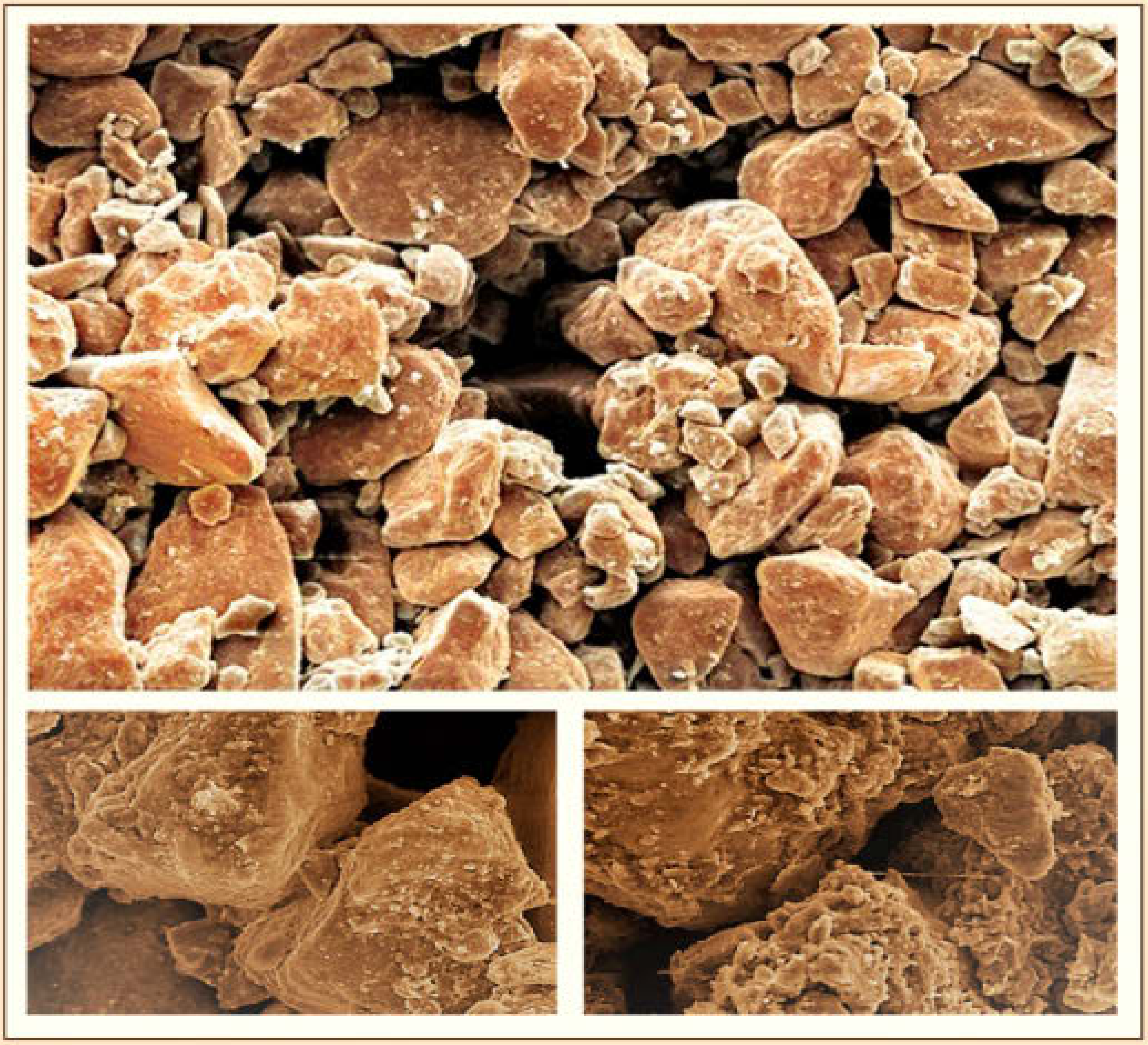
MICROSTRUCTURAL BEHAVIOR OF EXPANSIVE SOIL

Dayalan J
Dr. Madhavi T



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KRISHNA NAGAR, DELHI

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Regd. Office:
F-10/24, East Krishna Nagar, Near Vijay Chowk, Delhi-110051
Ph. No: +91-11-79669196, +91-9899073222
E-mail: info@booksarcade.co.in, booksarcade.pub@gmail.com
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CONTENT

CHAPTER - 1

INTRODUCTION TO ALCCOFINE MODIFIED EXPANSIVE SOIL

Mr. Dayalan J,
Assistant Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - dayalanj@presidencyuniversity.in

The top layer of the earth is made up of soils, which are created by the weathering of the rocks. Thus, organic and inorganic components are combined to form soil. The clayey soils are composed of fine-grained natural clay minerals [1],[2]. The most prevalent form of soil in the southern region of India is laterite soil, which is made up of red soil (RS) and black cotton soil (BCS). Because it contains oxide, which gives it colour, laterite soil is also known as RS. As the soil absorbs and holds water, its moisture content (MC), which affects several soil characteristics, changes. Additionally, BCS, which contains a lot of clay, is known as expansive soil because of its capacity for both expansion and contraction [3]. Due to their strong plasticity and improved permeability, laterite soil has significant compressibility and high volume fluctuations. Thus, the lesser strength and stiffness of these soils in the construction industry make it difficult for geotechnical engineers to develop any structures or paving. To improve the qualities and strength of the soil, we must stabilise it. Many researchers are experimenting with various admixtures to increase the strength attributes of soil in an effort to better the soil's properties. Cement, nanomaterials, ground finely ground slag from blast furnaces (GGBS), alkali activated volcanic ash and slag, construction equipment, waste products, recycled gypsum, polymers, sugarcane bagasse, polypropylene fibres (PPF), Alccofine, palm oil, bitumen emulsions, zeolites, bio-enzyme, and other substances are some of the various admixtures used.

