International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 4, July-Aug 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Performance of Fly ash concrete aggregate in DRY LEAN CONCRETE for Rigid Pavement

[1]Raghunath Duary,[2]Vikas Kumar,[3]Dr. Harish Sharma,
[1]MTech Scholar, Dept. of Civil. Engineering, PKGCET, PANIPAT, Haryana, India.
[2]Assistant Prof., Dept. of Civil. Engineering, PKGCET, Panipat, Haryana, India
[3]Prof, Dean Academics, PKG College of Engineering, PKGCET, Panipat, Haryana, India
Pkgi.civil@gmail.com

Abstract:

Dry Lean Concrete is a mixture in which the amount of cement is less than the amount of liquid that is present in the layers. It is smooth concrete with a large proportion of aggregate in relation to cement than conventional concrete and is generally used as a base/sub-base for hard paving. Although the actual thickness will be governed by the design considerations, a thickness of minimum150 mm is recommended for all major projects of State Highways and National Highways. When DLC is adopted as sub base in case of roads other than the above road sits thickness of 100 mm is recommended. Increase the strength of DRY LEAN CONCRETE by using FA & RCA. To Compare to Economic analysis for DLC &DLC added materials of FA and RCA

Study of bearing pressure revealed a good resistance of the granular mixture (recycled concrete aggregate + cement).It has been observed that by curing of blended RCA, it has gained very high strength which shows tat with the addition of cement to blend of sand and RCA, it becomes semi- rigid pavement i.e the pavement changes its nature from flexible to semi-rigid pavement.

INTRODUCTION

1. Dry Lean Concrete:

Rigid pavements (Portland cement concrete roads) are being constructed in many new projects due to added advantages of longer service life, smoother riding surface and little to no maintenance requirement. Government of India is encouraging the construction of cement concrete roads even at village and Municipal levels. The current practices of the construction of cement concrete road for highways in India require a layer of dry lean concrete (DLC) as a base course over which pavement quality concrete slabs rest. The concrete mix shall be proportioned with a maximum aggregate cement ratio of 14:1 where OPC used and 12:1 where PPC or PSC is used. The minimum cementations materials content shall not be less than 140 kg/cum of concrete.

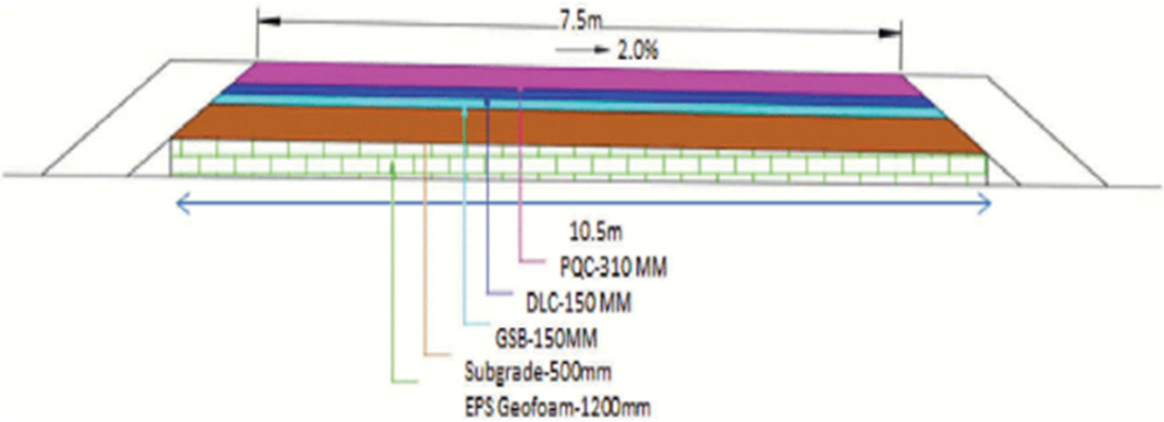

Figure1.2 DLC thickness layer section

DLC is a no slump plain concrete with a large ratio of aggregate to cement. It contains less amount of cement paste as compared to conventional concrete. DLC layer is an important part of modern rigid pavements. The major advantages of using DLC as base layer includes: provision of a uniform and strong support, high resistance to deformation, enhanced load transfer efficiency at joints, proper fixing of form work & proper placement of dowel bar cradles in semi mechanised construction, movement of construction equipments during construction of the roads, all weather construction and finally a reduction in the depth of pavement slab required from the point of view of axle load consideration etc.

