THE EFFECT OF COARSE AGGREGATE SIZES ON THEIR PHYSICAL PROPERTIES

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***Abstract*— Rock aggregates are the most fundamental material of highways, railroads, and other construction activities. Rocks from two different quarries were evaluated to determine the impact of aggregate size on the performance of materials. This study is to find out the effect of size on physical parameters of aggregate used in flexible and rigid pavement. In order to determine the effect of aggregate size on their physical properties, different sieve sizes were selected. The sizes are divided into four categories according to IS sieve standards: R1 (20 mm-16 mm), R2 (16 mm-12.5 mm), R3 (12.5 mm-10 mm), and R4 (10 mm-4.75 mm) for aggregate impact value, aggregate crushing value, water absorption, and specific gravity. It is observed that the larger size of aggregate has given better results in their physical parameters.**

Keywords*— *Particle size, materials strength, properties of rock, flexible pavement

I. INTRODUCTION

Aggregate on road construction was hugely important as it affects the overall performance based on the aggregate strength, durability, and resistance to sustained load after construction. The aggregate used in this study is river stones obtained from Niawhtlang and crushed aggregates (crushed stone) obtained from Hlimen quarry. Aggregate characteristics such as particle size, shape, and texture influence hot mix asphalt pavement performance and serviceability. Low resistance to deformation will ensue if the aggregate structure is weak, while too excellent stability in the aggregate structure may result in brittleness and low resistance to impact. In uniformly graded aggregates, particles are uniformly decreasing size, coarse to fine to dust. Such aggregate structures have a fairly uniform stress distribution. This type of grading is particularly important in utilising smooth, round aggregates such as alluvial sand and gravel. Careful grading control can yield high stability from aggregates possessing little strength [1].

The important fundamentals to consider in selecting aggregate size and gradation are that a large quantity of the maximum size aggregate within the size limits should be used for non-skid pavement. A uniformly graded aggregate is suggested for workability and freedom from segregation [2]. Permeability is a matter of pore size rather than void volume. Workability is most affected by the quantity and grading of coarse aggregate. Particle alignment tends to increase with the increasing size of aggregate particles [3]. As the nominal maximum size of the aggregate is increased, the amount of water needed for the same workability is reduced. Therefore, strength is greater at the same cementitious material content because the w/c is lower. But in the high-strength range, over 40 MPa, higher compressive strengths are usually obtained at a given w/c with a smaller nominal maximum-size aggregate. Similarly, higher flexural strength is obtained at a given w/cm with a smaller nominal maximum size aggregate [4]. Aggregates with good physical and mechanical properties can substantially improve the engineering properties of asphalt mixtures [5,6]. High density and good crush resistance can prevent aggregates from breaking under repeated vehicle loads and improve the fatigue resistance of asphalt pavements [7, 8, 9]. Aggregates with low water absorption can improve the low-temperature performance of mixtures [10, 11,12].

II. OBJECTIVES AND SCOPES

In this study, the effect of aggregate size on rock's physical properties is examined, along with the possibility of using a larger stone in flexible pavements. Mizoram terrain is, according to the Geological Survey of India, an immature topography, and the physiographic expression consists of several almost north–south longitudinal valleys containing series of small and flat hummocks, mostly anticlinal, parallel to sub-parallel hill ranges and narrow adjoining synclinal valleys with series of topographic highs. The general geology of western Mizoram consists of repetitive

