

A State-of-the-Art Review on Suitability of Granite Dust as a Sustainable Additive for Geotechnical Applications

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Abstract: The increase in infrastructure requirement drives people to use all types of soils, including poor soils. These poor soils, which are weak at construction, must be improved using different techniques. The extinction of natural resources and the increase in cost of available materials require us to think of alternate resources. The usage of industry by-products and related methods for improving the properties of different soils has been studied for several years. Granite dust is an industrial by-product originating from the primary crushing of aggregates. The production of huge quantities of granite dust in the industry causes severe problems from the handling to the disposal stage. Accordingly, in the civil engineering field, the massive utilization of granite dust has been proposed for various applications to resolve these issues. In this context, the present review provides precise and valuable content on granite dust characterization, its effect as a stabilizer on the behavior of different soils, and its interaction mechanisms. The efficacy of the granite dust in replacing sand in concrete is explored followed by its ability to improve the geotechnical characteristics of clays of varying plasticity are explored. The review is even extended to study the effect of binary stabilization on clays with granite dust in the presence of calcium-based binders. The practical limitations encountered and its efficiency over other stabilizers are also assessed. This review is further extended to analyze the effect of the granite dust dosage for various field applications.

Keywords: granite dust; stabilizer; particle size; plasticity; unconfined compression strength



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1. Introduction

Soil stabilization is a technique used to improve the geotechnical properties of soil, either physically or chemically. Different types of stabilization methods exist, and each process varies with the type of additive used. Additives include lime, cement, bitumen geosynthetics, and some industrial by-products like flyash, slag, coal, and stone dust, chemicals, reagents, and recycled materials like rubber tire chips, waste plastics, and crushed glass that follows recent advanced bio-stabilization techniques like microbial-induced calcite precipitation and enzyme-induced calcite precipitation [1]. Among these stabilization methods, the most commonly adopted process is the addition of calcium-based materials like lime, cement, and flyash [2,3]. However, these additives have their own limitations in terms of carbon emissions [4,5]. Stabilization with lime and cement also causes a problematic expansion in the presence of sulphate [6]. In silica-rich soils, adding lime decreases the soil performance beyond its optimum level because the soil develops silica gel that withholds water and retains the soil plasticity [7]. Expansive semi-arid soils have been treated with lime and tested for their lime leachability. At 4% lime content, the lime leachability was minimized with increase in the curing period due to pozzolanic reactions [8]. The laterite soil when stabilized with lime caused a decrease in the unconfined compressive strength (UCS) and California bearing ratio (CBR) with the increase in the delay of compaction in hours [9,10]. High-plastic clays stabilize with lime, and the UCS and the coefficient of permeability increase with the increase in the delay of

compaction due to the formation of pozzolanic reactions [11]. The stabilization of sand with cement induces cohesion, but is not effective in developing interfacial friction [12]. Previous studies have shown that brittleness is associated with cement-stabilized sands [13]. Alkaline materials, such as cement, lime, and gypsum, make the treated soil brittle with concentration increase and alter the soil pH [14]. Polypropylene fibers and flyash–cement mixtures are used to improve the unconfined compressive strength of clay. The presence of composite cement turns the treated soil to brittle; however, due to the presence of fibers, the treated soil exhibits a plastic behavior upon load application [15]. In order to curb the usage of cement and respective alkaline materials, researchers are working on disposal wastes that act as a sustainable supplementary cementitious material. Recently, biopolymer stabilization of plastic and non-plastic fines is gaining attention owing to its sustainable approach and associated low carbon footprint emissions [16]. Coal gangue is another sustainable generated from the coal production process. Coal gangue utilization can reduce ecological issues, but due care should be given to associated leaching of trace elements [4,5,17]. Enzyme-mediated calcite precipitation is a technique used to improve the compressive strength of sand. The substitution of magnesium sulphate in enzymes yields a better improvement compared to conventional calcite precipitation [18,19]. Many other additives like polypropylene fibers, cement kiln dust, ground-granulated blast-furnace slag, and slag play a major role in stabilizing specific soils [20]. In the previous works, every stabilizer has been limited to some aspects (e.g., carbon emission, production cost, groundwater chemistry, change in soil pH, UV radiation, reactivity, etc.) that drive sustainable stabilizers. This review explores the potential applications of granite dust, a waste by-product, as an efficient stabilizer for improving the geotechnical properties of problematic soils, including Atterberg's limits, compaction properties, unconfined compressive strength, permeability, and California bearing ratio, among others. The mechanisms responsible are described based on the physicochemical characteristics of granite dust. The optimum dosage of granite dust in various soils for different applications is proposed to facilitate practical utilization.

Granite dust is an industrial by-product with an ever-increasing demand in the construction industry. It is deposited in huge amounts at quarry sites and crushing industries [21]. Granite dust is a non-plastic material that exhibits high shear strength with zero carbon emissions. The fine state of stone dust results in a large specific surface area. The physical properties, chemical composition, and mineralogy of stone dust vary with the type of parent rock, but is consistent with the quarry site [22]. Granite dust is an industrial by-product originating from the primary crushing stage of aggregates [23]. These are fine aggregates produced with particle diameters less than 4 mm [24]. The quality of a stone dust depends on the rock type, origin, and processing method. The global production of stone dusts from different plants is approximately 1.48 billion tons and produced by 1430 companies. On an average, a typical rock produces roughly approximately 400–500,000 tons of aggregate every year [25]. Approximately, 20–25% of this goes as unused material [26]. In India, approximately 200 million tons of quarry by-products is produced annually [27]. Mined boulders and blasted rocks from quarry sites are hauled into a crusher bin and fed to crushers [25]. Crushing can be done in three to four stages (i.e., primary, secondary, tertiary, and quaternary). In the primary and secondary stages, two major crusher units are fed with quarried rock to produce aggregates of different sizes determined by demand [25]. An overview of production of quarry fines is described in the Figure 1. Screening is done in each crushing stage to obtain a usable end product.

