

Reusing Effectiveness of Kota Stone Quarry Residues on Concrete Mix Design

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ABSTRACT

Today, the development of any nation is reflected with its growth of industries. This growth will defiantly rise their residues disposal demand. The land dumping for disposal of such types of industrial waste is one of the conservative methods but it requires a very large precious area of land. Now a days, due to the sustainability demands, there are various alternatives are available which indicate that these waste materials will be used as a construction material in various civil engineering applications. The Kota stone Waste aggregate and slurry creates environmental pollution problem in the surrounding of mining and industrial area. There is no technology for proper disposal of Kota stone waste. There is large number of heaps of Kota stone waste aggregate created by dumping the waste surrounding the entire region. To decrease the influence of these types of residual on environment an experimental based study was conducted in laboratory, which was aimed to attain sustainability by reducing, recycling and reusing of this waste aggregates up to the optimum use. Numerous studies advocated the potential of stone mine and cutting waste as an aggregate in concrete mixes. For inspect the efficacy of material, different percentage of kota stone aggregates (KSA) replace with natural aggregate (0%, 10%, 20%, 30%, 40%) and evaluated various mechanical characteristics of concrete mix.

Keywords:-Quarry waste, sustainability, mechanical properties, workability, concrete mix, compressive strength

INTRODUCTION

Worldwide, the industrial residues generation rate reaches its maximum limit as compared to their utilization. In other hand construction rate is also increases which leads higher demand of natural aggregates, thus today aggregates have become an important commodity (Berwal et al., 2014). Mining and excavation of these natural resources have grown exponentially leading to its depletion at a rapid rate. Hence, this is need of the hour to find an alternative source of these natural aggregates. There are many natural stone wonders the earth offers us which we must pamper as unique treasures. India

offers a variety of natural stone viz; Granite, Sandstone, Slates, Kota stones, Quartzite, Kota stone in multi colours, shapes and size. Unique to the region of Kota, the exclusive range of Kota stone is easily available in the natural surroundings. Made up of limestone, Kota stones are usually preferred for interior decoration of an apartment. The suddenly growth of industries of Kota stone, generates a hazardous slurry dust at a large extent which creates a problem to the humans surrounding them as well as acts as a industrial pollutant so affect the ecological system of the environment. It is a type of a solid waste which is generated

from cutting and polishing of stone. Kota stone is found in Kota and Jhalawar District of Rajasthan and is widely used as decorative in house and office in the form of tiles and floor lying. Due to its enormous popularity among buyers and sellers, its mining has increased at a rapid rate and so is its wastage. Every year about 2.50 to 3.00 lakh million tons of stone polish (slurry) and 175 million tons of quarrying waste is produced, it is discharged into convenient local places during the process of cutting and polishing in the form of stone chips, fine slurry powder, and boulders which pose significant environmental and ecological threat. Researches are going on all over the world to use kota stone residual as a various mode of construction material in civil engineering.

The Recycling Techniques are being implemented all around the world to overcome the problems of waste materials and many countries has proved the effective use of these waste materials in the construction work without harming the environment and protecting the natural resources. Various literature study is available where quarry and mine waste used in partial substitution of aggregates in concrete mixes such as effectiveness of steel slag, glass, marble waste was used in different pavement layers (Sharma et al., 2016; Behiry 2013;). Ibrahim et al. (2009) use marble dust as replacement of fine

aggregate. Bekoe[12] assessed the suitability of utilization of concrete containing recycled concrete aggregate (RCA) in concrete pavement application. Keun-Hyeok Yang et.al.[13]investigated the effect of type and replacement levels of nine recycled quarry based aggregate concrete and a control concrete using only natural aggregates on the properties of concrete. Similarly, and [1-10] reported the effectiveness of quarry mine based waste residues in form of aggregates as a constructional material in civil engineering.

In aforesaid lectures it is clear that, the quarry-based aggregates potentially used a partial substitute of nature aggregates (NA). In this study, a potential has been made towards replacement of NA with various percentage of kota stone aggregates (KSA) (0%, 10%, 20%, 30%, 40%) and finding the optimum composition for concrete mixes.

