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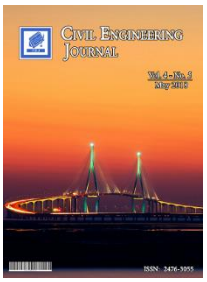

Evaluate the use of Recycled Asphalt Pavement (RAP) in the Construction of Roller Compacted Concret Pavement (RCC)

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Abstract

One of the issues and problems of today's world is the massive amount of debris and trashes, especially asphalts resulting from the removal of worn-out pavements of urban roads. Recycled asphalt crumbs (RAP) are waste materials that certainly have significant undesirable effects on the surrounding environment. Given the properties reported by these materials, there are various ways to reuse these materials. One of the applications that has been considered by researchers is the use of these materials in cement mixtures, including concrete production. This is while a large amount of asphalt fragment is continuously produced in the repair and maintenance of roads. It is therefore desirable to be used in conventional mixtures used in construction of road pavements. In this regard, the present study investigates the use of recyclable asphalt materials in pavement roller shuttle (RCC) with the aim of reducing waste and its negative impacts on the environment. By examining the documentation and performing numerous experiments, it has been found that roller concrete made from recycled asphalt can be used as a suitable pavement for low traffic and rural roads, as well as for the final covering of a wide range of sidewalks.

Keywords: Asphalt Fragment; Roller Compacted Concrete (RCC); Recycled Asphalt Pavement (RAP).

1. Introduction

One of the most important issues that has attracted the attention of researchers is recycling category. Recycling means reuse of materials that have already been used. In this direction, to be interested in the use of recycled materials in concrete and asphaltic products has grown among engineers and the environment fans. Recycled asphalt fragments, which are residue from the reconstruction and cutting the asphaltic surface, form a large part of the waste material, so that in many countries of the world, hundreds of these materials are disposed annually, which are often reused. Over the past decades, hundreds of millions of tons of recycled materials have been recovered annually since the renovation and repair projects of pavements in the United States. These recycled materials have been used in concrete and road construction in various ways. Studies also show that construction waste constitute 50 percent of the total waste material in the world. Iran has a potentially potential for investment in the recycling sector compared to advanced countries, including Denmark, where about 95% of its construction waste is recovered. The use of recycled asphalt fragments can help to preserve non-renewable resources and prevent environmental pollution and accelerate the process of building roads. Recycled asphalt fragments consist of coarse grain stone materials, fine grain, fillers and bitumen. One of the uses of recycled asphalt is the pavement layers. This strategy is being implemented in most countries of the world or is under consideration for implementing. Due to the lack of suitable road construction materials, which are often home-made or broken stone derived from mining, as well as the high cost of extraction and transportation of these materials, the use of recycled materials in most developed countries such as Germany, the Netherlands, Belgium and Norway,

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many studies have been carried out and special standards for the use of this material have been compiled. Every year, a lot of waste materials from the industry, home use, construction and destruction of buildings and cutting the asphalt are generated, and accumulation of them is an important factor in environmental pollution. On the other hand, a large amount of natural resources is used annually as materials for building construction projects. If it is possible to maintain quality or improve it, instead of using natural materials from recycled materials, a major step is taken to save on the economy and protect the environment.

1.1. Roller Compressed Concrete (RCC)

Roller concrete is a type of zero slump concrete, which includes aggregates with accumulated aggregation, sand, cement materials and water. The use of roller concrete for pavement construction has begun on a large scale since the 1970s and for the first time in the country of Canada, and the pavement made with this type of concrete is known as roller concrete pavement. In other words (RCCP) refers to pavements with roller concrete. In other words (RCCP) refers to pavements with roller concrete. The performance of roller concrete over the past years has shown that roller concrete can be used as durable and resistant materials for pavement construction, so that they can withstand heavy traffic loads and hard weather conditions with a series of low maintenance operations. This type of concrete is transmitted to the desired location, spread and is eventually condensed by road equipment such as roller bearings [4]. One of the main advantages of this type of pavement is the reduction of construction costs by between 15% and 40% compared with conventional concrete. Various accomplished projects have shown that RCCs have the following advantages over conventional cement concrete to pave the way.

- The bending strength (RCC) is equal to Portland Cement Concrete (PCC).
- The construction time of the pavement (RCC) is less.
- Making roller concrete is easier.
- When using RCC, construction and maintenance costs are reduced.