Each admixture has significantly enhanced the soil's strength, stability, expansion, shrinking, and many other characteristics. By absorbing moisture and engaging in oxidation processes with the presence of water, cement particles serve to bind the soil. According to studies, adding cement and zeolite aids in achieving the highest strength at 30% resistance. Additionally, it lessens the soil's expansion and contraction when subjected to temperature variations. Illite and montmorillonite are examples of hydrophilic minerals that contribute to the regulated behaviour of cement-mixed soil. These minerals result in a high particular region of the soil as well as a high potential for volume change and compressibility. When expansive soil absorbs water in the rainy season and shrinks during the summer, there is a significant volume change. The constructions constructed on such soil will sustain damage as a result of the behaviour owing to differential settlements. The key factor for the swell and shrink behaviour in this soil is the mineral montmorillonite. Burrow dirt is necessary for building roads, retaining walls, embankments, and in situations where Black Cotton soil cannot be prevented and soil stabilisation is unavoidable. Alcofine is one of the several compounds that researchers have employed to stabilise this type of soil. A typical micro-fine substance is alccofine. The material's diameter is extremely small and is thinner than cement. Silica fumes, fly ash, rice husk ash, etc. Alcon developers and Ambuja cement Ltd. make it in India.

Slag, a highly reactive industrial waste with a high glass concentration, serves as the primary raw material. Granules made from slag powder are produced in a controlled environment. To create enhanced particles with the necessary ideal particle size distribution, which is its distinguishing characteristic, specialised equipment is employed. It comes in two different forms: Alccofine-1203 and Alccofine-1101, which have different levels of calcium silicate in them. The Alccofine 1200 series includes the numbers 1201, 1202, and 1203, which, respectively, stand for fine, micro-fine, and ultra-fine particle size. Alccofine 1101 is a segments and sub concrete mixture grout material for soil stabilisation and rock drilling, whereas Alccofine 1203 is a slag-based SCM with ultra-fineness and tailored particle size distribution. Alccofine performs better than every other admixture utilised in India. Because it contains a lot of calcium oxide (CaO). By adding plastic strips from used plastic bottles, the engineering qualities of the soil + Alccofine mixture are improved. There is an increasing demand for sustainable ways to safely dispose of wastes without contaminating the air, water, or soil due to the seriousness of the difficulties linked with the disposal of plastic waste. Many researchers have concentrated their studies on the nation's socioeconomic development with an eye toward environmental preservation. Today, managing plastic trash is the greatest environmental concern in both India and the rest of the world. According to CPCB, 660,787.85 tonnes of plastic garbage were reportedly produced in India in the 2017–18 fiscal year [4],[5].

The massive amount of plastic waste produced clogsrivers, sewers, and landfills. Marine mammals ingest them when it enters the ocean. When these pollutants are absorbed by the earth and toxic dioxins are released into the environment, soil and water become poisoned. Therefore, there is a need for methods to safely dispose of these wastes. Therefore, utilising Alcofine and waste plastic strips, an effort will be made to improve the characteristics of expansive soils. The term "soil stabilisation" refers to the process of increasing the stability or bearing capacity of the soil through the use of proportioning, controlled compaction, and/or the use of suitable admixtures or stabilisers. The fundamental tenets of soil stabilization are:

- Assessing the soil's specific characteristics.
- Selecting an efficient and cost-effective method of stabilization of soil based on the properties of the soil that are lacking.
- Developing the stabilised soil mixture to get the desired levels of durability and stability.

Stabilization can boost a soil's shear strength and manage its shrink-swell characteristics, which increases a subgrade's ability to carry more weight and support foundations and pavements. From expansive clays to granular solids, stabilisation can be utilised to treat a variety of sub-grade materials. Better soil gradation, a decrease in flexibility index or swelling potential, and improvements in strength and durability are some of the most frequent benefits of stabilisation. Stabilization can also be employed in damp conditions to give construction projects a working surface. The process of improving soil quality in this way is known as soil modification. Higher resistance values, less plasticity, decreased permeability, decreased pavement thicknesses, elimination of excavation, base importing, material trucking and processing, and aid in compacted are all advantages of soil stabilization. It also enables all-weather access [6].