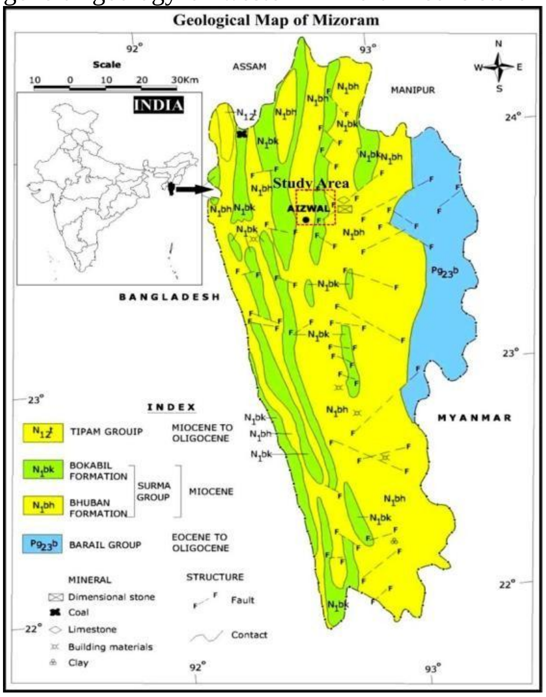

Figure 1. Geological Map of Mizoram

succession of Neogene sedimentary rocks of the Surma Group and Tipam Formation such as sandstone, siltstone, mudstone and rare pockets of shell limestone. The eastern part is the Barail Group [13]. As stipulated by IRC 37-2018 and MORT&H, the performance of rock size gradation used in the construction of flexible pavements is not satisfactory in terms of durability, mainly when applied to sedimentary rock that has a high absorption value. In Mizoram, most rocks cannot withstand repeated wheel loads in the presence of moisture during the long monsoon rainy season. Hydro-geological factors have also contributed to the longevity of the asphalt pavement. As a result of this study, there will be scope for using the coarse aggregate of larger size, especially on the friable and quickly disintegrated rock under weathering action. In relation to the same volume of rock, larger aggregate has better load resistance and lower water absorption.

III. MATERIALS AND METHODOLOGY

A. Material

Coarse aggregate is used for base and sub-base courses for flexible and rigid pavements. The aggregates which pass through 75 mm IS sieve and retained on 4.75 mm IS sieve is known as coarse aggregates. Aggregates influence to a great extent the load transfer capability of pavements. They are tested for strength, toughness, hardness, and water absorption. The aggregate size includes maximum size, size range, and gradation. Materials selections for the study are from two different quarries.

B. Methods

Two different coarse aggregates were selected and divided into four ranges of sizes. Each range of coarse aggregate were tested using physical and mechanical properties tests such as aggregate impact value, aggregate crushing value, water absorption and specific gravity test. The gradation ranges from A to G is adopted for classification of aggregate size in the Abrasion test. To determine the physical properties of rock, tests are performed to determine the performance of coarse aggregate in constructing flexible pavement under various loads, including impact, abrasion, and water absorption. The aggregate (rock) sizes are divided into the normally adopted size of four ranges of aggregate size as per IS sieve standards: R1 (20 mm-16 mm), R2 (16 mm-12.5 mm), R3 (12.5 mm-10 mm), and R4 (10 mm-4.75 mm) for aggregate impact value, aggregate crushing value, water absorption, and specific gravity. The size-dependent performance of rock with regard to physical properties is the main focus of the study.

IV. RESULTS AND DISCUSSIONS

Rock types within Mizoram area are mostly consist of sedimentary rocks. The two quarries are selected for these studies are from Hlimen and Niawhtlang quarry rock.

A. Effect of Aggregate Size in Aggregate Impact Value (AIV)

AIV is the test that measures toughness. As shown in Figures 2 and 3, larger sizes of aggregates have given better impact values. It means that a larger size of aggregate has a higher resistance to withstand more impact load compared to a smaller size of aggregate.

