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CRITICAL REVIEW ON SUBSTITUTION OF NATURAL INGREDIENTS WITH THE DIMENSIONAL STONE CUTTING WASTE IN MAKING OF BUILDING PRODUCTS

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ABSTRACT

This paper critically reviews available literature on the utilization of different types of non-metallic minerals obtained from the mining wastes. India is endowed with an inexhaustible mineral resource in the form of coal mines, limestone, sandstone, iron ore, bauxite, and manganese to name a few. The mining industry in India especially the dimensional stone mining is progressing by leaps and bounds but at the same time it is also generating lot of wastes which goes for landfill creating significant environmental issues.. Huge quantities of mining wastes are produced during various operations such as exploration, extraction, processing, cutting, sculpting and polishing. The construction industry too adds to the environment burden ensuing from use of concrete, mortar that uses cement as binder and energy intensive masonry units such as burnt clay bricks. Production of all these construction materials leads to green-house gas (GHG) emissions, depletion of natural resources by extraction of fertile soil, change in land use, dredging of river beds for natural river sand used in mortar and concrete. A substantially viable solution to this looming problem is in tapping the prospects of diverting these wastes as full or fractional replacement of conventional ingredients in making of construction units. This manuscript presents a comprehensive review of the different forms of dimensional stone cutting waste (DSCW) used in manufacturing of building products such as masonry items as brick, blocks, concrete, mortar followed by review of the efficacy of these end products.

I. INTRODUCTION

There has been a long felt need for the alternative material and technology for the production of construction materials. The premise of "the need for alternative material/technology" is based on the current problems ensuing from the construction industry that exerts a tremendous strain on natural resources. The increase in demand and continuous exploitation of natural resources to cater to the never ending demand of raw materials needed for constructing infrastructure has eventually led to its shortage as well as harmful impact on environment thereby posing a major threat to people's existence [1, 2].

In addition to this, the construction industry involves highly energy intensive, resource depleting and immensely polluting processes such as the production of cement, dredging of river sand, quarrying of coarse aggregates, sintering of bricks etc. A number of activities carried out under the aegis of the construction industry such as extraction of resources, production and transport generates large volumes of green-house gases that have scathing effects on environment. It is imperative that the alternative material and technology must have potential to mitigate the cited problems. The search for alternative materials and its effective utilization appears to be inevitable in light of demand of new constructions besides sustaining the construction industry [3]. Researchers' world over have been trying to investigate and evaluate the efficiency of using alternative materials as fractional or total substitute for cement, fine aggregates, coarse aggregates, fertile soil to develop sustainable and environment friendly construction materials [4, 5].

The utilization of the alternative materials aids in reducing the burden on the depleting sources of natural raw materials, have low carbon footprints, being renewable or recycled are less energy intensive and can also offer higher performance. Some of the most known sources of alternative materials are derived from recycled materials, agro-waste, natural materials and industrial by-products. By incorporating the discarded materials into construction products helps in reducing the menace of improper waste disposal and yields a number of environmental benefits [6].

Apart from the known industrial by products, one such industry which has raised concerns due its generation of huge quantities of wastes in varied forms is the Mining industry [7]. The mining industry has a major contribution in the socio-economic development of the countries bestowed with natural mineral resources. India is blessed with huge deposits of mineral resources making mining industry to be very important industry that contributes significantly to its Gross domestic product. The mining industry offers an array of benefits in terms of employment and revenue generation, source of essential minerals crucial for infrastructural development, energy production and enhance of foreign investment to name a few. Despite of its significance, the industry draws flak owing to the harmful effects emanating from mining activities as well as from improper management of mining wastes resulting into pollution of water bodies, air, contamination of soils, degradation of soil fertility and land, human health risks etc. [7,8].

Dimensional stone mining is one of the specialized off-shoot of the conventional mining Industry. Several states of India are endowed with abundant reserves of natural stones and have become hub for dimensional stone mining and processing industry. Just like the conventional mining industry, this industry also yields waste that poses threat to human health and environment. The dimensional stone wastes comprise of two groups, the first being the solid natural stone wastes generated during drilling, cutting, process, quality control process. The second group comprises of dust, semi-slurry, slurry and cake.

