



Review Article

Using of recycling materials in the construction sector

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ABSTRACT

The fact that the population is increasing day by day requires more careful use of limited resources. Making these limited resources reusable after use has a separate meaning in terms of both the environment and the economy. Therefore; the importance of recycling activities is increasing day by day. The managers of the countries; Due to the increasing importance of recycling activities, they make legal arrangements to encourage these activities. Particularly in the construction sector, because of the extensible resources are used extensively, recycling activities are applied intensively. Within the scope of the study, the recycling activities (asphalt, used vehicle tires, slags, glass waste and marble waste) in the construction sector were researched. In addition, applications after recycling of materials have been examined. The economic contribution of the acquisition of materials through recycling has been expressed.

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1. Introduction

The fact that the world population is growing rapidly brings with it many problems. One of these problems is that waste materials are produced by using industrial materials whose consumption is continuously increasing. Removal of these waste materials from the production facilities is of great importance. The removal of industrial wastes and the availability of suitable waste for these wastes are virtually impossible, especially in large cities. In addition to these negativities, excessive and unplanned use of natural resources may cause these resources to diminish or even disappear in the years to come [1].

Many countries are focusing on the policy of recycling these resources in order to avoid excessive consumption of natural resources and to combat the emerging energy crises. Investigations has begun on recycling in Europe in the 1970s, and recycling efforts in Turkey, but has come to a position to be effective after the 2000s [2]. Turkey will be able to turn back backwardness in this sector by speeding up the application, but in this area. For this reason, policies that encourage recycling through legal regulations must be passed on first.

The recycling efforts started with the asphalt recycling activities that took place especially in the 1970s due to the oil crisis. Along with the oil crisis, countries have experienced great difficulties in meeting oil demand, which has led to the start of their recycling efforts. Asphalt recycling is defined as the process of stripping the finished asphalt within certain criteria and reusing it in certain ways [3].

The recycling of natural resources is mainly done in the construction sector, textile sector, industrial sector and many other areas. In this study; the work carried out in the field of recycling in the construction sector is explained. The effects of the applications made using recycled materials on the desired values in the specifications are explained.

2. Literature Review

In particular, the materials used in our time will be harmful to nature, even if they are both remote and removed. Recycling is increasing the importance of day to day. In this part of the work, the studies on recycling in the construction sector are mentioned.

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Sefidehkan [4] compared the properties of concrete produced using recycled aggregate (RA) at different rates and the properties of concrete produced using crushed stone in study. It has been determined that the concrete produced using 100% recycled aggregate is in a lower class than the concrete produced with 100% crushed stone aggregate. Hosseinnazhad [5] investigated the recycling of concrete waste to the use of compressible concrete. For this purpose, prepared 15 different concrete mixes which can be compacted into cylinders by using 0%, 25%, 50%, 75% and 100% recycling aggregates. Examined the mechanical and durability properties of the produced blends. Found that the use of recycle aggregates up to 25% did not significantly affect the mechanical properties. However, the effect of the use of recycling aggregates has been reduced as the dosage of cement decreases. Süme [6] has studied the usage of the recycling aggregate for concrete road cover. It has been concluded that the concrete pressure resistance increases as the RA utilization rate increases and the bending strength shows a rolling-out curve, and that the concrete produced with 100% cleaned RA gives maximum yield and the pressure resistance gives maximum result and it should be used as concrete road cover. Çağrıci [7] conducted a study on the use of recycled materials obtained from construction and debris wastes on road superstructures. We have examined the effect of waste materials by applying a test path approximately 100 meters long at the Arnavutköy Bolluca site where all of the filler, subbase, plant-mix base and bituminous base plates of the materials produced by industrial scale production using demolition wastes are located.

Kaya [8] investigated the use of damaged or old asphalt coatings in new roads by scraping. As a result of researches, he found that recovering asphalt as much as possible from all over the world and our country reduces the consumption of natural resources with less aggregate and bitumen use. In this way, it has determined that economical profit is realized with decreasing the production costs of asphalt. Güner et al. [9] have worked on the selection of materials for environmentally conscious structures for the sustainable development model. As a result of analysis of the samples they examined in their studies, they obtained a table by creating subgroups as a result of the analysis of the headings and the headings in the selection of materials in ecological and sustainable structures. By analyzing the selected twenty sample projects on the chart, the effect ratings of the parameters included in the chart were determined and the obtained data was interpreted together with the sub parameters. Güner et al. [10] the construction industry has examined the recycling of building materials as a source of raw materials and recycling. In the works, recyclable materials are explained in the construction industry, waste

is considered as a source of raw materials and applications in the world are mentioned.