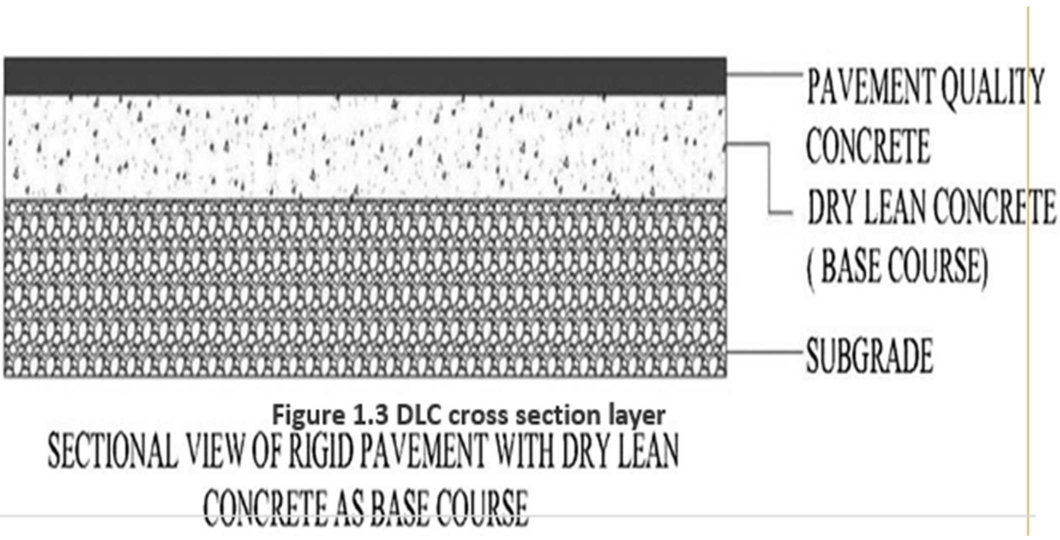

Figure 1.3 DLC cross section layer

Advantages of Dry Lean Concrete

- Provides even and stronger support to the hard floor.
- It has a high resistance to deformation.
- It has excellent improved load transfer efficiency at the joints.
- Helps in all weather conditions.
- There is a final reduction in the depth of the slab due to the DLC as a base layer.

1.3] Need for the study:

1] To increase compressive strength of the sub-base layer. 2] To increase life span of rigid pavement.
3] To minimize the pavement failure and enhance the sub-base layer. 4] To reduce overall cost of rigid pavement construction.
5] To make environment eco-friendly.

1. Objectives of study:

1] To study the check physical properties of cement and aggregate for DLC layer in rigid pavement.
2] To increase the compressive strength of dry lean concrete by using flyash & recycle concrete aggregate.
3] To determine economic analysis of DLC layer.
4] To study the check physical properties of aggregate for DLC layer in rigid pavement and water content for mix design.

Scopes of study:

Present study considering only on DLC layer of rigid pavement and considering foreign materials FA & RCA are replaced by cement and coarse aggregate respectively. In this study examined the various physical property of DLC, Compressive strength of DLC and determine Economic analysis of DLC layer.

LITERATURE REVIEW

Sub-grade soil provides base for the whole pavement structure. Weak sub-grades of expansive soil has great tendency to swell and shrink when in contact with water. This behaviour is believed to have been derived from clay rich of montmorillonite mineral. These expansive soils can be improved through the addition of chemical or cementitious additives. These additives range from waste products to manufactured materials which include fly-ash, cement, lime and proprietary chemical stabilizers.Weak subgrade soils are usually improved by cement or lime. In fact, cement stabilization provide an effective solution to the problem of fatigue failures caused by repeated high deflection of asphalt surfaces where a weak subgrade exists in the pavement structure, [1].

Experiences in areas of expansive sub-grades, show significant improvement in strength and a marked decrease in deflection when sub-grades are stabilized with cement, while treatment with lime or fly ash is a well-known practice adopted to reduce swelling behavior.