The following results were also obtained by comparing the use of roller concrete and asphalt concrete as a layer in pavement. Flexural strength in roller concrete pavements is 25% higher than asphalt pavements with a cement stabilized layer at the factory.

- The resistance of the roller concrete is more against abrasion.
- Created roller concrete have a higher resistance to spilled oil and greasy materials on the road surface.
- In the face of hot weather, roller concrete has more resistance than concrete asphalt.

According to the explanation, the replacement of concrete asphalt with roller concrete for using as a pavement layer can be a convenient and economical solution. Therefore, in the present paper, according to the previous studies, the characteristics and features of roller concrete are evaluated and investigated as one of the pavement layers of the roads.

1.1.1. Features of Roller Concrete

The concrete is sufficiently dry on one side to withstand the weight of the compacting roller, On the other hand, this type of concrete is sufficiently moist and has water to provide a good distribution of cement paste into the concrete mixture. As shown in Figure 1, the friction between the aggregates is achieved through roller compression and the bonding between the aggregates is provided by the cement paste used concrete construction, which ultimately leads to achieve full load capacity RCC.

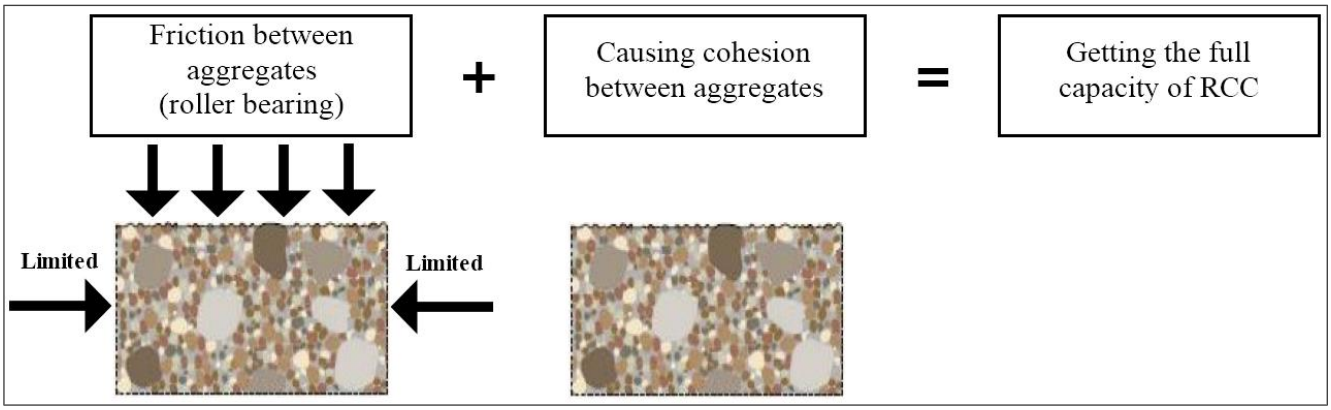


Figure 1. How to extend the strength of roller concrete and achieve full load capacity (RCC)

In a study carried out by Hassani et al. (RCC) have seen unlike ordinary concrete, reducing the water to cement ratio to less than optimal amount will not cause the increase of resistance (RCC). Also, very fine aggregate particles play a major role in controlling the roll concrete specifications, and the amount of cement in this connection is not effective, because the roller concrete strength characteristics are mainly obtained by obtaining sufficient condensation. Natural filler aggregates are added to the roller concrete, they are mainly from 1.18 to .075 mm. When using a natural filler of 7.5% (about 154 kg per cubic meter), the roller concrete will have the highest compressive strength.

2. Research Background

Roller compacted concrete is a concrete with zero slump that is used in road surfaces. The main advantages of this type of pavement, which has resulted in its superiority to ordinary asphalt pavements, are quick and easy execution, low execution costs, lower consumption of cement and high resistance to cold and hot weather. (ACI 325) has been defined this concrete that the roller concrete is a blend which has some condition in a new state that allows the roller to be conveyed through it, thus producing hard and compact concrete with roller density. In Canada, North America and some European countries, this kind of concrete has been used to make roadway surfaces, industrial surfaces with very heavy traffic has been useful in weather conditions such as extreme cold and frost [4]. Thirty years ago, when engineers used roller concrete as a pavement layer, it might never have been thought that this method would become one of the most durable and inexpensive ways to implement the road surface [3]. The expansion of this pavement was mainly due to the oil crisis of the 1970s, which has led to an increase in the cost of implementing asphalt pavement globally, and many countries have begun to use it for military and industrial areas, airport lands and roads too. This new technology has reduced operating costs about 30% [2]. Consequently, the roller concrete has no long history in the pavement, and perhaps it can be said the first use of it in the construction of the roadway is back to the 1930 Army Corps of Engineers in industrial flooring. Subsequently, this group of roller concrete used to build a runway at Washington Airport in 1942. Other applications of large-scale were in an industrial area in Vancouver, Canada in 1976 [3]. In the book published by Brito and Sycia, the use of recycled asphalt and waste as an alternative to roller concrete improves its properties. In this study, the mechanical properties and the strength of roller concrete with recycled asphalt materials have been analyzed and compared with roller concrete having 100% natural and coarse natural materials. The results showed that using up to 50% recycled asphalt, the best performance can be expected from roller concrete.