Table 1 shows that granite dust is an industrial by-product that has high density and zero carbon emission and is abundant and chemically inert with water. The specific gravity of granite dust is greater than the specific gravity of soils [21], which ranges from 2.6 to 2.8.

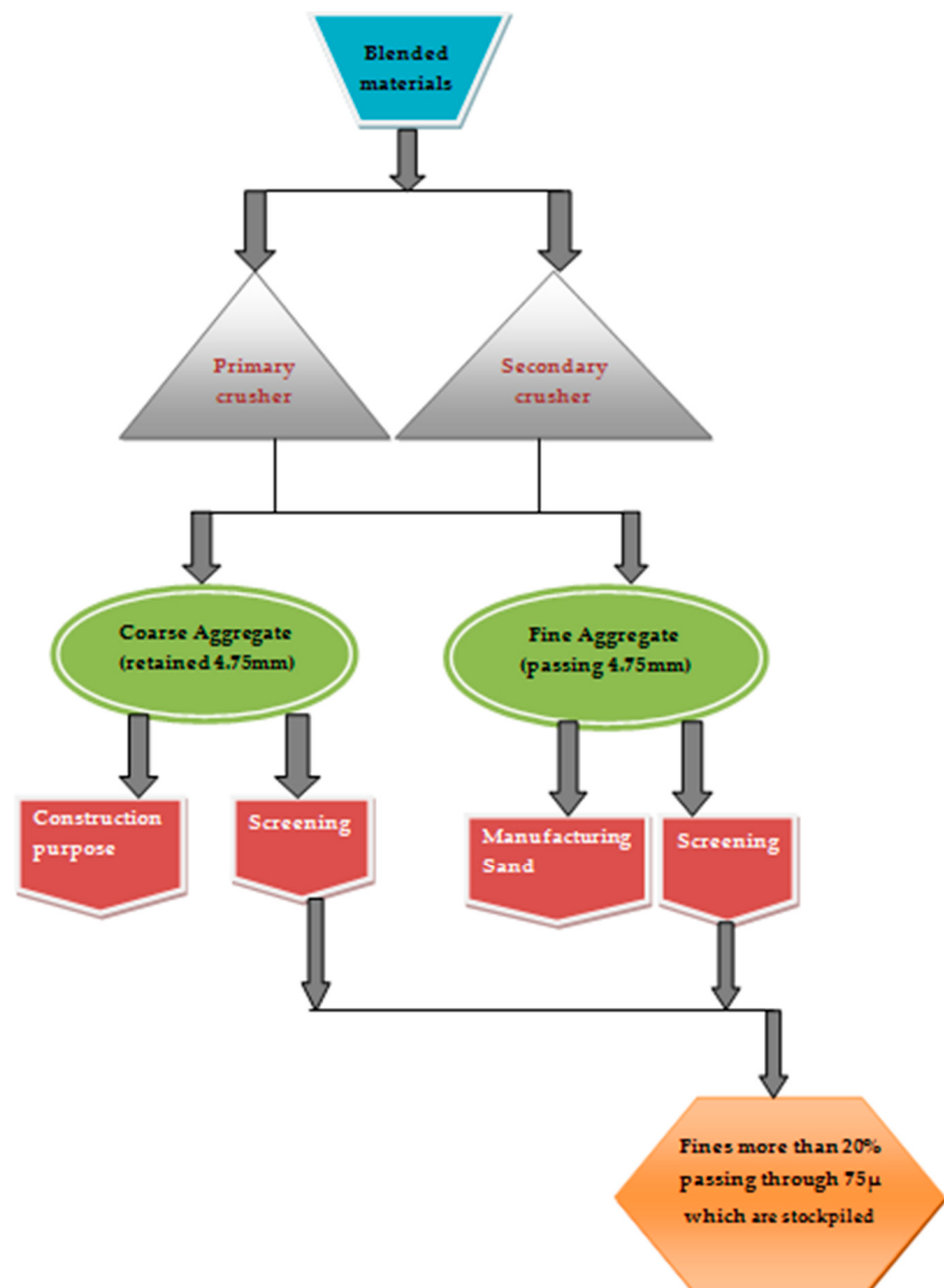


Figure 1. An overview of stages involved in the production of quarry fines.

Table 1. Applications of different types of stone dust.

Name of Rock Dust	Predominant Constituent	Specific Gravity	Civil Engineering Applications	Reference
Dolomite, metamorphic	Calcium magnesium carbonate	2.84	Aggregate, ballast, base material	[27]
Limestone, sedimentary	Calcium carbonate	2.7	Road base and railroad ballast	[28]
Shale, sedimentary	Silica	2.62	Fills and embankment	[29]
Sandstone, sedimentary	Silica	2.5	Replacement of natural sand	[30]
Granite, igneous	Silica	2.7	Filler, subgrade, replacement of natural sand and sub-base	[31]
Marble, metamorphic	Dolomite, quartz, and calcite	2.71	Filler in concrete production	[32]

2. Physical and Chemical Properties of Granite Dust

2.1. Morphology and Mineralogy of Granite Dust

The physical appearance of granite dust changes with topography. The X-ray diffraction and scanning electron microscopy (SEM) of granite dust show mineralogy and morphological variations. Granite is an intrusive igneous rock formed from magma. It is predominantly white, pink, or gray in color. These rocks mainly comprise feldspar, quartz, mica, and amphibole minerals. Dust formed out of granite quarry and aggregate crushing plants varies in the physical appearance of granite dust relevant to location. Table 2 presents petrological details of different granite dusts sourced from different parts of the world.

