PREPERATION OF ROAD USED WITH WASTE PLASTIC

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ABSTRACT

Global plastic pollution reported that; 1 million plastic bottles bought every minute, 100,000 marine animals killed by plastic each year, 500 years to degrade in the environment, 90% of bottled water contain plastic particles. Ethiopia is facing rapid urbanization and industrialization leading to packing of different industrial products with plastic bottles which finally becomes waste and on the other side pavements is behaving different structural failure and surface defects before the end of construction period and service year. In order to minimize the above serious problems, this research was initiated to do experimental investigation of waste plastic bottle as partial replacement of aggregate in bituminous concrete mix through dry process to enhance the desired performance of bitumen concrete mix and to reduce plastic bottles disposal problem. Before applying PET bottles as additives, optimum bitumen content was determined for conventional bitumen concrete mix which is selected as 5.33%; up on which the effect of PET bottles was experimented. Waste plastic bottles are collected and cut in to pieces using scissors. Then it was melted in oven at 180^0c for 30 minute. Then after cooling down it was pulverized. Finally weighing the required amount of pulverized plastic and replacing the aggregate by 0%, 4%, 6%, 8% and 10% by weight of aggregate, the marshal test were held and volumetric properties on each specimen were computed. Based on the laboratory result, the optimum plastic content was selected at the specimens that have high stability; high bulk density and minimum air void values are 20.66 KN, 2.59gm/cm3 and 3.25% respectively. The optimum plastic content is selected at 4% of plastic bottle by weight of aggregate. Lastly this study concluded that, partial replacement of aggregate by waste plastic bottle can increase the overall performance of bitumen concrete mix. Finally this study recommends it is better to apply this new construction technology on the ground and to adopt it. It is better to know the cost benefit analysis on partial replacement of aggregate by waste plastic bottles in flexible pavements. Keyword:- Bitumen Concrete, Modified Bitumen, Optimum Binder Content, Optimum Plastic Content, Plain Bitumen Experimental Investigation of Waste Plastic Bottles as Partial Replacement of Aggregates in Flexible Pavements.

1.INTRODUCTION

In general pavements are categorized into 2 groups, such as flexible and rigid pavement. Flexible pavements are those, on which the whole pavement have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on to the surface of the layer. If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement since the total pavement structure does not bend or deflect due to traffic loads. Bituminous concrete is one of the widely used and costliest types of flexible pavement layer used in the surface course. Properties of a good bituminous mix are skid resistance, stability, durability etc. The mix design should aim at economical blends with the proper gradation of aggregate and an adequate proportion of bitumen so as to fulfill the desired properties of the mix. Marshall Stability test carried out to find the stability, flow value, bulk density, air voids, voids filled with mineral aggregate, voids filled with bitumen and finally finding the optimum binder content of the mix. Marshall Stability test is conducted on compacted cylindrical moulds of bituminous mix to determine the optimum binder content . Semi-dense bituminous concrete is the most commonly used pavement material due to its construction procedures. The ever increasing economic cost and scarcity of availability of natural material have opened the opportunity to explore locally available waste material. If industrial waste materials can be suitably used in road construction, the pollution and disposal problems may be partially reduced . Utilization of waste material as secondary material is being developed world wide. One of these waste materials is plastic bottles which are being accessible in large amount. In food industries, plastic bottle is mostly made by PolyethyleneTerephthalate (PET). PET becomes very popular during the last decade because it is known as safe, durable and good material for packaging. The threat of disposal of plastic will not be solved until the practical steps are not initiated at the ground level. It is possible to improve the performance of bituminous mix used in the surfacing course of roads. Studies reported that the use of re-cycled plastic, mainly polyethylene, in the manufacture of blended indicated reduced permanent deformation in the form of rutting and reduced low temperature cracking of the pavement surfacing. The field tests proved that plastic wastes used after proper processing as an additive on flexible pavement would enhance the life of the pavement and also solve environmental problems . Plastic and tyre is a non-biodegradable material. Despite, the quantum of plastic waste is also increasing day by day which is hazardous to our health. Thus using plastic waste for construction purpose of flexible pavements will be one of the alternatives for disposing them in an eco-friendly manner.

2. Significance of the Study

The use of plastic bottles in bitumen concrete mixtures as partial replacement of aggregate reduces the negative environmental impact due to exploitation of aggregates for construction purpose and the problem of municipal solid waste disposal problem by win-win approach. And it also reduces the construction cost, since the plastic bottle is cheap and highly available. Moreover this can highly solve the plastic waste management problems since plastic bottle waste is one of enormously increasing, the reason due to that we use plastic bottles in our day to day life. It also solves the problems of municipal drainage system since the plastic bottles clog them. The use of plastic bottles as partial replacement of aggregate enhance the overall performance of flexible pavements when the marshal test results of conventional bitumen concrete mix and the modified bitumen concrete mix were compared.