Study of Fly Ash Cement Concrete Pavement (Anjali Yadav 1, Nikhil Kumar Yadav 2) (2017)

This experiment study is aimed to investigate the physical, chemical and mechanical properties of fly ash cement concrete for road construction. From research, it has been observed that the use of 30% of flyash and 70% of cement possess a superior performance. Moreover, in construction, the use of fly ash would result in the reduction of the cost of materials and the reduction of greenhouse gas emission. High strength of concrete can be prepared and the incorporation of admixture or substitute to improve the properties of concrete. Test result of specimens indicates the bonding strength of properties, workability, and different reaction when the water ratio a change its content. Slump test having an appropriate workable mixing the slump of a concrete, gave sufficient compressive strength. Now a day's concrete pavements are achieving popularity for its own good paving properties, as such consumption of cement is increased to a great.As cement demand increases, production also increases. Every ton of production of cement releases approximately 7% carbon dioxide to environment. In many industries, including power plants, coal is used as fuel. This generates tones of coal ash, which is very difficult to dispose off, which in turn causes pollution. Thus the production of cement and electricity contributes huge amount of carbon dioxide emissions and coal ash causing environmental pollution. Fly ash contains reactive constituents and un-reactive crystalline matter. Reactive constituents reacts with lime and offers hydrated minerals to impart strengthand unreactive matter gives packing effect to the concrete, filling up of pores and thus increases the strength. Here an attempt is being made to consume this pollution causing material to a utility by using it in concrete.

Electricity is important for development of any country. Coal is a major source of fuel for production of electricity in many countries in of the world. In the electricity generation process, a large quantity of fly ash gets produced and becomes available as a byproduct of coal-based power stations. Fly ash is a fine powder resulting from the combustion of powdered coal which is transported by the flue gases of the boiler and collected in the Electrostatic Precipitators (ESP). Conversion of waste into a resource material is an old practice of human society. In the year 1930, in USA, the fly ash became available in coal based thermal power station.

For its profitable utilization, scientist started research activities and R.E. Davis, in the year 1937, and his associates at university of California published research details on use of fly ash in cement concrete. This research had laid foundation for its specification, testing &usages.

The use of recycled concrete as a sub base layer for highway (Nakul Hans, Er. Dalvir Singh, Dr. Arvind Dewangan) (2019)

In this study, the highest dry densities are for additions of 5% cement in recycled concrete aggregates. The study of bearing pressure revealed a good resistance of the granular mixture (recycled concrete aggregate + cement), which resulted in high values of CBR due to improvement of grain size distribution during the compaction. It has been observed that by curing of blended RCA, it has gained very high strength which shows that with the addition of cement to blend of sand and RCA, it becomes semi- rigid pavement i.e the pavement changes its nature from flexible to semi-rigid pavement. Then there may be no need of construction of any wearing coarse over the base coarse, only surface coarse will be sufficient. It has been observed that by curing of blended RCA, it has gained very high strength which shows that with the addition of cement to blend of sand and RCA, it becomes semi- rigid pavement i.e the pavement changes its nature from flexible to semi-rigid pavement. Then there may be no need of construction of any wearing coarse over the base coarse, only surface coarse will be sufficient.

The properties of RCA has been established and demonstrated through several experimental and field projects successfully. It has been concluded that RCA can be readily used in construction of low rise buildings, concrete paving blocks &tiles, flooring, retaining walls, approach lanes, sewerage structures, sub base course of pavement, drainage layer in highways, dry lean concrete(DLC) etc. in Indian scenario. Use of RCA will further ensure the sustainable development of society with savings in natural resources, materials and energy. Concrete aggregate collected from demolition sites is put through a crushing machine, often along with asphalt, bricks, dirt, and rocks. Smaller pieces of concrete are used as gravel for new construction projects. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. This reduces the need for other rocks to be dug up, which in turn saves trees and habitats. C&D (construction & demolition) wastes are normally composed of concrete rubble, brick, tile, sand and dust, timber, plastic, cardboard, paper, and metal. Concrete rubbles usually constitute the largest proportion of C&D waste.

A study on compressive strength of recycled aggregates embedded concrete. (Nagaraja Ba, VinayK Va,Keerthi GowdaB S a,Karisiddappa b). (2017)

Now a day's demolition of concrete structural elements is quite common work. Lot of debris are generated by this task. Reuse of crushed concrete structural elements is an essential and challenging job. In the present study crushed concrete cube debris (of size20

Mm sieve passed and 10 mm sieve retained) are used as coarse aggregates for the production of cement concrete in economical way. Here compressive strength of conventional concrete is compared with crushed concrete debris embedded plain cement concrete. Percentage of replacement of debris are varied from 10, 20, 25, 30, 35, 40, 50 and 100 to compare the compressive strength results among them. 30 % replacement of debris for conventional coarse aggregate recorded the highest compressive strength of 31.11 MPa. Compressive strength of debris embedded concrete showed higher compressive strength compared to conventional concrete. Also, a plain cement concrete embedded with debris and 10 mm long raw Banana fibers (1% of cementitious material) recorded highest compressive strength compared to other concrete.

