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An Experimental Study on Recycled Concrete Aggregates Utilized in Bituminous Mixtures

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ABSTRACT
Now a days increasing population in the world, then the constructions for living humans could be more like houses, bridges, apartments etc. Rapidly wastage of concrete aggregates is increasing. To minimize the wastage of concretes by utilizing properly with hot mix asphalt mixtures for construction of road pavements .The objective of this study is to understand the vitality of using RCA for the construction of bituminous pavements. Recycled concrete aggregates (RCA) materials are resulted from milling process. In this study samples of Recycled concrete aggregates (RCA) materials were collected and analysed for suitability of their usage in flexible pavements. Their characteristics including gradation, Aggregate Impact value, Aggregate Crushing value, Specific gravity, Flakiness Elongation Index, Loss Angles Abrasion value, and Water absorption were determined and compared to the standard specifications. The present study deals with evaluation of Marshall Stability, de- formation and the moisture damage resistance values of HMA which is mixed with RCA in varying proportions.. The Marshall mix design method was adopted in this study to determine the optimum binder content (OBC) for the asphalt mixes containing five aggregate combination with RCA contents of 0, 10, 20, 30 percent was found to be 5, 5.5, 6 percent which is optimum respectively.

Keywords: Bituminous mixture, Marshall mix design, Re-cycled concrete aggregates

Chapter 1 INTRODUCTION

1.1 Introduction

The gradual increase of urbanization in addition the construction and demolition of buildings and renovation of cement concrete asphalt pavements on highway are produced up to 600 million tones of solid wastes in each year. Another study evaluated the feasibility of using aggregate from recycled construction and demolition waste (RCDW) in pavement applications. A laboratory program was conducted by geotechnical characterization, bearing capacity and repeated load tri-axial tests. The results show that the composition and the compact effort influence on the physical characteristics of the RCDW aggregate. The compaction process has promoted a partial crushing and breakage of RCDW particles, changing the grain-size distribution and increasing the percentage of cubic grains. This physical change contributes to a better densification of the RCDW aggregate and consequently an improvement in bearing capacity, resilient modulus and resistance to permanent deformation. The results have shown that the RCDW aggregate may be utilized as coarse base and sub-base layer for low-volume roads . Therefore the recycling of solid waste used as replacing natural aggregates and minimizing the shortage saving the natural resources.

So , we extract the recycled aggregates from the solid waste or recycling plants utilizing as per test results of aggregates and bituminous tests.

We determine the optimum content from the various number of test samples with different state of design mixes as per the IRC Marshall mix design.

The recycled aggregates are used up to 30% for conducting the marshal mix design. The properties of aggregates–asphalt binder mixture made of RA were investigated in terms of density-void analysis and stability per unit flow and were compared with the control specimens.

The results are discussed below.

Background of the study

Recycling of waste concrete is not a new concept and is effectively carried out in many parts of the world such as the UK, France, Denmark, Germany, the USA, Japan, etc. (McCree 1988; Mullehorn Mahoney 1990; Baldocchi 1993; Paul 1994; Richardson Jorden 1994; Chini Mon-
teiro 1999; Elias-Ozkan 2001; Thurber Engineering Ltd 2001; Kawano 2002; Chen et al. 2003; Park 2003; Zaharieva et al. 2003; Levy Helene 2004; Robinson et al. 2004; Oikonomou 2005). Recycled aggregates produced from crushed concrete are generally regarded as a higher quality product than aggregate from mixed CRD waste (Thurber Engineering Ltd 2001).

Extensive research is being carried out internationally to explore various cost-effective applica- tions of RA and to establish basic parameters for these applications. Its usage includes base material for roads, base material for footings and foundations, landscaping material, drainage material placed around underground pipes, aggregate in new asphalt or concrete, etc. The use of these alternative aggregate materials as a substitute for primary materials results in multiple environmental and economical benefits, which include (Nunes 1996) the following activities.

1. Reduction in primary quarrying activities and utilization of finite natural resources.
2. Reduction in new waste stockpiles.
3. Clearance and reduction of abandoned land.
4. Economical disposal or recycling of materials.

The engineering properties of aggregates and asphalt have also been investigated by carrying out physical and mechanical tests. The performance characteristics of these were evaluated on the basis of requirements given in the NHA specifications (NHA 1998). The research described in this paper can provide a model for local government/civic authorities in solving the problem of illegal dumping of waste. It may also be an aid in initializing economic recycling activities and creating employment opportunities. The data for design will be available to highway engineers to design the wearing course with RA.

The study may also be helpful in dealing with large quantities of rubble produced as a consequence of a seismic activity. This rubble can be effectively used in building new roads. However, the durability aspects of wearing course made up of RA were not investigated in this study. Similarly, economic considerations are also beyond the scope of the study.

1.1.1 literature review

Perez et al. (2012) evaluates the possibility of designing hot asphalt mix road pavements using construction and demolition waste as coarse recycled aggregates. The percentages of recycled aggregates used in the mixtures were: 0, 20, 40 and 60 percent. Cement and lime were used as fillers. The mixtures made with coarse recycled aggregates complied with the Marshall technical specifications for low volume roads. The mixtures also showed good resistance to permanent deformation evaluated by means of wheel tracking tests

Poon and Chan (2006) study indicated that the use of 100 recycled concrete aggregate increased the optimum moisture content and decreased the maximum dry density of the sub-base materials compared to those of natural sub-base materials.

The California bearing ratio (CBR) values (unsoaked and soaked) of the sub-base materials pre- pared with 100 recycled concrete aggregate were lower than those of natural sub-base materials. Nevertheless, the soaked CBR values for the recycled sub-base were greater than 30% , which is the minimum strength requirement in Hong Kong.

Paranavithana and Mohajerani (2006), study it was found that all the volumetric properties (except the percentage of air voids), the resilient modulus and creep values of as- phalt specimens containing RCA as coarse aggregates were relatively lower compared with S62

F. Moghadas Nejad et al. The effects of using recycled concrete on fatigue behavior of hot mix asphalt the values found for similar specimens made with only fresh aggregates.

Kou and Poon (2009) in other study, the fresh and hardened properties of self-compacting concrete (SCC) using recycled concrete aggregate as both coarse and fine aggregates were evalu- ated. Three series of SCC mixtures were prepared with 100 percent coarse recycled aggregates, and different levels of fine recycled aggregates were used to replace river sand. The SCC mix- tures were prepared with 0, 25, 50, 75 and 100 percent fine recycled aggregates in Series I and

II. The SCC mixtures in Series III were prepared with 100 percent recycled concrete aggre- gates (both coarse and fine). Different tests covering fresh, hardened and durability properties of these SCC mixtures were executed. The results indicate that the properties of the SCCs made from river sand and crushed fine recycled aggregates showed only slight differences. The feasibility of utilizing fine and coarse recycled aggregates with rejected fly ash and Class F fly ash for self- compacting concrete has been demonstrated.

Mill-Beale and You (2010) assessed the use of RCA at amounts of 25, 35, 50 and 75 percent of the total aggregate weight in asphalt mixes. In terms of moisture susceptibility, the tensile strength ratio increased with decreasing RCA; with only the 75 percent of RCA in the mix failing to meet the specification criterion. Finally, it has been recommended that a certain amount of RCA in hot mix asphalt (HMA) is acceptable for low-volume roads.

