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Use of Recycled Garbage in Road Construction

[1]*KOZHASSOV Sarsenbek, Junior Researcher, Kozhassov@mail.ru,
[2]KOZHAS Aigul, Associate Professor, kozhas@bk.ru,
[2]KIPSHAKOV Sultanmakhmut, Cand. Ped. Sci., Associate Professor, Head Department, Kipshakov@mail.ru,
[2]SADIRBAYEVA Akmaral, Senior Laboratory Assistant, Sadirbayeva@mail.ru,
[1]Kazakhstan Multidisciplinary Institute for Reconstruction and Development, Kazakhstan, 100027, Karaganda, N. Nazarbayev ave., 56/6,
[2]E.A. Buketov Karaganda University, Kazakhstan, 100028, Karaganda, Universitetskaya str., 28,
*corresponding author.

Abstract. The aim of the work is to study the technology of using recycled waste in road construction. The advantages of using recycled plastic in road construction are considered. It has been established that for the use of waste in construction it is necessary to improve the technology of separate waste collection; to increase the number of waste processing plants. Increasing the amount and variety of waste generated has led to the crisis in waste management. This issue can be resolved by reusing some of this waste to replace the known percentage of the primary materials used in road construction. In this way, natural resources are conserved and the growing crisis of waste management is solved. Numerous studies have shown that the optimal amount of such waste or modifiers, when added to asphalt mixes, results in improving various physical characteristics of the road. The article provides an illustrative example of a new road construction technology. The possibility of using plastic will significantly reduce costs and increase the quality of roads, which is very important for the Republic of Kazakhstan.

Keywords: plastic, road, innovation, technology, construction.

Introduction

The growth of the economy and continued urbanization in Kazakhstan are the reasons for the annual increase in the volume of municipal solid garbage (MSG). Today it is one of the most acute environmental problems in the country.

The total number of spoil disposals (Figure 1) exceeds 4,000, with only 307 legalized.

These numbers continue growing, so it is necessary to take some measures. One of them is recycling MSW, but things are not well with it: only 5% of solid garbage is recycled, the remaining 95% is placed in spoil disposals for storage and burial.

With such colossal volumes of garbage, recycling plants lack raw materials for treatment since there is no culture of separate garbage collection in the

Figure 1 – Spoil disposal

country. If to continue just bringing it to spoil disposals, our descendants will have no place to build houses: lands tend to run out, and some garbage, such as polyethylene, begins to decompose only centuries later.

At such a pace, in the near future, we are in danger of a bleak prospect of «choking from our own garbage», as the Danish physicist Niels Bohr predicted. In addition, not all spoil disposals have an appropriate insulation coating and a system for collection and treatment of garbage water, and harmful substances penetrate the soil and groundwater. But most often such spoil disposals, and in fact open dumps, are in close proximity to residential areas of large cities.

Research results

The country lacks garbage recycling enterprises, and the operating ones are not loaded at full capacity due to the absence of interaction between local authorities, public utilities and, accordingly, the institutions themselves.

A large problem for garbage recycling companies is high tariffs for rail transportation, which are necessary to transport garbage from various regions of Kazakhstan to their recycling sites. In Kazakhstan there is also no concept of «green» purchases, which assume the priority of products made using garbage, when purchasing. Therefore, many companies that produce such products face difficulties in its implementation.

To solve all these problems without assistance of the state is simply impossible, although it is impossible to say that state bodies are inactive. It is known that Kazakhstan is currently preparing amendments to the law on transition to the green economy. The developers of the draft law propose introducing a provision for extended producer responsibility (EPR), which obliges the manufacturer (or supplier, or importer) of products to ensure collection, utilization and recycling garbage after using their produced or marketed products. According to the Concept on Kazakhstan transition to the «green» economy, garbage recycling should be up to 40% by 2030, and 50% by 2050.

In addition, since 2016 the country has banned the disposal of mercury-containing lamps and appliances, scrap metal, garbage oils and liquids, batteries, electronic garbage. Since January 2019 the ban on the disposal of plastic, garbage paper, cardboard and garbage paper, glass comes into force. From January 2021 a ban on the burial of construction and food garbage comes into force.

