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PUTTING DISCARDED LIMESTONE (KOTA STONE) TO GOOD USE AS A PAVING MATERIAL

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ABSTRACT

The waste produced at various stages, such as mining, cutting, and polishing, has been attempted to be used in the current study to create various layers of flexible pavement. In the current study, the physical and chemical characteristics of Kota stone slurry (KSS) and Kota stone aggregate (KSA) were assessed. Black cotton soil (BCS) from Kota city, Kota stone slurry (KSS), and mining waste from landfills in the Kota and Jhalawar region were all used in this study. In order to account for any variations in quality, the material was gathered from five different dumping sites. Transported to a crusher, quarry waste was turned into aggregates with sizes ranging from 19 mm to 0.75 mm.

KEYWORD: Kota, stone aggregate, pavement, mining.

INTRODUCTION

Since more than 90% of the weight of pavement is made up of natural aggregate, it is obvious that the extraction and consumption of natural stone like basalt, andesite, and limestone will grow dramatically. The current rate of stone mining and processing already has a detrimental effect on the environment, and the persistent increase in demand for these natural aggregates makes the situation even less sustainable. On the one hand, the extraction of these natural resources accelerates their quick depletion, and on the other, a vast amount of these extracted materials are thrown away as trash. Open pit mining is the method employed to obtain Kota stone. Here, the overburden pressure is initially released, and quarrying then goes on till the end of the quarry site.

The geology of rock layers is what determines the mining technique most of all. Mining is carried out using three different techniques: cutting, splitting, and blasting (British Geological Survey 2005). Primary cuts are made to free the bulk of the rock, which is then divided from the parent bed. By utilizing a particular tungsten carbide drill to create a sequence of holes, which are then filled with a splitting agent, the splitting process is carried out.

Large amounts of waste are produced during the Kota stone quarrying and processing processes. The slurry and dust-form trash from Kota stone, which weighs close to 1.2 million tons, is being dumped at various locations (Krishnan et al. 2018). 50–60% of the trash produced overall is produced during the blasting process, while 30–40% of the waste is produced through mechanized cutting, mining, and polishing techniques.

At the moment, the garbage has covered nearby roadways and arable land, impacting the local ecosystem and environment. Areas that were once covered in open brush and forest have become barren ground since quarrying operations began. Dry slurry and stone chips from the dump are carried during rainstorms as surface runoff, where they build up on nearby fertile land, seep underground, and mix with nearby water sources, disrupting the local environment. Among natives, laborers who live or work close to the mining area, and other groups, cases of respiratory illnesses such silicosis are frequent.

LITERATURE AND REVIEW

Mamta B Rajgor et al (2013) Disposal of waste materials poses numerous issues in the population of the industrial era. There are serious issues with storage sites being occupied and how that affects the environment. Not only at the end of the product cycle life, but also at the beginning, the construction industries deal with these issues. Therefore, it's essential to find a use for this waste as well as find other sources of aggregates as alternatives. The primary objective of this paper is to demonstrate the viability of using stone waste in the construction industry. The paper makes an attempt to illustrate the handling of stone-related waste. We attempt to research stone waste, its impact on the environment, and identify workable solutions that will ultimately benefit the construction industry in this paper.

Harshwardhan singh Chouhan et al (2019) The goal of the current study was to determine whether dimensional limestone waste (DLW), which was produced during cutting and polishing operations, could be used as a fine aggregate in mortar mixtures. The created waste was used for this in two different ways: first as slurry, then as made sand. By substituting dimensional limestone slurry (DLSS) and manufactured dimensional limestone crushed sand for the traditional fine aggregates (river sand) that ranged from 0% to 60%, fourteen mortar mixes (volumetric ratios 1:3 and 1:6) were created. The workability, compressive, flexural, adhesive, and tensile bond strengths, drying shrinkage, water absorption, porosity, density, ultrasonic pulse velocity, and dynamic modulus of elasticity of these mortar mixtures were all evaluated. When used in place of traditional river sand to the extent of 20 to 60 percent, DLW has been shown to improve the strength characteristics of mortar mixtures. The use of DLW produced a combination that was considerably denser and more homogeneous, which decreased the water-cement ratio and enhanced the workability of mortar. Improved mortar strength attributes came about as a result of using DLW as a partial replacement for fine aggregate. However, all mortar mixes experienced a constant rise in drying shrinkage above a 20% replacement. The above findings are supported by structural matrix of mortar mixes that was examined using scanning electron microscopy (SEM) images, Fourier-transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD). Utilizing DLW as a partial substitute for traditional river sand could aid in the conservation of finite natural resources by providing an alternate form of construction.