Lee et al. (2012) study evaluated the pre-coated recycled concrete aggregate for hot asphalt mix. In this research, slag cement paste used for pre-coated RCA (PCRCA) The indirect tensile strength (ITS) test, moisture sensitivity test and wheel-track rutting test of HMA with substitution ratios of 25, 50, 75 and 100 percent PCRCA mixture are discussed. However, the physical properties of the PCRCA used as aggregate and test of HMA with PCRCA are within the range of the specification requirements.

Valeria (2010), an investigation of mechanical behavior and elastic properties of recycled-aggregate concretes is presented. Several concrete mixtures were pre- pared by using only virgin aggregates (as reference), 30 percent finer coarse recycled aggregate replacing fine gravel and 30 percent coarse recycled aggregate replacing gravel. Results obtained showed that structural concrete up to C32/40 strength class can be manufactured by replacing 30 percent virgin aggregate with recycled-concrete aggregate. Moreover, a correlation between elastic modulus and compressive strength of recycled-aggregate concrete was found and compared to those reported in the literature. Finally, on the basis of drying shrinkage results, particularly if finer coarse recycled-concrete aggregate is added to the mixture, lower strains could be detected especially for earlier curing time

1.1.2Objectives of the Study

1. To Determine the physical properties of natural aggregates and recycled concrete aggregates (RCA).
2. To Determine the optimum bitumen content for bituminous mix samples.
3. To Evaluate the effects of using RCA in bituminous mixture in terms of stability and flow value by using Marshal Mix design method.
4. Compare the test results with the performance of the traditional control convention asphalt mixes in laboratory with addition of RCA.

Chapter 2 MATERIALS

2.1 Materials

2.1.1 Aggregates

Aggregates are mainly used in building constructions and road pavements. Material used for mixing with cement, bituminous , lime ,gypsum or other purpose in pavements the amount of aggregates in asphalt pavement mixtures is generally 90-95 percent by weight and 75 - 85 percent by volume. Aggregates are primarily responsible for load supporting capacity of a pavement .

These are divided into following categories:

Fines:

Silt, clay , or dust particles smaller than 0.75mm usually the undesirable impurities in aggregates.

Figure 2.1: Fines

Fine Aggregates:

Aggregate particles mainly between the 4.75 mm size and the 0.75mm sieve.

Figure 2.2: Fine Aggregates

Coarse Aggregates:

particles mainly divided larger than 4.75 mm sieve size.

2.1.2Bituminous:

1. Bitumen, also known as asphalt in the United States, is a substance produced through the distillation of crude oil that is known for its waterproofing and adhesive properties.
2. Bituminous materials are used for road construction, roofing, waterproofing, and other applications as required grade such as VG-10, VG-20, VG-30 , VG-40.

Figure 2.3: Bitumen

2.1.3Recycled Concrete Aggregates:

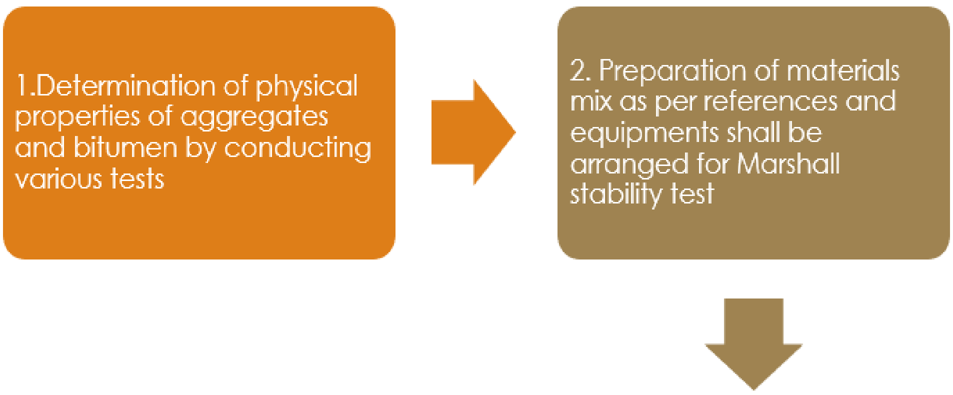
1. Recycled concrete aggregate (RCA) are aggregates obtained by recycling clean concrete waste from processing of demolition renovation of buildings , highways, bridges etc..where content of other concrete waste must be very low.
2. RCA are produced in stationary recycling plants.
3. It can be used in flexible pavements base layers.

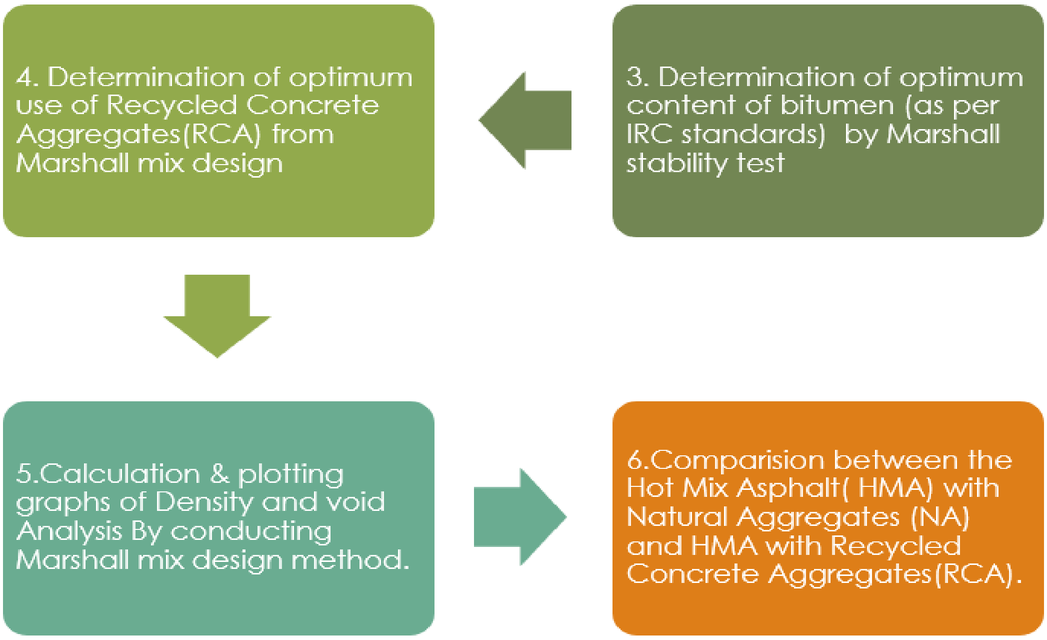
Figure 2.4: Recycled concrete Aggregates

Advantages of R.C.A

1. One of the main reasons to use RCA in structural concrete is to make construction more
2. green and environmentally friendly.
3. Reduces the amount of aggregates to be created, hence less evacuation of natural resources.
4. Cost saving.
5. Create more employment opportunities in recycling industry.
6. RCA are used to replace of natural aggregates to control environmental economical advantages.

Chapter 3
METHODOLOGY
1.1 Methodology





Flow chat of methodology

1.2 Properties

STRENGTH:

The aggregates used in top layers are subjected to (

- stress action due to traffic wheel load,
- wear and tear,
- crushing.

HARDNESS:

The aggregates used in the surface course are subjected to constant rupture or abrasion due to moving traffic.

The abrasive action is severe when steel tired vehicles moves over the aggregates exposed at the top surface.

TOUGHNESS:

Resistance of the aggregates to impact is termed as toughness.

*Aggregates used in the pavement should be able to resist the effect caused by the jumping of the steel tired wheels from one particle to another at different levels causes severe impact on the aggregates.