A number of research studies have been carried out to study the integration of these dimensional stone mining wastes into the construction materials in order to reduce the negative impacts accruing from disposal of mining wastes. The review paper aims to provide a concise summary of the research papers investigating the potential of different forms of DSCW used to prepare masonry units, binder for these units, cement concrete.

II. THEORETICAL REFERENCE

II.1 DIMENSIONAL STONE IN INDIA – AN OVERVIEW

Dimensional stone is defined as any natural rock quarried and shaped as per required dimensions and specifications for use in production of monumental structures, sculptures and building and construction. American society for Testing and materials (ASTM) defines a dimensional stone as any rocky material that can be sawed or cut in slabs, may or may not have a mechanical finishing and the one that excludes artificial products such as aggregates, fragments and broken or ground stones. [9].The term dimensional stone is at times interchangeably used as an "ornamental stone" also in lieu of its decorative aspect. The two major attributes that make any natural stone to achieve fame as a dimension stone is its appearance and feasibility of producing rectangular blocks of suitable dimensions. [10] According to United States Geological survey (USGS), dimensional stones production is reported in 27 countries with a major share accounting to about 72% of production pouring in from China, Turkey, India, Iran and Italy. The commercial marketability of dimensional stone is governed by geographical origin and colour [11].

India is endowed with plethora of minerals deemed as the back-bone of its economic growth [12]. The mineral production in India covers metallic, non-metallic and minor minerals. The gross domestic product (GDP) contribution from the mining industry accounts to 10-11%. The mainstay of this review paper is the Dimensional stone mining Industry of India. The latter garners a special attention as India is bestowed with wide spectrum and enormous deposits of dimensional stones such as granite, marble, limestone, sandstone, slate and quartzite [13]. Granite, marble and limestone are most commonly used dimensional stones across the world.

India contributes 2/3rd of the world's output of dimensional stones. The dimensional stone industry in India owing to its large tracts of high quality dimensional stone started in 3200 BC. The architectural heritage of India bears a deep imprint due to its wide spectrum of dimensional stones. The ancient Indian civilization that is known for its innumerable temples, palaces and forts have been carved out of these locally available stones. Today India has made its mark in the world of stones with its large exports. The products of the dimensional stone industry range from blocks, flooring slabs, structural slabs, calibrated - ready to fix tiles, monuments, tombs stones, sculptures, artifacts, cobbles, cubes, kerbs, pebbles and landscape garden stones.

II.2 GENERATION OF WASTE FROM DIMENSIONAL STONES

The production process of dimensional stone involves three phases comprising of exploration, quarrying and processing. [14]. The exploration phase involves volume estimation, resource characterization, study of environmental, socio-political and economic issues associated with exploration. The process of quarrying involves the preparation of excavation site, cutting and extraction of large blocks to be converted into smaller blocks to easy the transportation of the latter to the processing plant. At the processing plants these blocks are cut into different sized products that are polished and smoothened to cater to customer satisfaction and demand in market. [15], defines the mining waste as by-products generated during the exploration, mining stages, physical and chemical processing and treatment of minerals. The residues, liberates and other valueless material produced during manufacturing and processing are defined as mine wastes by [16].

The dimensional stone mining involves extraction of large sized intact blocks of sandstone, limestone, granites, slates, etc. without minor cracks or damages by means of manual, semi-mechanized and fully mechanized mining machineries. The first step in this process of mining is the removal of the overburden which is present in the form of soil, rubble or non-splitable stones. [13]. According to Center for development of Stones (CDOS), the mining and processing of dimensional stones results in generation of huge quantities of stone waste in form of khandas, trimmings, other solid wastes and slurry. It is estimated that approximately 50% of waste is generated during mining operation and 15% during processing of stones. [17]. The cutting process of big stone blocks which is carried out using frame saw or gang saw generates lot of dust. Water as a coolant is continuously sprayed during the cutting and polishing of stone to reduce the heat generation. This dust laden water also known as slurry waste is generally dumped into the nearby lands or in roadsides [18].