3. Research Method

3.1. Materials

A typical concrete, with a density of 3100 kg/m^3, and an average compressive strength of 28 days, about 42.5 MPa was used for all concrete mixtures. Three natural crushed limestones with specification (3/8 NG (Natural Gravel), 8/15 NG and 0/3 Fine RS (Recycled Bituminous Sand)) as well as three other parts of RAP (4/10 RG (Recycled bituminous Gravel), 10/14 coarse RG and 0.4 fine RS) of Road Asphalt was used for Mixture (RCC). Materials (RAP) have been used without bitumen extraction.

3.2. Methods

Five created mixtures each have natural sand, coarse natural grains (up to 50% and 100%) were replaced with recycled asphalt materials. Various experiments were carried out from the samples including:

- Natural and recycled aggregates according to ASTM C136-1984 standard.
- Compressive strength of samples according to ASTM C39-93a standard.
- Tensile strength of samples according to the national standards of Iran 6047 and ASTM C446 and BS 188 44.
- The stretch coefficient, based on concrete regulations of Iran (ABA), is obtained based on the relationship between compressive strength and stretch coefficient.
- Permeability, based on concrete regulations of Iran (ABA) 638.

After calculating the optimal amount of water for compacting, (RCC) should contain the amount of paste needed to fill the fine-grained skeletons and obtain the desired performance. At the end of mixing, the concrete is placed in two layers in a fixed form on the vibration table, the vibration is carried out in a minute. Figure 2. The main advantage of this method is the possibility of re-use the cylinders provided by compressed-air. This device allows RCC optimization through vibrational density energy applied to cylinders to be used to determine the specification of concrete. The compression on the sample is estimated at 7.5 kg. The concrete mold volume is (Solid V/Total V), which is actually measured.

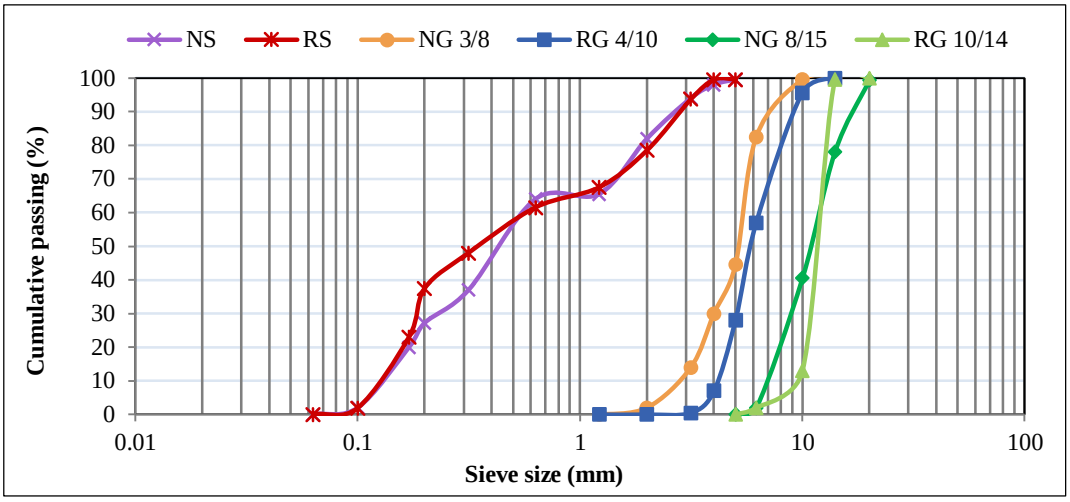
Figure 2. Vibration weigh Test

4. Experimental Results and Discussions

4.1. Materials

4.1.1. Distribution of Grain Size

The distribution of the natural size grains and (RAP) particles used in Figure 3 is presented. It seems that Recycled sand (fine particles of RAP) is thicker than natural sand, mainly composed of small sand and a small proportion of medium sand. According to Figure 3, it is observed that coarse recycled materials are similar to large natural materials. This result was confirmed by other researchers [2-16].



