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EFFECT OF ADDING KAOLIN WITH NATURAL AND RECYCLED COARSE AGGREGATES ON ASPHALT MIXTURE

Muhannd W. Majeed

Asst. Lacturer, Civil Engineering Department, Al-Mustansiryah University, Baghdad, Iraq.

Abstract: Last few years interesting in, recycled coarse aggregate (derived from old concrete) was increased in pavement construction. This type of aggregate has good results approximately and economically from natural coarse aggregate results. In this research Kaolin was used as a filler material addition in percentages (0, 5, 10, 15, and 20%) by weight of cement to know the effect of that type of filler material on asphalt mixture. The values show that the flow of asphalt mixture is between (2-5) mm, this is more accepted with recycled aggregate than the natural aggregate especially of mix (0 and 5%) of adding Kaolin. Also, the use of recycled aggregates gives values of stability of asphalt mixture more than the natural aggregates.

Keywords: *Normal aggregate, Recycled aggregate, asphalt, Kaolin.*

تأثير اضافة الطين مع الركام الخشن العادي والمعاد على الخلطة الاسفلتية

الخلاصة: زاد الاهتمام بالاونة الاخيرة بأستخدام الركام المعاد (المشتق من الخرسانة القديمة) في انشاء تبليط الطرق. ان هذا النوع من الركام قد حقق نتائج جيدة وقريبة واكثر اقتصادية من الركام الطبيعي. في هذا البحث تم استخدام نوع مادة مالئة كاؤلين بنسب مختلفة وهي (20,15,10,5,0) % من وزن السمنت ومعرفة تأثير هذه الاطيان على الخلطة الاسفلتية. اظهرت النتائج ان قيم الجريان لخلطة الاسفلت تتراوح بين (2-5) ملم عند استخدام الركام المعاد اكثر من الركام الطبيعي وخصوصاً عند اضافة(0و5)% من الكاؤلين. كذلك استخدام الركام المعاد اعطى قيم ثبات للخلطة الاسفلتية اكثر من الركام الطبيعي.

1. Introduction

"Asphalt" is a dark brown to black, highly viscous, hydrocarbon produced from petroleum distillation residue. This distillation can occur naturally, resulting in asphalt lakes, or occur in a petroleum refinery using crude oil. In 2001, the U.S. produced almost 35 million tons of asphalt at a rough value of around $6 billion. Roads and highways constitute the largest single use of asphalt at 85 percent of the total (Asphalt Institute, 2002) [1]. In HMA, asphalt functions as a waterproof, thermoplastic, viscoelastic adhesive. By weight, asphalt generally accounts for between 4 and 8

*Corresponding Author muhannd.w1981@gmail.com

percent of HMA and makes up about 25 – 30 percent of the cost of an HMA pavement structure depending upon the type and quantity (Roberts, et al, 1996) [2]. The paving industry also uses asphalt emulsions, asphalt cutbacks and foamed asphalt (Asphalt Institute ,2002) [1]. Asphalt cement refers to asphalt that has been prepared for use in HMA and other paving applications. This section uses the generic term, "asphalt binder", to represent the principal binding agent in HMA because "asphalt binder" includes asphalt cement as well as any material added to modify the original asphalt cement properties (World Highways, 2001) [3]. Increased amounts of recycled materials are being used to supplement natural aggregates (derived from crushed stone, sand and gravel) in road construction. An understanding of the economics and factors affecting the level of aggregates recycling is useful in estimating the potential for recycling and in assessing the total supply picture of aggregates. This investigation includes a descriptive analysis of the supply sources, technology, costs, incentives, deterrents, and market relationships associated with the production of aggregates (Hansen, T.C., 1985) [4]. Results derived from cash flow analyses indicate that under certain conditions aggregates derived from construction and demolition debris or reclaimed asphalt pavement can economically meet the needs of certain markets, but this material can only supplement the use of natural aggregates in construction applications because the available supply is much less than total demand for aggregates(World Highways, 2001) [3], (Hansen, T.C., 1985) [4]. Producers of natural aggregates benefit from their ability to sell a wide, higher valued range of aggregate products and will continue to dominate high-end product applications such as portland cement concrete and top-course asphalt (Hirokazu,et al., 2005) [5] .

2. Objective of this research

The main objective of this research is to study the effect of adding Kaolin to the asphalt mixture with two types of coarse aggregate (natural and recycled) on stability and flow of mixture.