This study genuinely proves that the use of plastic bottles as partial replacement of aggregate in flexible pavement is good for heavy traffic because of its surprising overall performance. It also enables to solve solid waste disposal problems in a useful and ecofriendly manner which imply that it solves the problems in a better way than that of incineration and land filling. Utilization of plastic waste with the bitumen is not new in the construction of flexible pavement. But in this study it was used as partial aggregate replacement. As indicated in many research; it did not only increase its smoothness life but also minimizes permanent deformations due to overload; increases resistance to flow at higher temperature, water repellent property, makes it environment-friendly and economical.

In this study waste plastic bottles were used as partial replacement of aggregate by various percentages by weight of aggregate and it increases flow value and marshal stability, decreases the unit weights (bulk density) which helps in enhancing hauling cost. Flexible pavement Roads which were constructed by using plastic bottles as an aggregate had better overall performance in the bituminous mixes as compared to those constructed without plastic (conventional BC mix).

3. LITERATURE REVIEW

This chapter provides a review of literature on the Effects of Using waste plastic bottle as partial replacement of aggregate in BC mixes. The main purpose of a literature review is to establish the academic and research areas that are relevant to the subject under study.

3.1 Theoretical Review

The benefits of using waste materials like fly ash and plastic waste are considerable reduction in the use of natural raw materials, responsible for industrial sustainability, solves the disposal problems of wastes as these are utilized in construction activities, plastic improves some properties of bituminous mixes used for paving roads.

3.2 Materials in Bitumen Concrete Mix

Bitumen is a black or dark colored solid or viscous cementitious substance having an adhesive property. And it consist chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt. And also it is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process . Bitumen is a black, highly viscous and very sticky liquid or semi-solid, found in some natural deposits. It is also the by-product of fractional distillation of crude petroleum. Bitumen is composed of highly condensed polycyclic aromatic hydrocarbons, containing 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), up to 5% sulphur, 1% nitrogen, 1% oxygen and 2000 ppm metals. It is the heaviest fraction of crude oil, the one with highest boiling point (525°C). Bitumen acts as binding agent for aggregates in bituminous mixes. Generally in India bitumen used in road construction of flexible pavement is of grades 60/70 or 80/100 penetration grade. Cutback bitumen is bitumen in which a suitable solvent is mixed to reduce viscosity. Bitumen emulsion is suspended in finely divided condition in aqueous medium 60% bitumen and 40% water. Bituminous primers are obtained by mixing penetration bitumen with petroleum distillate. Modified bitumen is blend of bitumen with modifiers such as waste plastics or crumb rubber or fly as. In order to withstand tyre and weather, pavement surface layers contain the strongest and most expensive materials in road structures. Characteristics they exhibit like friction, strength, noise and ability to drain off surface water are essential to vehicles? safety and riding quality . Bitumen content in the mix should be 4% (by weight) of the total mix. Bitumen grades can be industrial (which includes waterproofing) or pave grade (grading used for pavement structures). In India, 60/70 and 180/200 of bitumen are usually used. Often, choice of the grade depends on environment conditions of the area . Bitumen is a material which is a byproduct of petroleum refining process. It is a highly viscous at temperature above 100 degrees Celsius and is solid at room temperature . A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred. There are so many properties of bitumen required to be fulfilled as depicted in Table.

The Properties of bitumen

Sl No.	Properties	Grade		Test methods
		60/70	80/100	
1	Penetration at 25° C	67	90	IS:1203-1978
2	Softening point (R&B) °C	51	41	IS:1205-1978
3	Ductility @27°C, cm	73.5	75.5	IS:1208-1979
4	Flash point, °C	330	261	IS:1209-1981
5	Fire point, °C	345	283	IS:1209-1981
6	Specific gravity of bitumen	1.017	1.02	IS:1202-1980

Aggregate

Aggregate is a major component of asphalt mixes, so their properties play a significant role on the asphalt paving mixtures. An aggregate gradation that yields maximum solid density and maximum particle interlock is highly desirable for the asphalt concrete mixes. Maximum particle interlock leads to high mix density and stability. While minimum voids in a certain material composition leads to high strength Aggregate is the major structural framework of asphalt mixture to absorb and control different stresses on the pavement. Mineral aggregates make up 90 to 96% of a HMA mix by weight or approximately 75 to 85% by volume. The properties of the mineral aggregates have significant effects in performance of our roadways which offers the possibility of investment in these properties towards resisting different ranges of external applied loads and environmental conditions. Therefore, aggregate characteristics deeply affect the performance of asphalt pavements. Gradation is one of the important characteristics of aggregates affecting permanent deformation of hot mix asphalt. Fine, medium and coarse gradation mixtures for different aggregate types were tested to investigate the effects of variation in the aggregate types and gradation on mix properties. The asphalt contents of the mixes were maintained at the job mix design contents. Properties investigated were, Marshall Stability, Marshall Flow, unit weight, air voids, and voids in mineral aggregate.