Table 2. Petrological details of granite dust(s) from different regions of the world.

Location	Petrographic Description	Mineralogy	Reference
Thane, Maharashtra, India	Irregular shaped angular particles	Quartz from XRD	[33]
Local quarry in Kedah, Malaysia	Granular, irregular and angular geometry	Quartz, Microcline, Calcium Aluminium Silicate, Kaolinite, Magnesium Sulphate Hydrate from XRD	[31]
Quarry dust from local crushing plants, Guwahati, Assam, India	Sub-angular to angular	Quartz and feldspar	[34]
Local marble crushing plants, Pakistan	Angular and flaky in shape and bearing rough texture	Quartz, Crystobalite, Zeolite, Wollastonite from XRD	[35]
Garchuk quarry, Guwahati, Assam, India	Sub-angular to angular	Quartz, Feldspar, Biotite, Muscovite and others from petrographic analysis from XRD	[36]

Quartz, granite, limestone, dolomite, and sandstone are the major rock types used by the crushed stone industry. Granite dust is produced from aggregate crushing plants. Most parts of fines are passing the No. 200 sieve and defined as fine aggregate with a particle size less than 4 mm in diameter. The chemical composition of granite dust is an important material characteristic which plays a key role in stabilization. It differs with location, formation and the type of rock available.

2.2. Granite Dust and Composition

Table 3 provides the composition of a granite dust which give a rough estimate of various chemical elements in support of the content provided in Table 2.

Table 3. Chemical composition of granite dust (Sourced from [36–39]).

Element	Composition Range (%)
SiO ₂	45–75
Al ₂ O ₃	15–19
CaO	3–14
Fe ₂ O ₃	6–17
K ₂ O	3–4.5
MgO	1–3.6
Na ₂ O	0–3.7
P ₂ O ₃	0–0.02
TiO ₂	0–2.65

3. Granite Dust as a Sustainable Material

Sand mining is the process of removing sand from the foreshore. Approximately 47 to 59 billion tons of material is mined globally. Sand utilization in construction leads to unjustifiable sand mining caused by the increment in development activities, which are unacceptable. The available sources of characteristic sand are draining. High-class sand

can be moved from a significant distance, causing an economical constraint. Therefore, the structure quality relies on a partial or complete material replacement. Granite dust discarded in a huge amount creates a financial and ecological expense to the industry [40]. Granite dust can avoid detrimental effects on the environment, which are caused by the excessive mining of river sand [41]. Some granite dust applications are in geotechnical aspects like embankment, backfills, road-paving materials, underground cavity fillers, barrier wall materials and sub-base.

4. Effect of Granite Dust Addition on the Geotechnical Properties

4.1. Atterberg Limits

Granite dust is a non-plastic material that cannot be influenced by water. Hence, adding granite dust to plastic soils reduces the plasticity index by breaking the particle–water–particle bond and the liquid and plastic limits. Works have been performed on red earth, kaolinite, and sun-dried marine clay, where the Atterberg limits decreased with the dosage increase [21]. The sun-dried marine clay comparatively gave a better response with granite dust addition compared to the other two because the marine clay is a high-plastic soil with a poor gradation curve [21] (Table 4).

Table 4. Response of Atterberg limits with an increase in the dosage of granite dust (Modified after [21]).

Soil Type	% Granite Dust	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)
Red earth	0	2.70	40	25
	20	2.72	35	Non-plastic
	40	2.74	27	-
	60	2.76	25	-
	80	2.78	24	-
Kaolinite	0	2.6	55	30
	20	2.64	47	19
	40	2.68	37	Non-plastic
	60	2.72	30	-
	80	2.76	26	-
Sundried marine clay	0	2.62	73	36
	20	2.66	57	28
	40	2.69	44	21
	60	2.72	35	Non-plastic
	80	2.76	27	-

The high plasticity of soil decreased with the increase in the amount of added granite dust. The liquid limit decreased to 52%, with 60% granite dust addition. Similar works [42,43] have investigated the low-strength/weak soil and concluded that adding granite dust to plastic and high-plastic soils decreases the liquid and plastic limits. Work has also been performed on the granite dust–black cotton soil mixtures and observed the decreasing behavior of Atterberg limits with an increase in granite dust addition [44]. Table 5 lists the summary of the attempts made to improve the Atterberg’s limits of different soils with the addition of granite dust.

Table 5. Summary of the attempts to improve the Atterberg’s limits of different soils with the addition of granite dust.

Soil Type	Outcome	Reference
Red earth	Decreased gradually	[21]
Lithomargic clay	Significant decrease of liquid limit and plastic limit	[43]
Black cotton soil	Liquid limit is decreased by 42% at 40% addition of granite dust	[44]

Decrease in Atterberg's limits of the soil is due to the decrease in finer fraction of the heterogeneous mix. Change in the finer fraction affects the water absorbing capacity of the soil.

4.2. Compaction Attributes

Maximum dry density (MDD) and optimum moisture content (OMC) are two significant parameters used to assess the field capacity of soil. Adding granite dust to soil increases the MDD and reduces the OMC due to the increase in coarser fraction and the specific gravity of soil–granite dust mixes [43]. Moreover, the increase in the MDD was due to the shift in the gradation curve from a poor to a well-graded mix. In a work on quarry reclamation, granite dust was mixed with silty soil. A decrease in the OMC and an increase in the MDD were observed with the increments in the presence of granite dust (Figure 2) [45]. Generally high-plastic silts show an improved MDD and a decreased OMC with the gradual increase in granite dust substitution [42]. Nwaiwu [43] observed an increase in the MDD of black cotton soil–granite dust mixes and a decrease in the OMC at higher granite dust contents. Irrespective of compaction energy adopted, the addition of granite dust improved OMC and MDD relatively for several soils. Similar observations [22,46] were identified in the case of clays and red earth soils, where an increase in the MDD of mixes were observed with a simultaneous reduction in the OMC values at higher percentages of granite dust dosages was noted. The compaction characteristics of residual soils improved with the addition of granite dust, which consequently led to an increase in the compaction energy [37].

