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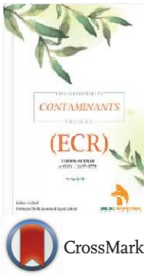

RESEARCH ARTICLE

THE POSSIBILITY OF RECYCLING ASPHALT WASTE IN LIBYA

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ABSTRACT

Libya suffers from the problem of the accumulation of asphalt waste resulting from road maintenance and reconstruction, which poses an environmental and economic challenge. This research paper aims to explore the possibility of recycling asphalt waste in Libya and examine the potential environmental and economic benefits of this process. Previous research indicates that old asphalt contains recyclable components that can be used in the manufacture of new asphalt. This requires remediation and crushing of the old asphalt before it can be reused. These processes can be performed using hot or cold recycling techniques. Waste asphalt recycling provides many environmental benefits. The extraction of natural raw materials used in producing new asphalt is minimized, reducing dependence on and conserving natural resources. It is also possible to reduce the amount of waste accumulated in waste sites, thus reducing environmental pollution. In addition, energy can be saved and carbon emissions can be reduced using recycled asphalt instead of new asphalt. Economically, recycling waste asphalt can reduce the costs of new infrastructure projects, as the price of recycled asphalt is usually lower than asphalt. In addition, the asphalt recycling sector can create new job opportunities and stimulate the local economy. This requires strong collaboration between the government, the private sector and the local community to implement these technologies and promote a culture of sustainability in Libya's road infrastructure.

KEYWORDS

asphalt waste, Libya, recycling asphalt, environmental

1. INTRODUCTION

The problem of asphalt waste accumulation is considered one of the most prominent environmental and economic challenges facing Libya now. This is due to the continuous maintenance and reconstruction of roads, which causes the accumulation of large amounts of old and worn asphalt. This waste is not only an environmental burden on the country, but it also represents a huge economic waste. Recycling waste asphalt is a conscious and sustainable solution to this problem, as old asphalt can be used as a raw material to produce new asphalt (Dedene, 2011). This approach is suitable for preserving natural resources and reducing dependence on the extraction of new raw materials. In addition, asphalt recycling can contribute to reducing environmental pollution and preserving the country's natural environment. Asphalt waste recycling requires strong cooperation between the government sector, the private sector and the local community.

The government should take action and provide adequate support to boost the asphalt recycling industry in the country. Appropriate policies and legislation should be put in place and funding provided to encourage projects related to asphalt recycling. Furthermore, training and awareness must be provided to technicians and professionals involved in implementing these technologies to ensure their success (Elmnifi and Amhamed, 2019). By analyzing previous research and evaluating the findings, this research paper will help clarify the potential environmental and economic benefits of asphalt waste recycling in Libya. It will highlight the importance of growing the asphalt recycling sector as a new source of economic opportunities and enhancing sustainability in the country's road infrastructure sector.

With the increasing population in the world, the demand for development projects is increasing. However, the currently prevailing construction methods are unsustainable. The word sustainability has become prevalent, and what is meant by the word sustainable is that it maintains the environmental balance by avoiding the depletion of natural resources (Tao and Malick, 2009). Therefore, in order to be sustainable, we need to use natural resources at a rate that meets our needs as well as the needs of future generations. The environment is also responsible for the pollution of large amounts of air, soil, and water, and millions of tons. Of waste in landfill so it is clear that, this situation needs to change.

Sustainable construction is the use of materials and products in construction that will help reduce the use of natural resources. Increasing the ability to reuse these materials and products for the same purpose and thus reducing waste. In order to achieve the construction of green projects, it requires the presence of specialists who have an ambitious vision that helps them design sustainable projects that are characterized by energy efficiency and use environmentally friendly materials. Due to the desire of the owners to improve the environment of their new cities and save energy in them, the demand for environmentally friendly building materials has increased for use in the construction of engineering projects in some cities in the world (Jenkins et al., 2019). Due to the increasing demand for the preservation and sustainability of natural resources, various alternatives for construction and infrastructure development are being evaluated to choose the most widely used strategies.