SCOPE AND OBJECTIVES

The Kota stone Waste aggregate and slurry creates environmental pollution problem in the surrounding of mining and industrial area. Due to lack in research and development study on kota stone waste proper disposal of kota stone waste in not done. There is large number of heaps of kota stone waste aggregate created by dumping the waste surrounding the entire region (Figure 1).



Fig.1:-Disposal of slurry waste near road side

The main objective of this project is to analyse the potential use of kota stone waste aggregates in Concrete mixes and its effect on mechanical and strength behaviour of the concrete made by it. The goal of this research work was focused on making a suitable mix design for the appliance of KSA as a coarse aggregate and analyse the compressive strength, and characteristics of concrete of grade M20. The main objectives of this study are:

- To study mechanical characteristics of Natural Aggregate and Kota stone Aggregate.
- To study Compressive strength for Pavement Quality Concrete (PQC).
- Specimen testing for compressive strength test after 7 days and 28 days for PQC.
- To determine the optimum dose of Kota stone Aggregate for Mix Design.

MATERIALS AND METHODOLOGY

Materials Used

The following raw materials according to suitability and availability of source have been used which are described here:

Sand

Kalisindha river sand was used in this study which was collected locally and tested for water absorption, surface moisture content, specific gravity and gradation using sieve analysis. Sand use was of zone I sand as per IRC15:2011 (Zone I).

Natural Aggregate (NA)

The basalt rock-based aggregates were used of nominal size of 10mm and 20mm in the ratio given in the respective standard. The aggregates were collected locally and tested for water absorption, surface moisture content, specific gravity and gradation using sieve analysis.

Kota Stone Aggregate (KSA)

Kota stone waste aggregate collected from local industry of kota stone tiles in waste cutting stone form. Afterward, by the use of crusher (Figure 2) cutting stones were crushed in small pieces by completed the gradation with the help of the sieves and get 10mm & 20mm size aggregates. Kota stone aggregates are quite impervious, hard, compact in nature. The physical properties of KSA is presented by Table 1.



Fig.2:-Crusher used for crushing

Table 1:-Physical properties of kota stone

Properties	Values
Compressive Strength (kg/mm ²)	21.75
Abrasion value (%)	18.12
Oil Absorption (%)	Nil
Water Absorption (%)	0.31
Density (Kg/m ³)	2.5- 2.65
Porosity	Quite Low
Weather Impact	Resistant

Cement

The Ordinary Portland Cement of grade 33 (OPC33) was used as per IS: 1489-part-1(1991). The specific gravity of cement

was recorded as 3.19. The Physical and Chemical Properties of Cement is presented in Table 2 and 3 respectively.

Table 2:-Physical properties of cement

Cement Tests	Result	IS Standard Used
Fineness of Cement	2.86%	IS: 4031-part-1 (1996)
Consistency of Cement	29.24%	IS: 4031-part-4 (1988)
Initial Setting Time	30 minutes	IS: 4031-part-5 (1988)
Final setting time	600 minutes	IS: 4031-part-5 (1988)

Table 3:-Chemical characteristics of cement

Chemical Compositions	Value (%)
SiO ₂	20
Al ₂ O ₃	6
Fe ₂ O ₃	3
CaO	63
MgO	2
SO ₃	1.5
Na ₂ O + K ₂ O	1.2
Loss on ignition	3.3

METHODOLOGY

The methodology section of present work contains determination of mechanical characteristics of the raw materials used in mix design, preparation of concrete mixes (substitution of various percentage of KSA along with NA), casting, curing and testing of specimens, evaluation and analysis of results and their discussion.

Firstly, the experimental investigation carried out to observe the suitability of KSA over NA. For this various property of aggregates, such as impact value, abrasion value, water absorption and specific gravity were checked as per relevant Indian Standards (Table 5) for various compositions of KSA and NA. Afterward, the workability of concrete mixes was checked using KSA Aggregate.