SHAPE OF AGGREGATES:

Particular shape range may have rounded, cubical, angular, flaky or elongated particles.

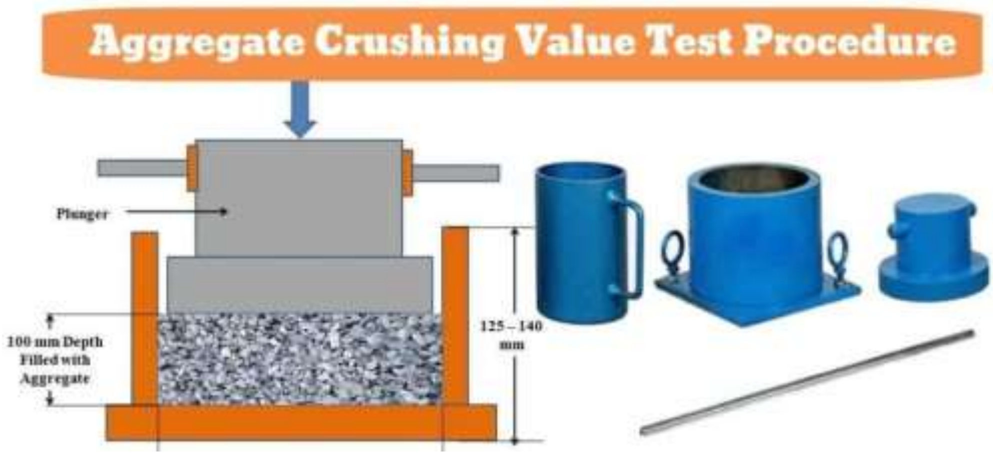
*Flaky and elongated particles will have less strength and durability (compared to cubical, angular or rounded particles of the same aggregates.)

*Hence too flaky and too much elongated aggregates should be avoided as far as possible.

Freedom from deleterious particles:

Aggregates should be clean, tough and durable. *It should be free from at or elongated pieces, dust, clay balls and other objectionable material.

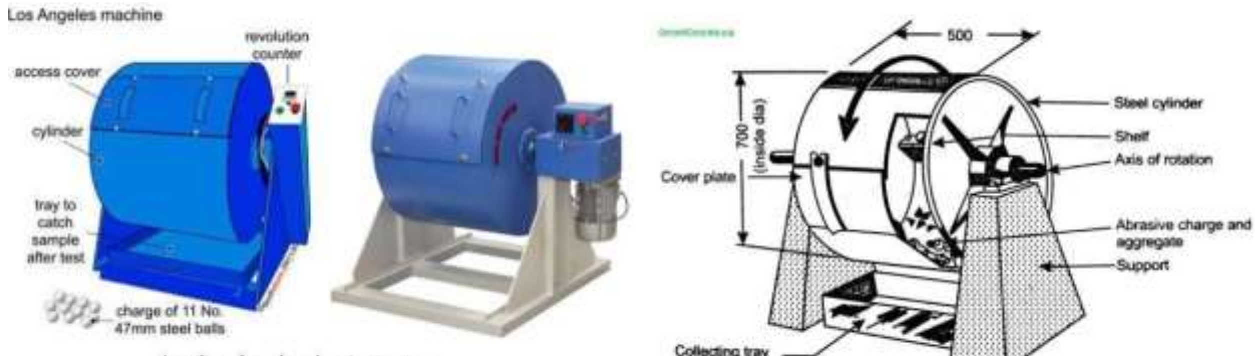
Chapter 4
Tests on Materials
1.1 Aggregate tests (IS-2386)
Aggregates influence, to a greater extent, the load transfer capability of pavements and slabs. Therefore, before using for construction, it is necessary that they should be completely tested. Not only the aggregates should be strong and durable, but they should also have proper shape and size to make the element slab/pavement act monolithically.
1.1.1Crushing test
One of the test in which concrete material can fail is due to crushing under compressive stress. Aggregate crushing test is standardized by IS: 2386 part-IV and used to verify the crushing strength of aggregates. The aggregates should be oven dried, which can passes through 12.5mm and retained on 10mm sieve.
The cylindrical steel cup is stuffed in three layers of aggregate. Each and every layer is tamped with 25 strokes by the rounded end of tamping rod. The surplus aggregate should get struck off by the tamping rod from a straight edge. The net weight of aggregate in the cylindrical steel cup is measured to the nearest gram (W1). The surface of the aggregates is leveled and the plunger is inserted. Consequently the plunger rests horizontally on the surface. The whole apparatus is then placed between the platens of compression testing machine and loaded at a consistent rate so it can reach to a load of 40 tons in 10 minutes. The load is then released and the sample is removed from the cup. The sample is then sieved on 2.36 mm IS sieve until no further significant amount passes in one minute. The fraction passing the sieve is weighed to nearest accuracy of 0.1g (W2).
The crushed aggregates (W2) is expressed as % of the total weight of sample (W1), which is the crushing value of the aggregate.
.Aggregate crushing value = (W1/W2)*100



1.1.2Los Angeles Abrasion test
The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregates and steel balls used as abrasive charge. During Los Angeles abrasion test, both abrasion or rubbing action between the aggregates and steel balls pounding action of these balls on the aggregates take place. Clean the aggregates dried in an oven at 105?c to 110?c to constant weight. Aggregates weight should be around 2.5 kg and then it is poured in the cylinder of the machine. The cover of the apparatus is fixed dust-tight .The machine is rotated at the specified speed of 30 to 33

revolutions per minute. After the specified number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust. Using a sieve of size larger than 1.70 mm test sieve, the material is first separated into two parts and finer position is taken out and sieved further on a 1.7 mm test sieve.

.Abrasion value = (W1/W2)*10



Los Angeles abrasion test setup

1.1.3Impact test

Toughness is the property of the material to resist impact. Aggregate impact test has been designed to evaluate toughness or the resistance of the stone aggregates to break down under repeated application of impact.

The test samples consist of aggregates passing 12.5mm test sieve and retained on 10mm sieve and dried in oven for 4hours at a temp of 100 - 1100c cooled. The aggregates are filled up to about 1/3rd full in the measuring cylinder and tamped 25 times with rounded end of the tamping rod. Further quantity of aggregate is added up to about 2/3rd full in the cylinder and 25 strokes of tamping rod are given. The measure is now filled with the aggregates to over flow, tamped 25 times. The surplus aggregates are struck of using the tamping rod. The net weight of the aggregates in the measure is determined to the nearest gram and this weight of aggregate is used for carrying out duplicate test on the same material. The aggregate impact test machine is placed with its bottom plate flat on the horizontal floor so that hammer guide columns are vertical. The cup is fixed firmly in position on the base of machine and the whole of the test sample from the cylindrical measure is transferred to the cup and compacted by tamping rod with 25 strokes.

The hammer is raised until its lower face is 380mm above the surface of the aggregates in the cup and allowed to fall freely on the aggregates. The sample is subjected to a total of 15 such blows of the hammer, each blow delivered at an interval of not less than 1 second. The crushed aggregates is than removed from the cup and whole of it sieved on 2.36mm sieve until no further significant amount passes. The fraction passing this sieve is weighed accurate 0.1gm.