Recently, materials resulting from scraping asphalt roads have accumulated and threatened civil life, the environment, and public health, which has prompted environmental policy makers and project managers to think about developing new technologies to recycle these materials using energy-saving methods (Jamshidi et al., 2012; Makhzom et al., 2023).

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An alternative has been proposed, which is these materials in building infrastructure and recycling Rehabilitation of modern roads, as roads are considered one of the most important infrastructures that provide safe and efficient transportation for human communities. This research paper aims to explore the potential for recycling asphalt waste in Libya and analyze the potential environmental and economic benefits of adopting this approach. The different technologies available for asphalt recycling will be studied and their efficiency and economic feasibility evaluated in the Libyan context. Previous research and studies related to asphalt waste recycling will also be reviewed, and the results and recommendations drawn from them will be analyzed.

2. Recycled Asphalt Materials

Recycling asphalt materials is a process through which asphalt pavements are rebuilt by recycling the layers of the current road. The current asphalt and basic materials are dismantled using a special machine. Recycling techniques in road projects are considered modern techniques in order to enhance environmental sustainability and preserve resources (Lee and Ahmed, 2013). Natural state and reduce the cost of projects. Figures 1 show the shape of the recycled asphalt materials and the shape of the roads after scraping the asphalt.

Figures 1: The shape of the recycled asphalt materials.

Road projects require huge monthly quantities of aggregate, most of which is obtained in some countries through imports, while there are huge quantities of construction and excavation waste in the dumps of these countries, which represents an internal and logistical challenge there (Elmnifi et al., 2018; Wu et al., 2011). This calls for experts and specialists to move in cooperation with the competent authorities to take advantage of these wastes and available resources in projects after recycling them. Initiatives to recycle asphalt materials and use them in project implementation contribute to a direct reduction in the cost of building materials of aggregate and bitumen, which may reach 17% when using asphalt. Recycled without taking into account the reduction in indirect costs such as import and transportation costs, etc. Recycled asphalt materials are materials produced from the removal of old asphalt roads. When the road is in need of maintenance, the old road is completely removed or only the first layer is removed (Elmnifi and Amhamed, 2019). The first use of recycled asphalt materials in road paving works dates back to the year 1915.

However, the actual use of these materials in hot asphalt mixtures began in the mid-1970s due to the high prices of bitumen, which is the binding material in asphalt mixtures. After good knowledge, the use of recycled asphalt materials began... Recycled asphalt can significantly reduce paving costs, conserve energy, and help protect the environment. In addition, several studies have concluded that properly designed and implemented recycled asphalt material mixes exhibit performance similar to hot asphalt mixtures. Furthermore, recycled asphalt material technologies In terms of production and processing, it has improved significantly in the past few years, while the binder in asphalt pavement is the most widely used material in road construction. Therefore, when the asphalt pavement reaches the end of its design life, the road surface is ground, resulting in crushed materials known as recycled asphalt materials containing... These materials contain the binding material, which is bitumen, and it is transported to asphalt factories for recycling.

It is clear that the higher the percentage of use of recycled asphalt materials, the lower the road construction costs. However, the maximum amount of recycled asphalt materials allowed to be used in hot asphalt mixes is only about 30% in many countries. This is due to reducing concerns about the intrinsic properties of Recycled asphalt materials such as old bitumen are desirable although 100% recycled asphalt materials can be used (Elmnifi and Amhamed, 2019). The use of recycled asphalt materials in the foundation and sub-base layers can reduce global warming by 20%, energy consumption by 16, water consumption by 11, and hazardous waste generation by 11%. Figure 2 shows the percentage reduction in these problems. Therefore, the use of recycled asphalt materials is consistent with efforts to develop sustainable methods based on the concept of green design, where 40% of global primary energy consumption and carbon dioxide emissions are related to material production (Tao and Malick, 2009).