There is a precedent: in Temirtau some businessmen conducted informational work on the need to separate garbage (Figure 2) into two boxes: organic (food) and others in kindergartens and schools, they distributed buckets with two compartments, and the children persuaded parents to sort the garbage.

The first eco-collection point for garbage (Figure 3) was opened in Astana. The capital residents can bring there a package with garbage paper or plastic bottles and get a symbolic reward for it.

The world experience shows that without using certain principles and mechanisms it is almost impossible to achieve success in the field of rational garbage management. These include: separate garbage collection, which helps to obtain valuable secondary raw materials, to reduce the cost of transporting and recycling garbage, green purchases that help stimulating the demand for products derived from garbage, an effective system for recording and reporting on garbage management activities [3].

All the civilized countries are already looking for cardinal solutions to the problem of garbage. New biodegradable materials are being developed, the propaganda work is underway to eliminate plastics, technologies of recycling and reuse of recycled garbage are being improved. As an example of using the recycled material let us take plastics and their

Figure 2 – Separate containers for garbage

Figure 3 – Eco-collection point for garbage

prospects in road construction.

Roads with holes and cracks are an integral part of the harsh realities in Kazakhstan. The roadbed wears out faster than it is updated and the reason for this is a high cost of the roadway, unscrupulous contractors and building materials, as well as limited, sometimes not fully received funding for new construction and reconstruction of roads. To make a «revolution in road construction» is possible with the help of the pavement made of plastics.

Recycled plastics have many uses, one of which is road paving.

There are about 40 million km of roads on the planet, 1.6 trillion tons of asphalt is annually spent for expanding this network and making new highways.

One of the main components of the asphalt mix is bitumen, the content of which varies from 10 to 60%.

Partial replacement of this material with recycled plastics will solve the problem of environmental pollution and improve the practical characteristics of the road surface.

In 2002 the engineers from the Indian company KK Plastic Garbage Management Ltd patented the technology of using plastic garbage for asphalting roads.

This company owns a factory in Bangalore, today processing up to 30 metric tons of plastics per day.

It took the Indians 5 years to develop the technology for processing PET bottles, plastic cups and bags into the asphalt mix component.

The company has developed the polymer KK Poly Blend, which replaces 8% of the bitumen in the asphalt mix and improves characteristics of the road surface.

The life of the roads made on the basis of this material is doubled. In its state the KK Plastic Garbage Management Ltd built 2,000 km of roads and recycled 8,000 tons of plastic garbage.

From India the idea migrated to Western Europe. One of the leaders of the Scottish MacRebur company brought it to his country and after 18 months of research he patented highly effective additives based on recycled plastics. They are produced in the form of granules and flakes that are added with the bitumen in the production of coating.

The modified asphalt concrete mix becomes 60% stronger, and the roadbed based on it is 10 times longer.

The technologies of using recycled polymeric materials in road construction in Kazakhstan are in their infancy.

It is necessary to make adjustments to GOST, SNiPs and technical regulations, to develop a technology similar to the Indian and Canadian ones, and in the future to use asphalt-concrete mixtures based on recycled plastics for road repairs, and later on for laying highways.

Implementation of the projects requires introducing the technologies of collecting and sorting plastic garbage, changing the current legislation.

The process of developing a building material for paving has several stages:

- collecting, sorting and cleaning plastic garbage;
- grinding polymeric materials;
- adding crushed and melted plastics to bitumen;
- heating the mixture and applying it to the aggregate at the temperature of 160 degrees;
- treatment with bitumen;
- adding the mixture with plastics to improve adhesion.

The result is an asphalt mix that is laid on the prepared base in the classical way. Pavers are used to compact and make a perfectly smooth roadbed.

The unique innovative technology of using plastic garbage is developed by the Dutch company Voler Wessels.

It consists in casting hollow slabs for road pavement using recycled plastics. It is planned to

lay city communications in the voids. Plates on such plastic roads will be laid on a pad of compacted sand [2].

A distinctive feature of the technology is using large amounts of garbage, as well as quick mounting.

The main advantage of using plastic garbage to make pavement is improving the environmental situation in large cities.