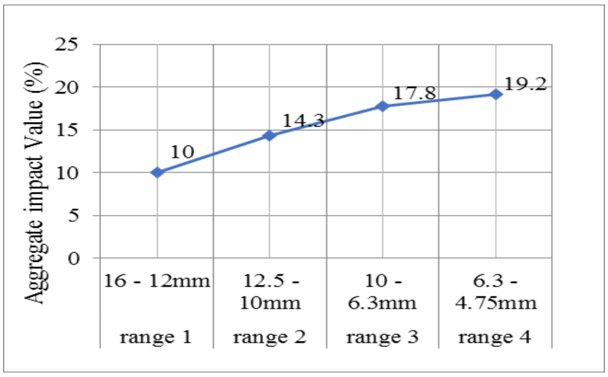

Fig.2:Aggregate Impact Value (Niawhtlang Quarry) with different size of rock

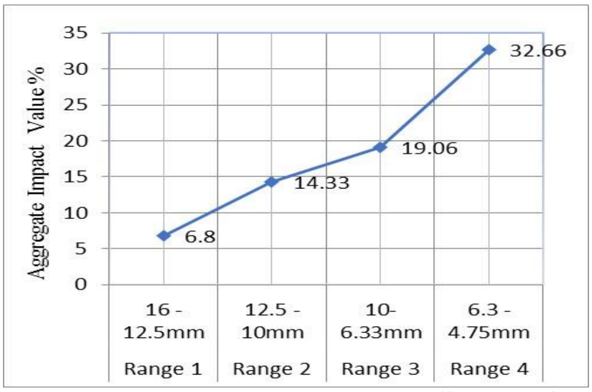

Fig.3: Aggregate Impact Value (Hlimen Quarry) with different size of rock

B. Effect of Aggregate Size in Water Absorption Value:

Water absorption values (WAV) measures the ratio between dry weight aggregate and saturated surface dry weight of aggregate to dry weight of aggregate. Larger sizes of aggregates have given lower absorption values compared to smaller sizes as shown in Figures 4 and 5. This may be due to the depth of water penetration remaining the same regardless of the size at a specific period of time. The quantity of water absorbed by large or smaller a size of aggregates remains the same.

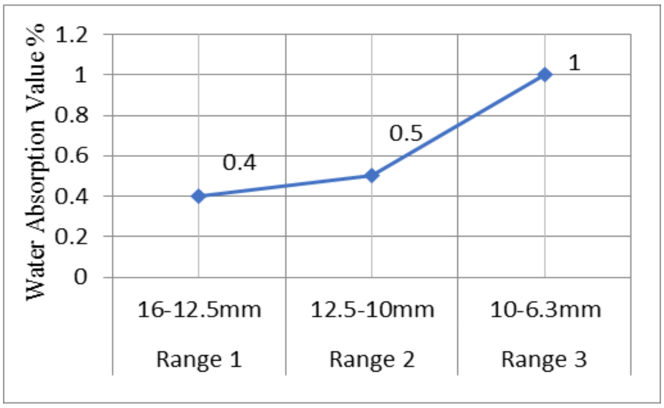

Figure.4 Water Absorption Value (Niawhtlang quarry) with different size of rock

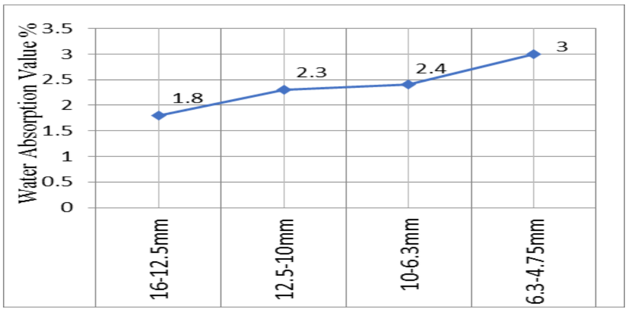

Figure.5 Water Absorption Value (Hlimen quarry) with different size of rock

C. Effect of Aggregate Size on Specific Gravity Test:

The specific gravity of rock measures the density of rock with respect to the density of the equal volume of water. The specific gravity values with respect to a particle size of aggregate do not change much as shown in Table.1. The size of the aggregate does not affect much as the density of aggregate remains the same for a particular rock.

TABLE .1 SPECIFIC GRAVITY VALUES FOR DIFFERENT SIZE OF AGGREGATE

Niawhtlang quarry rock		Specific gravity value
Sieve size	12.5-10mm	2.5
	16- 12.5mm	2.51
Hlimen quarry rock		**Specific gravity value**
Sieve size	16-12.5mm	2.5
	12.5-10mm	2.52
	10-6.3mm	2.54
	6.3-4.75mm	2.6

D. Effect of Aggregate Size on Los Angeles Abrasion Value (LAAV)

The percentage wear of the sample aggregates due to rubbing with steel balls and the falling impact of balls are determined as a percentage in the observation value. LAAV test involves two kinds of action i.e impact (pounding force) and abrasion (frictional force). In flexible pavement, these two action forces reflect the actual conditions of the site. It has been observed that gradations with a higher sieve size (coarser aggregates) have a lower level of abrasion, as shown in figure 6. The time required to wear away a larger size of the rock is more compared to the time required to disintegrate the smaller size of aggregate. LAAV test involves the combination of different gradation sizes of aggregate as shown in table 2. At a larger particle size, the desired value of abrasion is obtained, and the desired result is found in ascending order by aggregate size, i.e. D<C<B<A<G<F<E, grade E has the largest aggregate size, while grade D is the smallest. As the particle size increases, the abrasion value decreases. Los Angeles abrasion test has different gradation which is adopted to conduct the study. The Abrasion Value test was not performed on Niawhtlang quarry rock.