.Aggregate Impact value = (W4/W3)*100

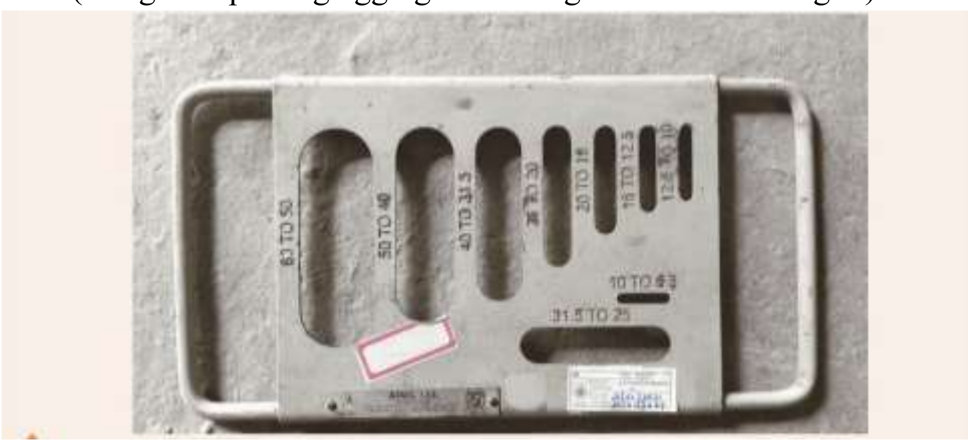
1.1.4Shape tests

Flakiness index

The shape of aggregate particles is determined by the percentage of flaky and elongated par- ticles contained in it. The flakiness index of aggregate is the percentage by weight of particles whose least dimension (thickness) is less than 3/5th or 0.6 of their mean dimension. The test is not applicable for sizes smaller than 6.3mm.

In the first stage sieve analysis is carried out and aggregates are separated into specified size ranges and in the second stage, the flaky particles are separated from each size range. The coarse aggregate sample is sieved from the set of sieves mentioned in the table. It is to be ensured that a minimum of 200 pieces are available in each size range. If the number of pieces of aggregates in any of the size range is too less, additional quantity of same aggregate sample is sieved through the specified set of sieves. The separated aggregates in each size range are weighed. These weights are recorded as W1, W2 etc., About 200 pieces of coarse aggregates from each size range is taken and weighed. These are recorded as P1, P2 etc., in order to identify flaky particles from each of the separated size ranges, each particle of this aggregate fraction is than tried to be passed through the specified slots of the thickness gauge the respective slots of the thickness gauge are given in table and these slot sizes also marked on the thickness gauge. The flaky particles passing the appropriate slot of the thickness gauge from each size range are collected and weighed as F1, F2 etc.,

.Flakiness index = (Weight of passing aggregates through sieve /total weight)*100

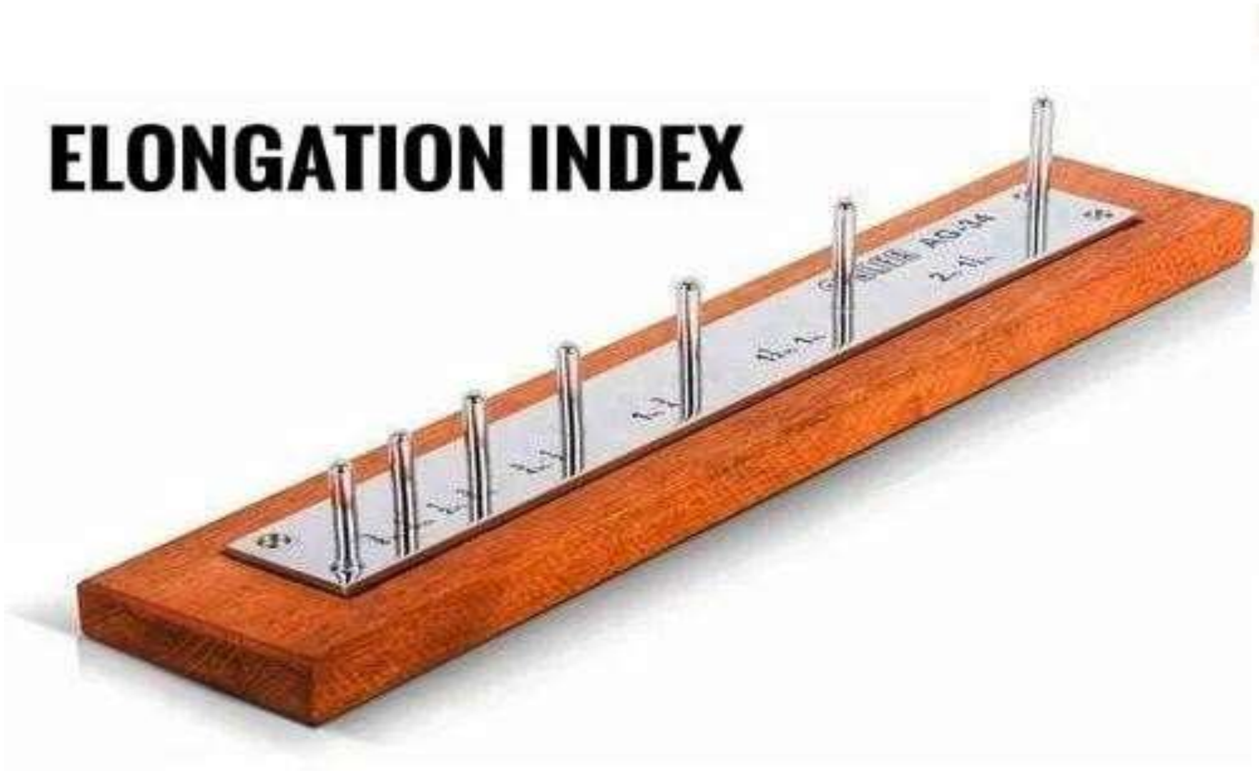


Elongation index

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

The sample is sieved through the IS sieves specified in given table. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate elongated material, each fraction is then gauged individually for length in a length gauge. The gauge pieces of aggregates from each fraction tested which could not pass through the specific gauge length with its long side are elongated particles and are collected separately to find the total weight of aggregate re- tained by the length gauge are weighted to an accuracy of at least 0.1 percent of the weight of the test sample. The results of flakiness index and elongation index are presented in the Table

Elongation index = (Weight of aggregates retained /total weight of aggregates)*100



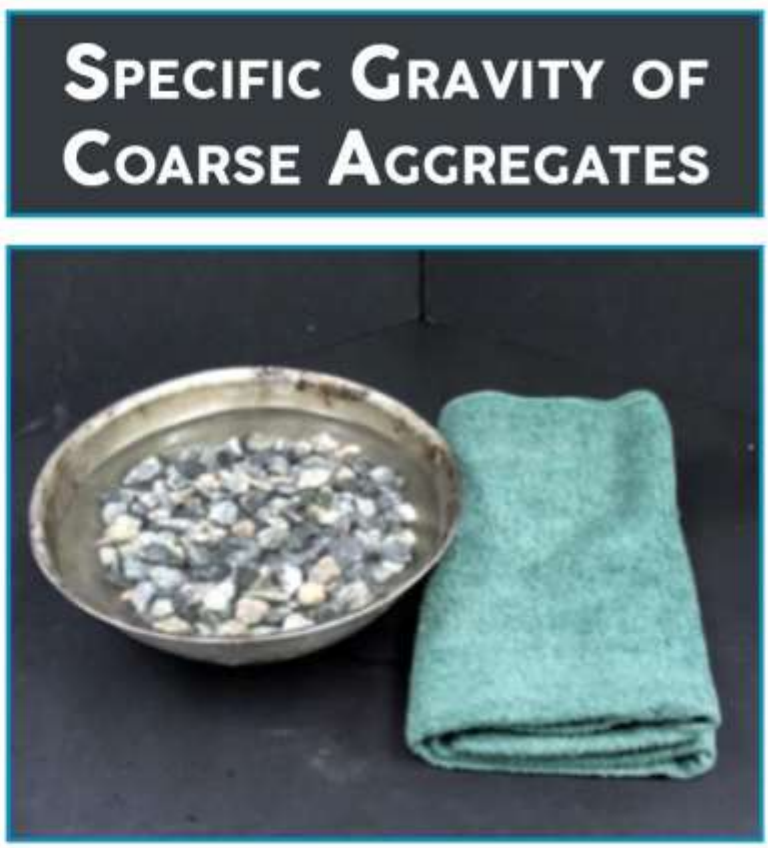
1.1.5 Specific gravity of coarse aggregate