3. Materials

3.1 Filler Material (Cement)

The cement used in this study is (Mass) Ordinary Portland Cement (OPC) type (I), Bazyan, Al-Sulaimaniya, Iraq. Plate (1) shows this type of cement.

Plate. (1) Mass Ordinary Portland cement

3.2 Natural coarse aggregate

Rounded gravel of maximum size 10mm from AL-Niba´ee region (AL-Dyala, Iraq) is used in this study as shown in plate (2). Table (1) and figure (1) show the grading of natural coarse aggregate, which conforms to (Iraqi Standard Specification No.45: 1984) [6]. Table (2) shows the physical properties of this aggregate, that are performed by construction material laboratory in Faculty of Engineering/ AL-Mustansiriya University.

Plate.(2) Natural coarse aggregate

Table (1) Sieve analysis of natural coarse aggregate

Sieve size mm	% passing by weight	Limits of Iraqi standard specification No. 45:1984
20	100	100
14	100	90-100
10	65.21	50-85
5	4.33	0-10
2.36	0.17	-

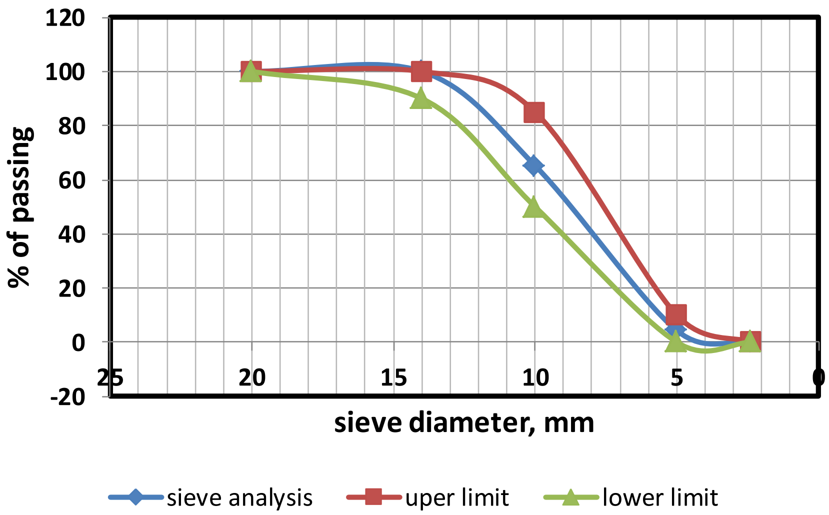

Fig.(1) Sieve analysis of natural coarse aggregate

Table (2) Physical properties of natural coarse aggregate

Physical properties	Test result	Limit of Iraqi specification No.45:1984
Specific gravity	2.62	-
Sulfate content	0.06%	0.1% (max)
Absorption	0.7%	-

3.3 Recycled coarse aggregate

In this research, crushed coarse aggregate used as a result of breaking big concrete masses weighing nearly 2 tons as shown in plate (3) into middle –sized pieces, by a drill-hammer. This is used to separate concrete from reinforcement in these concrete masses. Then these broken concrete pieces were taken into Construction Materials Laboratory at engineering Faculty, AL-Mustanisirya University to get small pieces with maximum size (10 mm) of recycled aggregate as shown in plate (4). After that the powder separated from (10 mm) pieces by using 5 mm sieve. These (10 mm) pieces were washed by tab water and left to dry for nearly (24 hrs) at the sun shine. Then, these pieces were put in bags ready for working. Table (3) and figure (2) show the sieve analysis of this type of coarse aggregate according to (Iraqi Standard Specification No.45: 1984) [6]. Table (4) shows physical properties of recycled coarse aggregate.

Plate(3) Concrete mass

Plate(4) Recycled coarse aggregate of 10 mm maximum size

Table (3) Sieve analysis of recycled coarse aggregate

Sieve size mm	% passing by weight	Limits of Iraqi standard specification No. 45:1984
20	100	100
14	100	90-100
10	83.09	50-85
5	8	0-10
2.36	6.27	-