Coarse aggregate used for road construction should be hydrophobic to the bituminous surface. Other than this it should be hard, tough and durable. Gravels should not have fineness modulus of less than 5.75 and should be well graded (6.4mm to 38mm and free from organic matter, silt and clay. Some of the required properties of aggregate were as depicted in Table. Aggregates without plastic and aggregates coated with of waste plastic equal to 0.5%, 0.55%, and 0.6% of weight of dry aggregates. The use of plastic waste in the construction of flexible pavement is one of the best methods for the safe disposal and better performance of the bituminous mix, if plastic coated aggregates are used.

OBC for conventional SMA, BC and DBM mixes are found as 6%, 4.5% and 4.5% similarly OBC are found as 4% for modified SMA, BC and DBM mixes with polyethylene at different concentration. With addition of polyethylene, stability value also increases up to certain limits and further addition decreases the stability. This may be due to excess amount of polyethylene which is not able to mix in asphalt properly. That polyethylene concentration in mix is called optimum polyethylene content (OPC) which is found as 2% for SMA and 1.5% for DBM bitumen mixes.

The required properties of aggregates.

Sl no	Aggregate tests	Test results obtained	Requirements as per Table 500-14 of MoRTH (IV revision) Specifications
1	Crushing value (%)	24.8	-
2	Impact value (%)	20.8	Max 24%
3	Los Angeles abrasion value (%)	32	Max 30%
4	Combined index (%)	29%	Max 30%
5	Water absorption (%)	0.25	Max 2%
6	Specific gravity of coarse aggregates	2.72	2.5-3.0
7	Specific gravity of fine aggregates	2.76	
8	Specific gravity of filler	2.5	

Waste Plastic Bottle

Polymers can be broadly classified as either thermoplastics or thermosets. The fundamental physical difference between the two has to do with the bonding between molecular chains. Thermoplastics have only secondary bonds between chains, while thermosets also have primary bonds between chains. Thermoplastic polymers can be melted or molded while thermosetting polymers cannot be melted or molded in the general sense of the term. Thermoplastic or thermosetting polymers are sometimes identified by other names such as "linear" and "cross-linked" respectively.

The ocean is estimated to already contain over 150 Mt of plastics; or more than 5 trillion micro (less than 5mm) and macroplastic particles. The amount of oceans plastic could triple by 2025 without further intervention. By 2050, there will be more plastics, by weight, in the oceans than fish, if the current "take, make, use, and dispose? model continues [6]. 90% of bottled water found to contain plastic particles, 83% of tap water found to contain microplastic particles, 50% of consumer plastics are single use, 10% of all human-generated waste is plastic. In the next 10-15 years global plastic production is projected to nearly double.

About 2.8 Mt of waste plastics is generated per annum in the India. Most of those recycled are from industrial and commercial sources; recycling from domestic sources (e.g. bottles) is more difficult, for economic reasons. A future increase in recycling relies on the successful recycling of plastics mixed with other waste, and the support from robust environmental assessment method. Data from UK WRAP indicate that about 0.4 Mt of waste plastics generated each year is suitable for aggregates use. Presently only 0.008 Mt is being recycled for that purpose. Although plastic packaging accounts for most waste plastics recycled in the India, PVC (polyvinyl chloride) is among the main types that have the lowest recycling rate. Financial incentives are believed to be more effective than specifications in affecting the recycling activity. Thus plastics used in asphalt pavements may provide an important outlet for such materials.

Solid waste management is the thrust area. Of the various waste materials, plastic waste and municipal solid waste are of great concern. Finding proper use of the disposed plastics waste is the need of the hour. The traffic intensity is increasing. The load bearing capacities of the road are to be increased. The use of PCA for asphalt pavement helps for the reuse of plastics waste and for the improvement of road strength. Plastics, a versatile packing material and a friend to common man, become a problem to the environment after its use. Most usematerials are bags, cups, films and foams, made up of PE, PP or PS. The use of plastics in India is hoped to reach 12 million tonne by the end of 2020. Around 55% is being used for packing. They are mostly littered after their use. The littered plastics, a non-biodegradable material, get mixed with domestic waste and make the disposal of municipal solid waste difficult. The municipal solid waste is either incinerated or used for land filling. Both are not right techniques to dispose the waste and it will create both land and air pollution. This process helps to dispose the waste by eco- friendly method. This process can promote value addition to the waste plastic too. Waste polymers namely PE, PP and PS are hydrocarbons with long chains. The bitumen is a complex mixture of asphaltenes and maltenes which are also long chain hydro carbon.