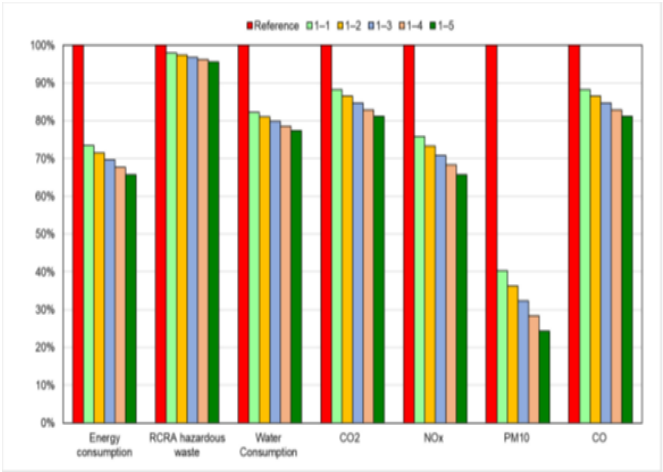

Figure 2: Shows the percentage reduction in these problems.

The production of high-quality hot asphalt mixes that contain recycled asphalt materials has become increasingly widespread. 25% or more is more available. However, several studies and reports have stated that the average use of recycled asphalt materials is estimated at 12% in hot asphalt mixes. Research has shown that a secondary benefit of recycled asphalt materials is that pavement containing recycled materials ages more slowly compared to pavements made entirely of new materials.

There may be problems when using recycled asphalt materials as an engineering material, such as the variation between the sources of these materials depending on the place from which they were sourced, as the type of bitumen may be different and the degree of aging of the materials may be different (Denede, 2011). In addition to the problems it causes with workability, compaction ability, and in choosing the temperature during mixing and compaction, which is often very high (Elmnifi and Amhamed, 2019).

3. Types of Recycled Asphalt Materials

The use of recycled asphalt materials has become increasingly attractive to government road institutions since liquid bitumen costs have more than doubled in the past few years from about $160 per ton in 2005 to $300 or even $400 in some areas in 2008. Recycled saves natural resources and money, so recycling old asphalt paving materials is environmentally friendly. There are millions of tons of recycled asphalt materials stored in the northeastern United States It makes it capable of implementing several road projects (Elmnifi and Amhamed, 2019). Recycled asphalt materials have been widely used in the United States. The 2007 average national use rate of these materials in hot mix asphalt was estimated at 12%. There is a goal to double this average over the next 12 to 24 years (4). In the United States, approximately Of the 100 million tons of recycled asphalt materials annually, with about 60 million tons being reused in the construction of new asphalt roads, while the remaining 40 million tons are used in other paving-related applications such as base layers and auxiliary foundations, given that the aggregate materials are non-recyclable natural resources.

For renewal, the main benefit of using recycled asphalt materials is to reduce the demand for extracting new materials and help reduce pressure on landfills. At the same time, some laboratories and experiments have concluded that it is possible to produce asphalt mixtures containing 30 to 40%, which are high percentages of recycled asphalt materials. Rotate it. However, studies have recorded that percentages of recycled asphalt materials exceeding 50% can be used to build roads using warm mix asphalt technology. The use of these high percentages is due to reduced aging of bitumen during the production of warm asphalt mixtures (Jamshidi et al., 2012). In Europe, warm asphalt mixtures have been successfully produced with up to 50% of recycled asphalt materials. In the United States, most projects used warm asphalt mixtures containing 20% (Oliveira et al., 2011). According to data provided by a previous study, increasing the use of recycled asphalt materials by 10% could save.

Figure 3: Types of recycled asphalt materials.