Recycling of waste concrete is beneficial and necessary from the viewpoint of environmental preservation and effective utilization of resources. For the effective utilization of demolished concrete, it is necessary to use that concrete as recycled aggregate for new concrete. Various investigations mainly engaged in the processing of demolished concrete, its mix design, physical and mechanical properties. Recycled aggregates generally produced by two stages crushing of demolished concrete, screening and removal of reinforcement, wood and plastic etc. The cement used in the experiment is ordinary Portland cement of a specific gravity of 3.15. M-sand is used for Concrete mix having a fineness modulus of 2.83 and specific gravity of 2.64 was used as fine aggregates.

Normal coarse aggregates of 20 mm maximum size of fineness modulus 6.8, bulk density of 1600 kg/m3 and specific gravity of 2.54 are used. Water conforming to the requirements for concreting and curing is used throughout. The recycled aggregates are obtained from demolished concrete crushed in the crusher and sieved to obtain a proper size of aggregates. . The recycled aggregates having maximum size 20 mm retaining on 10 mm and having a specific gravity of 2.63 is used. The bulk density of recycled aggregate obtained is 1515 kg/m3.

Blending of recycled concrete aggregates for use in base course construction (Mr. Alaa Hassoon, Dr. Jalal Al-Obaedi) (2014)

The use of recycled "reclaimed" materials has been increased during the last decades in order to obtain environmental benefits and to reduce the pressure on natural material resources. This paper focuses on using recycled concrete as a subbase material for highways. Concrete cubes produced from concrete tests such as compression strength, have been crushed to produce different particle sizes so as to satisfy the gradations requirements according to the Iraqi specifications for sub-base martial. These recycled samples as well as the samples obtained from ordinary subbase have been subjected to maximum dry density, California bearing ratio (CBR) and Atterberg limits tests.
The results obtained from maximum dry density test suggested that the waste materials could be compacted to reach reasonable density. The CBR test's results suggest that the CBR values obtained from recycled concrete is significantly higher than those CBR values obtained from the ordinary subbase. The Atterberg tests showed that the waste concrete material is satisfying Iraqi specifications for roads and bridges (SORB).
In this research work, waste concrete cubes (produces from concrete tests such as compression strength test) have been crushed(see **Figure1**, which shows the concrete cubes before and after crushing) to produce different particle sizes. This is to satisfy the gradations requirements according to the Iraqi specifications for subbase martial. Three different subbase types have been obtained from the crushing process; these are types B, C and D. Similarly, three types from the ordinary subbase materials have also been prepared for comparison purpose.

METHODOLOGY

BASIC TEST ON AGGREGATE:

SHAPE TEST (IS:2386-PART1)

Flakiness Index Elongation Index
SPECIFIC GRAVITYTEST (IS:2386-PART3)
IMPACT VALUE TEST (IS:2386 -PART4)
CRUSHING VALUE TEST (IS:2386-PART4)
ABRASION VALUE TEST(IS:2386-PART4

SHAPE TEST:

OBJECTIVE:
To determine the value of Flakiness and Elongation Index of Coarse aggregates. Combined Index = FI+EI

FLAKINESS INDEX:

The flakiness index of aggregates is the percentage by weight of particles whose least dimension (thickness) is less than three fifths (0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.

APPARATUS:

- IS Sieve
- Thickness Gauge
- Balance

PROCEDURE FOR FLAKINESS INDEX:

1] Flakiness index test and therefore the sample is passing 6.3 mm Sieve removed.
2] The test sample is 200 pieces of coarse aggregate from each size range is taken weight.
3] Passing sieve is 63mm, 50mm, 40mm, 31.5m, 25mm, 20mm, 16mm, 12.5mm & 10mm. and retained sieve is 50mm,40mm,31.5m,25mm,20mm,16mm,12.5mm,10mm& 6.3mm.

4] This sample respective slot thickness gauge are given tried to passing specific gauge.
5] The flaky particles passing the appropriate slot of the thickness gauge.
6]]Each passing aggregate size range are collected and weighted.