Polyethylene Terephthalate commonly abbreviated PET, is the most common thermoplastic polymer resin of the polyester family and is used in fibers for clothing, containers for liquids and foods, thermoforming for manufacturing, and in combination with glass fiber for engineering resins. Its chemical formula is denoted as $(C_{10}H_8O_4)_n$

Reuse of bulk wastes is considered the best environmental alternative for solving the problem of disposal. The large volume of composite materials required for the construction and maintenance of road pavements in the India is potentially a major area for the reuse of waste materials. Because the amount of "new? materials like mineral aggregates required in the road construction industry is large, approximately 20,000 t per mile of motorway constructed, the environmental benefits are not only related to the safe disposal of bulk waste but also to the reduction of environmental impacts arising from the extraction of aggregates which include the loss of mature countryside, visual intrusion, heavy lorry traffic on unsuitable roads, noise, dust and blasting vibration. In 1995, the plastic consumption in India . The major users of plastic are the packaging industries, consuming about 41%, 20% in building and construction, 15% in distribution and large industries, 9% in electrical and electronic, 7% in automotive, 2% in agriculture and 6% in other uses. In the India, the total plastic waste was estimated at around 2,158,000 t in 1995; 1,279, 000 t (59.2%) arising from municipal solid waste, 446,000 t (20.7%) arising from distribution and large industry, 15 1,000 t (7%) from automotive industries, 128,000 t (5.9%) d from electrical and electronics, 122,000 t (5.7%) from construction/ demolition and civil works, and 32,000 t (1.5%) from agriculture. From the total household waste in Western Europe in 1995, about 129,061, 000t; the amount of plastic waste is about 8% by weight, approximately 10,139, 000 t. The largest component of the plastic waste is low density polyethylene/linear low density polyethylene (LDPE) at about 23%, followed by 17.3% of high density polyethylene, 18.5% of polypropylene, 12.3% of polystyrene (PS/extended PS), 10.7% polyvinyl chloride, 8.5% polyethylene terephthalate and 9.7% of other types. Cross-linked polyethylene (XLPE) is widely used as an insulating material for electric wires and cables. XLPE wastes are non-biodegradable components. The accumulation of polymer wastes including waste plastic, waste rubber and polyethylene materials such as XLPE has become a worldwide concern. The total amount of cable waste produced in Japan in 2003 was approximately 10,000 tons. Also, in Sweden, the amount of electrical cables waste was estimated to be 40,000 tons in 2007. These statistics indicate large quantities of XLPE waste. In recent years, cross-linked polyethylene (XLPE) is one such waste material that has been growing rapidly. In fact, XLPE used for the insulation of electric wires and cables is a nonbiodegradable component. Some plastics items such as plastic bottles become waste only in a short time after being purchased. After collecting plastics from customer or plant cycle, recycling plastic is more preferable method because plastics can lend themselves to be recycled many times over. PET is selected in the soft-drink container market or plastic bottle because this material is tough (so that it can withstand when it drops), cheap, clarity, durability, excellent, odour resistance and low permeability to carbon dioxide. PET also is used as high performance films such as photographic, magnetic tape, electrical insulation and decorative film laminates. The performance of PET as aggregate replacement had been done in concrete technology. For example, Algeria has investigated the usage of PET as an aggregate for concrete. The usage of waste PET granules pellet was experimented as a partial fine aggregate replacement in asphalt mixture. According to the Waste and Resources Action Program (WRAP) survey, most plastics collected for recycling from the household waste stream are plastic bottles. The

majority of bottles are made from Polyethylene Terephthalate (PET), estimated that the ratio is 55-60%. This plastic material was identifiably Low Density Polyethylene (LDPE) principally used as a recycled material in manufacturing of plastic bags and allied products. However, the RPWA may contain traces of other plastic waste materials such as HDPE, PET and PP and so on [26]. Plastic disposal is one of the major problems encountered in all countries. In India, more than 15,000 tons of plastic wastes are generated every day, of which 6,000 tons remain uncollected and littered as per the Government statics. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. One such waste is plastic, which could be used in various applications .

Disposal of huge amount of discarded waste materials like plastic, polythene bags, bottles, rubber tyre and so on, which are generated in huge quantity and causes environmental hazards after their disposal. A recent survey of 60 cities in India by Central Pollution Control Board estimated that about 33.7 million pounds of plastic waste is being generated out every day, of which about 13.2 million pounds remain uncollected and are choking environment. Being non-biodegradable products, plastic and rubber stay for a long time on site and cause environmental pollution. Conventional techniques such as land filling and incineration which are used to dispose plastic waste and rubber tyres create leachate on degradation, which have negative effect on land, water and air.

Disposal of waste plastic materials, e.g. bottles, baskets, is becoming urgent issue and is the main reason which causes environmental pollution.