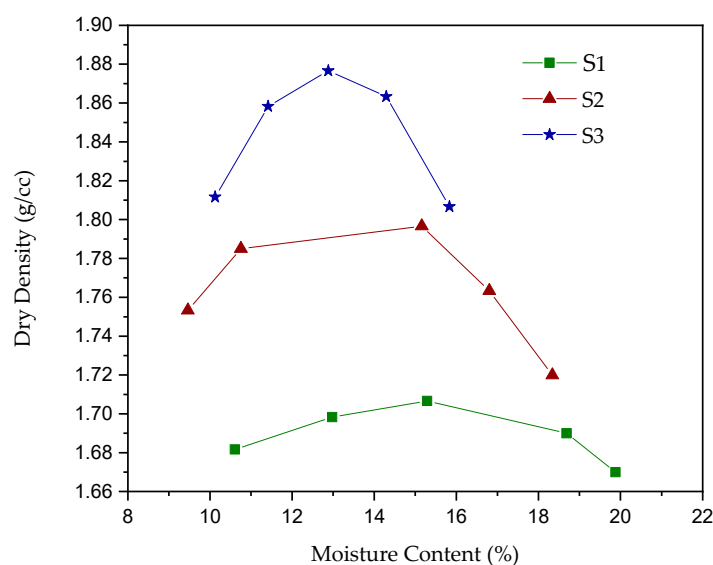


Figure 2. Influence of the granite dust dosage on the compaction characteristics S1: 75% soil + 25% granite dust; S2: 50% soil + 50% granite dust; and S3: 25% soil + 75% granite dust (Modified after [45]).

The maximum dry density of mixed soils improves because of the substitution of dust particles in the clay voids and, to some extent, in silts. This will ensure that macro and micro-voids are minimized at higher compactive efforts. The MDD of marine clay increased by approximately 88%, which is higher compared to other soils as seen in Figure 3 (Adding granite dust to soils allows less water to absorb due to the increase in the coarser fraction compared to fines, which is particularly observed in clays, silts and clayey soils). These changes in the soil–granite mix help to improve the engineering properties of the soil.

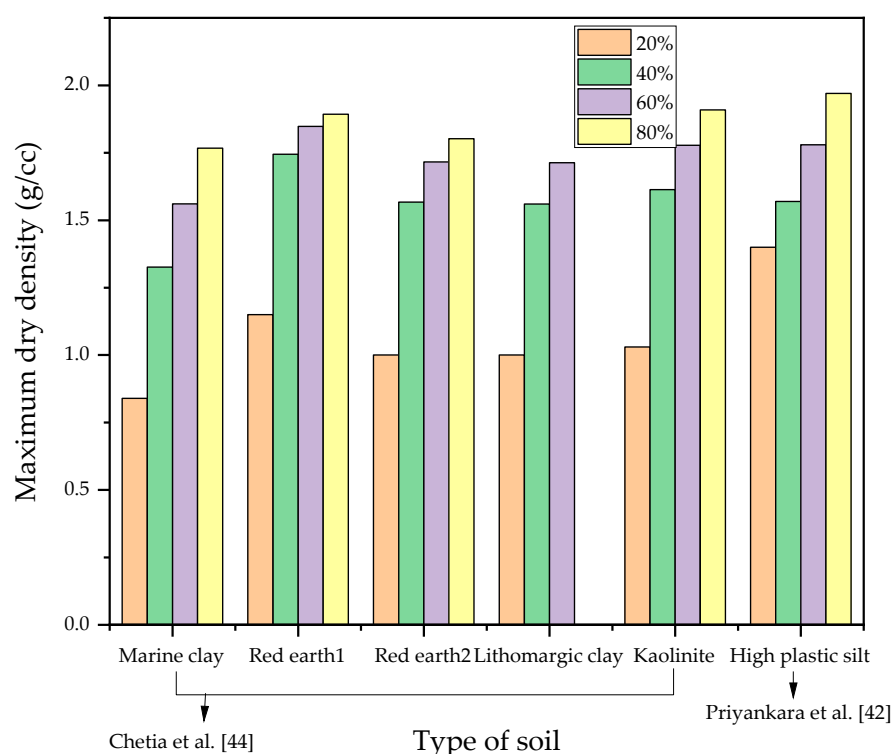


Figure 3. Variation of MDD of different soils with granite dust (Modified after [42,44]).

The change in compaction characteristics is due to the change in particle size distribution of the granite dust mixed soil. Formation of a well graded mix offers greater density and presence of granite dust breaks the water film around the clay particles.

4.3. California Bearing Ratio

To obtain the CBR, a static penetration test is performed to obtain the susceptibility of soil against wheel load penetration. According to [42], the CBR value recommended by the RDA is 15% for subgrade in highway construction. In the case of kaolinite, red earth, and sun-dried marine clay, the CBR values increased with an increase in the percentage of granite dust [21]. However, the percentage increase in CBR for a particular dosage of granite dust is more for clay soil due to the change in grain size distribution (Table 6). Soils with high clay content showed a high improvement with granite dust addition.

Table 6. CBR characteristics of Granite dust amended soils (Modified after [21]).