III. MATERIALS AND METHODS

III.1 MINERALOGICAL COMPOSITION, GEOTECHNICAL, PHYSICAL AND CHEMICAL CHARACTERIZATION OF DIMENSIONAL STONE CUTTING WASTE (DSCW)

The dimensional stone cutting waste when used as a partial or total substitute in making of construction materials ought to be compatible with conventional materials in terms of its chemical and mineralogical composition. The Table 1 depicts the several important properties evaluated by the authors to validate the efficacy of reuse of DSCW in varied forms.

Table 1: Physical, geotechnical properties of DSCW reported by different authors.

Stone type	TType of waste	Specific gravity; Grain szie distribution	Mineralogical content	Ref
Granite	Granite sludge	2.58; Gravel- 0% Sand – 75% Silt – 25% Clay – 0%	Oligoclase, Microcline, Melilite	[19]
	Granite fines	2.46; Sand – 44.47% Silt – 51.03% Clay – 4.5%	-	[20]
	Granite dust	2.8; 60% finer than 75 microns	-	[21]
	Granite powder	2.19; 63% finer than 600µm, 17% finer than 150 µm	Quartz, Sodium feldspar, Mica- major minerals; Biotite, Calcite, Potassium feldspar – minor minerals	[22]
		2.46; Fineness modulus – 0.9	Quartz, Potassium feldspar (Orthoclase)	[23]
Limestone	Limestone slurry waste	2.59;36.4% finer than 150 µm	-	[24]
	Limestone powder waste	2.67;60.27% finer than 150 µm and 44.45% finer than 75 µm	-	[25]
Marble	Marble powder	2.71; Finer than normalized sand	Calcite, traces of quartz, feldspars, phyllosilicates	[26]
		2.70; 50% finer than 50 µm	Calcium & Magnesium carbonate	[27]
Sandstone	Crushed sandstone sand	2.59; Fineness modulus-3.41; Sand zone-I, 8% microfine content	-	[28
	Sandstone powder	2.51; Fineness modulus- 2.8	-	[29]
	Sandstone cutting waste	2.56; Fineness modulus- 2.8; Clay content less than 5%	Sub mature group and sub-arkose type	[30]
	Sandstone slurry waste	2.44; -	Quartz	[31]
	Dried sandstone slurry	2.62; 100% passing through 90 µm, Surface area (m2/kg) – 968.7	Quartz, Burnt ochre, Calcite, Chromium	[18]

Source: Authors, (2023).

III.2 USE OF THE DIMENSIONAL STONE CUTTING WASTE IN CONSTRUCTION MATERIALS

Many researches have been carried out in this area of utilization of the mining waste majorly obtained from the Dimensional stone industry. These wastes owing to their suitable chemical and mineralogical composition exhibit tremendous potential to be used as secondary raw materials in the making of bricks, blocks, concrete, mortar by partial or total replacement of conventional raw materials such as top fertile soil, sand, fine aggregates, coarse aggregates and cement. The Table 2 below summarizes the different types of mining waste and corresponding products, the percentage of raw material replaced and the properties evaluated to ensure the efficiency of the substitution.

Table 2: Dimensional Mining waste in making of construction materials.