3.1 Asphalt recycling techniques

3.1.1 Using warm asphalt mix techniques

Warm asphalt mixes have been used widely around the world with the aim of saving energy and reducing gas emissions during production processes without reducing service performance. This has been achieved with organic additives, chemical additives, and the use of foamed bitumen techniques. Using these techniques has advantages and disadvantages (Leng and Al-Qadi, 2011). During the past two decades, the production of asphalt mixtures has evolved and has been improved to achieve economic and environmental goals. Recently, more attention has been paid to reducing energy consumption during production processes without changing the mechanical performance of these asphalt mixtures and as a result of increasing international pressures to reduce fossil fuel consumption and emissions greenhouse gases such as carbon dioxide .It is known that the production of hot asphalt mixtures results in the consumption of a large proportion of energy and the emission of polluting gases. This is the result of heating the aggregate to dry it and heating the bitumen to high temperatures exceeding 100 degrees Celsius. We can say that reducing temperatures when producing asphalt mixtures without affecting the workability of the asphalt and achieving mechanical performance enables us to obtain good results for the environment and society in general.

Figure 4: Hot asphalt mix techniques.

3.1.2 Cold grinding techniques

The worn pavement is removed using cold grinding equipment, and the material is transported to an asphalt plant where it is recycled and forms part of the new asphalt. This new asphalt is paved and compacted to create a new wear path. Cold milling is an integral part of the construction cycle of any road. Asphalt milling is used to remove the old and eroded wear layer or the entire asphalt pavement. It can also be used to improve surface friction in a wear path that is in good condition. Connections can be prepared for the new overlay and the manholes directed downward can be cut so that they can be pulled back to the correct level. A narrow trench can also be cut to lay fiber optic cables, for example. Different machines are used for different applications depending on capacity requirements, job site size, maneuverability, etc. The material removed is largely recycled as a base layer of unconsolidated gravel. It can also be added as part of virgin asphalt mixtures produced in different types of asphalt plants (O'Sullivan, 2009).

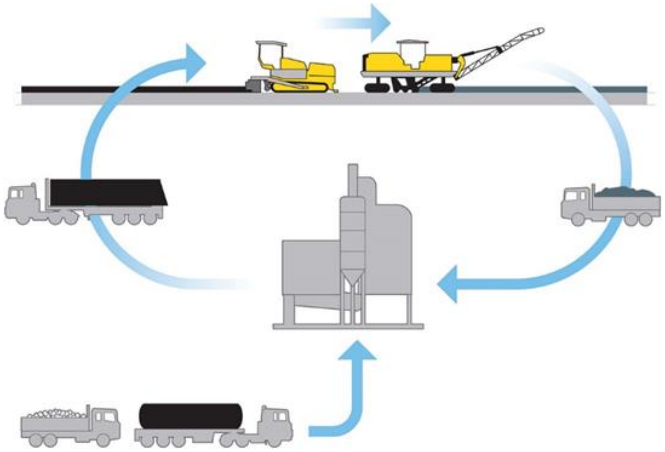

Figure 5: Cold grinding techniques.

3.1.3 Additives to asphalt mixture

3.1.3.1 Organic additives

Various organic additives can be used to lower the viscosity of the binder (bitumen) at temperatures above 90°C. A commonly used additive is a special paraffin wax produced by natural gas conversion. Organic additives typically give a temperature drop of 20-30°. Celsius while also improving the deformation resistance of modified asphalt.

3.1.3.2 Chemical additives

Chemical additives do not change the viscosity of bitumen. As surfactants, they work at the microscopic interface of aggregate and bitumen. They regulate and reduce frictional forces at that interface in a temperature range that usually ranges between 140 and 85 degrees Celsius. Therefore, it is possible to mix bitumen and aggregate and compress the mixture at a temperature at low levels; chemical additives may reduce mixture temperatures and pressures by approximately 20-40°C.