Soil Type	% Granite Dust	Soaked CBR (%)	Unsoaked CBR (%)
Red earth	0	8.8	9.9
	20	9.8	10.5
	40	10.8	12.0
	60	13.0	14.3
	80	14.7	15.5
Kaolinite	0	5.2	7.8
	20	6.7	8.8
	40	8.8	10.8
	60	18.7	20.8
	80	20.8	22.8
Sun-dried marine clay	0	3.8	4.7
	20	4.3	5.2
	40	5.1	6.2
	60	8.9	9.4
	80	11.2	11.8

This increase in the CBR value is also influenced by the shear strength of the particular soil. In spite of the presence of weak soil, stabilization with granite dust brings the CBR value to the field requirement that helps to reduce the pavement thickness. The increase in the CBR values with the increase in the percentage of granite dust was observed until 50% granite dust addition in the case of black cotton soil [44]. The CBR values of the residual soils increased with an increase in granite dust in soaked and unsoaked conditions [37]. Table 7 shows summary of earlier works related to improvement in CBR characteristics of different soils.

Table 7. Summary of works to improve the CBR of the soils with granite dust.

Soil Type	Outcome	Reference
Marine clay	Good improvement at less amount of granite dust	[21]
Residual soil	Soaked CBR value is comparatively higher than un soaked	[37]
Black cotton soil	Significant increase at 50% addition of granite dust	[44]

4.4. Shear Strength

Sun-dried marine clay highly responded to the granite dust addition compared to red earth. The presence of granite dust in clays filled the voids and developed friction among the mixed particles [22]. A significant improvement in the shear strength with the increase in internal friction and a corresponding decrease in the cohesive nature of high-plastic silt was observed up to 60% addition of granite dust as seen in Figure 4.

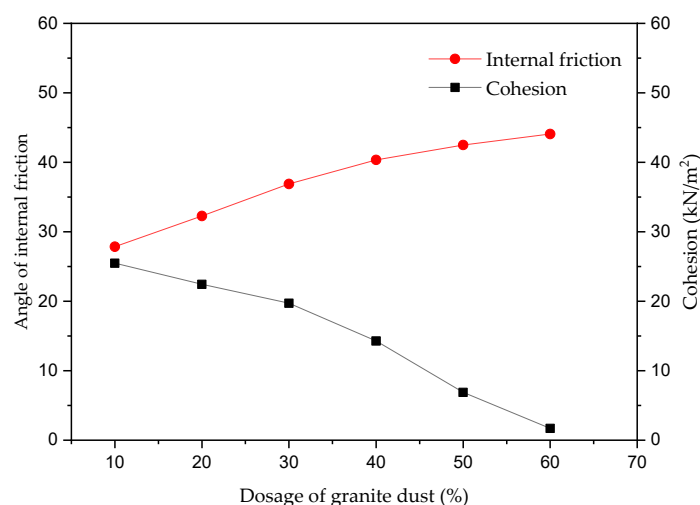


Figure 4. Variation of shear parameters of high-plastic silt with granite dust addition (Modified after [42]).

4.5. UCS and Permeability

The unconfined compressive strength of lithomargic clay is improved with addition of granite dust content up to 20% and decreased with a further increase in granite dust addition. The coefficient of permeability of lithomargic clay proportionally increased with the addition of granite dust [46].

The wealth of literature summarized reveals that, granite dust enhances the geotechnical properties of silts and clays. High-plastic clays and clayey soils hold poor gradation; thus, the granite dust addition turns the mix into a well-graded complex that yields a high confinement as seen from Figure 5.

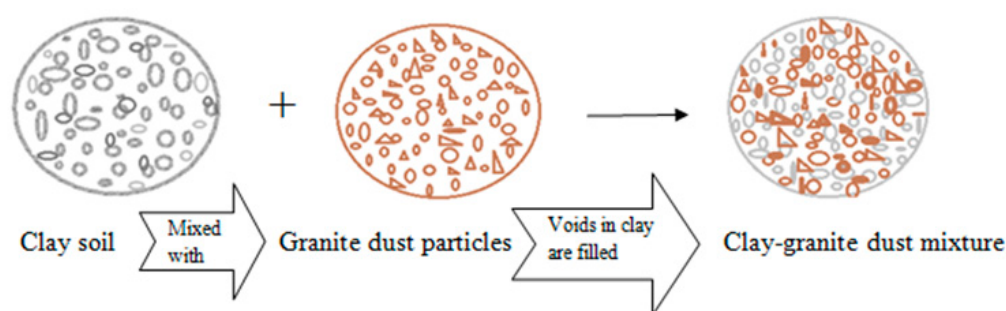


Figure 5. Change in the particle gradation of clay soil with granite dust addition.

5. Granite Dust as a Substitute for Sand

Kumar [47] worked on different sub-base materials like flyash, coarse sand, granite dust, and river bed material (RBM). Granite dust was found to have the least resistance to rutting compared to the other three materials used in this study. The RBM has the maximum resistance to rutting. The static and resilient moduli were both higher for the RBM, implying that it had a better performance than the other three materials in the field. The internal friction angle ranged from 26° to 39° , and the specific gravity was nearly close to the specific gravity of river sand, which is required for the fractional sand replacement [36]. From the chemical composition of granite dust, silica/quartz (SiO_2) is the predominant mineral that helps give a high shear strength similar to sand. Therefore, practically, granite dust can be used as a substitute for sand. Some previous investigation(s) [31,35,48–50] proved that sand can be partially replaced with granite dust without changing the workability and durability of concrete. Furthermore, the shear strength of sandy soil increases with an increase in the percentage of the granite dust content in sand–granite dust mixes to a certain limit. This work concludes that granite dust is the best source of alternative to save sand availability.