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CHAPTER - 2

SOIL STABILIZATION

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

By altering the engineering features of the soil, soil stabilisation is a technique for turning natural soil into an engineered construction material that is more stable for use [1],[2]. When the accessible soil for building is unsuitable for the intended use, it is necessary. Chemical or cementitious material is added to soil for soil stability [3],[4]. The main goal of stabilisation is to strengthen the natural soil for highway building by reducing permeability and deformability of the soil and increasing its shear strength. Geotechnical soil stabilisation is the process of modifying the qualities of soil to increase strength and durability. Either adding additives or combining various soil types mechanically improves the changes in the qualities of the soil. The following are various techniques for stabilising soil that are frequently employed:

Mechanical Stabilization: This category includes physical processes like compacting or tamping using equipment like rollers or rammers. This process requires the use of huge compressive force-applying heavy machines. This often involves a sizable compactor or, in exceptional circumstances, a crane with falling weight. Rocky and sandy soils are typically stabilised when mechanical soil stabilisation is applied. Due to improvements in alternative methods of soil stabilisation, mechanical stabilisation is no longer the only stabilisation technique used. Even though mechanical soil stabilisation is not frequently employed, it has benefits. The fact that the soil samples are physically altered is one benefit, since it suggests that no chemical changes are occurring that will eventually degrade.

The physical alteration is known to make the process time-consuming, complicated, and expensive.

Benefits:

- Permanent.
- Environmentally responsible.

Disadvantages

- Time-consuming.
- Expensive
- No longer widely used as a method.

Chemical Stabilization: As the name suggests, it is reliant on the chemical reaction that occurs between the soil particles and the chemical/stabilizer applied. Examples of materials that are used include cement, lime, magnesium chloride, bitumen emulsion, and fly ash.

Soil stabilization with lime and cement

Lime or cement soil stabilisation is one of the most used techniques for preserving soil. In order to strengthen and prevent erosion, this method of soil stabilisation involves incorporating cement or lime into the soil. Depending on the characteristics of the native soil, different amounts of lime or cement are put into the soil. The amount of lime or cement normally applied increases with plasticity. Since both lime and cement are used as binders, they are usually mixed. Although using cement or lime to stabilise soil is a standard practise, it is most frequently employed on paved roads. Typically, it would be too expensive to treat unpaved roads with cement. The application of cement or lime to stabilise soil is frequently influenced by geography. Lime is more easily accessible in some places than in others, which lowers the cost of cement. By fusing all of the soil's constituent parts together, lime or cement stabilisation strengthens the soil. Practically all soil types are suitable with this method of soil stabilisation because it requires the addition of cement or lime to the soil. To ensure that the right amount of chemicals is applied, soil testing is crucial. The soil won't reach the right strength if only a modest amount of addition is used. If more is utilised, the earth can contract or crack [5]**.**

Advantages

- Tested and proven
- Long-lasting and irreversible.
- It is suitable with the majority of soil types.
- The soil is very compact.
- Lowers the amount of soil moisture.

Disadvantages

- Pricey
- Possible health hazards.
- Suited only to roads made of cement.
- Comprehensive soil testing is needed prior to application.

Soil Stabilization Process: Any stabilizing project must have proper design and testing. In order to obtain the specified technical qualities, this testing will create correct design criteria for selecting the additive and mixing rate to be employed. For all Soil Stabilization work, it is essential to seek the professional counsel and engineering know-how of a licensed Geotechnical Engineer. One of the most crucial elements of a project's success is the presence of a geotechnical engineer. Similar techniques to those used in full depth reclamation are used for soil stabilization. The soil material is first ground up by a reclamation machine. After that, an additive is added on top of this substance. The dirt is blended with this additive repeatedly until the appropriate qualities are obtained. A motor grader compacts the new base after shaping it to the right profile. The specs or design are expanded to include the building pad or road materials. Depending on the necessary soils and additions, this method can change. When subsoils are unsuitable for building, soil stabilization can be used on roads, parking lots, proposed construction projects, and in a variety of other scenarios.

Need for Soil Stabilization:

- To increase the durability of bases, sub-bases, and occasionally surface courses, especially in the case of affordable roadways.
- To employ subpar soils or other materials that are readily available locally. When locally accessible materials cannot provide the required or stipulated strength, we can resort to soil stabilising techniques.
- To reduce the unfavourable characteristics of soil, such as its extreme flexibility, excessive swelling/shrinking, and difficulties compacting.
- To improve load-bearing capacity and aid compaction.
- To lessen settlements and, hence, compressibility.
- To enhance permeability properties.

Advantages of Soil Stabilization:

- It increases the stability of the soil.
- Enhancing the soil's ability to support weight.
- Instead of choosing a deep foundation or raft foundation, it is more cost- and energy-efficient to boost the soil's carrying capacity.
- It is also used to prevent erosion, which is especially helpful in dry and arid conditions, as well as to provide the soil more stability in slopes and other similar places.
- It aids in minimising the change in soil volume brought on by variations in temperature and moisture content.
- It increases the soil's overall resilience and workability [6].

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CHAPTER - 3

DIFFERENT CATEGORIES OF SOIL

Mr. Ajay H A,
Assistant Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - ajay@presidencyuniversity.in

Understanding the type of soil you are working with is the first step in choosing the soil stabilization technique that will work best for your application. Soil can be divided into four main categories: sand, silt, clay, and loam. Each type of soil has unique qualities and stabilization requirements [1],[2]. The organic content of the soil is one of the most important aspects to take into account when working on soil stabilization. The Plasticity Index of the soil, a consequence of an Atterberg Test, is frequently used to gauge the organic content [3]. Understanding the organic content is crucial because it will enable you to predict how the shape of the soil will change. When moist, soil with little organic content frequently does not change shape, whereas soil with high organic content changes shape significantly [4].