NS: natural sand, RS: recycled bituminous sand, NG: natural gravel, RG: recycled bituminous gravel

Figure 3. Assessment of natural and recyclable compounds

4.1.2. Properties of Materials

Ocular analysis showed that the coarse particles (RAP) is rough and contains several small gaps, but the surface of natural materials is smooth. Fine materials (RAP) contains a significant number of fine particles arising from crushed gravel at the bottom of the street. Particles RAP (RS and RG) are lighter and absorb more water compared to natural materials (NS, NG). In contrast, other researchers found that particles (RAP) had less porosity and water absorption than natural materials [4].

4.2. Properties of Hardened Concrete

4.2.1. Compressive Strength

The results of the compressive strengths of multiple compounds for the ages of 7, 28 and 90 days are presented in Figure 2. Compared to reference concrete (RCC 0/0), it can be clearly stated that the increase of RAP content has negative effects on the volume of compressive strength. The authors showed in their studies that mechanical properties of roller concrete decreased with increasing material content (RAP). If 100% of natural sand replaces 100% of the fine material (RAP), the compressive strength is reduced by about 30%. If 100% of RAP materials are used, the reduction will be

about 50%. If 50% of both coarse and fine-grained RAPs are used, the movement of coarse and fine-grained materials (RAP) should be carried out with caution, since it would adversely affect the compressive strength.

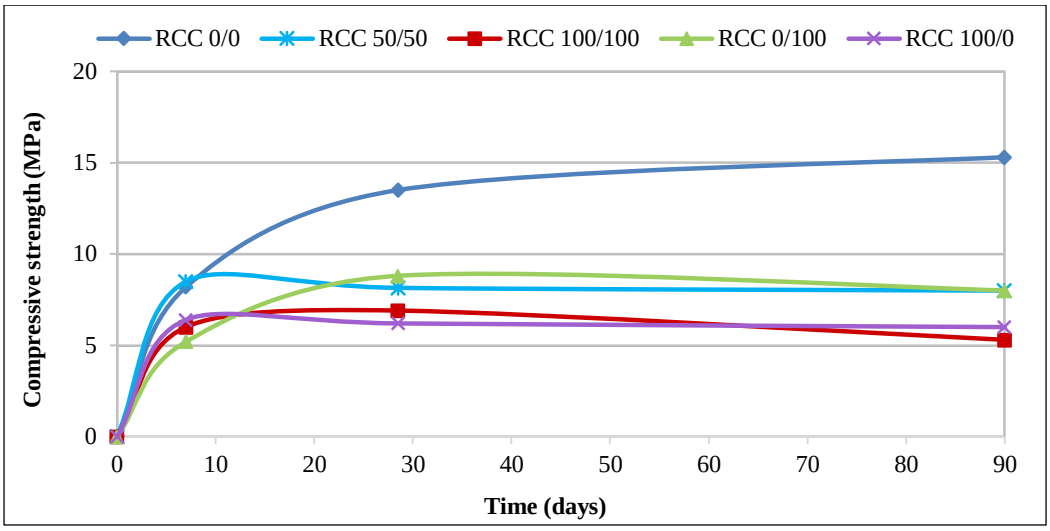


Figure 4. Result of compressive strength

4.2.2. Tensile Strength

Figure 5 shows that the results of the tensile strength (RCC) with or without materials (RAP) at the ages of 7, 28 and 90 days are not more than 1.6 mega-Pascal in the first 10 days, and in long term (90 days), in comparison with the control concrete, which is about 2 mega-Pascal in 28 days, is fixed. As it seems, the tensile strength (RCC) with 100% of the material (RAP) is reduced by about 26% compared with control concrete (RCC0 / 0). According to other results [4-11], the tensile strength is not more than 2.5 Mega PPS in 28 days. Other researchers found that the reduction in tensile strength was approximately 56%. Debieb et al. [11]. It is observed that with 50% of both RAP and TAP, the tensile strength increases by about 23% in 28 days, and then decreases in the following days.