A control mix for concrete was made with 466.67 kg/m³ of Ordinary Portland Cement (OPC) with water/cement (w/c) ratio of 0.40. Concrete mixtures were then prepared by replacing 0%, 10%, 20%, 30%, and 40%, replacement of NA with KSA in control mix. Workability and compressive strength of about 30 cubes of

various aforesaid compositions, at 7 days and 28 days were tested and recorded. The Compressive Strength Test of hardened concrete was applied after 7 days and 28 days curing of the samples. For compressive strength test 3 cubes of nominal size 150x150x150mm is taken and their surface area is determined by measuring dimensions of cube. Compressive strength is calculated by dividing maximum load applied on the sample with cross-sectional area. So cross sectional area should be measured before doing this test because small variation in area causes deviation in compressive strength. The maximum load applied on all three samples was noted down and the average values of these three samples were taken as compressive strength of the concrete sample.

Mix Proportioning for Concrete Mix Design

The mix proportioning for *Concrete Mix Design* for M20 grade as per IS: 10262-2009 of was carried out compliant with IRC: 15-2011. The Table 4 Represents the Materials quantity for concrete mix design.

Table 4:-Material quantity for concrete mix design casting D0% to D40%

Particular	D0%	D10%	D20%	D30%	D40%
Cement (Kg)	466.67	466.67	466.67	466.67	466.67
NA 20 mm (Kg)	699.85	433.18	503.70	573.92	648
NA 10 mm (Kg)	699.85	433.18	503.70	573.92	648
Sand (Kg)	699.85	699.85	699.85	699.85	699.85
KSA 20 mm (Kg)	0	299.85	225.77	151.70	77.03
KSA 10 mm (Kg)	0	299.85	225.77	151.70	77.03
Water (l)	244.44	244.44	244.44	244.44	244.44

***D0%, 10%, D20%, D30%, and D40%represents 0, 10, 20, 30, and 40 replacement of KSA by NA**

RESULT AND DISCUSSION

Aggregate Test

Various characteristics ofKSA and NA were analysed, recordedand to checked for suitability for the construction work. Table 5 shows the various physical comparative

properties of NA and KSA observed in laboratory. Afterward, various percentage replacement of KSA with NA carried out and same tests were repeated on all the combination of KSA-NA mixes.

Table 5:-Physical properties of NA and KSA

Properties	Indian Standard	KSA	NA	Permissible Limit
Specific Gravity	IS:2386 PartIII	2.68	3.0	2.5 – 3.0
Impact Value (%)	IS:2386 PartIV	18.78	10.87	30
Crushing Value (%)	IS:2386 PartIV	23.21	16.42	30
Los Angeles Abrasion Value (%)	IS:2386 PartIV	26.82	14.87	35
Combined Flakiness and Elongation Index (%)	IS: 2386 PartI	31.26	22.52	35
Water Absorption (%)	IS:2386 PartIII	1.6	0.7	2%

Effect of KSA on Impact Value of Aggregates

Due to application of sudden dynamic shock during and after the construction on aggregates, it may break down into smaller pieces. Impact value test gives the knowledge about how much impact load can be resisted by particular aggregate. Thus, aggregate should be sufficiently tough to resist their disintegration due to

impact. This distinctive property is measured by impact value test. The Figure 3 represents the variation in impact value of all the studied compositions of KSA-NA mixes. Results of impact test shows that, after replacing of KSA over NSA up to 40%, the impact value goes increases almost linearly but within the permissible values as prescribed in Table 5.