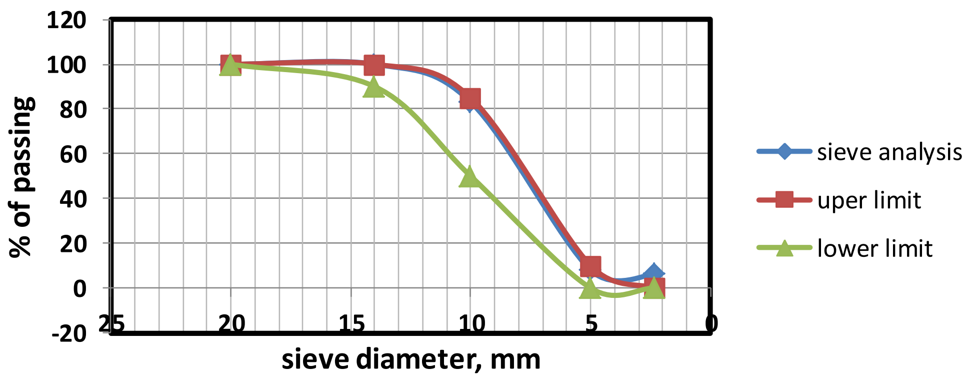

Fig.(2) Sieve analysis of recycled coarse aggregate

Table (4) Physical Properties of Recycled Coarse Aggregate

Physical properties	Test result	Limit of Iraqi specification No.45:1984
Specific gravity	2.58	-
Sulfate content	0.06%	0.1% (max)
Absorption	3.1%	-

3.4 Asphalt binder

Asphalt binder is a sticky, black and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product; it is a substance classed as a pitch. Asphalt occurs naturally in a few places in the world, but most of the asphalt used today for paving comes from petroleum crude oil (http://www.vaasphalt.org/liquid-asphalt-2/)[7].

3.5 Kaolin as clay

The name "kaolin" is derived from the word Kau-Ling, or high ridge, the name given to a hill near Jau-chau Fu, China, where kaolin was first mined Kaolin, commonly referred to as china clay, is a clay that contains 10–95% of the mineral kaolinite and usually consists mainly of kaolinite (85–95%). (Dr, Zoltán.,et al,2005) [8].table 5 shows the physical properties of Kaolin were brought from the state company of Geological survey and mining.

Table (5) Properties of Kaolin

Property	Value	Standard
Plastic limit %	21	ASTM D4318
Liquid limit, %	34	ASTM D4318
Plasticity index, %	13	
Liquidity index, %	25.8	
Specific gravity	2.72	
Maximum dry unit weight kN/m^3	16.57	ASTM D1557
Optimum moisture content, %	17.65	ASTM D1557
Soil symbol according to (USCS)	CL	

3.6 Preparation of Test Specimen: as shown in (plate 5)(Marshall test)

1. 1200(cement+ coarse aggregate + clay + asphalt) grams of aggregate blended in the desired proportions is measured and heated in the oven to the mixing temperature.
2. Clay of (0, 5, 10, 15, 20) % by weight of cement was taken in the work.
3. Bitumen is added at the mixing temperature to produce viscosity of 160 ± 10 centi-stokes at various percentages.
4. The materials are mixed in a heated pan with heated mixing tools.
5. The mixture is returned to the oven and reheated to the compacting temperature (to produce viscosity of 280±30 centi-stokes).
6. The mixture is then placed in a heated Marshall mould with a collar and base and the mixture is spaded around the sides of the mould. A filter paper is placed under the sample and on top of the sample.
7. The mould is placed in the Marshall Compaction pedestal.
8. The material is compacted with 75 blows of the hammer (or as specified), and the sample is inverted and compacted in the the other face with same number of blows.
9. After compaction, the mold is inverted. With collar on the bottom, the base is removed and the sample is extracted by pushing it out the extractor.
10. The sample is allowed to stand for the few hours to cool.
11. The mass of the sample in air and when submerged is used to measure the density of specimen, so as to allow, calculation of the void properties.

Plate (5) Marshal Test Specimen

3. Loading Machine

It is provided with a gear system to lift the upward direction. Pre-calibrated proving ring of 5 tonnes capacity is fixed on the upper end of the machine, specimen contained in the test head is placed in between the base and the proving ring. The load jack produces a uniform vertical moment of 5 cm per minute.

4. Flow meter

Consist of guide, sieve and gauge. The activating pin of the gauge slides inside the guide sleeve with a slight amount of frictional resistance. Least count of 0.01 mm is adequate. The flow value refers to the total vertical upward movement from the initial position at zero load to value at maximum load. The dial gauge of the flow meter should be able to measure accurately the total vertical moment upward.