The specific gravity of aggregates is considered to be a measure of strength or quality of the material. Stone having low specific gravity are generally weaker than those with higher specific gravity values. About 2kg of the aggregates sample is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in the distilled water at a temperature between 22 and 320c and cover of at least 5cm of water above the top of the basket. Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing it to drop

25 times at the rate of 1 drop per second. The basket and the aggregate should remain completely immersed in water for a period of 24+(or)- hours afterwards.
The basket and the sample are than weighed while suspended in water at a temperature of 22 to 32. The weight is noted while suspended in water (W1 grams). The basket and aggregate are than removed from the water and allowed to drain for a few minutes, after which the aggregate is transferred to one of the dry absorbent cloth. The empty basket is than retained to the tank of water and weighed in water (W2 grams).
The aggregates are placed on the absorbent cloths are surface dried till no further moisture can be removed by this cloth. 10 to 60 minutes of drying may be needed. The aggregate should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying. The surface dried aggregate than weighed (W3 grams). Than aggregates are oven dried and weighed (W4 grams).
Specific gravity = (W2-W1/(W2-W1)-(W3-W4)

Table 4.1: Physical properties of Aggregates As per(IS-2386)

SI.NO	TEST	Rsults for N.A(%)	Results for R.C.A(%)	RANGE %
1	Crushing test	19.07	23.16	≤ 30
2	Abrasion test	16.92	19.76	30
3	Impact test	14.37	23.31	20 - 30
4	Shape test	33.2	32.3	35
5	specific gravity	2.58	2.515	2.5 - 3.0
6	Water Absorption	1.01	2.53	0.1 - 2.0



1.2 Bituminous

Experience in using bitumen in engineering projects has led to the adoption of certain test procedures that are indicative of the characteristics that identify adequate performance levels. Some of the tests have evolved with the development of the industry and are empirical methods. Consequently it is essential that they are carried out in strict compliance with the recommended procedures if they are to be accurate measurements of the (VG-30)grade bitumen's properties.

Table 4.2: Types of viscosity grades of bitumen

Description test	VG10	VG20	VG30	VG40
Softening point	40 min	45 min	45 min	50 min
Penetration	100-80	80-60	50-70	40-60
Ductility	25 min	40 min	50 min	70 min
Flash point	220 min	220 min	220 min	220 min
Viscosity at 60 C	800-1200	1600-2400	2400-3600	3200-4000

Viscosity grade bitumen in four different types including VG10, VG20, VG30 and VG40 is the most widely used bitumen in India

VG10: bitumen is the softest grade of viscosity bitumen. This type of bitumen is widely used for spraying applications and surface coating. VG 10 bitumen means that your bitumen is also suitable for paving roads in a very cold climate instead of the old 80/100 penetration grade.

VG-20: bitumen is a grade of viscosity bitumen used in cold climatic and high altitude regions.

... In North India, vg20 is used for road construction in hot mix asphalt. The standard penetration value of bitumen viscosity grade VG-20 is 60 mm at 25 C. The absolute viscosity of VG-20 bitumen is 1600 to 2400 poise at 60 C.

VG 30: bitumen. This bitumen is primarily used for the construction of extra-heavy bitumen pavements that have to bear significant traffic loads. Bitumen VG30 is the most widely used type of bitumen in road construction, insulation, building construction industries, and also in the production of cutback bitumen.

VG40: bitumen is used in areas in which high pressure comes from heavy traffic loads, such as intersections, near tolls booths, and truck parking lots.

1.2.1 Softening point test

The softening point is the temperature at which the substance attains particular degree of softening under specified condition of test. For bitumen, it is usually determined by Ring and Ball test.

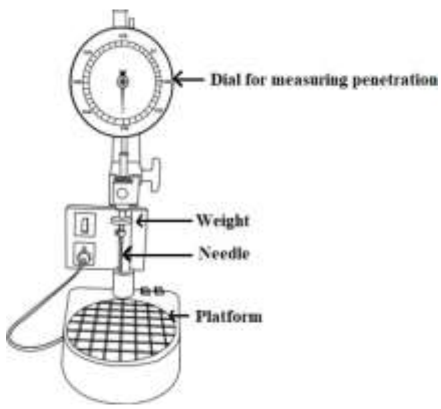
Sample material is heated to a temperature between 75 and 100 C above the approximate softening point until it is completely fluid and is poured in heated rings placed on metal plate. To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin. After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support. At this time the temperature of distilled water is kept at 5 C. This temperature is maintained for 15 minutes after which the balls are placed in position. The temperature of water is raised at uniform rate of 5 C per minute with a controlled heating unit, until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made. For materials whose softening point is above 80 C, glycerin is used as a heating medium and the starting temperature is 35 C instead of 5 C.

1.2.2 Penetration test

Various types and grades of bituminous materials are available depending on their origin and refining processes. The penetration test determines the consistency of these materials for the purpose of grading them, by measuring the depth to which a standard needle penetrate vertically under specified conditions of standard load, duration and temperature. Thus the basic principal of penetration test is the measurement of the penetration of a standard needle in a bitumen sample maintained at 25 during 5 seconds, the total weight of the needle assembly being 100gm .

The bitumen is heated to a pouring consistency, about 75 to 100 % above the temperature at which bitumen softens. The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water. The bitumen sample is than poured into a container of depth 35mm. the sample containers are placed on the transfer tray, and cooled in atmosphere at a temperature between 15 to 30' C for 60 to 90 minutes. Than the transfer, with the containers is placed in the thermostatically controlled water bath maintained at a temperature of 25 for a period of 60 to 90min .

The transfer tray with the sample container and water is removed from the water bath and placed under the needle of penetrometer. The initial reading of the penetrometer diameter is either adjusted to zero or the initial reading is taken before releasing the needle. The needle is released exactly for a period of 5 seconds by pressing the knob and the final reading is taken on the knob.



The needle assembly is than raised and the penetration needle is removed and replaced by clean dry needle test is repeated on the same sample by conducting the repeat test at a distance of not less than 10mm apart.

1.2.3 Flash and Fire point test

Bituminous materials out volatilize at high temperatures depending upon their grade. These volatile vapours catch fire causing a flash. This condition is very hazardous and it s therefore essential to qualify this temperature for each bitumen grade, so that the paving engineering may restrict the mixing or application temperature well within the limits.

Flash point

The flash point of a material is the lowest temperature at which the vapor of substances mo- mentarily takes fire in the form of a flash under specific condition of test.