Sand: One of the most well-liked or well-known soils is sand. Sand from a beach is the ideal illustration of a sandy soil. Sand has the biggest soil particle size of any type. Both in terms of size and organic content, it is primarily composed of very small rock. Sand is typically created when rock breaks down. Because sandy soils typically lack flexibility and have very little organic content, there isn't much growth on the beach. There are no nutrients in the soil to support plant growth. Despite the disadvantages that have been mentioned, there are some advantages to sand. The sand particles are big and will not alter shape when wet, which helps with stabilization. Because the sand particles may be pressed together, an extremely hard surface can be produced.

A benefit of sandy soils:

- Rapid warming in the spring

Negatives of Sandy Soils

- During the heat, dries out quickly.
- Water and nutrients frequently leak out, especially after rain.
- Usually acidic

Silt: After sand, silt is the most common form of soil. Silt is frequently mistaken for clay, however it differs greatly from clay. Rock that has been eroded, such as when it has been scraped away by water or wind, produces silt. Silt has a small amount of organic stuff but does contain some quartz because it is a byproduct of the decay and erosion of rocks. Demonstrating the conventional non-plastic nature of silty soils. Since silty soils are made of rock, the silt is frequently thick and tends to sink to the bottom of bodies of water. Silty soils are ideal for growing crops since they frequently contain a lot of the nutrients that the plants need. More crucially, because the soil is solid yet does not adhere to one another, the silt encourages air circulation and water retention. Although silt is excellent for agricultural settings, because of the size and density of the silt particles, it can be a difficult soil for construction. As a result, silt is frequently difficult to compact and will shift when moist.

Benefits of Silt Soils:

- Rich soils with greater nutrient retention than sandy soils
- Greater capacity to hold water than sandy soils
- More manageable than clay soils

Negative Effects of Silt Soils:

- Poor water filtering is possible.
- Has a propensity to develop a crust
- Can condense and harden

Clay: The smallest of all soil types are clay soils. In contrast to all other forms of soil, clay soils come in a variety of species with a wide range of features and colours. Although everyone is familiar with the reddish clay soils, this particular soil can also appear in nearly all-white to extremely dark black shades. The fact that clay soils become pliable when wet is the biggest distinction between them and other forms of soil, other than particle size. When soil is wet enough to make it plastic, the soil's shape is permanently altered. As a result, everything that is on the soil's surface may also experience shape distortion since wet soil will either expand or contract. When undertaking building on the soil, the soil's expansion and contraction will present significant obstacles due to the clay soil's flexibility. Clay-based soils are typically removed from construction sites or given a mechanical or additive treatment to permanently harden the soil.

Benefits of Clay Soil

- Clay soils retain nutrients
- Giving plants the sustenance they require.
- They are ideal for growing plants that require a lot of water.

Problems with Clay Soils

- Sluggish to drain and holds onto water
- In the spring, slowly warming
- Easy to compact Tends to be alkaline

Loam: A combination of sand, silt, and/or clay makes up loamy soil. A loamy soil is frequently listed as a type of soil after loam. "Clay Loam" or "Sandy Loam," for instance. When a loamy soil is preceded by a particular soil type (such sand, silt, or clay), it signifies that soil makes up the bulk of the soil. For instance, "Sandy Loam" denotes a soil type where sand predominates and is mixed with clay and silt. Due to the features of the majority of the soil, each classification and type of loamy soil differs. The term "loam" is frequently used to describe different types of soils. Conduct a loam test to identify the various soil types, such as a screen analysis to identify the particle size and an Atterberg test to identify the flexibility and organic content of the soil.

Benefits of Loamy Soils:

- because to its ability to hold water, resistant to drought
- quicker than clay to warm up in the spring
- may retain nutrients, resulting in productive soil
- good air and water infiltration

Problems with Loamy Soils:

- Particular loamy soils can include stones that could interfere with some crops' ability to be harvested, dependent on how your soil was created [5].

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CHAPTER - 4

BLACK COTTON SOIL

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

Expansive soil is characterized as plastic soil that is partially saturated and displays a significant volume shift when the surrounding conditions change from dry to wet. Whether or not the soil mass includes active day minerals will determine how much expansion occurs [1],[2]. These soils shrink when dried out and swell when wet because they are above the water table. The key factor for the swell and shrink behaviour in such soil is the mineral montmorillonite [3]. From the perspectives of design and construction, this issue is regarded as a serious engineering challenge. Buildings constructed on this sort of soil may heave, exhibiting movement in the opposite direction from what one would often anticipate as a result of building loads. The foundations of buildings may be susceptible to swell pressures, which can result in extreme movements and failure. Additionally, roads may heave, and differential movements may result in pavement distortion and cracking.

With the resultant displacement and damage, expansive soil backfills in underground constructions like canal linings and retaining walls may be subjected to significantly higher earth pressures. Effects on structures erected on expanding soil that are detrimental:

Expansive soils may result in the following issues in buildings or construction projects as a result of their swelling and shrinking tendency [4].

- Damage to the structural integrity of lightweight constructions, such sidewalks and roads.
- Building lifting, basement damage, and building settlement are all examples of this.
- Wall and ceiling cracks.

Expansive soils can undermine foundations in several ways, but uplift caused by their swelling as moisture levels rise is the most visible. Swelling soils frequently cause damage to floor slabs and lift up and crack lightly laden, continuous strip footings.