5. Test Results

Table (6), shows the percentages of asphalt mixture used in this research. Also, it shows weight, density, stability, flow and the percent of voids filled with asphalt. The figure (3) shows the relation between stability and % of adding Kaolin as clay in the mix for both natural and recycled coarse aggregate. In all mixes, the higher values of stability with recycled coarse aggregate than natural coarse aggregate.

Table (6) percent of asphalt mixture specimen and stability, flow and the percent of voids filled with asphalt

% of asphalt in mix.	% of cement in mix.	% of Kaolin by weight of cement	% of Natural coarse aggregate In mix.	% of Recycled coarse aggregate In mix.	Sample Height (mm) H	Sample Weight in air (gm) A	Sample Weight Saturated surface dry (gm) B	Sample Weight In water (gm) C	Density (gm/cm^3)	Stability (kg)	Creep (mm)	% of voids filled with asphalt
5	5	0	90		6.4	1210.78	1231.6	688.9	2.41	807	6.9	83.16
5	5	5	90		6.5	1208.7	1222.71	703.6	2.369	775	5.36	77.98
5	5	10	90		6.5	1202.15	1204.35	699.5	2.356	753	4.25	73.63
5	5	15	90		6.3	1145.38	1197.32	695.6	2.316	687	4.01	71.98
5	5	20	90		6.4	1125.37	1143.28	702.5	2.24	576	3.49	71.27
5	5	0		90	6.9	1289.13	1293.54	630.2	2.38	990	4.2	85.58
5	5	5		90	6.8	1206.39	1213.62	643.7	2.26	945	4.15	81.94
5	5	10		90	6.8	1174.36	1178.5	637.8	2.2	883	3.96	80.68
5	5	15		90	6.8	1158.35	1187.2	643.8	2.17	774	3.62	73.31
5	5	20		90	6.9	1153.71	1175.9	643.5	2.13	722	3.37	71.3

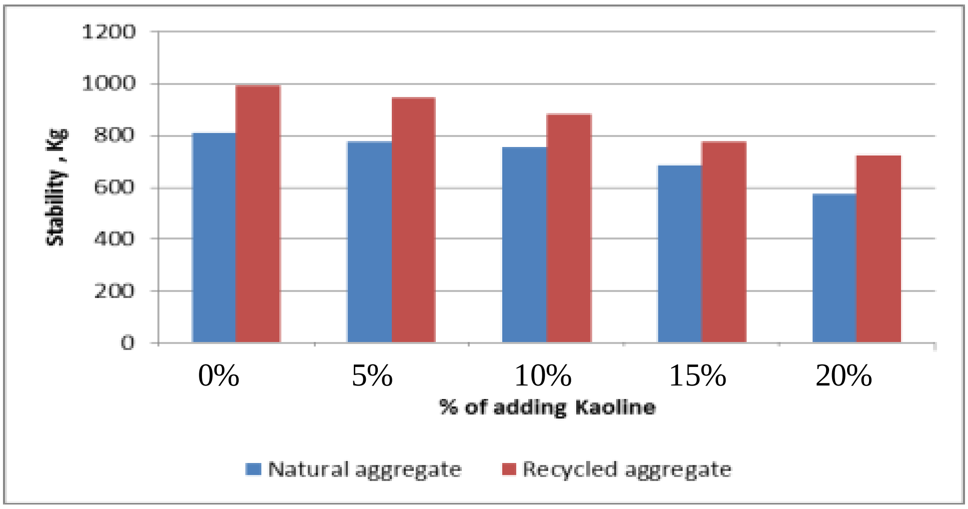

Fig. (3) Relation between stability and % of adding Kaolin as clay in the mix

From figure above the following notes can be drawn:

a. The stability decreased as the percentage of adding Kaolin increased.
b. Recycled coarse aggregate gives stability higher than natural coarse aggregate.

Figure (4) shows the relation between flow and % of adding Kaolin for both natural and recycled coarse aggregate. In all mixes natural aggregate gives values of flow greater than recycled coarse aggregate.