A great potential of plastics consumption by road companies is stable and permanent disposal of garbage that pollutes not only large cities, but also the global ocean.

The advantages of paving with plastics are as follows:

- increased strength;
- high water resistance;
- increased the intervals between repairs;
- reduction of operating costs;
- high tensile strength;
- operation at the temperatures ranging from –40 to +80°C;
- good road holding of car wheels;
- increased resistance to engine oil and fuel;
- reduction of coating deformation and absence of gauge;
- minimum number of cracks due to plasticity of plastics;
- long service life.

The advantages of using recycled plastic coating for cities are as follows:

- reduction of road maintenance costs;
- minimum costs for modernization of asphalt plants;
- the cost of asphalt is lower than when using coatings with modified bitumen;
- reduction of garbage utilization costs at spoil disposals.

Roads with asphalt based on plastic bottles and other garbage will improve the socio-economic status of the city.

The disadvantages of the coverage are as follows:

- the cost is 3% higher than that of the usual asphalt concrete pavement;
- deterioration of performance at high temperatures;
- absence of regulatory framework for introducing the coverage.

For production there is required a large amount of plastic garbage: a separate garbage disposal system is needed.

One of the ways of managing garbage plastic is by using it in construction material for pavements and roads which serves the dual purposes of imparting stability and durability to the roads and resolving the issue of environmental hazard due to ever increasing garbage plastics. To understand the role of plastics in construction material, one must be familiar with the material specific properties and the processes used in laying roads. Having said this, further discussion details the use of each component and the processes involved in creating construction material.

Bitumen plays an important role in binding the aggregate together by coating over the aggregate thereby imparting strength to the road. However, due to a poor resistance towards water and high costs involved, there is a demand for high quality bitumen at low costs. This can be accomplished by modifying the rheological properties of bitumen by using additives such as plastic or rubber [1].

The drawbacks of using only bitumen in road construction are as follows:

- the performance of road is reduced at high temperature due to bleeding of bitumen.
- cracking phenomenon takes place due to oxidation of bitumen.
- potholes are easily formed as bitumen strips off from the aggregate as it is water repellent material. This reduces the life of the road constructed.
- the material and processing costs are much higher.

Bitumen based concrete mixes may be further classified into Bituminous Concrete (BC), Modified Bitumen Mix (MBM) and Semi-dense Bituminous Concrete (SDBC) as revealed in (Figure 4). BC is a conventional concrete mix which performs satisfactorily; however, it needs improvement in the properties for certain special applications, such as heavy traffic. MBM has exhibited improved properties such as fatigue life, resistance to permanent deformation of paving mixtures and enhanced stability of the pavements by the addition of modifiers such as sulphur, crumb rubber, polymers etc. SDBC is a high density and thoroughly controlled hot mixed material composed of graded mineral, aggregate, filler and bitumen.

The road construction involves the use of

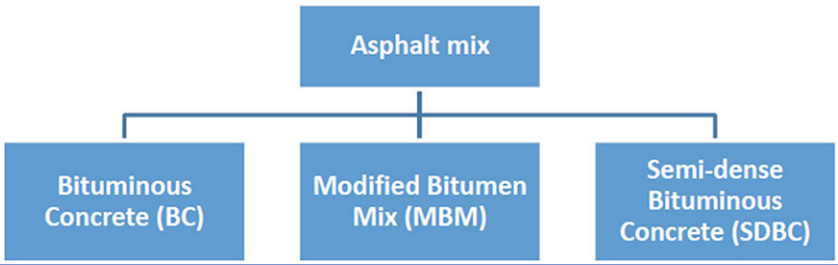

Figure 4 – A flow chart demonstrating classification of asphalt mixes

aggregate mixes which can be of different types as shown in figure below.