6. Alternate Treatment Methods

Reinforced Granite Dust

Sand was earlier referred to as the best backfill material because of its shear strength and permeability characteristics. In view of sustainability, being a cohesion less inert material that can also be used as a backfill due to its bulk utilization, granite dust is also the best substitute for sand [33]. A backfill material should not possess any lateral displacement of facia walls and should be able to resist the settlement due to loading. Granite dust is limited in cohesion property and high density; hence, the concept of granite dust reinforcement has been explored by certain authors. Among several reinforced materials, geosynthetics are considered as the best reinforcing materials due to their workability. Rama Subbarao [51] stated that geo grid reinforcement reduces the shear deformations of granular materials. Reinforced granite dust exhibits a ductile behavior and improves apparent cohesion, but is insignificant in the case of friction. The deviator stress is the governing factor of shear strength in the case of reinforced stone dust, especially in ductile reinforcements. The EPS geofoam was introduced in granite dust as the load-reduction key. Geofoam is more noticeable for gravelly and sandy fills. The interface shear strength of geofoam–granite dust is highly influenced by normal stress applied [52]. In addition, the presence of geofoam reduces the backfill weight. Reinforced granite dust could be used as a backfill material, even at a lower relative density that reduces facia displacement and vertical settlements [53]. The change in the dimensions of the reinforcement and its location also greatly influence the backfill behavior. Waste plastic strips serve as a reinforcing material for improving the penetration resistance of granite dust. Granite dust is highly influenced by the increase in the density of intruded plastic strips [54]. Earlier works have stated that approximately 1% of plastic strip addition with an aspect ratio of 3 increases the soil CBR. The CBR was improved by the particle interlocking in reinforced layers under

the dry condition (unsoaked) and the sedimentation of fines, in which the coarser particles to the top led to a confinement in the wet condition (soaked) [51].

Backfills and soil walls are some of the bulk applications in geotechnical engineering. The reinforced granite dust material is the best substitute for sand. Being a high-density material, the reinforcement helps reduce the pressure on the facia walls, which consequently leads to the reduction of the horizontal displacement and the vertical settlement due to the interlocking phenomenon (Figure 6). The concept of reinforced granite dust also helps improve the penetration resistance due to the development of a confinement among particles.

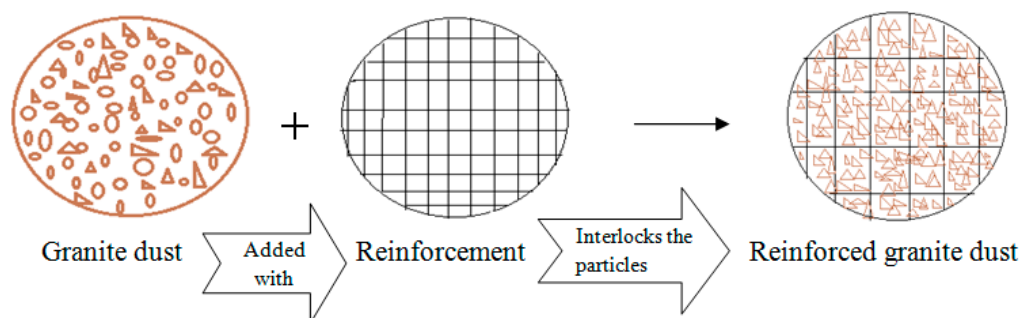


Figure 6. Mechanism of reinforced granite dust.

7. Effect of Granite Dust and Stabilizer(s) on Geotechnical Behavior

Importance of the Stabilizer

Granite dust is a non-plastic cohesion less material with a specific gravity greater than that of soil. Adding granite dust to cohesive soil filled the voids in cohesive soil, which increases the density and the shear strength. However, in some cases, granite dust alone will not be sufficient to fulfil the requirements that may cause sudden drawdown or a slip as seen from Figure 7. The soil-granite mix requires a binding agent to bring an efficient product to work in the field that can withhold the heterogeneous mass.

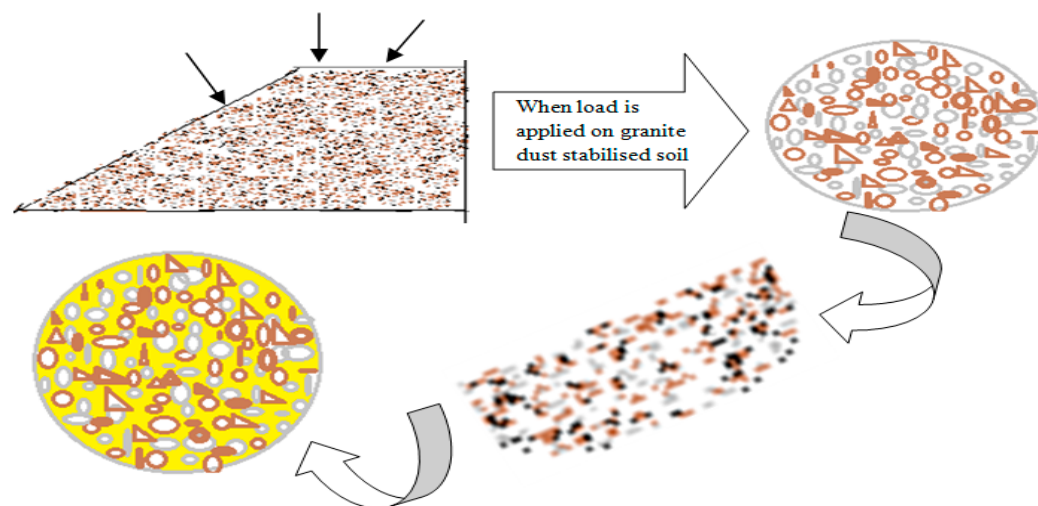


Figure 7. Significance of the secondary stabilizer.

