346 g/cm3 = 2.346 ton/m3
- OBC = 5%
- WPB content = 8 % (By weight of OBC)
- WPB weight required for the section = WPB content x Density X Volume
  = 0.08 x 0.05 x 2.346 x 10 x 1000 x 0.06 = 5.84 ton

From previous example it's obvious that asphalt pavement consumes large amount of raw materials and considerable amount of WPB can be reused in valuable application rather than disposal.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions and Recommendations

In light of exploratory work comes about for WPB changed black-top blends contrasted and traditional black-top blends, the accompanying conclusions can be drawn:

- WPB can be advantageously utilized as a modifier for black-top blends for the economical administration of plastic waste and in addition to enhanced execution of black-top blend.

- The ideal measure of WPB to be included as a modifier of the black-top blend was observed to be 8.0 % by weight of ideal bitumen substance of the black-top blend.

- Asphalt blend altered with 8.0 % WPB by OBC weight has roughly 24% higher solidness esteem contrasted with the regular black-top blend.

- The bulk density increased from 2.33 g/cm to 2.39 g/cm on 6% added WPB.

- The stability increased from 1518.16 kg to 2100.3 kg on 8% added WPB.

- The air voids compared to 4.02% from base asphalt was better at 8% added WPB which is 4.42%.

- Asphalt blend adjusted with WPB show bring down mass thickness as the WPB rate expanded. This increase in mass thickness can be disclosed to be because of the low thickness of the included plastic material.

- Asphalt blend altered with WPB show higher stream an incentive as the WPB rate expanded. In any case, the solidness of the altered blend is expanded.

- Further considers are required in different points identified with successful use and best-joining methods of waste materials in black-top asphalts.

- Constructing test street segments utilizing WPB adjusted black-top blend for additionally field investigations of its execution.

- Further considers is suggested for joining other waste plastic materials in the black-top blend, for example, plastics shaped from High-Density Polyethylene (HDPE) and Polyethylene Terephthalate (PET) which broadly utilized as a part of soda bottles.

  8% of waste plastic bag is obtained as an optimum percentage added to the asphalt mixture which helped to improve the asphalt mixture in its stiffness, stability and air voids resulted by lab tests. This process showed that waste plastic bag can be used as a modifier added into the asphalt mixture as first and help the environment from health problem on the other hand. Most of the roads are being affected by traffic load problems that lead for cracking, and with this lab test, in economical way these asphalt roads can be improved to avoid these daily problems.

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