Swati Jain et al (2016) Marble, granite, lime stone, and Kota stone are just a few of the infinite sources of dimensional stones that may be found in Rajasthan. One of Rajasthan's well-known industries is the production of Kota stones. The demand for Kota stone is growing, which has caused a significant amount of waste to be produced during mechanical processing in the form of slurry and solid waste. Recycling of industrial wastes and byproducts is becoming a crucial requirement by the environmental laws in accordance with the concept of sustainable development because improper waste disposal has resulted in land degradation, loss of aesthetics, pollution, health and safety hazards, and hazards to the environment. Many organic and inorganic components found in Kota stone waste can be converted into many useful, valuable, and easier-to-access forms. Through XRF, the chemical composition of Kota stone debris was analyzed. This research identifies the existence of a few micro, macro, and ultra-micronutrients that have a great deal of potential as soil amendments and may be helpful for the proper development of the plants.

Ganesh Nimbark et al (2020) Today, an economy's development can be seen in the expansion of its industries. Clearly, this growth will increase the demand for their residue disposal. Although it requires a sizable amount of precious land, land dumping is one of the conservative methods for disposing of these kinds of industrial waste. Due to the demands for sustainability, there are now a number of alternatives that suggest these waste materials will be used as a construction material in a variety of civil engineering applications. Slurry and waste Kota stone contribute to environmental pollution in the vicinity of mining and industrial areas. For the proper disposal of Kota stone waste, there is no technology. By dumping waste throughout the area, numerous heaps of Kota stone waste aggregate were produced. An experimentally based study was conducted in a lab with the goal of achieving sustainability by reducing, recycling, and reusing these waste aggregates up to the point of best use in order to lessen the impact of these types of residuals on the environment. The potential use of stone mine and cutting waste as an aggregate in concrete mixes has been supported by numerous studies. Different percentages of Kota stone aggregates (KSA) were substituted with natural aggregate to test the effectiveness of the material. These percentages were 0%, 10%, 20%, 30%, and 40%.

Adel Djellali et al (2017) Different laboratory and fieldwork tests were performed on a pavement construction to understand and forecast how flexible pavement will behave over expanding soils. The old pavement was replaced with a new one that was developed using the California Bearing Ratio (CBR) approach. Over the course of six months, the new pavement was subjected to traffic loads ranging from 12.1 to 155.52 cycles of standard axle load (80 kN). Deflection measurements were made at the asphalt surface layer utilizing a Total station at various distances depending on truckload applications as the first stage. The 2012 version of the Finite Element software program PLAXIS is used to conduct the numerical analysis. The pavement was exposed to a static loading using a ratio factor of dynamic additional charge in the new model, where the computation of the imparted pressure to the pavement through the contact area of tires is a 3D problem that was converted into a 2D problem. Nonlinear models were used to simulate the behavior of the materials under saturated, drained, and undrained conditions: Mohr-Coulomb (MC) for pavement layers and soft-soil model (SSM) for the expanding subgrade. According to the findings, field measured deflections are most closely matched by displacements under static loading in saturated drained circumstances and when non-linear materials are present.

METHODOLOGY

The current study focuses on using quarry and polishing waste from locally accessible limestone (also known as Kota stone) as flexible pavement material. With studies on using limestone quarry waste as flexible paving material, the review procedure was launched. The pavement layer, or subgrade, is the basis for this paper's research.