When clay soil was stabilized with granite dust, the plastic nature of the soil decreased with the increase in the granite dust dosage, leading to failure. The presence of a binding material prevented failure and increased the cohesion which enhanced the engineering properties. Black cotton soil when amended with lime and granite dust exhibited better performance compared to untreated scenario [55]. The ettringite formation increased the strength of the soil-granite dust mix (Figure 8). Granite dust, along with calcium carbide residue (CCR) in equal amounts, showed a good influence on problematic silty clay in

terms of the CBR (Figure 9) [26]. The presence of the CCR in silty clay led to pozzolanic reactions and increased the chemical bonding between particles.

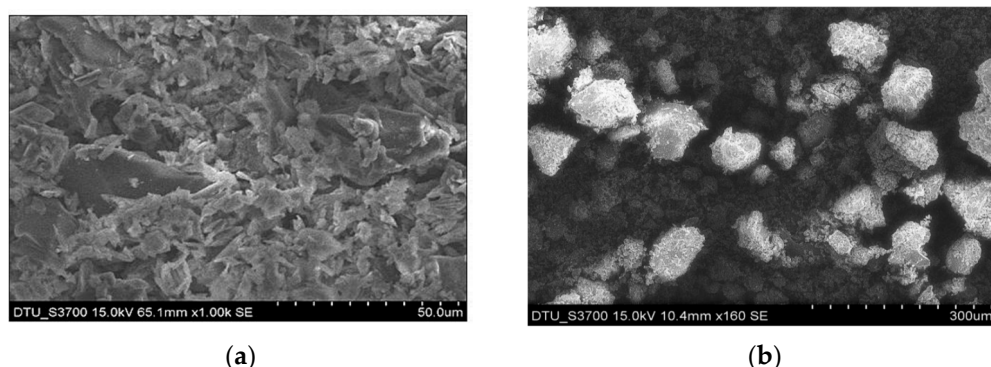


Figure 8. SEM images (a) of black cotton soil and (b) black cotton soil mixed with 9% lime and plugged with 25% granite dust (Sourced from [55]).

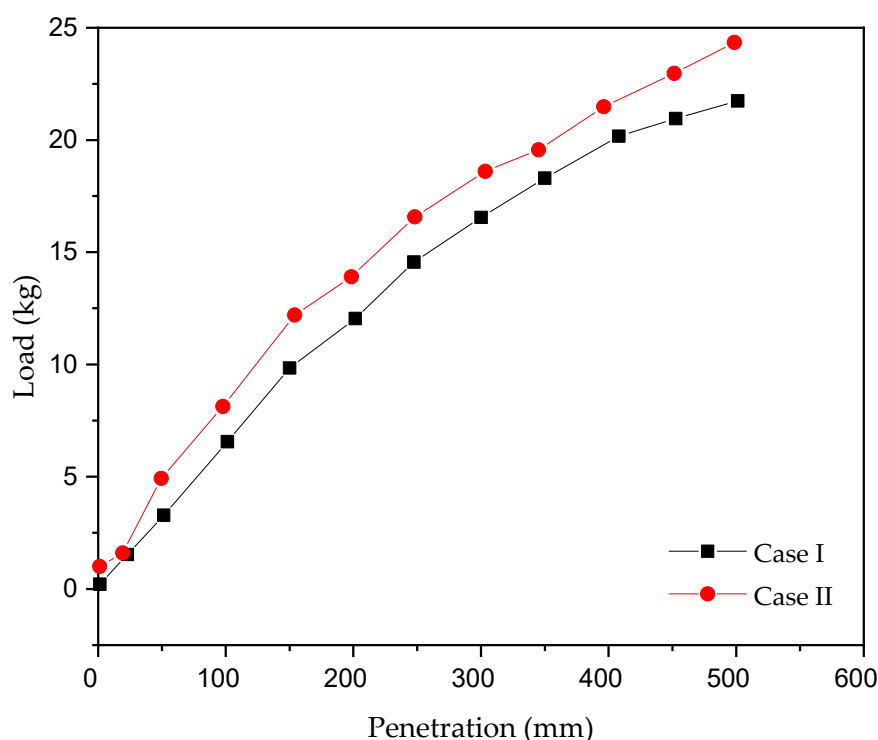


Figure 9. Response for the soaked CBR test after 14 days of curing. Case I-Soil + 5% granite dust + 5% CCR. Case II-Soil + 10% granite dust + 10% CCR (Modified after [26]).

Some works on foundation soil improvement were performed using granite dust and cement, where the soil was improved with the incremental addition of granite dust with 4% cement addition. Granite dust with 10% cement addition improved the shear strength and the hydraulic properties of lithomargic clay [46]. The presence of cement led to ettringite formation, which helps in developing additional strength and cohesion. The presence of cement also helped in decreasing the pore volume. Dutta and Sarda [54] used a waste plastic strip with granite dust/flyash to improve the kaolinite clay properties. The CBR variation in the mix was attributed to the strip intrusion and the strip length in granite dust. The high-plastic silt was added with cement and granite to improve the CBR [42]. Quarry wastes in the form of granite powder and muck could be used as a supplemental subgrade material when added with lime [56]. The effects of quick lime on compacted granite dust were also studied, and the bearing capacity was found to improve with quick

lime addition. Table 8 provides the summary of various earlier works which necessitated the inclusion of binder to granite dust.

Table 8. A Summary of works to improve the properties of soil mixed with granite dust and a binder.