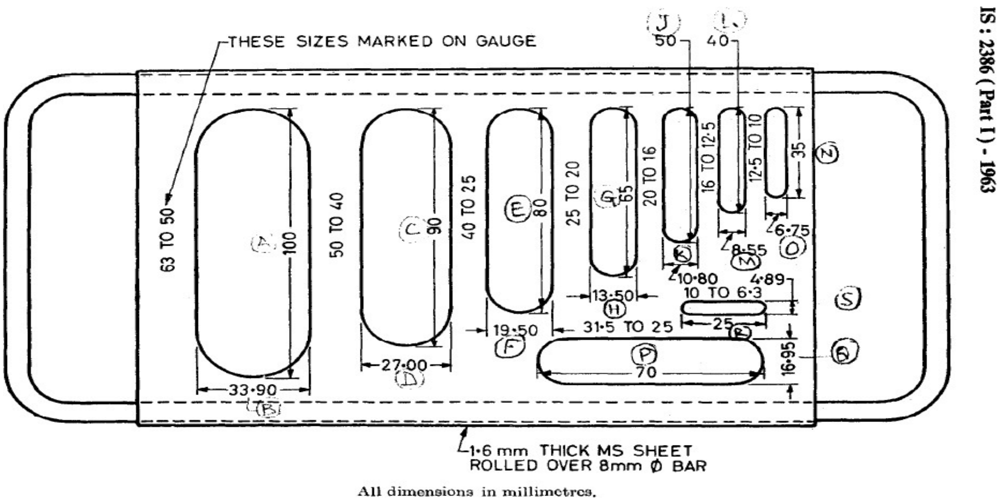

Figure3.2 Thickness gauge

(B) ELONGATION INDEX:

The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and fifth times (1.8times) their mean dimension. The elongation test is not applicable to sizes smaller than 6.3 mm

APPARATUS:

- IS Sieve
- Thickness Gauge
- Balance

PROCEDURE:

1] The portion of coarse aggregate sample IS6.3mm sieve removed.
2] The test sample is 200 pieces of coarse aggregate from each size range is taken weight.
3] The sample of coarse aggregate separated into different size range for length gauge.
4] Passing sieve is 50mm, 40mm, 31.5m, 25mm, 20mm, 16mm, 12.5mm & 10mm and 40mm, 31.5m, 25mm, 20mm, 16mm, 12.5mm, 10mm & 6.3mm.
5] This test using coarse aggregate of passing by thickness gauge.
6] Length gauge retained on the specific slots of the length gauge and weighted.

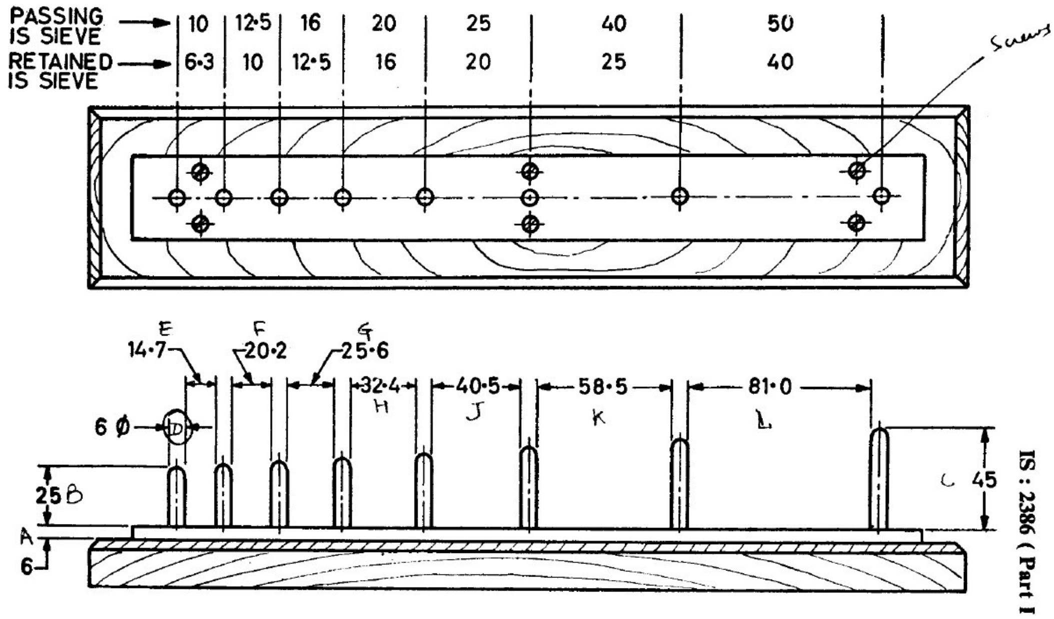

Figure3.3Length gauge

2] SPECIFIC GRAVITY TEST:

OBJECTIVE:

To determine the specific gravity and water absorption of aggregates by perforated basket.