3.1.3.3 Foaming techniques

To begin the bitumen foaming process, a set of foaming techniques are applied to reduce the viscosity of the bitumen. Various methods are used to introduce small amounts of water into the hot bitumen. The water turns into steam, increasing the volume of the bitumen and reducing its viscosity for a short period. Expanding bitumen allows the aggregate to be coated in different degrees. Low temperature and residual moisture support asphalt compaction at construction site, production and paving temperatures can be reduced in parallel.Two foaming methods are commonly used:

The direct method of foaming is to inject a small amount of controlled water into hot bitumen via foaming nozzles. This results in a significant but temporary increase in the effective volume of the adhesive, facilitating coating at low temperatures. Some steam remains in the bitumen during compression, reducing the effective viscosity. Compaction is easy, and upon cooling, the binder returns to normal. Since the amount of water is minimal, this technology can reduce the temperature of the asphalt mixture by about 20 to 40 degrees Celsius.

Indirect foaming technology uses a mineral as the foam water source. Hydrophilic minerals from the zeolite family are commonly used, and contain about 20 percent crystalline water, which is released above 100°C. This water release produces a controlled foaming effect, which can Provides improved workability For 6 to 7 hours, or until the temperature drops below 100°C, foaming results in improved workability of the mixture which can subsequently allow the mixture temperature to drop by approximately 30°C with equivalent compression performance.

The second indirect foaming technology uses moisture on sand (or RAP) to generate natural foam. It is a sequential technology. The coarse aggregate, which represents about 80% of the mix design, is dried, heated to 130-160°C, and then covered with bitumen, thus forming a layer Thick

bond on coarse particles, the next stage involves adding the cold, wet fraction, where moisture contacting the hot bitumen causes foaming which facilitates the coating of cold, wet RAP or fine aggregate.

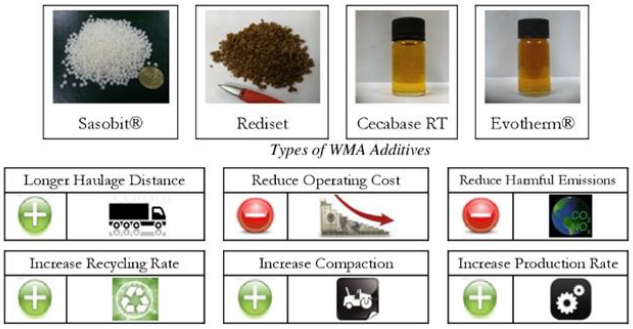

Figure 6: Additives to asphalt mixture.

4. Use Warm Asphalt Mixtures and Recycled Materials

To improve construction costs and adhere to the green revolution, many highway agencies are actively exploring the use of warm mix asphalt technology and recycled materials. Compared to traditional hot mix asphalt, warm mix asphalt technology has the potential to reduce the production temperature of mixing and compaction in a cost-effective manner by about 20%. °C to 55 °C. In addition, the warm asphalt mixture technology is considered environmentally friendly (Mo et al., 2012).

The term warm asphalt mixtures represents technologies, including various products and special processes, that allow to significantly reduce the production temperatures of asphalt mixtures, in addition to lower fuel consumption and emissions at production plants, and other advantages of using warm asphalt mixtures, such as facilitating compaction operations, delivering mixtures over long distances, and opening early traffic and reduce aging of bitumen during production operations (Sampath, 2010; Elmnifi et al., 2019). Several studies have concluded that the use of recycled asphalt materials in hot asphalt mixes can help offset increased initial costs, conserve natural resources and avoid disposal problems, Furthermore, it has been shown that the material properties of properly designed recycled asphalt mixtures are comparable to new asphalt mixtures. When old bitumen is mixed with new bitumen, the old bitumen will have some effect on the grade of bitumen produced from the mixing if warm asphalt technologies are incorporated into Mixtures that contain recycled asphalt materials. It is expected that the ideal mixing and compaction temperatures for recycled mixtures will decrease by 30 degrees Celsius without negatively affecting the performance of the new mixtures.