Flash point of VG 30 grade bitumen = 210C Fire point

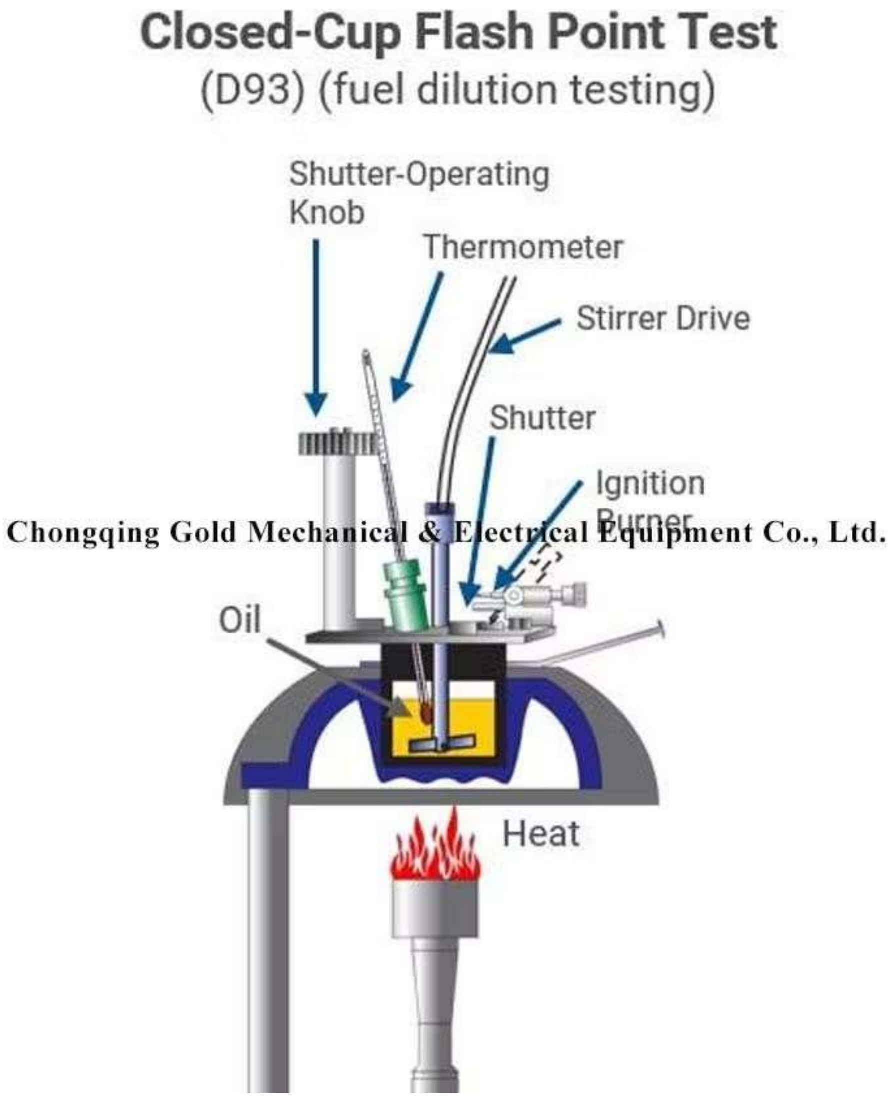
The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test.

Fire point of VG 30 grade bitumen = 240C

As per IS73-2006 requirements the values for the VG30 (60/70) grade bitumen penetration 50- 70, softening point 47, flash point 220.Obtained results are well within the specified values hence its VG30 bitumen.

Table 4.3: Physical properties of Bituminous (VG30)

SI.NO	TEST	Results for N.A	RANGE
1	Ductility	63	Min 50
2	Softening point(C)	49.7 C	30 C
3	Penetration test	62.3	60 - 70
4	flash point	210 C	200 C
5	fire point	240 C	220 C



Chapter 5

MARSHALL STABILITY TEST

1.1 Marshall Mix Design

introduction

The Marshall stability and flow test provides the performance prediction measure for the Mar- shall Mix design method. The stability portion of the test measures the maximum load sup- ported by the test specimen at a loading rate of 50.8 mm/minute Load is applied to the specimen till failure, and the maximum load is designed as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm(0.01 inch) increments at the same time when the maximum load is recorded. The important steps involved in Marshal mix design are summarized next.

APPARATUS: Marshall stability test machine, hammer, cylindrical - moulds , hanger with weight, compaction pedastal,Set of sieves (19, 13.2, 9.5, 4.5, 2.36,1.18, 0.6 0.3, 0.15, 0.075)mm , water bath, VG 30 bituminous grade.

Figure 5.1: Marshall test machine

Table 5.1: Grading of Aggregates

IS Sieve size (mm)	**GRADE-1**	**GRADE-2**
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34- 48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content ($^0/0$)	min 5.2	min 5.4
Bitumen grade	VG -30	VG -30

1.1.1 Design requirements of bituminous mixes for pavement layers:

The minestry of road transport and highway has suggested that the mix design specifications to be fulfilled by compacted specimens of dense bituminous mixes (compacted with 75 blows on either side of Marshall test specimens) for use in the bituminous concrete (BC) surface coarse and dense bituminous macadam (DBM) pavement layers are as follows:

Marshall stability value, kg (min) = 900 Marshall flow value ,mm = 2 – 4

Air voids in total mix, Vv $^0/0$ = 3–6 Voids filled with bitumen, VFB $^0/0$ = 65–75

1.1.2 Apply Stability correction value

Table 5.2: Stability correction value

volume of specimen (cm^3)	Thickness of specimen (mm)	Thickness of specimen (mm)
457-470	57.1	1.19
471-482	68.7	1.14
483-495	60.3	1.09
496-508	61.9	1.04
509-522	63.5	1.00
523-535	65.1	0.96
536-546	66.7	0.93
547-559	68.3	0.89
560-573	69.9	0.86

Table 5.3: Preperation of mix with GRADE-1 aggregates

IS SEIVE size(mm)	percentage	weight(gm)
19	10	88.235
13.2	20	176.470
9.5	20	176.470
4.75	20	176.470
2.36	16	141.176
1.18	14	123.529
0.6	12	1056.88
0.3	10	88.235
0.15	8	70.588
0.075	6	52.941
Total	100	1200
Bituminous content	5 5.5 6	60 66 72

1.2 Procedure

Firstly take 1200 gm of grade-1 aggregates as per the sieve sizes and it heated to a tem- perature of 175-190 C.

Bitumen is heated to a temperature of 121-125 C take bitumen content of VG30 grade as 5 percent(60gm).

The heated aggregates bitumen was heated thoroughly mixed with temperature of 154- 160 C.
The mix is placed in a pre heated mould and compacted by a hammer with 75 blows on either side.
The mould is placed at room temperature for 24hrs.
After completion of 24hr remove the specimen from the mould and weight it with help of thread in air condition submerged in water.
Now, the specimen is placed in the water bath maintaining 64 c for half an hour.
After removing the specimen from water bath immediately place the specimen in the Marshall stability apparatus.
The equipment is set up by fixing dial gauge.
The horizontal level is checked by placing level tube.
Flow dial reading and proving ring reading are noted down after applying load.