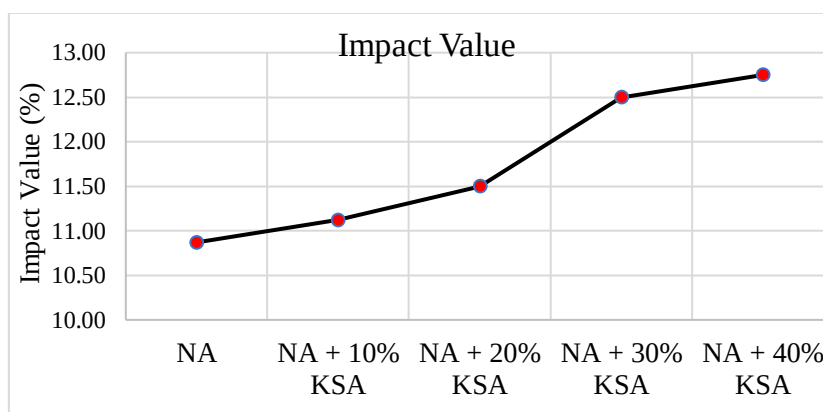


Fig.3:-Variation in impact value of all the studied compositions of KSA-NA mixes

Effect of KSA on Abrasion Value

Abrasion resistant on aggregate indicates the good hardness and capability of aggregates to resist the wear and tear. The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as an abrasive charge. The Figure 4, represents the variation in abrasion value of all the studied compositions of KSA-NA mixes. Results of abrasion test shows that, after replacing of KSA over NSA up to 40%, the abrasion of aggregates goes increases almost linearly or in other word the resistant efficiency of aggregates blends goes loosen against abrasion but still the results were comes within the permissible values as prescribed in Table 5.

Effect of KSA on Specific Gravity and Water Absorption

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregate. The Figure 5, 6 represents the variation in specific gravity and water absorption values of all the studied compositions of KSA-NA mixes. Tests Result represents that, after replacing of KSA over NSA up to 40%, the specific gravity of aggregates goes decreases and water absorption values goes increases almost linearly pattern but still the results were comes within the permissible values as prescribed in Table 5.

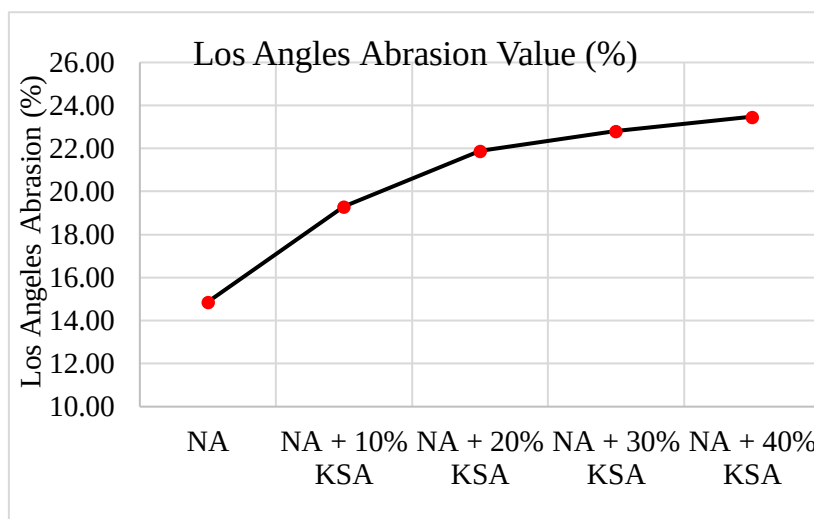


Fig.4:- Variation in abrasion value of all the studied compositions of KSA-NA mixes

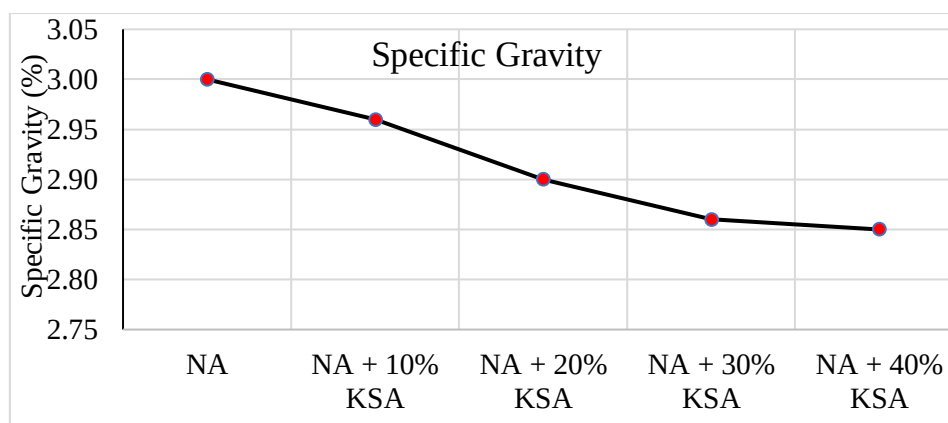


Fig.5:- Variation in specific gravity of all the studied compositions of KSA-NA mixes