EXPERIMENTAL DESIGN

Kota stone slurry and stone samples were obtained at the road material testing laboratory of MNIT Jaipur to evaluate them as black cotton soil pavement material. Black cotton soil (BCS) and mining debris were obtained, Kota stone slurry (KSS), and landfill sites in the Kota and Jhalawar region, respectively. The material was gathered from five different disposal sites in an effort to account for any variations in quality. Waste from the quarry was brought to the crushing location and processed through a commercial jaw crusher into aggregates with sizes ranging from 19 mm to 0.75 mm. At the Malaviya National Institute of Technology, chosen samples of Kota stone quarrying and cutting waste were used to create aggregates larger than 19 mm, which were then manually crushed. The in-situ soil sample had lumps and dampness. Before beginning the experimental investigation, the material was visually checked for the presence of any impurities, such as pebbles or stone, and any found were removed.

Soil Subgrade: Experimental Investigation and Sample Preparation

a) Chemical Analysis the Centre for Development of Stones, Jaipur, determined the chemical makeup of Kota stone slurry and Black cotton soil. Table No. 4 contains an overview of test results. 2. Calcium oxide was the main component of the Kota stone slurry (37.15%), whereas silica dioxide (SiO_2) accounted for 65.45% of the black cotton soil sample.

b) Sieve Analysis Sieve analysis was done to ascertain the distribution of particle sizes in the slurry and soil. Mechanical sieve analysis was used to determine particle size higher than 75 microns in accordance with IS 2720 part IV (1985). Using a laser diffraction particle size analyzer, the distribution of particles smaller than 75 microns was determined.

c) Atterberg limit Based on the liquid limit (LL), plastic limit (PL), and plasticity index (PI) characteristics of the soil, classification was done. The Casagrande device is used to calculate the liquid limit, which is the percentage of water content at which soil transitions from a liquid to a plastic state. The plastic limit is the water content percentage at which a soil sample transitions from a plastic to a semi-solid state. The Plasticity Index is the result of LL and PL's difference. According to IS: 2720 Part V (1985), which is depicted in Figure 1, the LL, PL, and PI of each replacement mix were calculated. Before using the mixture that passed a 425-micron sieve for testing, soil and slurry were first mixed uniformly in the desired proportion for the test samples.

Figure 1 Liquid Limit and Plastic Limit Testing

d) Optimum Moisture Content and Maximum Dry Density The process of mechanically applying stress to soil in order to increase its density is known as soil compaction. Air between soil particles is displaced by the application of stress. By acting as a lubricant, the addition of water makes it simple for soil particles to move over one another while being compressed, creating a structure that is much denser. Reduced dry unit weight occurs when water is added in excess of what is optimal because it fills spaces that soil grains would have otherwise filled. Therefore, the ideal water content results in the maximum dry density. The Standard Proctor test was carried out in accordance with IS: 2720 part VII to determine the ideal water content (OMC) and maximum dry density (MDD) of soil samples. Each sample was cast in a detachable collar and base plate mold in three layers. Each layer received 25 blows from a hammer weighing 2.5 kg while falling freely from a height of 30 cm.

e) California Bearing Ratio (CBR)

Test The CBR test is used to gauge the soil's ability to support loads. A penetration test is a CBR. It is the ratio of force per unit area needed for a plunger with a diameter of 50 mm to penetrate test soil at a rate of 1.25 mm/min to the force needed for a standard material to penetrate at the same rate, represented as a percentage. According to IS 2720 part XVI, a soaked CBR test was conducted (1987). Samples were collected at their respective OMCs and immersed in water for 96 hours at room temperature with a surcharge weight of 2.5 kg.