1.2.1 Void analysis equations

Voids analysis:

- **Correction stability** = proving ring value x 0.026 x correction factor
- Vv (%) = 100(Gt-Gb)/Gt
- Vb(%) =Gb*(W4/G4)
- VMA =Vv + Vb
- VFB = 100 Vb/VMA

- Vv = volume of voids
- Gt = theoretical density
- Gb = specific gravity of specimen
- Vb = bulk density of specimen
- VMA = volume of aggregate mineral
- VFB = percent voids filled with bitumen

Table 5.4: Observations for Natural Aggregates

Sample NO:	Bitumen Content (%)	Mean height (cm)	Flow dial reading	Flow value (0.01mm)	Proving ring reading(0.026mm)	Correction factor	Correction stability(KN)
1	5	6.18	214	2.14	255	1.04	6.89
2	5.5	6.23	240	2.32	360	1.03	9.64
3	6	6.3	225	2.56	340	1.04	9.19

Table 5.5: Density and Void Analysis

S. NO:	Sample	mix. Temp °C	Comp Temp °C	Height of sample in (cm)			Mean height (cm)	Wt of sample (gm)		Bulk density (Gb)	Theoretical density	Vv in (%)	Vb in (%)	VMA IN (%)	VFB in (%)
				h1	h2	h3		In air	In water						
1	VG30	160	150	6.0	6.3	6.4	6.23	1225	760	2.50	2.57	2.72	12.37	15.09	81.97
2	VG30	160	150	6.1	6.3	6.15	6.18	1250	750	2.54	2.57	1.16	12.57	13.73	91.55
3	VG30	160	150	6.2	6.3	6.4	6.3	1270	770	2.4	2.57	0.38	12.67	13.05	97.08