Classification of plastic

A). Polyethylene Terephthalate Safe and recyclable, plastic bottles and containers made of it used for water, juice, soft drinks and peanut butter packaging . Polyethylene terephthalate (PET or PETE) is the workhorse of America?s plastic drinking bottle industry, polyethylene terephthalate (PET) is one of the most versatile and widely used types of scrap plastic.

B). High-Density Polyethylene

It is one of safe and recyclable, used for the manufacturing of packages for shampoo, detergents and milk, as well as plastic toys. It is safer than any other plastic material especially the transparent type . HDPE (High Density Polyethylene) is scrap types of plastic which is used to make milk jugs, detergent bottles, juice bottles, butter tubs, and toiletry bottles. HDPE is a higher density, heavy duty scrap plastic and recycled. HDPE is often used to make more durable product which is as shown in Figure 2.3 below.

C). Polyvinyl Chloride Polyvinyl chloride is harmful and toxic if used for long time. It is commonly abbreviated PVC and used in the manufacturing of plumping pipes, bathroom curtains, toys, and transparent plastic wraps for meat and cheese. It is widely used because of its cheap price, so it is considered the most dangerous type of plastic . PVC (Polyvinyl Chloride) is used for all kinds of pipes and tiles, but it is most commonly found in plumbing pipes. This kind of plastic should not come in contact with food items. Recycled PVC is used to make flooring, mobile home skirting, and other industrial-grade items. The Figure 2.4 below depicted PVC types of plastic.

D). Low-Density Polyethylene LDPE is proportionally safe, recyclable, used for the manufacture of CDs, bottles and grocery bags . LDPE (Low Density Polyethylene) tends to be both durable and flexible. Plastic cling wrap, sandwich bags, squeezable bottles, and plastic grocery bags all are made from LDPE. Recycled LDPE is used to make garbage cans, lumber, furniture, and many other products seen in and around the house .

E). Polypropylene Polypropylene is one of the best and safest types of plastic, suitable for cold and hot liquids and other products. It is not harmful, used in manufacturing of food containers, plates, medicine bottles and all food related products. It is recommended that all food containers should be made of this substance, especially children's food containers used for school meal packaging, and water bottles reused for multiple times . PP (Polypropylene) is strong and can usually withstand higher temperatures. Among many other products, it is used to make plastic diapers, Tupperware, prescription bottles, and some stadium cups. Plastic bottle caps often are made from PP as well. Recycled PP is used to make ice scrapers, rakes, battery cables, and similar items that need to be durable. The Figures 2.6 below represent PP (Polypropylene) types of plastic

F). Polystyrene is dangerous and unsafe, used for burger, hotdog and teacups packaging. It looks like the cork and was being used in the international fast food chains in our region until recently, although the USA has prohibited the use of it for 20 years. MacDonald's also has stopped using it since 1980, so let us be cautious of this material that is still being used here in fast food and popular restaurants. This material has impact on the ozone layer because it is made of harmful ChloroFloro Carbon gas (CFC) . Recycled Polystyrene (PS) is used to make many different kinds of products, including insulation, license plate frames, and rulers . The figure 2.7 below depicted PS (Polystyrene) class of plastic.

G). PC and Others Such material does not come under any category of the above mentioned types of plastic. It can be mixture or compound of the six international companies started to produce toys and baby-feeding bottles made of it . PC and Other (Polycarbonate and Other Recycled Plastic) are products produced from polycarbonate include sports equipment, medical and dental devices, CDs, DVDs, and even . The Figure 2.8 below shows Polycarbonate and other recycled plastic.

The word plastic is derived from the greek (plastikos) meaning capable of being shaped or molded. Plastic those are made up of polymers having only aliphatic (linear) C atoms in their backbone chains. e.g.: poly propylene. Plastics that are made up of heterochain polymers contain O, N, and S in their backbone chains, in addition to C. e.g.: poly carbonate behaviour of polymers is influenced by their morphology (arrangement of molecules).they are either amorphous or crystalline. Most thermosets are amorphous, while thermoplastics may be amorphous or semi crystalline. Plastics are a range of synthetic or semi-synthetic polymerization products that can be molded into a permanent object having the property of plasticity. Plastic are found extensive industrial applications. Plastics having a variety of properties are available at present. They have low specific gravities, ease of fabrication, resistance to low thermal and electrical conductivities. Many plastics can take range of colour to enable them useful for decorative purposes. Plastics are widely used in making electical instruments, telephones, panelling for walls, instrument boards, automoblile parts, lamps, googles, optical instruments, household appliances and so on.

Waste plastic bottles that used in this study were obtained from waste PET bottles. In order to, provide appropriate plastic particles the bottles were cut to small parts then crushed and sieved. The particles which were smaller than 2.36 mm were considered for this investigation. It should be noticed that different percentages of crushed plastic bottled were designated for this study namely: 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1 % by weight of aggregate particles .