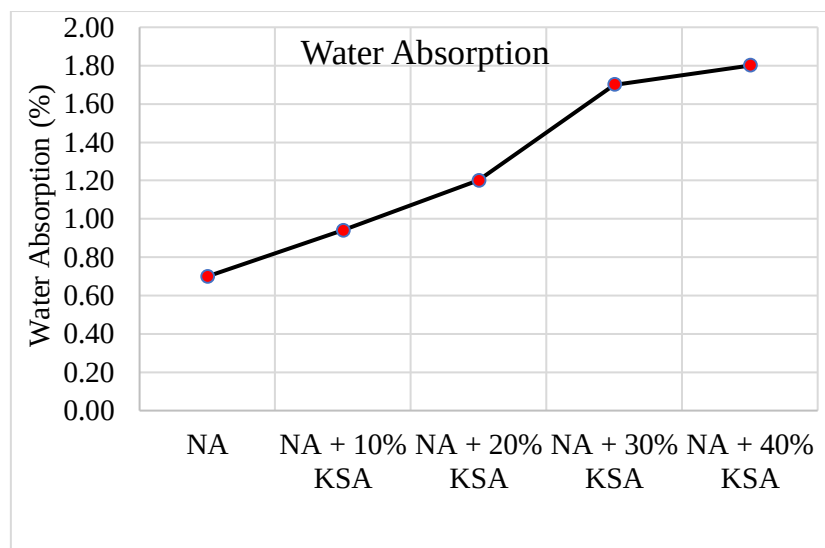


Fig.6:- Variation in water absorption value of all the studied compositions of KSA-NA mixes

Effect of KSA on Workability Slump Test

For measuring the workability of Slump Test was applied as per the rules of IS: 1199-1959. The slump was taken for every mixing of concrete with 0%, 10%, 20%, 30% and 40% replacement of KSA. The Figure 7 shows the results of slump test, from which it is revealed that concrete

made with natural aggregates has greater value of slump while the slump of concrete made with 40% replacement of KSA has lower value of slump but under permissible limit as prescribed in Table 5. The low slump in KSA is caused because of high water absorption of RCA which absorbs water during the blending process.

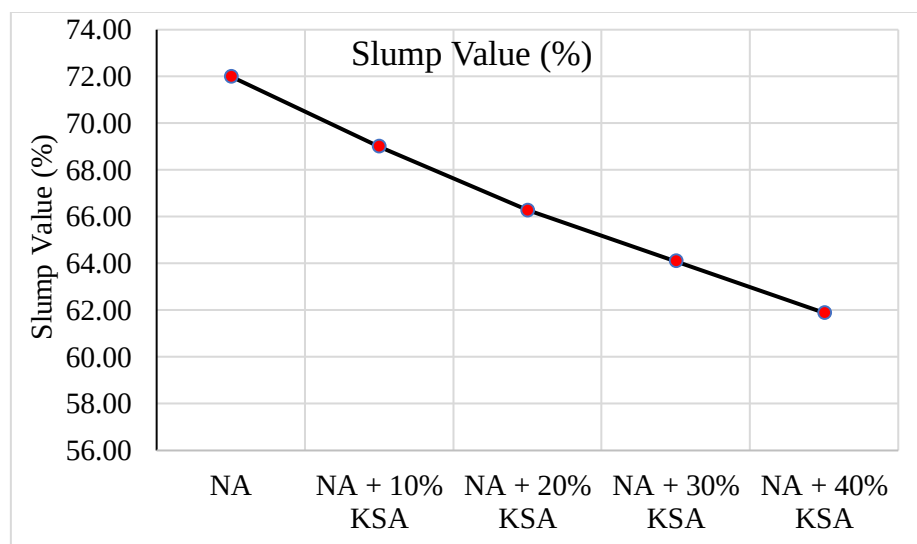


Fig.7:- Graph for Slump value at different % replacement of RA with NA

Effect of KSA on Compressive Strength

Following are the results of Compressive Strength Test at different replacement levels of NA with KSA. Figure 8 represents the variation in compressive strength of