1.. Analysis by graphs

Figure 5.2: Graph-1

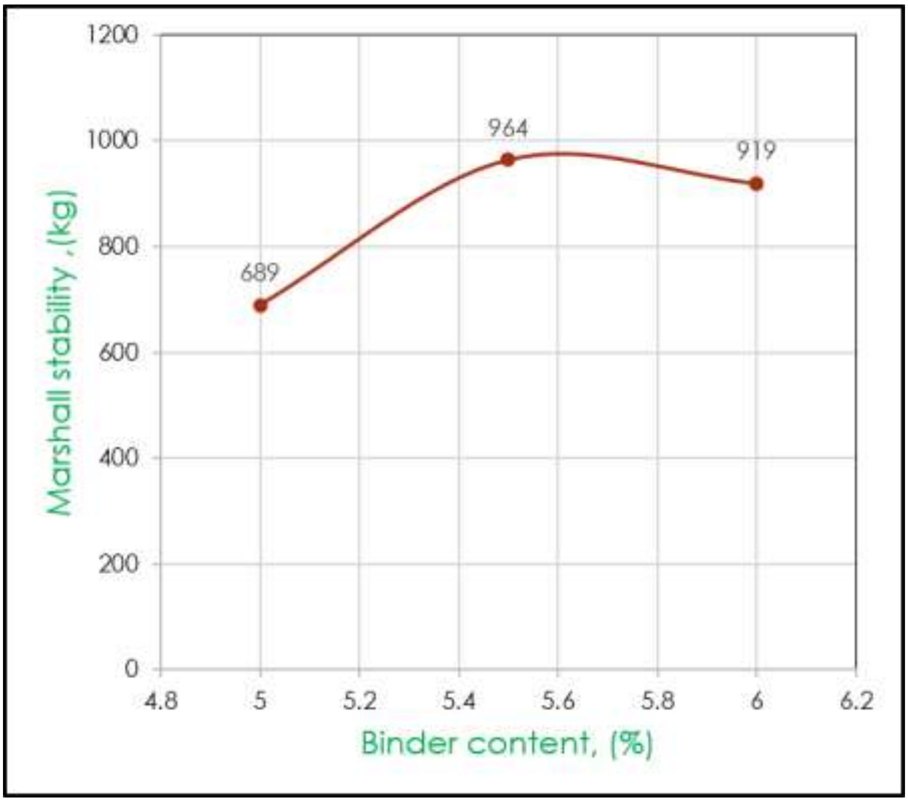


Figure 5.3: Graph-2

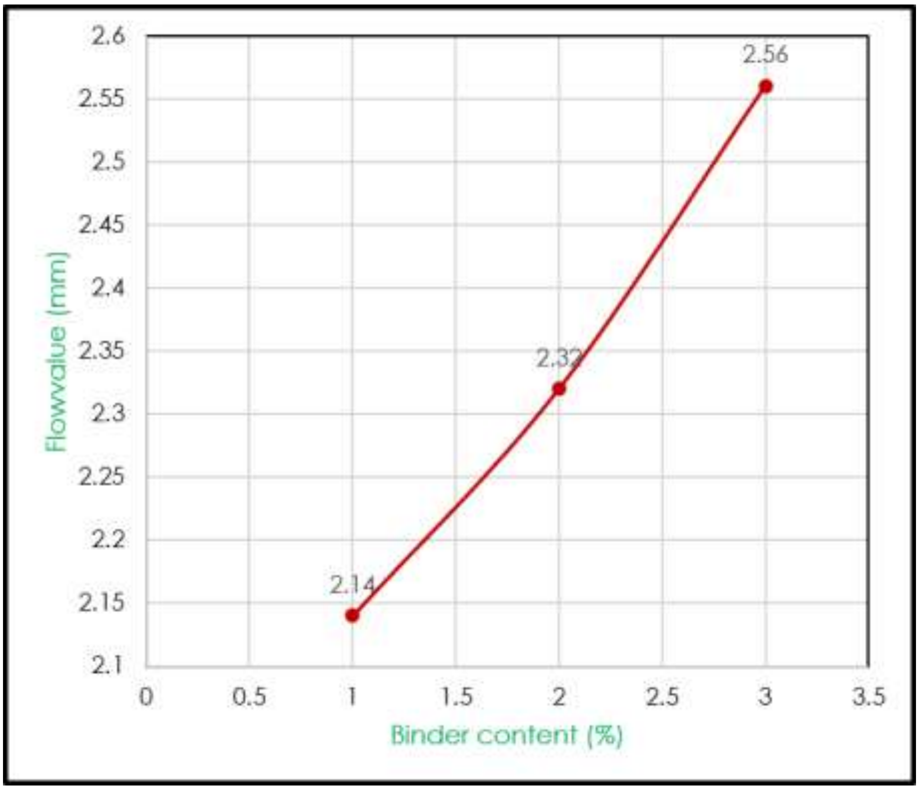


Figure 5.4: Graph-3

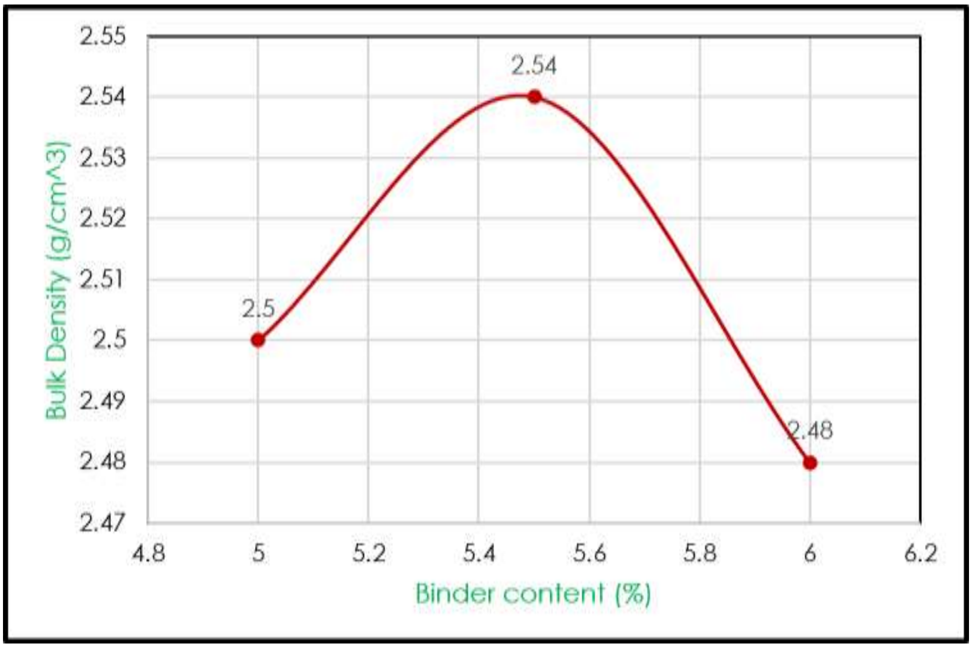


Figure 5.5: Graph-4

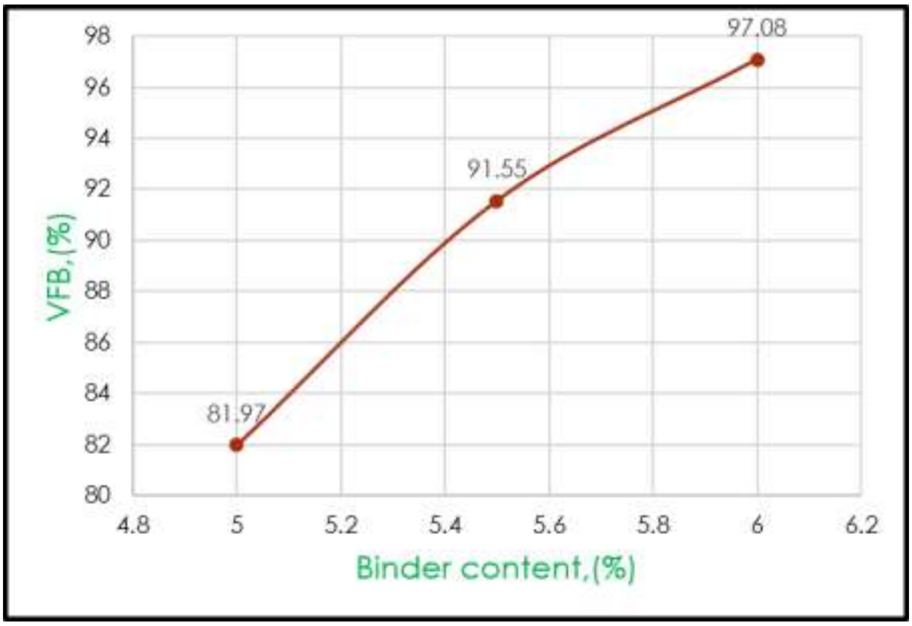
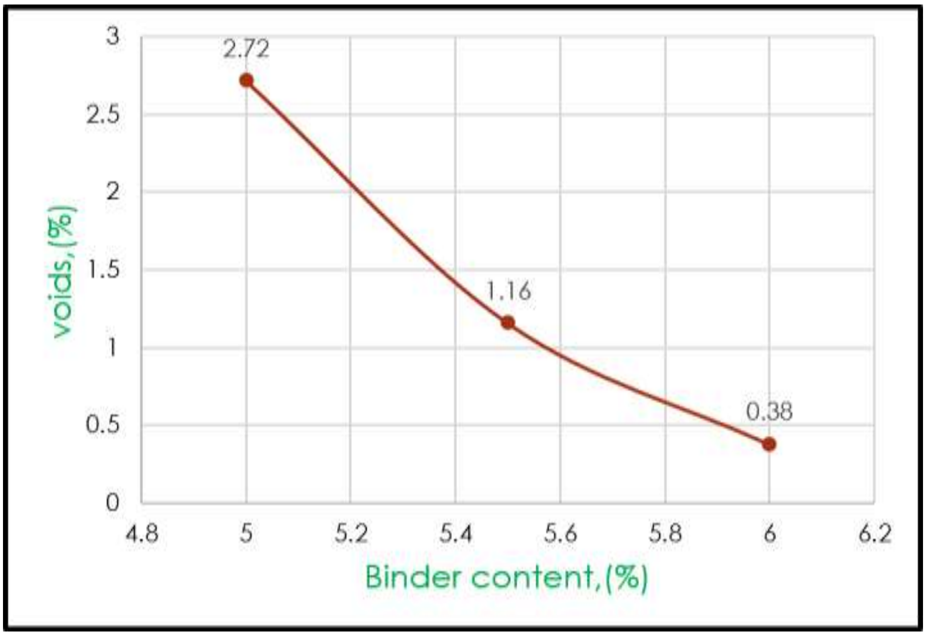


Figure 5.6: Graph-5



1.3 Preparation of mix Design with RCA

Similarly, adopt normal mix design procedure with replacing the natural aggregates to the recycled concrete aggregates percentage such as 10,20,30(120,240,360 gm) respectively.

The remaining procedure was same as normal mix design .

After that note down the values of flow dial gauge reading proving ring reading.

Calculate the marshal stability value flow value.

Table 5.6: Preparation of Design mix with R.C.A

Bituminous content (⁰/0)	(⁰/0)*N.A*	(⁰/0)*R.C.A*	weight(gm)of R.C.A
5.5	90	10	120
5.5	80	20	240
5.5	70	30	360

Table 5.7: Observations for R.C.A

S. NO:	Bitumen Content (%)	Percentage of R.C.A content	Weight of specimen(gm)		Mean height (cm)	Flow dial reading (0.01mm)	Flow value (mm)	Proving ring reading (0.026mm)	Correction factor	Correction stability (KN)
			In air	In water						
1	5.5%	10%	1300	795	6.5	370	3.70	365	1.00	9.49
2	5.5%	10%	1260	750	6.5	290	2.90	260	1.00	6.76
						Average	3.3		Average	8.12
3	5.5%	20%	1250	755	6.6	420	4.20	575	1.00	14.95
4	5.5%	20%	1260	775	6.4	355	3.55	545	1.04	14.73
						Average	3.87		Average	14.84
5	5.5%	30%	1255	765	6.3	215	2.15	550	1.09	15.58
6	5.5%	30%	1245	755	6.3	355	3.55	640	1.09	18.13
						Average	2.85		Average	16.85

Chapter 6

ANALYSIS OF RESULTS

6.1 Comparision of results

Table 6.1: Comparison of Marshall Parameters obtained at optimum bitumen content with RCA .

S.NO:`	parameters	Results	
		N.A	R.C.A(30%)
1	OBC%	5.5%	5.5%
2	Stability (kg)	964	1685.5
3	Flow (mm)	2.84	2.85

Chapter 7 CONCLUSION

The following conclusions can be drawn from the results and discussion presented in this study.

The impact, crushing, and Los Angeles values of selected virgin aggregates in this study were found to be within the limit (i.e., less than 30percent,)

The penetration softening point, viscosity, and ductility values of collected VG30 binder were found to be within the limit as per IS codes, and hence found to be appropriate to use for construction of pavements.

The optimum bitumen content was found from the above plotted graphs of Bulk den- sity(Gb),Vv , VFB, Marshall stability flow values OBC as 5.5percent in R.C.A.

The graph shows percentage of RCA increases the stability will be increased until 30 per- cent thereafter it will decreases.so, the more percentage of RCA increases automatically the strength will be decreases.

The optimum R.C.A content for the satisfactory Marshall mix design was found 30 per- cent as per above Marshall test results.

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