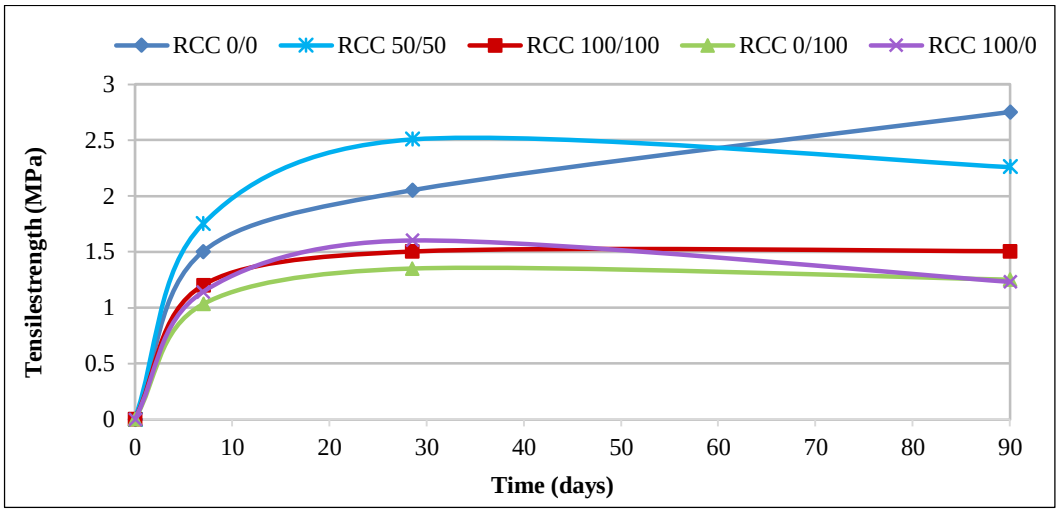


Figure 5. Ratio of tensile strength (RCC) with materials (RAP) in terms of mega-pixel versus time in days

4.2.3. Tensile Coefficient

The tensile strength of the concrete changes in the same direction, the results are shown in Figure 4. Replacement of natural sand and fine material (RAP) reduces tensile coefficient significantly about 41 percent. When the 10% of coarse natural materials are replaced by copper recycled asphalt materials, this reduction falls to 53%. This issue has been confirmed by other researchers [1]. Contrary to what was supposed, the amount of bitumen reached to particles (RAP) did not strengthen the tensile coefficient of new concrete over 28 days. Perhaps this is due to the weak cohesion between the new concrete cement glue and this bitumen.

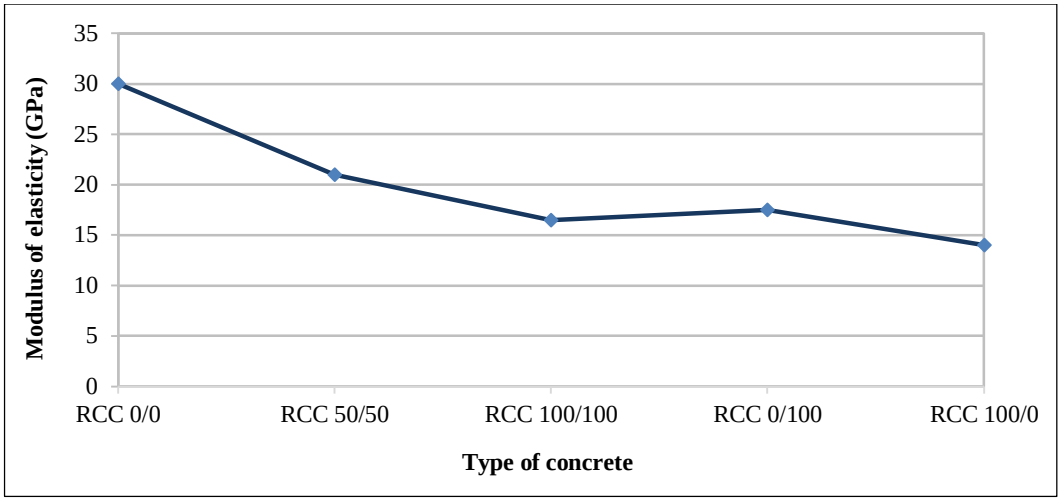


Figure 6. RCC mixture alpha mixture diagram in Giga Pascal in a variety of roller concrete mixes

4.2.4. The Relationship between Mechanical Properties and Permeability

It can be assumed that mechanical properties of roller concrete are very sensitive to the porosity caused by the increase in recycled asphalt materials. This porosity may be due to low adhesion between recycled particles and new concrete cement. Therefore, it can be concluded that if the recycled asphalt is added to the mixture with a good percentage, it reduces permeability and generally improves the mechanical properties of the roller concrete mixture. Based on the results and analysis mentioned above, it appears that RCC with 50 percent of both materials of coarse and fine recycled asphalt is a positive response to this request.