Losses from building on expansive soil:

- A few billion dollars' worth of damage to homes, buildings, roads, and pipelines is caused each year by shrinking and growth.
- More than twice as much harm caused by earthquakes, tornadoes, hurricanes, and floods.
- Each year, more than 250,000 homes are constructed on vast soils.

In India, the following locations have expansive soil:

- Nearly 20% of the land in India is made up of expansive soils, which are known as Black Cotton Soils (hereafter BCS) due to their colour and cotton-growing ability.
- Expansive soil deposits can be found in large portions of the Deccan plateau, Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, and Gujarat. India's other regions are included.
- Unfavorable volumetric changes are possible in expansive soils with a high clay component. When the soil's moisture content changes, the volume changes as well.

Additives Required For Expansive Soil Stabilization:

Lime, cement, fly ash, and other stabilisers are some of the ones used.

Lime: Adding lime to a fine-grained soil causes a multitude of reactions. Some of them happen right away, while others take time to happen. Base-exchange is one of the early reactions. Clay particles typically have interchangeable ions of sodium, magnesium, potassium, or hydrogen absorbed on the surface, leaving them negatively charged. Positive charges calcium ions abound on the surfaces of the clay particles as a result of lime's strong positive electrode calcium ions replacing weaker sodium, potassium, potassium, or hydrogen ions. This in turn lessens the soil's flexibility. The clay particles have a propensity to flocculate into large-sized particles, giving the combination a friable quality. Any subsequent lime will chemically react with the clay minerals once the first reaction has finished. In the presence of water, the aluminous, siliceous components in the clayey soil will react with the lime to generate cementitious gels, which strengthen the mixture's strength and durability. The pozzolonic reaction is sluggish and can take months or years to complete in some cases. The creation of calcium carbonate as a result of atmospheric carbon dioxide absorption is another potential source of strength [5].

Cement: The quality of cement has been checked and is guaranteed. It has a very high load spreading property due to its extremely high flexural strength. Soil-cement can transfer the load over a larger area and cover locally vulnerable sub-grade or sub-base areas as a result**.**

Fly ash: Under ionised conditions, fly ash can produce a variety of chelating and trivalent cations (Ca2+, Al3+, Fe3+, etc.) that can facilitate the cations exchange process that causes flocculation of scattered clay particles. In addition to the direct flocculation of clay particles caused by chemical reactions, the stabilising action is partially attributed to the combined action of additional silt-sized particles**.**

Environmental effects of plastic waste generation in India:

There is an increasing demand for sustainable ways to safely dispose of wastes without contaminating the air, water, or soil due to the seriousness of the difficulties linked with the plastic waste disposal process. Many researchers have concentrated their studies on the nation's economic growth with an eye toward environmental preservation. Plastic waste management is currently the most difficult environmental concern in both India and the rest of the world. According to the Central Pollution Control Board, the amount of plastic garbage produced in India for the 2017–18 fiscal year was estimated at 660,787.85 tonnes (CPCB). The massive amount of plastic waste produced clogs rivers, sewers, and landfills. Marine animals ingest them when it flows into the ocean. When these pollutants are absorbed by the earth and toxic dioxins are released into the environment, soil and water become poisoned [6].

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CHAPTER - 5

BASICS OF ALCCOFINE

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

Cement-based materials are currently the most significant building material, and it is quite likely that they will maintain this status in the future [1],[2]. The engineering and construction materials must satisfy new and increased requirements. Other building materials like plastic, steel, and wood must compete with them in terms of productivity, economy, quality, and the environment. Concrete should be resistant to weathering, chemical attack, and other degrading processes in order to be durable [3],[4]. When exposed to the environment, durable concrete will maintain its starting at age quality and functionality [5],[6]. These materials include of conventional Portland cement as well as additional cementitious substances like Alccofine. When producing concrete, alccofine is either blended at the cement plant or in the cement mixer. Mineral powders are finely ground cementitious ingredients used in concrete. When this substance is combined with water, a chemical reaction results in the formation of a solid, hard mass that fuses the aggregate particles in concrete. Alccofine is a brand-new generation of micro-fine material that is produced in India. It is considerably finer than other hydraulic materials such as cement, fly ash, silica, etc.

Due to its adjusted particle size distribution, Alccofine offers special qualities that improve the "performance of concrete" in both the fresh and hardened stages. In the current environment, gaining strength properties is not the only factor in producing high-quality concrete. One of the key requirements for achieving high-quality concrete is improving the concrete's resilience, reducing porosity to support a longer lifespan, and producing greener concrete. Because these are concrete's primary characteristics, its compressive strength is crucial. Since it is simple to administer and most of the needs to be improved qualities of concrete are subjectively connected to its compressive strength, the compressive test is the most frequently performed on hardened concrete. In this work, the impact of replacing cement with ultra-fine slag (Alccofine) on the mechanical characteristics of high strength concrete is investigated. Ultrafine slag has been proven to improve the flow ability and fluid of the mix in addition to the concrete's compressive strength. Additionally, it enhances the dependability and longevity of reinforced concrete structures and demonstrates resistance to segregation.

