Застосування надлишкових матеріалів і відходів при влаштуванні дорожнього покриття

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На сьогоднішній день у світі існує багато проблем, пов'язаних з виготовленням надлишкових матеріалів і будівельного сміття. Величезна кількість відходів завдає серйозної шкоди для навколишнього природного середовища. Їх повторне використання в інших процесах, наприклад, у будівництві або влаштуванні дорожніх покриттів було б надзвичайно корисним для довкілля. Існує декілька способів для переробки будівельного сміття і його повторного використання на нових об'єктах або в інших матеріалах.

Асфальтобетон – це основний матеріал дорожнього покриття, який застосовується в більшості країн світу. Разом із постійним збільшенням кількості доріг, потреба у його виготовленні стрімко зростає.

У роботі наведено останні результати і висновки щодо використання відходів при виготовленні асфальтобетону і їх вплив на його властивості. У даному дослідженні розглядалися, між іншими наступні матеріали:

- Бите скло
- Пластмаса
- Гума
- Будівельне сміття
- Електронна сміття (Е-сміття)
- Важке поліетиленове сміття

У висновку наведено декілька пропозицій складу оптимального виду асфальтобетону з вмістом цих матеріалів і представлено вплив їхнього використання на економічні і екологічні умови окремих країн.

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Application of surplus and waste materials in roads pavement making

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Nowadays there are a lot of problems about surpluses and debris made by humans all around the world. Lots of these surpluses seriously harm our natural environment. Reuse of this kind of materials in other processes like building constructions or pavement help our natural environment in every aspect.

Asphalt concrete is the main part of pavements in most parts of the world with an increasing rate of production in need of more ways and roads.

In this paper we will provide the latest conclusions of using these kinds of materials in making asphalt concrete and their impact on its properties. Some of these materials investigated in this article are,fragmented glass,plastic,rubber,construction debris,electronic debri and heavy polyethylene debris.

And at the end we will provide some proposals to making the optimum kind of asphalt concrete using these materials and will investigate the impact of using such material on economical an environmental conditions of countries.

Keywords – surplus materials,reusable materials,asphalt concrete,pavement,natural environment

I. Introduction

New technologies and methods of life are growing faster and faster and they deliver us a better way of living. Among these technologies we have seen a huge improvement in green technologies in last decade. Greentech provide an high orientation on recyclable and reusable materials. In this way we can use surpluses made of our other activities in construction of new material instead of burial or triggering them[1].

Asphalt concrete is one of the most important and applicable part of making the cities. Next generation of asphalt concretes will be made under these new green technologies with recyclable materials [2].

In this paper we will introduce some of this debris and then study the impact of using them in making pavements based on studies done by researchers around the world.

Glass is one of the best products of human than can be recycled for many times without any change in its quality [3].

There is about 10 million tons of daily production of debris in big cities of world that 3% through 5% of it is fragmented glass [4].

In the year 2003 there was 2.3 million tons of glass waste among the garbage produced in England that 71% percent of it was glass bottles, 23% was pure glass and the rest was other types of glass. Recycling rate of bottles and pure glass

were 36% and 31% respectively. In overall 1.1 million tons of glass waste was recycled [5].

Yearly production of plastic waste in England is about 2.8 million tons. It is showed that about 0.4 million tons of is recyclable but only about 0.008 million tons of it recycles every year. [6].

Another important problem for our natural environment is PET plastic plates. Because of the specific polymeric structure it is very late decomposition material . We can use these PET materials in manufacturing of heat formable plates with engineering usage specially making alloys in combination with other polymers like poly carbonates. We can also use them in making other usable stuff like bumpers, sport stuff, electric and electronic stuff, etc [7]

Based on statistics ,in industrial countries there is one tyre consumption per person and about 9 kg per capita consumption of tyre .Despite the other recycling procedures it is very hard to recycle rubber or tyre and need preparative stages before the main recycling. Burial and gathering of tyres is not a good choice for them. They are flammable and have a very thick smoke made of unburned hydrocarbons that are very poisoning [8].