Soil Type	Outcome	Reference
Black cotton soil with lime and granite dust	Cohesion increased. Good improvement observed in engineering properties	[55]
Silty clay with CCR and granite dust	Good chemical bonding appeared. CBR increased	[26]
Lithomargic clay with granite dust and cement	Strength and cohesion increased. Pore volume decreased	[46]
Kaolinite clay with granite dust/flyash with waste plastic	CBR increased	[54]
High plastic silt with cement and granite dust	CBR improved	[42]

8. Practical Applications of Granite Dust

An embankment was constructed in Korea using locally available silty material and granite dust sourced from two different quarry sites (biotite granite quarry from Yangju, Gyeonggi province; granitic gneiss from Gongju, South Chung cheong province) [45]. The granite dust is added in multiples of 25% from 0 to 100 and its response to enhancement in targeted geotechnical properties was determined. This case study revealed the fact that, an embankment of silty material stabilized with granite dust should attain a gradient of 1:1.8 for 10 m height and 1:1.5 for 15 m height in order to satisfy the stability analysis as per Korean standards. Up on inclusion of granite dust, the specific gravity of the mix increased whereas the MDD and shear strength of the mix decreased as seen from Table 9.

Table 9. Effect of granite dust on the shear parameters of a local silty soil (Modified after [45]).

Granite Dust: Natural Soil	Yangju, Gyeonggi Province		Gongju, South Chungcheong	
	C (t/m ²)	ϕ	C(t/m ²)	Φ
100:0	0.52	30.2	0.45	29.3
75:25	0.51	30.8	0.51	30.6
50:50	0.48	32.1	0.48	31.5
25:75	0.44	33.4	0.4	34.2

In Jimma town of Ginjo kebele, Ethiopia, an expansive soil (clayey soil) at subgrade level was stabilized using granite dust [57]. The dosage of granite dust was limited to 50% (added in increments of 5%). CBR requirements for subgrade were met at 30% to 35% of granite dust addition as seen in Figure 10. The thickness of the subgrade was found to reduce by 20.6% compared to an untreated case. Their study concluded that clay-granite dust soil satisfies the requirements for subgrade layer [57].

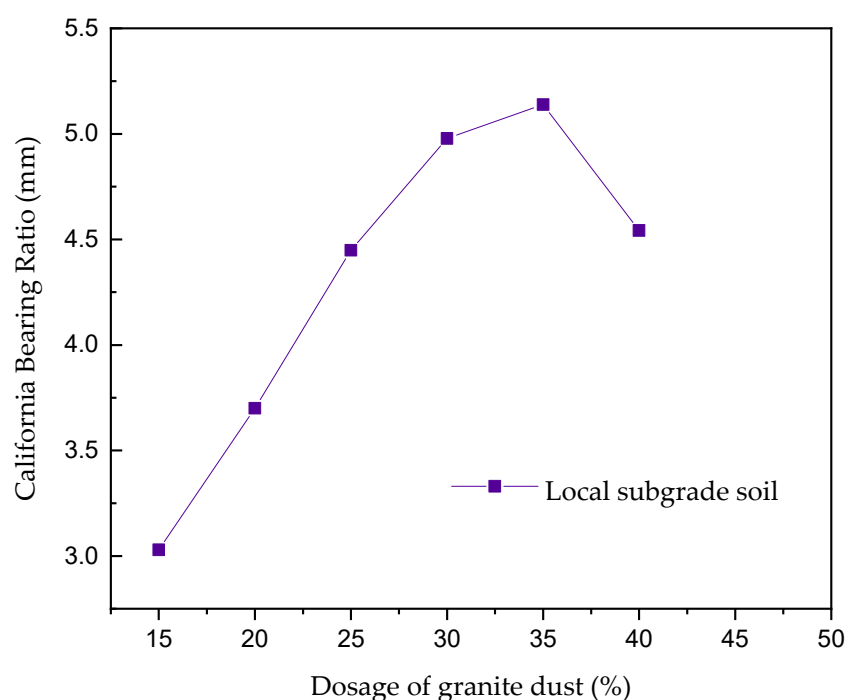


Figure 10. Improvement in the CBR of subgrade soil with addition of granite dust (Modified after [57]).

9. Conclusions

The current review article dealt with the generation of granite dust and shed light on its influence on the engineering properties of soils exhibiting different mineralogy. The workability of granite dust amended soils in the presence of an additional stabilizer is critically reviewed. The performance of granite dust as a backfill and a pavement material is discussed. The mechanism behind the improvement of each soil engineering property with granite dust addition is explained. The major outcomes of this review article are:

- This significant improvement in Atterberg limits and Compaction characteristics is attributed to the increase in the coarser fraction and specific gravity, followed by a decrease in the water absorption capacity of the soil.
- The interfacial friction of cohesive soil increased and cohesion value decreased due to the presence of coarser particles that fills the voids in clays, thereby increasing the friction component between the soil particles.
- Soaked CBR values are increased due to the improvement in corresponding Maximum dry density and Shear strength.
- A small amount of additive (calcium-based stabilizers) (<10%) with granite dust enhances the engineering properties of cohesive soils by causing net reduction in the pore volume, assisting in the rapid formation of ettringite, and substantially enhancing the tensile strength.
- Granite dust is a highly recommended material as a replacement of sand in concrete and geotechnical applications due to its chemical composition and interfacial friction angle.

Granite dust is a sustainable and remarkable material exhibiting relatively low embodied energy levels. For a given scenario, when granite dust is amended with native soil, the amount of CO₂ released due to granite dust addition is compensated by the reduced use of locally available materials. Accordingly, granite dust addition results in reduced carbon footprint values, and this treatment strategy is close to carbon neutral.

Proposed Research Gaps

- To explore the particle size effect of granite dust on the strength characteristics of the soil.

- Dynamic studies on the granite dust stabilized soil can be explored for future rail and roadway applications.
- The stability of embankments and long-term durability of highways constructed with granite dust amended soils may be carried out.

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