APPARATUS:

- Specific gravity bottle
- ISSieve (20mm&10mm)
- Oven
- Basket
- Weight machine (10kgcapacity)
- Shallow tray

PROCEDURE:

1] This test sample consists about 2 kg is coarse aggregate removed fines, drained.
2] This sample is placed wire basket in water temperature between 22 to 32°C and covered of least above to 5 to 10cm of water.
3] This sample is fully saturated of basket.
4] The weight noted of saturated aggregate suspended in water(W1). 5] The empty basket weight is W2.
6] Weight of saturated surface dry aggregate in air is W3. 7] The Weight of oven dry sample is W4.
8] Weight of saturated aggregate in water is Ws.

1] SPECIFIC GRAVITY:

W4 W3–WS

2] WATER ABSORPTION:

(W3–W4)100

W4

COMPRESSIVE STRENGTH TEST:

3.4.1] GENERAL:

The procedure for casting of specimens for compressive strength test is discussed in this section. Cube specimens of dry lean concrete were cast for each percentage of moisture content 6.5% with various combinations of RCA i.e. 10%, 20%, 30% And FLY ASH 15%. Five number of cube specimens were cast for each combination of RCA with each percentage of moisture content. Six cube specimens of size 150×150×150mm were cast for static compressive test. The quantity of cement, coarse aggregate, fine aggregate, Fly ash, RCA and water for each mix was weighed separately. Cement is mixed into the blend in dry form. The coarse aggregates were mixed to get the same throughout the batch. The compaction of concrete in molds was carried out by using Vibrating needle.

3.4.2] PROCEDURE:

Method of Casting:

Concrete's strength mostly depends on the mix design. But it's affected by several other factors. Such as mixing of concrete, placing of concrete, curing of concrete, as well as quality of concrete ingredients. So we can't be assumed that if we produced that if we produce concrete as per mix design we will get desired strength.

Procedure of making concrete Specimen:

Making Concrete specimen such as cube for compressive strength, cylinder for splitting tensile strength and beam for flexural strength are simple and it's done in three simple steps.

1. Cleaning & Fixing mould.
2. Placing,compacting & Finishing Concrete.
3. Curing.

RESULTS

MIX DESIGN OF DRY LEAN CONCRETE (DLC):

GENERAL MIX DESIGN PARAMETER:

1.] TYPES OF CONCRETE :Dry lean concrete 2.] MINIMUM CEMENT CONTENT : 150kg/cum
3.] MAX.SIZEOF AGGREGATE :20mm

4.]AGGREGATE CEMENT RATIO :1:12

5.] GRADATION :As per table 600.1of MoRTH 6.] STRENGTH REQUIRED AT 7 DAYS: 7 N/SQMM

MIX DESIGN OF DLC:

Cement:Aggregate	1:12
Cement,Kg	150
Water,%	6.5
Aggregate,Kg	1800
Sand(34%)	612
Coarse Aggregate	1188
20mm(33%)	594
10mm(33%)	594
Total wt. of Concrete	1950
L	0.15
B	0.15
H	0.15
No.Of Cube	5
Volume of Cube	0.016875
Qun. Of Cube 5	32.9

Cement	2.15
Sand	10.33
20mm	9.018
10mm	9.018
Water	2.14

Table4.5.2 Mix properties of materials

Materials mixed	C.A(20mm)	C.A.(10 mm)	F.A
Percentage mixed	**33%**	**33%**	**34%**

1.5.3. MIX DESIGN OF 15% FLY ASH ADDED IN DLC:

Cement: Aggregate	1:12	
Cement,Kg	150	
Water,%	6.5	
Aggregate,Kg	1800	
Sand(34%)	612	
Coarse Aggregate	1188	
20mm(33%)	594	
10mm(33%)	594	
Total wt. of Concrete	1950	
L	0.15	
B	0.15	
H	0.15	
No. Of Cube	5	
Volume of Cube	0.01687 5	
Qun. Of Cube 5	32.9	
Cement	2.15	FA=0.38
Sand	10.33	
20mm	10.02	
10mm	10.02	
Water	2.14	
Dry Density	2350	