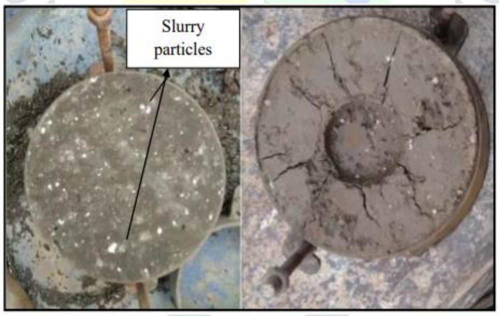

Figure 2 CBR Sample Before and After Testing

RESULT AND DISCUSSION

Kota Stone Slurry and Aggregates as Pavement Material

In the current study, the physical and chemical characteristics of black cotton soil (BCS), Kota stone slurry (KSS), and recycled Kota stone aggregates (KSA) were assessed. 10 soil samples prepared by substituting KSA for basalt aggregates between 2.5% and 20% were assessed.

Soil and Slurry Properties

Table 1 provides an overview of the geotechnical characteristics of soil and slurry. Table 2 provides a summary of the chemical make-up of Kota stone slurry/aggregates. This substance is limestone because calcium oxide is its predominant component. To increase the properties of soil, stabilizers based on calcium oxide have always been preferred. Studies on the successful application of limestone waste as a stabilizing agent for black cotton soil, as summarized in the literature review, imply that this waste can also be used to stabilize black cotton soil found nearby.

Table 1: Properties of Black Cotton Soil and Kota Stone Slurry.

Parameters	BCS	KSS	Code
Soil Type	CI	-	IS: 1498 (1970)
Liquid limit (%)	49.2	23.90	IS:2720 Part V (1985)
Plastic limit (%)	20.1	Non-Plastic	
Optimum moisture content (%)	20.5	21.9	IS: 2720 Part VII (1980)
Maximum Dry density (gm/cc)	1.524	1.604	
Specific Gravity	2.62	2.87	IS: 2720 Part III (1980)
Fineness Modulus	5.17	2.16	IS: 383 (1970)

Table 2: Chemical Composition of Black Cotton Soil and Kota Stone

Chemical composition (in %)	CaO	SiO_2	MgO	Fe_2O_3	Al_2O_3	LOI
Black cotton soil	6.15	65.45	2.01	4.98	Traces	Nill
Kota Stone	37.15	23.14	7.02	Traces	Nill	31.89

*LOI= Loss on ignition

a) Gradation

Black Cotton Soil (BCS) and Kota Stone Slurry (KSS) material passing grades are depicted in Figures 3, 4, and 5, respectively. According to the results of individual particle size distribution tests, KSS is finer than BCS. Compared to KSS, where particle sizes range from 0.5 microns to 100 microns, the majority of 75 microns passing BCS particles are between 10 and 100 microns in size.

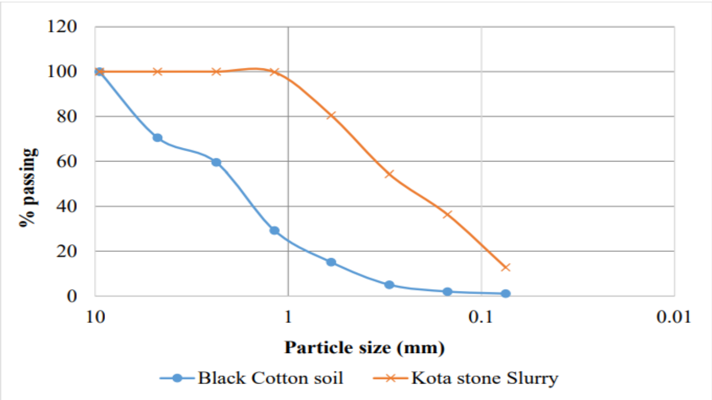

Figure 3: Gradation of Soil and Slurry Particles.