Type of waste	Product formed	Composition/Substituion amount	Properties evaluated for final product	Ref
Granite fine waste	Building blocks- (i) Adobe and (ii)Mardini pressed soil blocks	(i) 46% Quarry dust + 46% Granite fines + 8 % cement (ii)30.6% Granite fines +30.6% locally available soil + 30.6% quarry dust + 8% cement	Moisture content, 28th day compressive strength	[20]
Granite dust & sludge lime	Bricks	(0-45)% of Granite dust + 10% of Sludge lime + (35-80)% of Class F fly ash + 10% of sand	7,14,21,28th compressive strength	[21]
Granite sludge	Compressed stabilized earth blocks	3 different mixtures with Sand (0, 30, 60)% + Red earth fines + Granite sludge (0, 30, 60)% + 4% cement 6 % Lime	Wet compressive strength, water absorption	[19]
DLSW	Mortar for masonry	Mortar of proportion 1:4 with natural river sand replaced in proportion of (10-100)% with DLSW	Workability, compressive strength, flexural strength, water absorption	[24]
Marble and granite	Concrete bricks	30% fine aggregates in ratio of 3:7 for coarse and fine sand prepared from mixed sizes of marble and	7,28 the compressive strength, Water absorption, Moisture and durability	[32]

Type of waste	Product formed	Composition/Substituion amount	Properties evaluated for final product	Ref
waste		granite + 50% coarse aggregate + 10% cement + Marble and granite slurry powder in range of 10-40%		
Granite and Marble sawing powder	Clay based Sintered Brick	Raw clay + Mixed waste in range of (0-50)%	Petrographic investigation, Compressive and flexural strength	[33]
Sandstone cutting waste	Concrete	Concrete with 3 w/c ratios 0.35,0.40, 0.45 with fine aggregates replaced with Sandstone waste in range of (0-100)%	Fresh concrete properties such as Slump, hardened concrete properties	[30]
Limestone powder waste and cotton	Brick material	Cotton waste : Lime powder waste replaces aggregates by 10%,20%,30%, 40% and in ratio of 40:20%	Compressive strength, flexural strength, USPV, water absorption, unit weight	[25]
Marble powder	Mortar mixes	Natural river sand replaced with marble powder in range of 0%-100% in steps of 20%	Workability, drying shrinkage, compressive strength, bond and adhesive strength, density, water absorption, dynamic young's modulus	[27]
Marble powder	Cement mortar	Cement mortar mixtures were prepared replacing portion of cement by marble powder by 5,10,15,20 & 25% and not exceeding 25%	Mechanical and physical tests	[26]
Waste granite powder	Cement mortar	Fine aggregate in cement mortar replaced by 30-40% by volume of waste granite powder	Workability, compressive strength, tensile bond strength, adhesive strength, water absorption, drying shrinkage, USPV, dynamic modulus of elasticity	[23]
Granite powder	Cement mortar	Mortar mix of 1:3 proportion with 85% NRS and 15% granite powder	Effect of fire exposure on compressive, flexure and split tensile stength	[22]
Granite stone waste	Red ceramics	Granite stone waste was incorporated in ceramic mass in 0-50% in steps of 10%Extruded specimens were sintered at 1050 – 1100 degrees	Density, water absorption, porosity, linear shrinkage and mechanical strength.	[34]
Waste marble powder	Clay bricks	Different percentage proportions of marble powder were considered as a partial substitute for clay, i.e., 5–30%	water absorption, bulk density, apparent porosity, salt resistance, and compressive strength.	[26]
Sandstone slurry	Cement concrete	Coarse and fine aggregate replaced with sandstone slurry in varying percentages from 0% to 30% in steps of 5%	Density of fresh and hardened concrete, depth of water penetration and carbonation, compressive strength and effect of sulphate attack	[31]
Sandstone cutting waste	Cement concrete	Fine aggregate replaced sandstone cutting waste in varying percentages	Slump, density of fresh concrete, Mechanical properties such as compressive, flexural, split tensile strength and abrasion resistance	[30]
Sandstone powder	Mineral additive for concrete	Cement replaced by sandstone powder in range of 20%,25%,30% and 50% by mass	Compressive strength and Alkali silica reaction in concrete	[35]
Quarry waste of sandstone	Normal strength concrete	100% of river sand replaced with crushed sandstone sand	Mechanical properties such as compressive, flexural, split tensile strength and Ultrasonic pulse velocity	[28]
Dried sandstone slurry (DSS)	Self-compacting concrete (SCC)	Portland pozzolana cement (PPC) partially replaced with DSS	Strength and permeability performance of SCC mixtures	[18]

Source: Authors, (2023).