Chen et al. reviewing 1639 articles on the topic of recycling in total with a three-stage literature review; they stated the deficiencies in the current studies and suggestions that would encourage the current studies [11]. Kisku et al. the aggregate in the waste concrete formed due to the demolition of buildings; emphasized the importance of using in recycling. They compared the properties of conventional concrete with prepared concrete by using demolition wastes in recycling. They have reached the conclusion that the properties of the concrete prepared using recycling aggregates are lower than those of conventional concrete. However, they stated that the desired properties can be obtained by using some additives and modified mixing approaches [12]. Li et al. highlighted the environmental and economic advantages of the application of recycled solid waste in road pavement. In particular, they examined the applicability of recycled asphalt pavement and steel slags on the road [13].

The intensive consumption of raw materials in many sectors leads to depletion of resources and increases the importance of recycling activities. There is no doubt that recycling activities are widely performed in many different fields. In this study, especially recycling activities in the construction sector are mentioned and application areas of recycling materials in transportation sector are explained.

In this study, the practices related to the recycling activities in the construction sector are mentioned. Furthermore, the applications of the materials obtained from these recycling activities in the transportation sector are explained and their contributions are expressed.

3. Material

The development of technology, the speeding up of countries' recycling efforts and the necessity of recycling efforts have resulted in the use of very different structural materials in the field of recycling. In this part of the work, the methods of recycling in the construction sector are explained. In addition, the structural positive effects of the materials used in the recovery are explained. In the scope of the study, old asphalt coatings, used vehicle tires, slags, glass wastes and marble wastes were investigated and determined the effects of using these materials.

3.1 Scratched old asphalt pavements

Recycling is achieved by using the material obtained by scraping from the existing road superstructure in the production of bituminous hot mix to be constructed (Figure 1). Both economic and environmental advantages are achieved by using bitumen and agglomerate, which have high economic value in existing road pavement layers, after they have passed certain operations, again on the road superstructure [14].



Figure 1. Asphalt Recycling [15]

Depending on the type of asphalt production plant, different amounts of scrapped asphalt can be used to save both bitumen and mixtures that meet asphalt specifications. There are many applications where the use of recycled materials in the base, binder and bituminous base layers has been successful. In general, asphalt is added at a certain rate with 10%, 10%, 20% and 35% of the amount of recycled asphalt in the bituminous base layer, resulting in a mixture of asphalt specification criteria.

3.2 Used vehicle tires

Tires whose tread depth has fallen below 1.6 mm become unusable because of their physical properties and lack of reliability. Most of the finished tires are used in recycling plants. Particularly in America and Europe, used automobile tires, which cause major environmental problems, are broken up and separated from steel wires (Figure 2).

After this process it is reduced to dust or granular size and used in various industries. Used vehicle tires are widely used especially in the concrete and cement industries after being recycled. According to the results of



Figure 2. Old vehicle tires recycling [16]

the tests made, the increase in the amount of ground vehicle tire usage was reached as a result of decreasing the volume weight, bending strength and compressive strength values of concrete unit. Accordingly, it has been determined that rubber-reinforced concrete can be used in low-volume-weighted situations or in undesirable situations where the carrier properties are desired.

3.3 Slags

Slag is a side product of iron production in blast furnaces in iron and steel plants in shown Figure 3. The slags produced during the steel production are used for road cover. Slag is used in the bituminous base layer 45% and in the binder layer 35%.

It is known that, in the works carried out, the binder and bituminous base layers are generally used as artificial aggregates in slag asphalt mixtures at certain ratios. In addition to these studies, cement with no binding properties alone has achieved binding properties when used with cement. It has been proven in many studies in the literature that it has a very positive contribution to the physical and mechanical properties of slag concrete [1].

3.4 Glass

Glass between recyclable materials; although it is not as harmful as abandoning plastics to the environment or wasted paper, it is one of the most energy-saving substances when conversion is made. Also, since it is a simpler structure than a few raw materials in its structure, recycling is also very easy compared to others. Although asphalt mixtures have no positive effect on performance, they are preferred because they increase the visibility coefficient of road surface in concrete way [1]. Glass wastes increase the stiffness in asphalt mixtures but decrease the resistance against cracking which may occur at low temperatures is the biggest reason why glass wastes are not used.