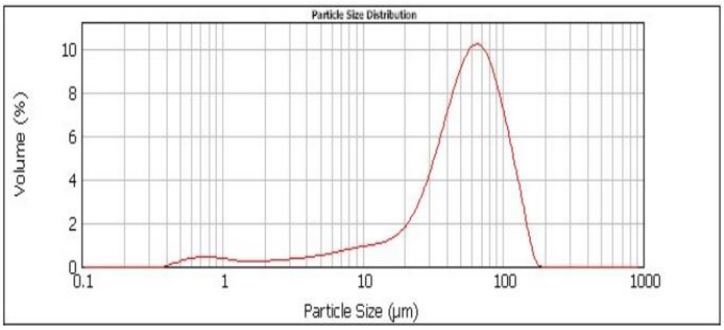

Figure 4: Particle Size Distribution (finer than 75 microns) of Black Cotton Soil.

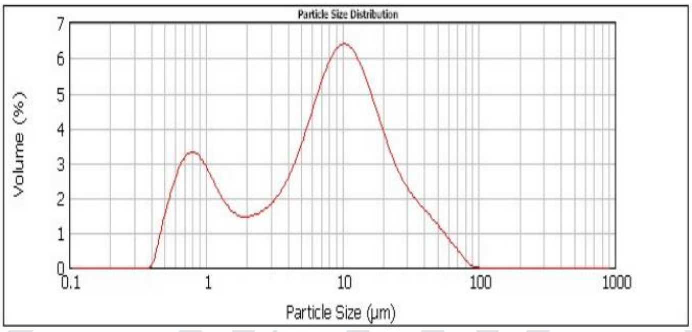

Figure 5: Particle Size Distribution (finer than 75 microns) of Kota Stone Slurry

Black Cotton Soil- Kota Stone Slurry Mixes

a) Index Properties

the results of replacing Black cotton soil (BCS) with Kota stone slurry in terms of liquid limit, plastic limit, and plasticity index the addition of slurry to the soil samples caused the liquid limit to drop and the plasticity limit to rise, which in turn caused the soil's plasticity index to drop overall, indicating improved workability of the mixture. This was also observed during sample preparation for the proctor test and the CBR test, where a higher slurry proportion in the mixes made mixing, casting, and removing the material from the mould easier than it did for the control soil sample. The cation exchange reaction between clay particles and calcium ions in the slurry was thought to be the cause of the decreased plasticity index because it caused flocculation of the particles, which act like silt particles. When 20% slurry was added to the soil, the classification of the soil under IS 498 (1970) changed from lean clay to mild silt, depending on the liquid limit value and plasticity index that were discovered.

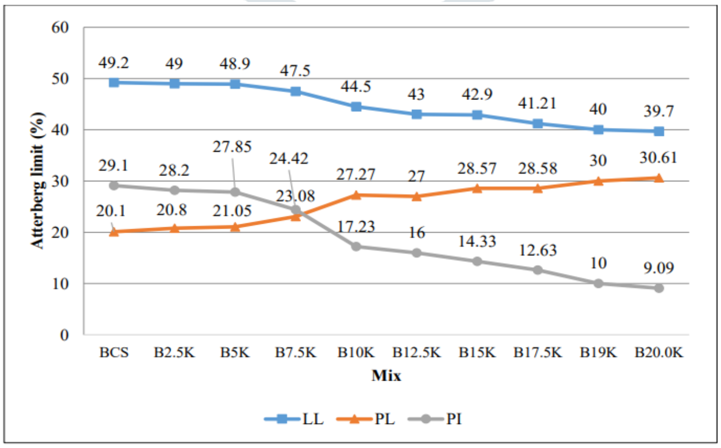

Figure 6: BCS-KSS Atterberg Limits.

b) Optimum Moisture Content and Maximum Dry Density

OMC and MDD of samples produced by adding slurry of Kota stone. According to an overall analysis of OMC data, the water needs and maximum dry density of soil samples followed a trend that increased with the addition of slurry. A higher percentage of slurry particles with a smooth texture was blamed for the increase in water needed for lubricating (Modarres & Nosoudy 2015). With the addition of the slurry, a firm cementitious matrix was created with an enhanced maximum dry density. When 19% of the original soil was replaced, the MDD of the soil increased to 1.66gm/cc, but the MDD of the mix decreased as a result of an increase in the volume of voids caused by flocculation and agglomeration of soil and slurry particles.