The production rate of plastic is getting increased day by day in all parts of the world since past few decades. Due to the tremendous growth in population, consumerism, industrialization and technological development, there has been a rapid increase in the rate of the production of plastic which is a toxic persistent material

Addis Ababa, the capital city of Ethiopia suffers from poor solid waste management. The inadequate solid waste management system has rendered development, lessened the aesthetic beauty of the city and most importantly endangered the lives of the people. Regard-less of the harmfulness of the waste, solid waste management has not been given the amount of attention it requires. The insufficient management and lack of attention to the matter can be observed from the unbearable litter in the rivers, drains and streets in Addis Ababa. It is obvious that immediate action is needed in the solid waste management sector .

The daily SW generation rate of Sodo town for low-income, middle and high-income was 28 kg/capita/day, 0.38 kg/capita/day 0.76 kg/capita/day, respectively. This indicates that the waste generation rate of higher income was about 2.7 times higher than lower income. The average SW generated in town is estimated to be 0.47 kg/capita/day; 14.2 Kg/capita/month 170.4Kg/capita/year.

Hot stone aggregate (150?c) is mixed with hot bitumen (170?c). The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding Property, Penetration value and visco-elastic property. The aggregate, when coated with plastics and rubber improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic and rubber decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

Marshall Properties such as stability, flow value, unit weight, air voids were used to determine optimum polythene content for the given grade of bitumen. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover the softened plastics have a binding property.

Here waste plastic/polymer was used as modifiers added on the aggregate before mixing Optimum Binder Content (OBC) in dry process at 150-160?C temperature which increases the bonding between aggregates coated with plastic/polymer which increases the strength of the bituminous concrete mixes. Stability values and indirect tensile strength values were observed to be more in polymer modified bitumen than in conventional bitumen.

The mechanical properties obtained from the Marshall test are Marshall Stability and Flow value. Marshall Stability indicates the maximum load that a sample can carry when being tested at 60°C, and Marshall Flow is the deformation that a sample undergoes during loading until the maximum load is reached. An increase in the Marshall Stability value indicates an Experimental Investigation of Waste Plastic Bottles as Partial Replacement of Aggregates in improvement in the stability of an asphalt mixture to resist shoving and rutting under heavy traffic load . Optimum dose of HDPE in VG30 bitumen is between 0.2 to 0.4%. Using Marshall Method of mix design the optimum binder content and optimum plastic has been determined which is 5.66% and 0.6% respectively. It has been observed that addition of HDPE waste plastic into the conventional mix can enhance the stability of mixture with lesser flow value in comparison with conventional mix, up to a certain dose of HDPE. The existence of waste plastic and waste glass cullet in bituminous binder course mixture is considered as an ecofriendly material and sustainable management of these waste products in Pavement construction.

2.3 Plastic as an aggregate

Recycled LDPE can substitute a portion between 15 and 30% of aggregates depending on its particle size

Polymer material is coated over stone aggregate and this PCA is used as a raw material for pavement construction. Plastics waste like PE, PP and PS is coated over stone aggregate and the PCA is mixed with bitumen and the mix is used for flexible pavement construction. Higher percentage of plastic waste (10-15%) can be used without separation. Different waste plastics used for coating over the aggregate then PCA along with stone aggregate, next to this PCA mix with bitumen and Polymer coated bituminous road scrap. Most of the packing materials used are made up of PE, PP, PS. All these materials can be shredded and used for road construction. For the asphalt pavement, stone aggregate with specific characteristics is used for road laying. The waste plastics namely films, cups and foams shredded to the required size of 2.5-4.36 mm. The aggregate is heated to 170 ?C. The shredded waste plastic was sprayed over the hot aggregate. Plastics got softened and coated over the aggregate. The extent of coating was varied by using different percentage of plastics. The shredded plastics on spraying over the hot aggregate get melted and spread over the aggregate giving a thin coating at the surface. When the aggregate temperature is around 140-160 ?C the coated plastics remains in the softened state. Over this, hot bitumen (160 ?C) is added. The added bitumen spreads over the aggregate. At this temperature both the coated plastics and bitumen are in the liquid state, capable of easy diffusion at the inter phase. This process is further helped by the increase in the contact area (increased surface area). In the construction of asphalt pavement, hot bitumen is coated over hot stone aggregate and rolled. Bitumen acts as a binder. Yet when water is stagnated, over road it penetrates and results in pot holes, a defective spot on the pavement. Use of plastic as virgin as well as waste to modify the bitumen and also the use of PCA are being studied to find better results for the better performance of the pavement.

Intending to minimize the dependence on the supply of stone aggregate, it has become essential to inspect the possible applications of alternative materials for the construction of roads as a substitute of stone aggregate.