IV. RESULTS AND DISCUSSIONS

IV.1 EFFECT OF THE DSW IN END PRODUCT

The Table 2 clearly presents the broad range of the potential use of dimensional stone waste as a replacement to cement, sand, coarse aggregate, soil in making of bricks, blocks, binder, cement mortar and concrete. The percentage of substitution of conventional materials by mining waste was ascertained by every researcher listed in Table 2, only after carrying out the preliminary investigation based on chemical, mineralogical, geotechnical and physical characterization of the various DSW used in different studies. The subsequent section attempts to collate the effect of using dimensional stone waste in the final product.

IV.2 DIMENSIONAL STONE WASTE IN MORTAR

The study assessed the replacement of fine aggregate by dried granite slurry powder in mortars of 1:4 and 1:6 mix proportions [23]. The mortar were prepared using combination of coarse sand of Zone-II with Granite powder were evaluated for adhesion strength, drying shrinkage and mechanical properties after exposure to salt crystallization and sulphuric acid medium. The research concluded that granite powder when used to replace

30-40% of sand in cement mortar mixes has no adverse effect on mechanical and durability properties of the cement mortar.
The mortar prepared by the researchers in [27] by partial substitution of natural river sand by 20% of marble powder results into dense microstructure besides the formation of superior quality of hydration products. 4 different proportions of mortar mixes were prepared by replacing the natural river sand by marble powder in range of 0% to 100% in steps of 20%. The research concluded that inclusion of marble powder in mortar reduces the water requirement, gives improved mechanical performance in terms of enhanced compressive, bond and adhesive strength. The mortar prepared with 20% partial substitution achieved a peak both in compressive strength and dynamic modulus of elasticity.

A study carried by [24] explored the suitability of dimension limestone slurry (DLS) as a replacement to fine aggregate in mortar. The authors reported that up to 40% replacement of river sand improved the workability at lower water/cement ratio. The water absorption and porosity of mortar mixes were found to be increasing with the increment in the percentage replacement by DLS. This was attributed to the higher water holding capacity of the latter. The maximum values of compressive strength and adhesive strength were reported at 40% replacement with water absorption and porosity also comparable to that of control mix.

The study by [26] evaluates the efficiency of marble waste as a replacement to cement in mortar. The cement was replaced in varying percentages from 5% to 25% at an increment of 5% for each mortar mix. The uniaxial compressive strength at the end of 28d of curing was reported to be decreasing with increase in percentage replacement. However for certain structural applications a partial substitution of less than 25% was found acceptable with a compressive strength obtained slightly higher than 43 MPa.

In one of the studies [22] the effect of elevated temperature and water quenching on mortar prepared by replacing the natural river sand (NRS) with 15% granite powder and 100% replacement of NRS with Manufactured sand (MS) is explored. The study found that in comparison to NRS mortar samples, the compressive strength, flexural and split tensile strength were enhanced for mortar prepared with Granite powder and MS. One important finding from the study was that all the mortar when exposed to elevated temperatures followed by rapid cooling by water quenching lost their strength at all temperature exposure levels.

IV.3 DIMENSIONAL STONE WASTE IN MASONRY UNITS

In a study by Algin and Turgut [25] the researchers investigated the use of Cotton waste (CW) and Limestone powder waste (LPW) combination for producing lightweight composite as an alternative to concrete blocks. The study shows that CW-LPW composition produces a composite that is 60% lighter than conventional concrete bricks with high energy absorption capacity. Compressed stabilized earth blocks (CSEBs) prepared by replacing sand present in soil with 0%, 30% and 60% of granite sludge are presented in a study by HB Nagaraj et al.[19] The CSEBs prepared with granite sludge have a wet compressive strength of more than 3.5 MPa, found to be doubled at an ageing of 5 years. The blocks are reported to be durable even after 12 cycles of alternate wetting and drying proving its suitability as load bearing masonry units.