Alccofine: Alccofine is a brand-new, micro-fine substance produced in India that has significantly smaller particles than existing hydraulic materials like cement, fly ash, ground granulated blast furnace slag (GGBS), silica fume, etc. Because of its adjusted particle size distribution, Alccofine has particular qualities that improve the performance of concrete in both the fresh stage and the hardened stage. Since Alccofine has an ideal particle size distribution—not too fine or coarse—it can be used as a suitable alternative for Silica. Alccofine's distinctive attribute, optimum particle size distribution, is manufactured under strict control using specialised equipment and instrumentation.

Types of Alccofine

Alccofine 1101: It is an Alccofine with a high calcium silicate content, It is a type of cementitious grout that is micronized and used to stabilise soil and anchor rocks. Alccofine's high calcium oxide (Cao) content makes it the finest all-around additive utilised in India in terms of performance.

Alccofine 1203: The Alccofine 1203 has a low calcium silicate content. Fine, micro-fine, and ultrafine particle sizes are represented by the Alccofine 1200 series numbers 1201, 1202, and 1203. A supplementary cementitious material (SCM) based on slag called Alccofine 1203 has ultra-fineness and an ideal particle size distribution. Due to Alccofine 1203's ultra-fineness, it reduces the amount of water needed to make concrete workable, even up to a 70% substitution level.

FIELDS OF APPLICATION

- RCC buildings for homes and businesses
- Concrete may be easily pumped in high-rise structures despite their difficult conditions.
- Mass concrete with temperature control for raft and piling foundations
- Aluminum and self-compacting or high flow concrete tunnel reinforcements
- Concrete with a very low binder to water ratio, high early stiffness (HES), and high performance
- All-grade concrete to increase features for long-term durability
- Shotcrete that has better cohesiveness and gains initial strength more quickly
- Precast concrete components for bridges, tunnels, blocks, and hollow core slabs in addition to commercial precast products.
- Concrete slab that has been pre- and post-stressed
- Repair mortars, plasters, and grouts for construction
- Buildings that are LEED / GREEN compliant

Advantages:

- refines pore architecture to increase concrete's durability attributes and decrease permeability
- increase the concrete's resilience to harsh environmental agents
- keeps the pH of the concrete mix constant to safeguard the steel reinforcing
- enhances concrete's capacity to be pumped
- without increasing the chemical admixture dosage, the concrete's increased slump and extended slump retention
- Faster shuttering removal and form rotation in the precast sector

- Enhance the strength output rate of concrete mixtures including significant amounts of pozzolanic materials, such as fly ash, GGBS, etc.

Uses: Alccofine is essentially an innovation that has developed through time as a result of research into how micro-fine products, such as slag, interact with cements and meet demand in ways that regular grey cement cannot. Alccofine is the brand name for a group of goods that are generally categorised as microfines and can either be primary or auxiliary cementitious materials. Alcofine is a specific type of processed material made from slag with a high glass content and high reactivity. The particle-size distribution calculated by the Bleans is approximately 12000 cm2/gm, which is genuinely ultrafine. Alccofine-1203 is a substance that essentially improves the characteristics of concrete. Additionally, it has demonstrated excellent laboratory results. Their knowledge led them to conclude that commonly used SCMs, such as fly ash, metakaline, or micro silica, offered the best ways to improve concrete, the hydration process, and particle-size distribution. These SCMs also contained calcium oxides, which, when hydrated, converted to calcium hydrooxide, which increased concrete's alkalinity and could prevent or at least mitigate corrosion. Alccofine-1203 is a common type of ground, granulated blast slag that has had some chemical admixtures added to it. So that it provides the necessary qualities for the purpose for which the concrete was developed. The main objective was to make concrete more impermeable and to guarantee higher tensile strength at all phases**.**

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CHAPTER - 6

WASTE PLASTIC STRIPS

Mr. Gopalakrishnan N,
Assistant Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - gopalakrishnan@presidencyuniversity.in

Clay soil soils are a particular type of soil that significantly alters in volume when exposed to moisture [1],[2]. When exposed to excess water, they expand, and when there is not enough water available, they contract in hot temperatures. During dry seasons, they are simple to spot in the field thanks to their deep polygonal fractures [3]. Expanding and contracting expansive clay soils have a negative impact on the stability of structures placed on top of them, which poses a major risk. By uplifting as they swell, it significantly impacts the bearing capacity and stability of foundations and may result in cracks, differential movements, or structural failures. Expanding soils must be stabilised to lessen their swelling and increase their mechanical capabilities before construction can begin. The process of improving the engineering properties of soil and making it more stable is known as soil stabilization. It is utilized to raise the soil's shear capacity and lower the unfavourable traits like permeability and compaction potential. The technique is mostly used for projects constructing roads and airports.

Commonly, already-healthy soil types are improved using techniques like pre-consolidation and compaction. But soil stabilisation goes much further than that. It also encourages the use of weak soil and lessens the uneconomical process of replacing weak soil. This approach also focuses on chemically changing the soil material itself in addition to working on how the soil mass interacts. For city and suburban streets, soil stabilization is occasionally utilised to increase their noise absorption. Various techniques have been created in the past to stabilise weak and inappropriate soils. Among these techniques are grout stabilization by geotextile and textiles, chemical stabilisation, thermal stabilization, electrical stabilization, cement stabilisation, lime stabilisation, mechanical (granular), bituminous, and lime stabilization. Researchers recently developed a new technique for stabilising soil using waste products. One of the most common waste items that are proven to be useful for this purpose is plastic. They significantly lower the price of stabilising. Utilizing plastics for this purpose also addresses the issue of inappropriate plastic waste recycling, which is still an emerging issue in the majority of poor nations. In most African nations, improper plastic trash disposal is turning into a serious environmental problem [4].