Figure 3. Slags recycling [17]

3.5 Marble waste

Recycling is very important in marble which constitutes 60% waste material during production and processing. The marble, which forms two types of waste, namely dust and piece, is recycled in different forms. The marbles emerging as waste in marble production and cutting facilities are used as coarse / fine aggregates in the basement and plent-mix base layers which are connected water at the road surface and are also used as filling materials at certain ratios in asphalt mixtures. Marble dust can be used as road superstructure material. Fine dust can be used to reduce filler voids [1]. Delays the decomposition of asphalt at high temperature. The investigations have shown that the marble dust added to the pavement delays asphalt aging considerably. Asphalt added marble increases the viscosity of asphalt. This reduces the formation of treads. Marble dust is called a marble filler. This filler can be used on asphalt with little stone filler (Figure 4).

Apart from that, marble is used in lime production, cement production and ready-mixed concrete production. Investigations to increase the durability of concrete using 10% marble filler in concrete.



Figure 4. Marble waste recycling [18]



Figure 5. Concrete waste recycling [22]

3.6 Concrete waste

Most of the construction and demolition wastes are concrete wastes. Although recycling of concrete is not as much as paper, plastic and similar materials, it is a recycling material that is important to realize and to bring it back to the economy (Figure 5) [19]. There are many different applications related to the recycling activities of concrete in many countries in the world. It is estimated that 175-370 million tons of construction and demolition waste is produced annually in European countries. 72% of these wastes are stored and 28% are brought to the market through recycling activities [20]. By recycling the construction and demolition wastes, raw material (cement and aggregate) production and energy consumption are prevented. Image pollution is prevented by recycling the construction waste that covers a certain area and volume in the environment. Less energy is consumed by using waste rather than using natural resources. In addition, it contributes to the economic development of the country [21].

Since the content of the mixtures used in the pavement layer in the road flexible pavements consists of aggregates of 90-95%, it is used as aggregate in the road pavements together with the recycling of waste concrete.

3.6 Plastic waste

In recent years, plastic products have been used extensively in many sectors. One of the most important reasons why plastic materials are flexible, easy to process, light and cheap. However, pollution that occurs after the use of these plastic wastes is an important environmental problem [23]. Because plastic wastes decay and dissolve in the environment much more difficult than other wastes. This increases the importance of recycling activities of plastic wastes. Although very new, plastics used in the automotive industry are recycled by pyrolysis. Solid products obtained by pyrolysis are used as additives in hot asphalt pavements.

Milled pet bottle; it can be used in asphalt pavement only within the scope of waste assessment, provided that it does not exceed 0.5%, furthermore it has no positive effect on asphalt mixtures [24].

3.7 Lime waste

The raw material of lime is a natural raw material containing calcium carbonate (CaCO_3) and magnesium carbonate in the limestone chemical structure [24]. In soil improvement works due to calcium content; soil expansion and contraction of the soil as a result of the physical changes that occur as a result of applications to eliminate damages. With lime stabilization, optimum water content increases in the short term, proctor densities decrease, plastic limit increases, liquid limit decreases and CBR values increase [25]. In the long term, the CBR value increases, the free pressure and shear strength values increase, and the stability against swelling and shrinkage

increases. It was stated that the stabilization studies using lime contributed to the positive results.

As a result of the study conducted with the aim of improving the road infrastructure by using fly ash and limestone, the CBR value of the ground was increased [26].

3.8 Roof Shingle Waste

Syringe pieces are milled and their effects on hot bituminous mixtures are examined. Marshall Test is used to determine the stability of hot bituminous mixtures prepared for this purpose.

Although the roof waste is not in general a serious problem so far; the fact that its use is increasing day by day shows the importance of taking precautions in advance (Figure 6). When the roof waste is ground and used at a rate of 1.5% with 50/70 bitumen, it gives positive results on bituminous hot mixtures [27, 28].

3.9 Iron Waste

Iron wastes collected from construction wastes can be reused after melting and shaping (Figure 7). There are applications that iron, copper and magnesium wastes collected from construction wastes are mixed with bitumen in certain proportions in order to give hardness and frictional strength to the asphalt. Particularly in stone mastic asphalt pavements prepared using these mixtures, positive results were achieved [31].