4.2.5. Water Absorption by Capillary

Figure 5 shows that the process of absorbing roller concrete with recycled asphalt materials is the same as the control concrete, except for the mixture (RCC 50/50), all samples have the increase of water absorption by 20 to 60% compared to control concrete. Compared to Figure 2, this result confirms the highest density concrete (RCC 50/50). Hence, it can be concluded that the generated density significantly influenced by the amount of added materials (RAP).

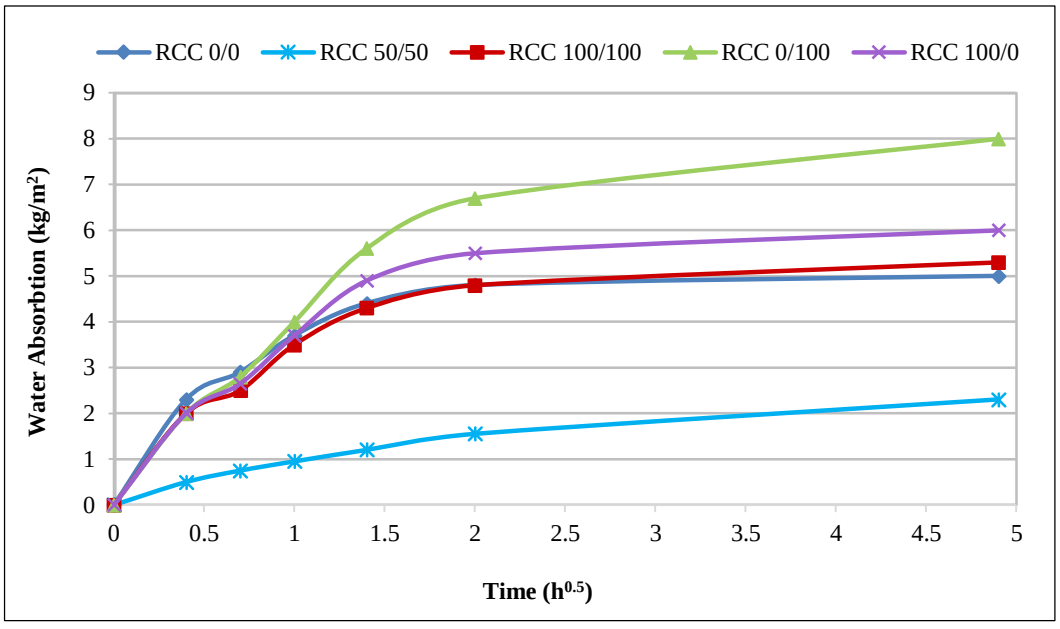


Figure 7. Water absorption graph of roller concrete made by recycled asphalt, in terms of kilograms per square meter versus time

5. Conclusion

In this research, the effects of recycled asphalt materials on the properties of roller concrete were experimentally investigated. Based on accomplished tests and analyzes, the following results can be expressed as follows:

- RAP is different due to the amount of bitumen in the particles and the lower density and more water absorption capacity than the natural materials.
- Concentration and density (RCC) with materials (RAP) are significantly affected by the amount of material (RAP).
- When natural materials, fine or coarse, or both are replaced by asphalt, the 28 day compressive strength of the roller concrete is reduced by about 32 to 55 percent.
- The use of small asphalt, fine, coarse or both reduces the compressive strength of the roller concrete.
- Mechanical properties and water absorption (RCC) are heavily influenced by the amount of bitumen (RAP) and is greatly sensitive to increase of permeability.
- The use of recycled asphalt in roller concrete, in addition to eliminating some of the amount of waste, helps the needs of natural aggregates in concrete.

Due to low performance (RCC) with materials (RAP), other recycled materials are more suitable for use as materials in (RCC). Therefore, the replacement of natural aggregates with these types of recycled seeds should be done with caution and limited to 50% for both fine and coarse grains. However, (RCC) with materials (RAPs) can be used as substrates for road asphalt or for some similar projects, low-traffic and rural roads, as well as an extensive coverage of sidewalks.

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