Currently, they are engulfing water and landfills, clogging sewage systems, upsetting the natural balance, and destroying an aesthetically pleasant environment. As a result, the life of animals, plants, and people are seriously harmed. PET (polyethylene terephthalate) bottles are a common type of plastic bottle that are widely used nowadays. They are employed to package a variety of liquids, including water, soft drinks, liquid foods, and others. Their disposal is increasingly challenging because to the rise in demand for them. Waste PET bottle disintegration in nature takes a very long period (more than a century). With its enormous consumption potential, the construction industry is a suitable option for recycling and using these plastic bottles to stabilise expanding clay soil. This will be a respectable substitute for removing waste plastic bottles from the environment and conserving it.

Engineers frequently have to build structures on or in soils that are insufficiently strong to handle the stresses placed on them during construction or for the duration of the structure's service life. In many parts of India, the soils have low bearing capacity, high silt concentrations, and low strengths. Engineers have been driven to try and enhance the engineering qualities of poor quality soils due to the poor engineering performance of such soils. There are several techniques that could be employed to enhance the performance of subpar soils. The soil type to be improved, its features, and the kind and level of improvement needed in a given application all play a role in the decision of which method to use. The performance of pavement systems and the qualities of soil can both be improved through soil stabilisation [5].

Any stabilising method utilised aims to improve the soil's workability and constructability as well as its strength, durability, and erosion management. Instead of removing and replacing the material, stabilisation may be more successful in improving the soil's characteristics for any given soil. The choice of the stabilising agent may also be influenced by factors like availability or cost. The availability of suitable land for construction is decreasing daily as a result of the rapid expansion in population and growth activities. Due to this circumstance, it is now possible to use unsuitable land for construction by enhancing the soil's inherent qualities. One of the best ways to enhance the qualities of soil is soil stabilisation. Plastic waste strips are included in the reinforced earth technology category for soil stabilisation. Products made of plastic are now a necessary component of our daily lives.

Plastic garbage is what remains after the plastic has served its purpose. Use the plastic waste from used cement bags because plastic waste never dissolves and stays on the environment for a long time. Plastic waste is recycled most frequently, although recycled plastics are better for the environment since they contain chemicals and colours. One effective way to increase the engineering qualities of soil and reduce the amount of plastic waste in the environment is to employ waste plastic strips in geotechnical engineering applications. Since subgrades act as the foundation for pavements, they have a significant impact on the stability and functionality of pavements. Roads on black cotton soils make it difficult to choose an effective method of soil modification. The durability of a pavement's sub-grade determines the pavement's quality. According to IRC-37, a post soil must meet the necessary strength standards (2007). If not, another soil with superior properties must be used to replace the native soil [6].

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CHAPTER - 7

INTRODUCTION TO ALCCOFINE EXPANSIVE SOIL

Dr. Chandankeri Ganapathi Gurlingappa,
Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - chandankeri@presidencyuniversity.in

Expansive soil is a type of soil or clay that is susceptible to expansion or contraction as a direct result of changes in water volume. Expansive soils expand when exposed to a lot of water, and then contract when the water dries up [1],[2]. Structures erected on this soil sink or rise unevenly, frequently requiring foundation maintenance, as a result of the constant cycle of wet to dry soil. Expansive soils have a high mineral content and very little to no organic matter, making them extremely viscous and challenging to drain. When expansive soils get dry, they also contract and shrink [3],[4]. A house or other structure's structural support may be lost due to this shrinkage, which could cause destructive subsidence. The soil might also develop wide fractures and cracks. This constant cycle of expansion and contraction places a great deal of stress on the foundation of your home, leading to either foundation heave or settlement, both of which will worsen over time. Although chemically driven changes can cause expansion, expansive clay minerals are typically found in soils with swelling and shrinkage behaviour. It can be explained by the fact that the soil swells more and can hold more water the more clay there is in the soil. Additionally, they gain volume as more water is absorbed into them. One of the main issues with expansive soil is that distortions are significantly more severe than those predicted by the traditional elastic and plastic theory. Alccofine is a brand-new, micro-fine substance made in India that has significantly smaller particles than existing hydraulic materials such as fly ash, ground granulated blast furnace slag (GGBS), silica fume, etc.

Due to its adjusted particle size distribution, alccofine has particular qualities that enhance the effectiveness of soil in both the fresh stage and the hardened stage. Since Alccofine has an ideal particle size distribution—not too fine or coarse—it can be used as a suitable alternative for Silica. Alcofine's distinctive attribute, optimum particle size distribution, is manufactured using specialised equipment and instruments under completely regulated settings. Other construction materials like plastic, steel, and wood must compete with them in terms of productivity, economy, quality, and the environment. In order for soil to be durable, it must be resistant to deteriorating processes including chemical attack, weathering, and others. When exposed to the environment, durable soil will maintain its original form, quality, and usability. Traditional soil and other cementitious substances like Alccofine are among these ingredients. Alccofine is a brand-new generation of micro-fine material that has far smaller particles than some other hydraulic materials made in India, such as fly ash and silica. We have discovered the reactivity, variance, and changes that were noticeable in the clay soil after making certain modifications in the amount of alcofine and moisture content after undergoing the project's experiments, such as the Variable head permeability test, UCS, and Standard Proctor test. Because of their inherent mineralogical behaviour, expansive soils are well known around the world for their volume change behaviour in response to moisture fluctuation.