Table 4.5.3 Mix properties of materials

Materials mixed	C.A(20mm)	C.A.(10 mm)	F.A
Percentage mixed	**33%**	**33%**	**34%**

4.5.4.]MIX DESIGN OF 15 % FLY ASH & 10 % RCA ADDED IN DLC:

Cement:Aggregate	1:12	
Cement,Kg	150	
Water,%	6.5	
Aggregate,Kg	1800	
Sand(34%)	612	
Coarse Aggregate	1188	
20mm (33%)	594	
10mm (33%)	594	
Total wt. of Concrete	1950	
L	0.15	
B	0.15	
H	0.15	
No. Of Cube	5	
Volume of Cube	0.01687 5	
Qun. Of Cube 5	32.9	
Cement	2.15	FA=0.38
Sand	10.33	
20mm	9.018	RCA=2.00
10mm	9.018	
Water	2.14	
Dry Density	2350	

Table 4.5.4 Mix properties of materials

Material s mixed	C.A(2 0mm)	C.A.(10 mm)	F.A	RCA
Percenta ge mixed	**33%**	**33%**	**34%**	**10%**

4.5.5.]MIX DESIGN OF 15 % FLY ASH & 20 % RCA ADDED IN DLC:

Cement:Aggregate	1:12	
Cement,Kg	150	
Water,%	6.5	
Aggregate,Kg	1800	
Sand(34%)	612	
Coarse Aggregate	1188	
20mm(33%)	594	
10mm(33%)	594	
Total wt. of Concrete	1950	
L	0.15	
B	0.15	
H	0.15	
No. Of Cube	5	
Volume of Cube	0.01687 5	
Qun. Of Cube 5	32.9	
Cement	2.15	FA=0.38
Sand	10.33	
20mm	8.016	RCA=4.00
10mm	8.016	
Water	2.14	
Dry Density	2350	

Table4.5.5 Mix properties of materials

Material s mixed	C.A(2 0mm)	C.A.(10 mm)	F.A	RCA
Percenta ge mixed	**33%**	**33%**	**34%**	**20%**

4.5.6.]MIX DESIGN OF 15 % FLYASH & 30 % RCA ADDED IN DLC:

Cement: Aggregate	1:12	
Cement,Kg	150	
Water,%	6.5	
Aggregate,Kg	1800	
Sand (34%)	612	
Coarse Aggregate	1188	
20mm (33%)	594	
10mm(33%)	594	
Total wt.of Concrete	1950	
L	0.15	
B	0.15	
H	0.15	
No. Of Cube	5	
Volume of Cube	0.01687 5	
Qun. Of Cube 5	32.9	
Cement	2.15	FA=0.38
Sand	10.33	
20mm	7.019	RCA=6. 00
10mm	7.019	
Water	2.14	
Dry Density	2350	

CONCLUSION

- It is well observed the compressive strength increase is noticed in addition of FA15% & RCA 10%, by weight of respectively cement and coarse aggregate in all the mixes. The result of 7 DAY is 8.62 MPA.
- It is well observed the compressive strength increase is noticed in addition of FA15% & RCA 20%, by weight of respectively cement and coarse aggregate in all the mixes. The result of 7 DAY is 9.48MPA.
- It is well observed the compressive strength increase is noticed in addition of FA15% & RCA 30%, by weight of respectively cement and coarse aggregate in all the mixes. The result of 7 DAY is 9.43 MPA.
- In this observed compare to pure DLC & DLC added mix FA & RCA. That most economical mix design is DLC+FA+RCA.

REFERENCE

1. Er. Dalvir Singh, Nakul Hans, BLENDING OF RECYCLED CONCRETE AGGREGATES FOR USE IN BASE COURSE CONSTRUCTION, IJCE, MAY 2019
2. Keerthi Gowda B S, A study on slump and compressive strength of recycled aggregates embedded concrete, IJOF, AUGUST 2018
3. Alaa Hadi Hameed Hassoon, Jalal Taqi Shaker Al-Obaedi THE USE OF RECYCLED CONCRETE AS A SUBBASE LAYER FOR HIGHWAY, ELSEVIER, January 2014.

MANUALS:

1. IRC:SP:49-2014 GUIDELINESFORTHEUSEOFDRYLEANCONCRETEASSUB- BASE FOR RIGID PAVEMENT.
2. MoRTH Specification