Plastic garbage can be used in hot mix to improve physical properties of bituminous aggregate mix by 'Dry Process' or 'Wet Process'. The technology as developed and explained by Dr Vasudevan, a Chemistry Professor at Thiyagaraja College of Engineering, Madurai, incorporates the use of 'Plastone', a mixture of stone chips and garbage plastic bags (thickness 40-70 μm) which is heated at 150-1700C during production, in laying roads, pavements and flooring purposes as an alternative to interlocking paver blocks. At this processing temperature, the plastic garbage is heated enough to act as an adhesive in binding stone chips and not generating any toxic gases. The aggregate becomes water proof after getting coated with molten plastic. This step is followed by the addition of hot plastic-aggregate mix to hot bitumen while maintain the process temperature. This approach is known as 'Dry Process'. The 'Wet Process' involves mixing of plastics to hot bitumen followed by mixing with hot aggregate. Both processes lead to the formation of plastic modified bituminous aggregate mix with enhanced properties imparting strength, stability and durability to the roads.

Conclusions

Recently, a new method called 'Cold Mix' has been developed which incorporates mixing of materials at lower temperatures. The process offers the following advantages over the hot mix:

1. The heating of aggregate and binder is not required.
2. It is an environmental friendly approach which saves energy. An impressive 50% of energy saving in case of cold mix over hot mix has been reported. Therefore, it can be considered to be a green bituminous mix for road construction.
3. It is a straightforward preparation using only a small set up on site. A manual production for small scale job is also feasible.
4. It is a suitable method particularly for construction of roads in remote and isolated areas of a country.
5. The method is suitable for road construction in wet or humid conditions.
6. Cold mix is a versatile method due to availability of a large number of grades of emulsion and cut backs.
7. It offers an economical and high production approach.

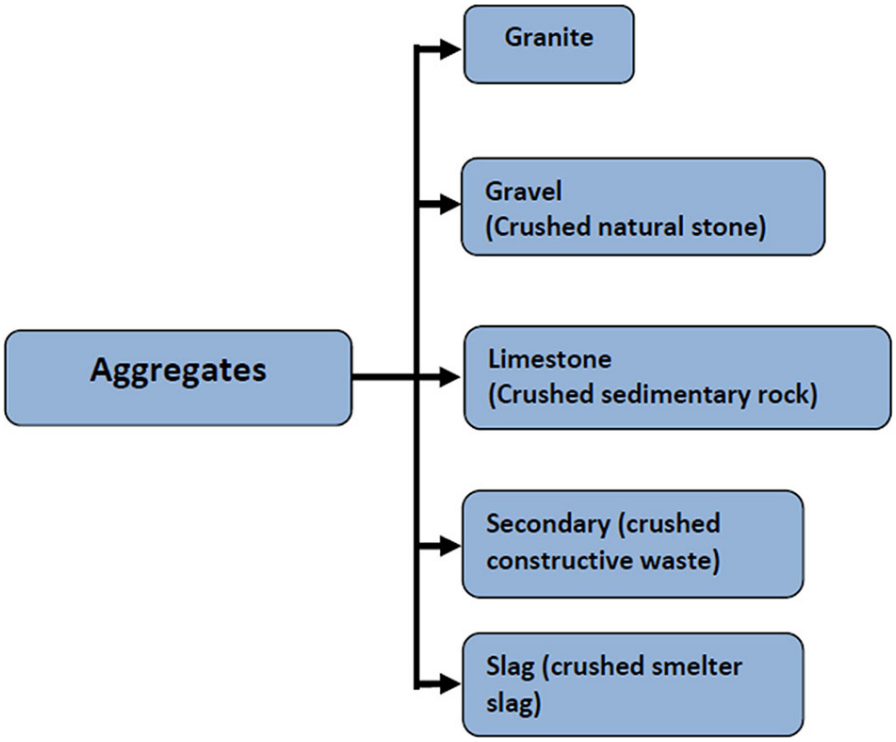

Figure 5 – A flow chart demonstrating various types of aggregate mixes used for road construction

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Қайта өңделген қоқысты жол құрылысында пайдалану