Waste Electrical and Electronic Equipment (WEEE) or E-waste is one of the fastest

growing waste streams in the world. In developed countries, it equals 1% of total solid

waste on an average[9].

Construction debris is another type of polluting problems in our cities that needs high cost to burial or obviation. Moreover it has serious impact on environment [10].We can use recycled construction debris in these ways:

- Concrete: In Europe there has been done a lot of investigations to use recycled concrete in producing new concretes [11]
- Brick: We can also use these trashes in making bricks.
- Pavement: One the best ways to use construction trashes is using them in producing asphalt concrete [12].

We will see the impacts and usage of these kind of surpluses on Asphalt concrete in next part of these article.

II. Impacts of using different surpluses on asphalt concrete

1. Impact of fragmented glass on the behavior of asphalt concrete: Glass can reduce the cost of making asphalt concrete when providing a better dynamic behavior.

Glass provides a better reflection of light on the pavement and increases the crack resistance and internal friction.

Considering smooth face of glass particles and silica content of them, they are categorized in water friendly materials so they should be armed against water. Hydrated lime can increase the stiffness modulus and resistance of asphalt concrete with changes that it makes in tar of asphalt. To resolve this defect it is recommended to add 2% through 11% of hydrated lime to mixture [13].

Best performance of pavements reaches when we use 10% through 15% of fragmented glass in mixture weight. Size of glass particles should be under the maximum of 4.75 mm due to technical and safety considerations [13].

Using of fragmented glass more than the allowed extent will decrease the stiffness modulus of asphalt concrete and make it fragile and reduce the attraction of tar because of over smoothness of faces of particles [14].

2. Impact of usage PET plastic trashes in asphalt concrete: We can use 2 kinds of PET plastics in pavements:

- Granule: Granules particles with a diameter of 3mm with specified values that can be replaced with aggregates in specified quantities in mixture.
- Chips: Chips that are made of PET bottles and can be added to mixture in different percentages.

Based on results of researchers replacing 20% of aggregates left on sieve No4 with PET granule can save 5% in aggregates usage and reduce the weight of mixture about 2.8% [Maghanaki]

Marshall ratio of new mixture has an increase about 0.5% and while Marshall resistance reduced about 1.8% it is still about two times the minimum allowed strength.

Results of these studies provide a optimum mixture that can reduce aggregates using about 0.5 million tons per year [15]

3. Impact of using high density polyethylene on asphalt concrete (HDPE): With increase in HDPE we see a reduction in mixture stability due to lack of cohesiveness. Maximum stability in mixture is reached when we use a 4% HDPE in 165c in 30 minutes. With replacing of HDPE4% with a AC-20 we can see a 50% increase in Marshall strength. A high Marshall strength is representative of resistance of mixture against permanent deflection so mixtures with HDPE4% have a better strength comparing conventional mixtures [16].

4. Impact of using recycled plastic aggregate in asphalt concrete: Marshall strength of plastic-asphalt mixture is more than conventional mixture and its fluency is more than the conventional mixture because plastic gives the mixture more flexibility.

With an increase in stiffness and loss of fluency the modulus of stiffness will increase and there will be more cracks in asphalt but in plastic-asphalt mixture there is an increase in both stiffness and fluency so we have a better stiffness strength in mixture.

Creep of this mixture is less than the conventional mixture. Indirect tension strength is also increased and we see a better strength against cracks in asphalt concrete [17].