In order to meet the challenges resulting from the increasing demand for environmentally friendly asphalt mixtures and the increase in raw material costs, warm asphalt mixture additives and recycled asphalt materials were combined to produce new asphalt mixtures (Jamshidi et al., 2013). In Sasol Wax Sasobit Advera. Zeolite warm mix asphalt additives such as reducing mixing and compaction temperatures while maintaining the required workability of asphalt mixes are suitable additives for enabling hot asphalt mixes with high contents of recycled asphalt materials (Liu, 2008). A recent experimental study conducted confirmed the feasibility of making asphalt mixtures with 100% recycled asphalt materials with the help of @Sasobit or zeolite (Wu et al., 2011). When bitumen extracted from recycled asphalt materials is mixed with fresh bitumen and used in hot asphalt mixtures, the aged bitumen affects the resulting mixture, and the production temperatures of asphalt mixtures that contain recycled asphalt materials will be higher than the temperatures of traditional hot asphalt mixtures. When using warm-mix asphalt additives such as Sasobit, they reduce the viscosity of the bitumen mixed with bitumen extracted from recycled asphalt materials, and the interaction between Sasobit and the aged bitumen increases the high failure temperatures, which indicates a lower probability of rutting defects occurring. Studies showed that the use of a mixture of new bitumen and old bitumen containing Sasobit reduced the rutting coefficient by approximately 42% and the hardening coefficient at 12 degrees annually with a structure of 235 to 35 % (Mo et al., 2012; O'Sullivan, 2009). In another study, it was confirmed that the use of 900 of 120 heated at 125 degrees Celsius with Similar properties to recycled talc allowed the production of an asphalt mixture that is produced at 150°C, where 35% and 45% of recycled asphalt materials were used with the addition of 1.5% of 4 Sasobit.

5. Conclusion

At the conclusion of this research, it can be said that there is great potential for recycling asphalt in Libya and exploiting it effectively. Asphalt recycling is a sustainable and economical option that contributes to preserving natural resources and reducing environmental pollution. By reusing spent asphalt, the need to use new resources can be reduced and the costs associated with purchasing new asphalt can be saved. It also contributes to improving the quality of roads and reducing costs related to their frequent maintenance. With the availability of technical capabilities and knowledge in Libya, factories and facilities dedicated to recycling asphalt and converting it into new products can be developed. This requires awareness and continuous training for workers in this field to raise awareness of the importance of asphalt recycling and adopt this practice in future road projects in Libya. It is necessary for the government sector, the private sector and civil society to cooperate in promoting asphalt recycling and providing the necessary support and facilities to implement relevant projects. Companies and contractors should be encouraged to adopt sustainable practices in road projects and prefer to use recycled asphalt. By exploiting the potential for asphalt recycling in Libya, tangible environmental and economic benefits can be achieved and contribute to the construction of sustainable and durable roads. There must be a clear commitment by all to promote this practice and achieve sustainable development in the road sector in Libya and around the world.

Recommendations

1.Evaluation of existing asphalt: Before beginning the reuse process, the condition of the existing asphalt must be evaluated. It should be inspected to ensure it does not have major wear or structural damage. If asphalt is renewable, it can be used in the reuse process instead of being disposed of.

2.Appropriate Use: Recycled asphalt should be used in appropriate applications. For example, recycled asphalt can be used as a finishing layer in new roads or to repair old roads.

3. Recycled asphalt processing: Recycled asphalt must be cleaned of any impurities or unwanted materials. Magnet or air screeners can be used to remove foreign materials and unwanted metals.

4.Remixing: Recycled asphalt must be mixed with new aggregate and appropriate adhesive to ensure a consistent, well-bonded mixture. Various asphalt mixing equipment can be used to achieve this goal.

5.Quality control: Periodic tests must be conducted on recycled asphalt to verify its quality. Concrete tests, compressive strength tests, and other tests can be used to ensure that recycled asphalt meets required standards.

6. Preserving the environment: Correct environmental practices must be followed during the asphalt reuse process. Any harmful materials must be disposed of safely and adhere to local and national regulations regarding environmental protection.

7. Audit and Maintenance: Once the asphalt reuse process is completed, it must be monitored and maintained regularly. Performance must be monitored and necessary repairs made to maintain the quality of recycled asphalt over the long term.

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