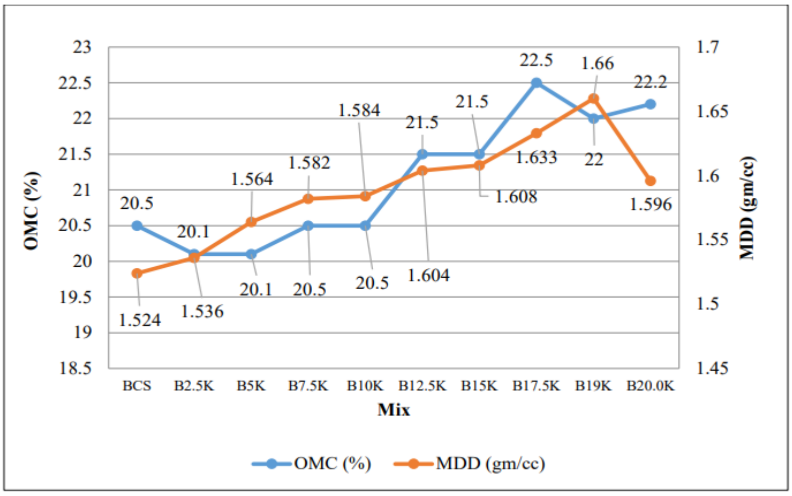

Figure 7: BCS-KSS OMC and MDD

c) California Bearing Ratio

the results of soil sample CBR tests after being saturated. After adding 19% slurry, the CBR value rose from 2.05% of the neat soil sample to 15.63%, then fell. The improvement in bearing capacity was more noticeable when the mix's slurry proportion exceeded 7.5%. This behavior was explained by the fact that, up to 7.5%, KSS was filler material that filled spaces left by clay particles. After 7.5% replacement, pozzolanic components found in the addition were blamed for the sample's increased strength (Bell 1996). When slurry is added to soil samples, pozzolanic activity occurs in immersed water, resulting in the formation of calcium silicate hydrate gel, which has better strength properties. The usage of Kota stone modified black cotton soil as a subgrade in flexible pavements was determined based on test results.

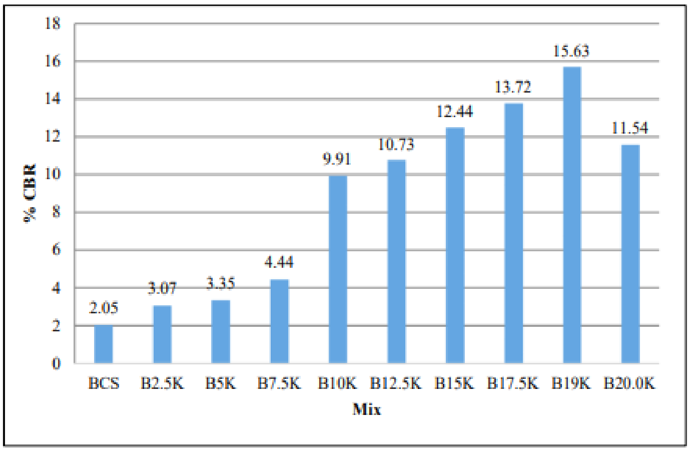

Figure 8. BCS-KSS CBR

CONCLUSION

In the current study, an effort was made to use waste generated during the processing of the locally accessible Kota stone mining as a construction material for the flexible pavement. Despite meeting specifications, Kota stone aggregates were found to be subpar to basalt aggregate. The results of the tests demonstrate that mixes containing Kota stone aggregate outperform conventional stones under typical test conditions. However, under challenging test conditions, the hot asphalt mixtures with the aforementioned Kota stone aggregates performed poorly.

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