Figure 6. Roof shingle waste recycling [29]



Figure 7. Iron waste recycling [30]



Figure 8. Bituminous waste recycling [32]

3.10 Bituminous Membrane Wastes

Bituminous membrane wastes can be re-produced after shredding and grinding and can be used in asphalt construction (Figure 8). It was determined that the content of membrane wastes was 45% bitumen and 2.5% elephant material [32].

As a result of the studies, as a result of the recovery of bituminous membrane wastes, 45% bitumen can be used as binder in asphalt [24].

4. Results and Discussion

The importance of recycling activities is increasing day by day due to the limited natural resources, the continuous increase in population, global warming and environmental pollution. In order to use exhausted resources more effectively and efficiently, recycling activities need to be done in a widespread manner. In addition to all the economic advantages of recycling material, it provides protection of natural resources and prevents the pollution of the surrounding area by preventing the formation of waste areas. It is obvious that the recycling trend that started in Europe and in the World has started to spread in our country. However, the majority of licensed recycling companies are located in major cities where the industry is concentrated. In this case, about 50% of the idle materials in our country are recycled. In the absence of recycling plants, the natural resources used cannot be recycled.

It is a fact that the recycling systems established based on existing laws and regulations are not very effective and cannot reach the desired result. In order to avoid these negative consequences, a number of legal arrangements have to be made. The legal shortcoming of negative consequences comes not from the regulations but rather from the legal inadequacies. In order to remedy this situation, the Turkish Grand National Assembly did some work in 2006 and the following years, but the inadequacy of these studies is easily noticed because the desired performance in recycling is not taken.

Building materials and construction costs as well as within the entire industry occupies an important place in Turkey. Ministry of Environment and Urbanization General Directorate of Environmental Management Waste Management Department; In Turkey, 45 million tons of annual structural 10 million tons of waste during the first three years together with the Urban Renewal Act, the amount of material to be recovered is estimated at 6 million tons yearly [15]. For this reason, second hand use and dissemination of recycling practices are important for energy and resource conservation. As a result; considering recycling activities in Turkey is seen as lagging behind the state in Europe. General information about the recycling materials used in the construction sector is given in the Table 1 below.

Table 1. Application areas of recycling materials

Material	Advantages	Usage Areas
Scratched old asphalt pavements	Preventing the formation of waste areas, reducing the need for new materials	Bituminous mixtures, road construction
Used vehicle tires	Contribute to the economy, prevent environmental pollution	Asphalt mixtures and highways
Marble waste	Economy and environmental effect	Cement admixture, improving the properties of ground
Glass	Increasing the visibility of the road surface but causing a lower level of stability compared to conventional mixtures	Bituminous hot mixtures
Concrete waste	Contribute to the economy, prevent environmental pollution	Highway pavement, as concrete material
Plastic waste	Environmental effect	As additives in hot asphalt pavement
Lime waste	Preventing the formation of waste areas, prevent environmental pollution	Ground improvement
Roof shingle waste	Contribute to the economy, prevent environmental pollution	Bituminous hot mixtures
Iron waste	Economy and environmental effect	Flexible pavement
Bituminous Membrane Wastes	Contribute to the economy	Used as binder in asphalt

5. Conclusions

In recent years, there has been a significant increase in the formation of structural waste materials due to technological developments and variations in applications. It is known to everyone that the prevention of structural wastes at the source of waste management policies. Appropriate forms of evaluation of waste should be preferred, such as reuse, recycling, reproduction and energy conservation, as there is no world without waste.

The recycling and recovery of construction waste is also closely related to the economy of the country. It seems that the construction industry is of great importance in recycling. In the construction sector, energy and raw material savings are achieved by creating a potential raw material source through recycling. In the construction sector there are many construction materials that can be recycled during construction and demolition. The waste issues in the construction industry should be assessed well and the economic and environmental losses should be minimized. During the recycling of the recycled materials into the production system, new job opportunities are created and the employment of the economy is seen to be increasing. In the world where natural resources are limited, recycling activities have social, economic and environmental impacts, highlighting the importance of these activities. Recycling, which is one of the most important branches of waste management, is seen as an efficient economic investment by including recyclable wastes into the production process through various methods. For this reason, recycling is important both at the macro level in terms of environment and economy and in micro level in terms of businesses and consumers. As a result, it should not be forgotten that recycling has a large share in the protection of the environment and in the promotion of economic development and prosperity in terms of value added to the economy.

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