concrete casted with different composition of KSA over NA and cured at 7 & 28 days respectively. It is revealed from the result that concrete made with natural aggregates has greater value of compressive

strength whereas concrete made with 40% replacement of KSA has lower values. But still the compressive strength results were satisfactory and helping for

user/engineering to choose appropriate percentage of KSA-NA blends corresponding to desired compressive strength.

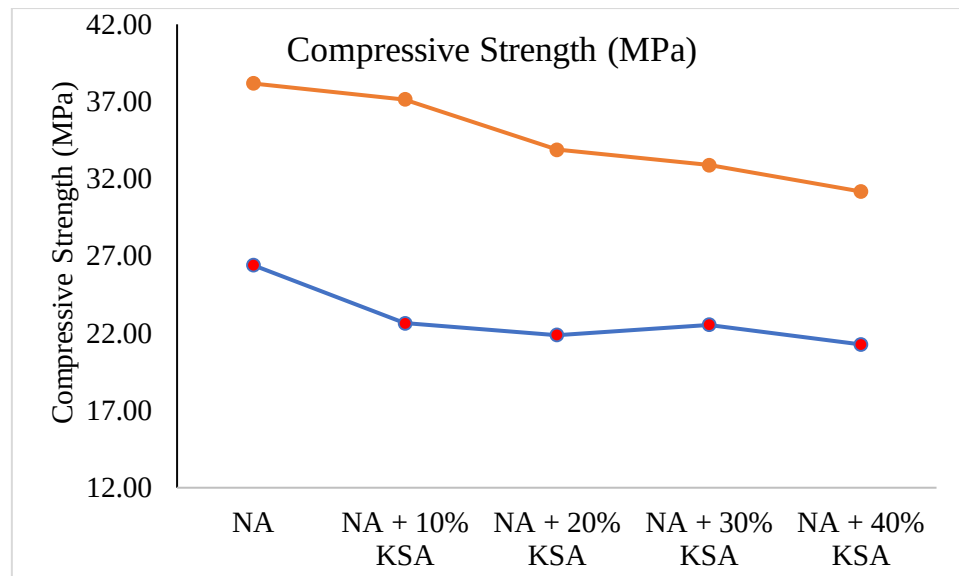


Fig.8:- Variation in compressive strength of all the studied compositions of KSA-NA mixes

CONCLUSIONS

The outcome of this extensive experimental based laboratory research work explores the opportunity of utilizing kota stone waste over precious natural aggregate. The Intention of this research work was set out to work out the extent up to which the NA can be replaced with KSA concrete work; so that new methods of application can be evolved which will study way to natural aggregate and effective utilization of kota stone aggregate waste thus reduces the industrial waste. By replacing NA at different percentage of KSA in the concrete layer given the appropriate results which are concluded as follow:

The impact and abrasion value of various blends of KSA-NA, increases as KSA substitution increases up to 40%. The impact value goes increases almost linearly but within the permissible values.

The specific gravity and water absorption value of various blends of KSA-NA were linearly increases and decreases

respectively as KSA substitution increases up to 40%.

The conclusions drawn from the above results are that use of up to 40% KSA can be permitted. The 28 days specified characteristics compressive strength remained within limits of average 28 days compressive strength of 3 samples not less than 20 MPa for 40% of KSA.

Results indicate that replacement of NA with KSA 20-40% is desirable, as its compressive strength and workability were within the permissible limits. However, depending upon the desired strength an engineer/ user will easily choose the appropriate compositions of NA-KSA mixes.

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