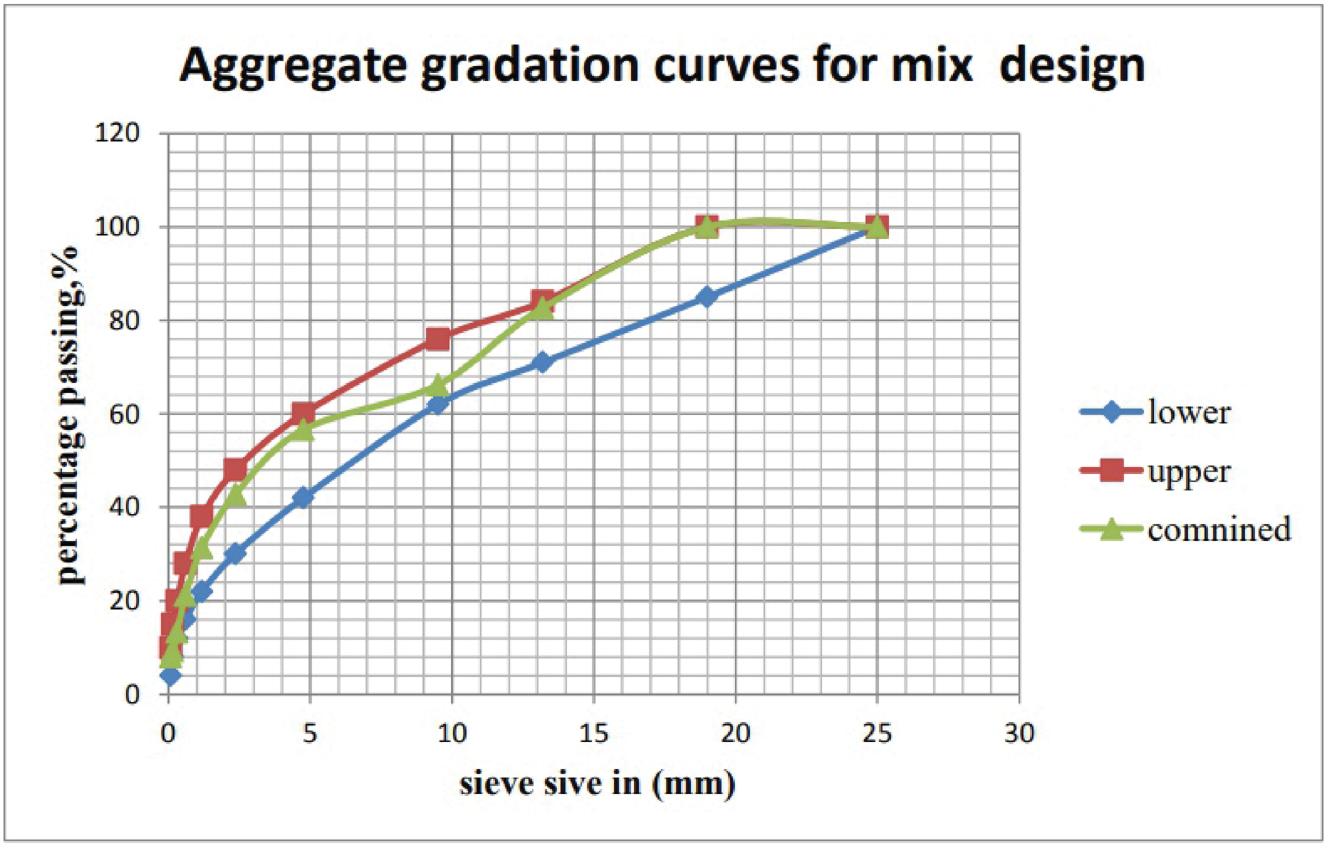
Recycled waste plastics, predominantly composed of low density polyethylene (LDPE) in pellet form, were used in dense graded bituminous mixes to replace (by volume) a portion of the mineral aggregates of an equal size, i.e., 5.00.-2.36 mm. The origin of the plastic materials employed in the investigation was municipal waste (plastic bottles, plastic containers, washing-up liquid bottles, etc.) Based on the selected AC grading and the size of the waste plastic pellets, a maximum of 29.7% by weight of the total control mix was replaced with waste plastics. The main variable between the Plastiphalt and the control AC mix would therefore be the bulk density of the combined aggregate fractions. Laboratory design methodology and test results of a continuously graded bituminous composite Asphaltic concrete (AC) containing recycled plastics aggregate replacement is called (Plastiphalt). The test results were compared to those obtained from a control mix having a very similar gradation manufactured with conventional mineral aggregates. The potential for recyclability of the aged Plastiphalt mixes, containing recycled waste plastic was also investigated. Softer bitumen was selected for the Plastiphalt because early trials indicated that the mix was very strong and did not require the use of hard bitumen. This has added advantage that the mixing and compaction temperatures of the bituminous mix, which are controlled by the viscosity of the binder, can thus be lowered .