[1]***КОЖАСОВ Сарсенбек Кенжебекович,*** *кіші ғылыми қызметкер, Kozhassov@mail.ru,*
[2]***ҚОЖАС Айгүл Кенжебекқызы,*** *т.ғ.к., доцент, kozhas@bk.ru,*
[2]***КИПШАКОВ Султанмахмут Аккаевич,*** *п.ғ.к., доцент, кафедра меңгерушісі, Kipshakov@mail.ru,*
[2]***САДИРБАЕВА Акмарал Махмутовна,*** *аға лаборант, Sadirbayeva@mail.ru,*
[1]*Қазақстандық көп салалы қайта құру және даму институты, Қазақстан, 100027, Қарағанды, Н. Назарбаев даңғылы, 56/6,*
[2]*Е.А. Бөкетов атындағы Қарағанды университеті, Қазақстан, 100028, Қарағанды, Университет көш., 28,*
**автор-корреспондент.*

Аңдатпа. *Жұмыстың мақсаты – жол құрылысында қайта өңделген қалдықтарды пайдалану технологиясын зерттеу. Қайта өңделген пластикті жол құрылысында қолданудың артықшылықтары қарастырылады. Құрылыста қоқысты пайдалану үшін: қоқысты бөлек жинау технологиясын жетілдіру; қоқысты қайта өңдеу зауыттарының санын ұлғайту қажет екені анықталды. Шығарылатын қалдықтардың саны мен алуан түрлілігінің артуы қалдықтарды жою дағдарысына әкелді. Мұндай мәселе жол құрылысында қолданылатын бастапқы материалдардың белгілі бір пайызын ауыстыру үшін осы қалдықтардың кейбірін қайта пайдалану арқылы шешілуі мүмкін. Осылайша, табиғи ресурстар сақталып, қалдықтарды жою дағдарысы шешілуде. Көптеген зерттеулер асфальт-бетон қоспаларына қосылған кезде мұндай қалдықтардың немесе модификаторлардың оңтайлы мөлшері жолдың әртүрлі физикалық сипаттамаларының жақсаруына әкелетінін көрсетті. Мақалада жол құрылысының жаңа технологиясының нақты мысалы келтірілген. Пластикті пайдалану мүмкіндігі шығындарды едәуір азайтады және жолдардың сапасын арттырады, бұл Қазақстан Республикасы үшін өте маңызды.*

Кілт сөздер: *пластик, жол, инновация, технология, құрылыс.*

Использование переработанного мусора в дорожном строительстве

[1]***КОЖАСОВ Сарсенбек Кенжебекович,*** *младший научный сотрудник, Kozhassov@mail.ru,*
[2]***ҚОЖАС Айгүл Кенжебекқызы,*** *к.т.н., доцент, kozhas@bk.ru,*
[2]***КИПШАКОВ Султанмахмут Аккаевич,*** *к.п.н., доцент, зав. кафедрой, Kipshakov@mail.ru,*
[2]***САДИРБАЕВА Акмарал Махмутовна,*** *старший лаборант, Sadirbayeva@mail.ru,*
[1]*Казахстанский многопрофильный институт реконструкции и развития, Казахстан, 100027, Караганда, пр. Н. Назарбаева, 56/6,*
[2]*Карагандинский университет им. Е.А. Букетова, Казахстан, 100028, Караганда, ул. Университетская, 28,*
**автор-корреспондент.*

Аннотация. *Целью работы является исследование технологии использования переработанного мусора в дорожном строительстве. Рассмотрены достоинства применения переработанного пластика в дорожном строительстве. Установлено, что для использования мусора в строительстве необходимо: усовершенствовать технологию раздельного сбора мусора; увеличить количество мусороперерабатывающих заводов. Увеличение количества и разнообразия образующихся отходов привело к кризису в области удаления отходов. Такой вопрос может быть решен путем повторного использования некоторых из этих отходов для замены известного процента первичных материалов, используемых при строительстве дорог. Таким образом, сохраняются природные ресурсы и решается растущий кризис утилизации отходов. Многочисленные исследования показали, что оптимальное количество таких отходов или модификаторов при добавлении в асфальтобетонные смеси приводит к улучшению различных физических характеристик дороги. В статье приведен наглядный пример новой технологии дорожного строительства. Возможность использования пластика значительно снизит расходы и увеличит качество дорог, что очень актуально для Республики Казахстан.*

Ключевые слова: *пластик, дорога, инновация, технология, строительство.*

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