Lokeshwari and K.S Jagdish [20] conducted a study on building blocks prepared by replacing the fine aggregates with granite fines. Sun dried Adobe blocks were cast by mixing cement, quarry dust and granite fines in *%:46%:46% and mardini pressed soil blocks were prepared by mixing 50% of locally available soil with cement, quarry dust and granite fines. The compressive strength of both the types of blocks were found to be greater than 3 MPa, making it acceptable to be used as a masonry unit in accordance to IS 1905. The particle size of the granite fines being finer ensures pore refining by filling of pores leading to increase in strength of building product.

Rania Hamza et al. [32] explored the making of concrete bricks using combination of marble and granite wastes of different sizes. The compressive strength, density and absorption of the bricks is found to be adhering to the Egyptian standards. The concrete bricks prepared using 100% replacement of aggregates by marble and granite mixed pieces and using 10% of granite and marble slurry complies Egyptian code requirements of structural bricks.

The marble powder in different percentage proportions ranging from 5-30% was used as a partial substitute to clay by Sufian et al., [36] in making of clay bricks. The clay bricks prepared using marble powder was found to be light in weight but with increase in portion of marble powder, there was a decline in bulk density, compressive strength and increase in porosity eventually increasing the water absorption capacity of the bricks. Hence the study recommended used of marble bricks in area with low moisture rate in air.

S.Dhanapandian et al., [33] evaluated the possibility of using granite and marble sawing waste as an alternative raw material in production of sintered clay bricks. Based on the results, it was inferred that both the types of the wastes can be added up to 50% into the raw clay material. The addition in percentage weight of granite and marble waste tend to increase the compressive and flexural strength with increase in the sintering temperature.

IV.2 DIMENSIONAL STONE WASTE IN CONCRETE

Mohammad Arif et al., [31] carried out a study to establish the efficacy of sandstone slurry as a partial replacement to total aggregate (coarse and fine) in concrete at same workability. Concrete grade of M20 with a water/cement ratio of 0.45 was prepared by using sandstone slurry replacing total aggregates from 0% to 30% at an interval of 5%. Workability of concrete mix was kept consistent by using varying dosages of super-plasticizers. The concrete mix was tested for various parameters such as compressive strength, flexural strength, water absorption and durability of prepared mix was tested against sulfate attack, acid attack, carbonation, permeability and sorptivity. The researchers found that the density of fresh and hardened concrete, compressive and flexural strength were found to be decreasing with increase in percentage replacement, however up to 15% replacement all the parameters were found to be favourable for use in structural concrete and beyond that the utilization of sandstone slurry was found useful for non structural purpose.

Sanjay Mundra et al., [30]carried out a study on concrete mixes in which the natural river sand (NRS-fine aggregate) was replaced with sandstone cutting waste in varying percentages ranging from 0%,10%,20%,30%,40%,50% and 100%. Sandstone cutting was procured from Rajasthan. Concrete mix design with three different w/c ratio of 0.35, 0.40 and 0.45 were prepared for each fractional replacement of NRS with sandstone cutting waste.

Properties such as workability, saturated and oven dry density of concrete mixes were measured. The study revealed that increase in replacement levels of sandstone cutting waste resulted in reduced workability attributed to higher water absorption by finer particles of SCW. The density of the concrete mixes were high only up to 25-30% replacement, beyond that the density was found to be decreasing due to lower values of specific gravity of scw. The compressive strength, flexural strength and tensile strength analysis was carried out for hardened concrete of the above mixes. The study concluded that compressive strength increases up to 10% replacement where else flexural and split tensile strength increases for mix with 25-30% replacement due to filler effect of waste.