The use of XLPE waste as an aggregate in roller compacted concrete pavement (RCCP) mixes. XLPE waste as an aggregate with several volume percentages was utilized to replace the natural coarse aggregate of concrete mix. This replacement was conducted with 5%, 15%, 30% and 50% contents.

4. RESULT AND DISCUSSION

The analyses were categorized in two divisions. The first one was analyzing marshal test result and volumetric properties of conventional (plain) BC mix to determine the optimum bitumen content (OBC). The second one was investigating the effects of replacing the aggregate with waste plastic bottle (PET/PETE) in modified BC mix was experimented and analyzed to determine the optimum plastic content (OPC). In Hot Mix Asphalt, binder and aggregate are blended together in precise proportions. The relative proportions of these materials determine the physical properties of the HMA and ultimately how the HMA performs as a finished pavement. In this investigation the Marshall tests such as stability, flow value were measured and volumetric properties such as bulk density, voids in mineral aggregate, voids filled with asphalts and air voids were computed to obtain optimum bitumen content on conventional asphalt mixture which was 5.33% after laboratory results. In similar manner it was done for modified asphalt concrete mixture to determine the optimum plastic content (OPC) which was finally selected as 4% by weight of aggregate.

4.1 Aggregate Gradation Curve for the Mix Design Asphalt mix requires the combination of fine and course aggregates, having different gradations, to produce an aggregate blend that meets the gradation specifications for a particular asphalt mix. All AASHTO sieve size were used, those are 25mm, 19mm, 13.2mm, 9.5mm, 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm, 0.075mm and filler. The Table 4.1 below shows that, the final proportion of each aggregate material in asphalt binder surfacing. The proposed aggregates gradation curve is found to be satisfying ERA standard technical specification (2002, 6400/8). All aggregate pass through the first sieve size two sieve sizes which mean that 100% pass and zero percent retained. After so many trial and errors, the blend proportion of 36%, 8%, 14%, 37% and 5% were used for combined aggregate of 10-20mm, 5-10mm,5mm, 0-3mm and filler respectively. Then after combined aggregate were computed by using the blend proportion determined and it was fall within range of specification.



5.1 CONCLUSIONS

As the laboratory results of marshal test indicate, application of waste plastic bottles in road construction especially in flexible pavement construction increases the performance of pavement since the overall performance of plastic modifies bitumen concrete mix are better than that of conventional one. And this reduces the aggravating negative impact of plastic bottle (PET/ PETE) on environment since the incineration and land filling does not solve problem because the plastic bottles can stay up to 500 years to decompose. According to the marshal test results and volumetric properties on conventional bitumen concrete mix the optimum bitumen content was determined as 5.33% by weight of total mix. Then after the specimen were prepared to the modified BC mix with partial replacement of aggregate with waste plastic bottle by (0%, 4%, 6%, 8% and 10%) by weight of aggregate. The performance of BC mix according to marshal flow value and percentages of plastic have direct relationship which mean that as the percentages of plastic increase the marshal flow values also increases and there is strong linear correlation between flow value and percentage of plastic. And there is no constant increment or decrement of marshal stability values, but the marshal stability values fluctuate as the percentage of plastic increase. But there is maximum stability of (20.66KN) at the 4% of waste plastic bottle (PET/PET) was added as an aggregate which was higher than that of 0% plastic (conventional BC mixes) which was recorded as 20.00KN. As percentage of plastic increases the bulk density decreases; this has the advantage to reduce the hauling cost and there is strong linear correlation between the two. As percentage of plastic increases the VFA decreases and there is strong linear correlation between the two. There is direct relationship between percentages of plastics and VMA but further increment of amount of plastic decreases the value of VMA and there is strong linear correlation between voids in mineral aggregate and percentages of plastic. And there is no constant increment or decrement of percentage of air voids with increment of plastic, but the percentage of air voids fluctuate as the percentage of plastic increase. But to a little extent imply that there is inverse relationship between percentages of plastics and VA. There is no linear correlation between percentage of air voids and percentages of plastic since r-squared value is near to zero. According to the comparison of laboratory test result and the standard specification of AASHTO, the marshal stability value should be greater than or equal to 9KN, marshal flow value should be with in ranges of 2-4mm, voids filled with mineral aggregate should be greater than or equal to 13%, voids filled with bitumen should be within 65-75%, the optimum percentage of air voids should be 3-5% and all the test results at each percentage replacement of aggregate by plastic content fulfills the standard specification requirement of stability, flow value and voids filled with mineral aggregate. But only 4% replacement of aggregate by plastic fulfills the requirements of voids filled with mineral aggregate and air voids at 8% of plastic content was tolerable.

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