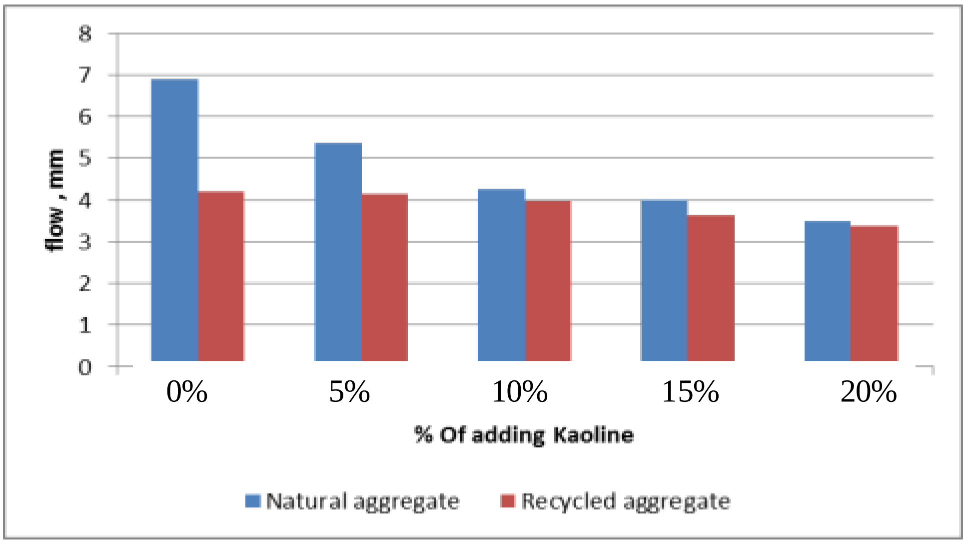

Fig. (4) Relation between flow and % of adding Kaolin

Figure (5) shows the relation between density and % of adding Kaolin for both natural and recycled coarse aggregate. In all mixes, the higher values of density with natural coarse aggregate than recycled coarse aggregate.

From figure above the following notes can be drawn:

1- The flow values decreased as the percentage of adding Kaolin increased.
2- Recycled coarse aggregate gives flow lesser than natural coarse aggregate.

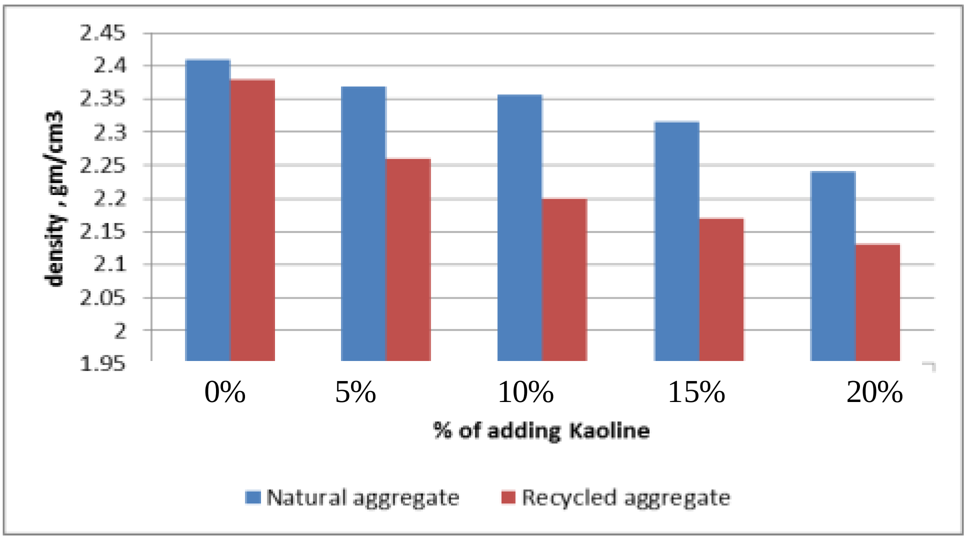

Fig. (5) Relation between density and % of adding Kaolin

From figure above the following notes can be drown:

1- The density values decreased as the percentage of adding Kaolin increased.

2- Recycled coarse aggregate gives density lesser than natural coarse aggregate.

Figure (6) shows the relation between stability and % flow for both natural and recycled coarse aggregate. When the flow is increased, the stability is decreased.