5. Impact of using rubber trash in asphalt concrete: We can use rubber (tyre) trashes in two ways:

- Wet method: In this method rubber particles with a dimension about 0.15 through 0.6mm connect to tar in high degree before adding the aggregate. Light weight parts of tar go through rubber particles and make them bigger and stiffer [18]. This procedure gives the mixture a better viscosity so its thermal cracking reduces and its durability increases (fatigue strength, Oxidation strength, etc). Researches of FHWA believe that rubber particles in wet method reduce the modulus of resilience and so its strength against permanent deflection will be decreased. In Brazil it has seen that rubber particles increase stiffness tension strength in high temperatures. For a better behavior of mixture in low temperature it is recommended by KSU(Kansas state university) to use 6 through 9% of rubber particles instead of 18-22%. By the researches of

Liverpool university recommends rubber particles with dimension of 0.3 – 0.6mm with a 10% tar 50 through 100 that has a good strength against fatigue, fracturing and corrugation. This mixture also decrease the noise of pavement construction about 50%. Some project in late 80th showed that usage of rubber can reduce the thickness of pavement layer about 20-50%. Another benefit of using rubber is increasing of life of pavement. A project in Brazil showed that using of 15% rubber in mixture in high temperature can reduce the cracking procedure five times slower than normal mixture.

- Dry method: In this method rubber particles are about 0.85 through 6.4mm that we replacing ratio of 1-3%. One of the benefits of dry mixture is reducing noise reducing [19]. Increasing of Binder asphalt content up to 10-20% is needed to reduce the modulus of resilience and cause the layer increase .

6. Impact of using electronic trashes (E-Waste) in asphalt concrete: Another way to strengthening the asphalt is using tiny hard materials obtained from electronic trashes. First use of these kind of materials was done by Chinese researchers. Things like microchips, used as an important part of computer technologies, are used as a cheap and important part of ways production today.[E-WASTE]

Statistical studies show that there are million tons of electronic equipment and structures trashes all around the world every year that are buried and can cause serious damage to nature. By using them as a part of asphalt mixture we can strengthen the pavement and increase its efficiency ratio and also reduce the cost of manufacturing of pavements. These kinds of pavements also have a longer life comparing to conventional pavements and have a great compatibility with greentech.

Based on result from studies done by Chinese researchers, Because of having glassy fibers and different classes of plastic fibers electrical circuits can be used as retaining structures inside of asphalt layers so we can build a thin and cheap asphalt layer with a great strength capacity. I n this way that is a new and quick recycling method we make a metal less powder of these kind of waste after isolation of poisoning metals. After adding this powder to mixture there will be a mixture with a better resistance ratio and a great resistance to thermal changes so we can use this kind of asphalts that have a heavy traffic and are in high temperature zones.

7. Impact of using construction trash in pavements: Though CBR of these materials are not very high, But we can use them in subsidiary ways specifically in base course and subbase zone of pavement. It is recommended to use these kind of trashes in ways with a lower importance and a lower traffic capacity. Cement is one the additives that can increase capacity and quality of recycled construction trashes. Non confined pressure capacity of strengthened samples of samples with different percentage of cement showed that they are absolutely compatible with subbase layer.

III. Conclusion

As it showed based on tests and researches that have done we can see that by using recycled surpluses in pavements we can easily limit burying and releasing surpluses into nature and so it'll help our natural environment. It is also showed that some of these recycled items can improve behavior of pavements and reduce cost of production too. With using such recycled material instead conventional materials helps countries their conservations.

At the end of this article we can recommend these methods to use recycled materials in pavement construction:

- Adding fragmented glass to asphalt concrete mixture for a better dynamic behavior, reducing cost of construction and a better cracking strength.
- Replacing 20% granule instead normal aggregate for reducing use of aggregates about 5%, reducing fluency, Marshall strength, specific weight with no change in Marshall ratio.
- Using rubber particles to lowering the creep and increasing stability of mixture and a better strength against cracks.
- Using heavy polyethylene particles in pavement that are in high temperature circumstances.
- Using rubber particles with a 10% tar content to control scratching, cracking, fatigue problems and to reduce thickness of pavement layer.
- Using construction trashes strengthened with cement in base course and subbase layers of pavements in low traffic ways.

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