Kusum Rathore et al., [28] used quarry waste of sandstone as a replacement to fine aggregate in making of normal strength concrete. A three stage crushing plant was used to crush the quarry waste resulting into crushed sandstone sand (CSS) used to replace 100% of river sand. Microfines that were generated during the sand manufacturing were also incorporated as a filler to finer aggregate. Parameters such as workability, compressive strength, flexural strength, split tensile strength and ultrasonic pulse velocity (UPV), abrasion resistance and permeability were studied. 6 concrete mixes were prepared by incorporating the microfines in increment of 5% from 0% to 25% besides the already 8% microfines present in CSS. The mechanical strength of mix with microfines in range of 10% to 20% were found to be improving at the end of 28 days with proper dosage of superplasticizers. The inclusion of CSS and microfines resulted in dense concrete with improved pore structure confirmed by the UPV tests. The permeability of mix upto 15% microfines were found to be less. The study recommended use of crushed sandstone sand with microfines in normal strength concrete of M30 grade.

Zhen He et al., [35] in their study evaluated the efficacy of finely grounded sandstone powder (SP) as a partial replacement to cement to improve the durability of concrete. This was ascertained by testing the pozzolanic behavior of finely grinded sandstone powder. The latter was to be increasing attributed to increase in specific surface area. The mixes were prepared by replacing cement with SP in range of 20%, 25%, 30% and 50% by mass. The hybrid batch with addition of 5% of silica fume with 25% and 50% of SP was also cast. The major conclusion of the study was that in case of the only available source of coarse aggregate is that of sandstone, then the finely ground SP can be used to improve the durability of concrete that can be hampered by possible alkali silica reaction (ASR) expansion owing to the reactive sandstone aggregates. A hybrid combination of SP and 5% of silica fume can also improve the compressive strength of concrete mix.

Prathita Basu et al., [18] studied the use of dried sandstone slurry (DSS) in strength and permeability of self-compacting concrete by partial substitution of pozzolana Portland cement (PPC). Six different SCC mixtures were prepared in which DSS replaced PPC in varying percentages from 5% to 30% in steps of 5%. Compressive strength and permeability in terms of water absorption, sorptivity and depth of carbonation was found favourable till 20% replacement of DSS as powder content in SCC. The surge in substitution quantity of DSS leads to increase in porosity, water absorption, and decreased compressive strength. The large surface area of DSS was instrumental in increasing the surface water absorption capacity resulting into a weak pore structure and rapid ingress of water.

V. CONCLUSIONS

Based on the review of various studies carried out by researchers on production of building products using different forms of dimensional stone cutting and mining waste, the following major conclusions can be drawn.

The review highlights of the potential of diverting the mining wastes as alternative to conventional ingredients used in making of different types of construction materials such as brick units, ceramics, compressed stabilized earth blocks, mortar and concrete. The paper highlights the importance of carrying out the basic characterization of mining waste to ascertain it's chemical, mineralogical and geotechnical properties as these parameters have a strong bearing on deciding the final composition prepared using the mining wastes. The comprehensive review presents the variety of building materials that can be produced using different types of mining wastes thereby aiding in reducing the menace causes due to these wastes when dumped in open lands. However the review also highlights shortcoming of many studies in the sense that many of the researches have limited evaluation of the efficacy of the final products only to the basic laboratory tests rather than extending it to the detailed evaluation. Some of the authors in their studies have used a combination of two or more wastes that eventually leads to increase in manufacturing cost of the end product. Many researchers have explored the possibility of using mining waste in preparation of ceramics or sintered bricks, however this does not serves the ultimate purpose of reducing the environmental strain as manufacturing of latter involves the burning of fossil fuels.

Thus it can be concluded that these mining wastes can prove to be a promising alternative to conventional renewable ingredients used in construction sector such as top fertile soil cover, natural river sand and coarse aggregates however a detailed study needs to be carried out before putting these in use in production of end products.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Poonam I. Modi.
Methodology: Poonam I. Modi.
Writing – Original Draft: Poonam I. Modi.
Writing – Review and Editing: Poonam I. Modi.
Supervision: Rajul K. Gajjar.
Approval of the final text: Rajul K. Gajjar.

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