TABLE.2 GRADATION OF AGGREGATES FOR LAAV

Sieve Size		Weight in gm of test sample for grade						
Passing (mm)	Retained (mm)	A	B	C	D	E	F	G
80	63					2500		
63	50					2500		
50	40					5000	5000	
40	25	1250					5000	5000
25	20	1250						5000
20	12.5	1250	2500					
12.5	10	1250	2500					
10	6.3			2500				
6.3	4.75			2500				
4.75	2.36				5000			

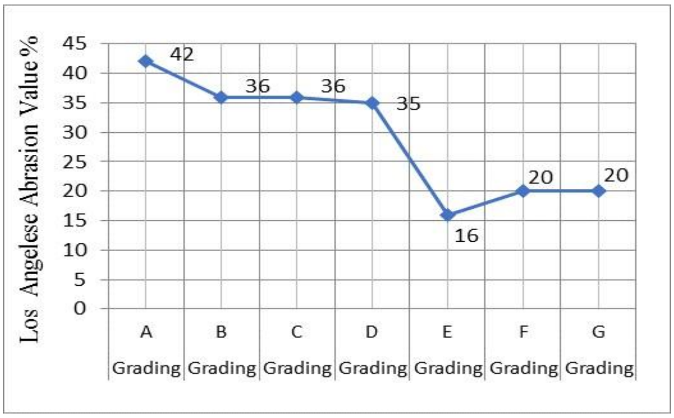

Figure.6 LAAV (Hlimen quarry) with different gradation of rock

E. Effect of Aggregate Size on Aggregate Crushing Value

Aggregate Crushing Value is used to measure the crushing strength of aggregate. As the size of aggregate gets larger, the crushing value decreases. The larger size has the ability to resist more loads (traffic load) due to individual thickness of aggregate that imparts more strength as shown in figure:7. Hlimen quarry rock sample is used here to fine the effect of particle size on crushing value.

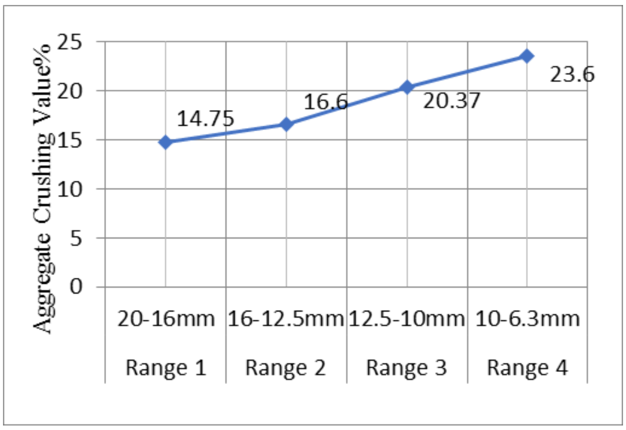

Figure.7: Aggregate Crushing Value with different size of Hlimen rock

V. CONCLUSION

The size of the aggregate plays a significant role in its permeability and strength. In high moisture content in the pavement structure, weak aggregate cannot withstand repeated traffic loads. This study will pave the way for introducing a larger size aggregate or boulder in the base layer of the pavement to counter the problem of early disintegration of rock in the presence of moisture under load. In areas where the rainfall intensity exceeds 2m/year with a high water absorption value of the rock, it is required to have good subsurface drainage and high loading capacity. Based on the resilient data obtained from the investigation, the following conclusions can be drawn:

The nature of the rocks, being sedimentary and having high water absorption of Hlimen rock, has shown a lower value of physical properties of rock under the application of load compared to Niawhtlang rock. The larger size of aggregate has been found to have higher toughness (impact), strength (crushing) and abrasion resistance than the smaller size of aggregate. Larger sizes of aggregates have given lower absorption values as the depth of water penetration remained the same regardless of the size and weight of aggregate.

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