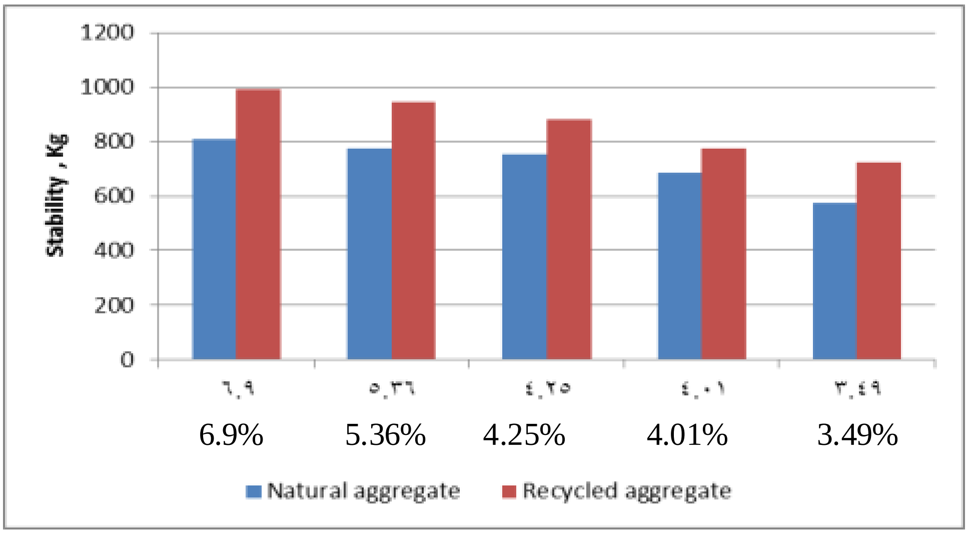

Fig. (6) Relation between stability and % flow

Figure (7) shows the relation between V.F.A and % of adding Kaolin for both natural and recycled coarse aggregate. In all mixes natural aggregate gives values of V.F.A Less than recycled coarse aggregate.

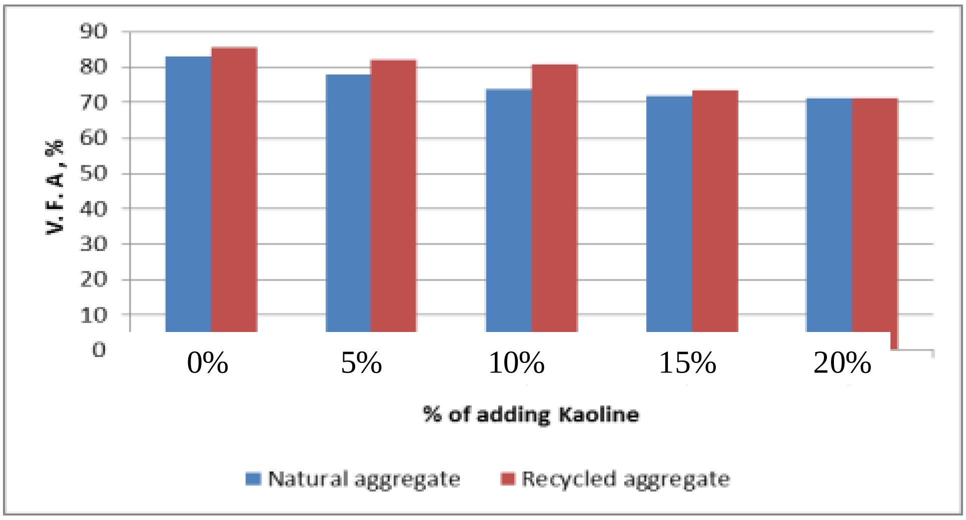

Fig. (7) Relation between V.F.A and % of adding Kaolin

6. Conclusions

From the results mentioned above, the conclusions listed in the following points:

1- The use of recycled aggregates gives values of stability more than the natural aggregates, because their rough texture and angular shape which leads to excellent bond between the aggregates and asphalt particles and the mix become more homogenous.

2- The values of flow are between (2-5)mm, this is more accepted with recycled aggregate than the natural aggregate especially of mix (0 and 5%) of adding Kaolin because these mixes have more asphalt than other mixes this leads to more liquidity and more flow.

c. The use of Kaolin in the mixes gives results approximately the same as mixes without adding Kaolin with a simple difference and for this reason it can be used to decrease the cost of the mix then decrease the cost of the project.

d. The percent of voids filled with asphalt(V.F.A) % for both natural and recycled aggregate between the standard values which it is between (70-85%), which it is the larger value in recycled aggregate mixes because the rough texture.

e. The densities of natural aggregate is more than recycled aggregate because the natural aggregate have more weights than recycled aggregate.

6. References

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