Most of the world's dry and semi-arid regions, including Australia, South Africa, China, Canada, India, and the United States, have these kinds of soils. About 20% of the country's total land area is covered by the massive black cotton dirt track in India. Due to the basalt's high iron and magnesium mineral content, which gives the rock its dark colour. Clayey soils with a large specific area and a significant cation exchange capacity are considered expansive soils. Clay-like minerals like montmorillonite, which expands in volume when wet, are present in expansive soil. A structure, sidewalk, driveway, basement floors, pipelines, and foundations may be damaged as a result of this volume change. Given that expansive soils are widespread, civil engineers face difficulties on a global scale. Expansive soils can operate as a natural hazard and cause multiple damages to structures if they are not properly handled. It is estimated that annual losses to civil engineering structures cost 150 million dollars in the United States and many billions of dollars globally. A building built on expansive soil experiences differential movements due by the earth's alternating shrinkage and swelling during moisture entry and egress, leading to severe structural issues [5].

There are numerous published data on the soil heave profile at the surface, at different depths below the ground, and on covered areas. It is usually observed that the magnitude of soil movement tends to decrease with depth and that there is a rise in time lag with movement at content compared to that at the surface. Too far, the enormous distress issues associated with these types of soils have resulted in billions of dollars in lost repair and restoration costs. The issue created by the expanding soils has been addressed using a variety of cutting-edge techniques, including the development of specific foundations that include belled piers, drilled piers, friction piles, and moisture barriers. In addition to these methods, stabilizing expansive soils with a variety of additives, such as flyash, lime, cement, and calcium chloride, has also been very successful. The physical-chemical mechanisms by which soil is treated with lime are widely known. For the most part, the modification and stabilization of lime-treated soils are attributed to four mechanisms: cation exchange, coagulants, carbonation, and pozzolanic processes. As a result of the massive storage and production of waste materials, there has also been a rise in awareness of how to effectively and economically stabilize unstable soil, either alone or in combination with lime.

Due to their comparatively low cost and potential to dramatically cut CO2 emissions, industrial by-product minerals including fly ash, GGBS, cement kiln dust, and lime stone dust are becoming more and more popular as cement additives. These products are currently discarded in landfills and lagoons. The ability of the stabilizer to give an adequate amount of calcium is the most crucial component in the stabilization of clay soils. A new improvement on the traditional granular pile, transformed into anchors, is the granular pile- anchor (GPA) approach. The ability of soils to fluctuate in volume is controlled by the stabilization of expansive soil using admixtures. Many stabilisers from diverse sectors have recently been created for the goal of stabilizing soil. Stabilizers' cementitious and pozzolanic capabilities can be improved by adding activators like lime or cement. Alcofine stabilization increased the compressive strength unconfined of expanding soil. In a study, clay soil was stabilised as cushions (CNS) beneath footings, pavement slabs, and behind canal lining using various ratios of $Cacl_2$ and RHA combinations. This study's goal is to determine how the addition of alccofine to calcium chloride ($Cacl_2$) affects the stability of expansive soils. Ambuja Cement Private Limited produces an industrial product called alccofine material in India. The majority of this material is used in excellent performance concrete structures as an addition to cement or as a cement replacement to enhance the properties of the concrete in both the fresh and hardened states as well as for soil stabilization, whereas Cacl2 is primarily used to decrease swelling and increase shear strength of expansive soil for soil stabilization. Their absence of pozzolanic reactivity is the fundamental cause of their underutilization. When compared to all other mineral admixtures used in India, Alccofine, also known as ultrafine ground granulated blast furnace slag (UFGGBS), performs better. It is a significantly finer material than other hydraulic materials like cement, lime, and fly ash, with particle sizes that range from 0-17 microns.

However, because Cacl2 is hygroscopic and collects water from the air, it is ideally suited for stabilizing expansive soils because it inhibits shrinkage cracks from developing in expansive soils over the summer. When used together as a stabilizing agent, the two components may be more advantageous than when used alone. However, too far, there haven't been any investigations on the combination activation of alccofine and Cacl2 as stabilizing agents for expansive soils. In this work, an effort has been made to stabilize expansive soil by using a binder comprised of an alcofine and Cacl2 mixture. Performance has been assessed taking into account the effect of the binder on the FSI, swelling potential, swell pressure, plasticity, compaction, strength, hydraulic conductivity, SEM, XRD, and Cation exchange capacity (CEC) features of expansive soil [6].

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CHAPTER - 8

SOIL DEPOSITS

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

The unpredictability of earth elements, particularly expanding soil, has long perplexed humans. Expansive soils, commonly referred to as real nice soil, have a propensity to shrink and swell in response to changes in moisture content [1],[2]. These are dry and hard one day then wet and squishy the next. Due to this variance in the soil, there is severe distress in the soil, which is followed by damage to the structures above. These soils absorb the water during times of increased rainfall, such as monsoons, and swell [3],[4]. As a result, they become soft and lose some of their ability to hold water. India has seven different soil deposits. They include forest and mountainous soil, marsh soil, alluvial soil, black soil, red soil, laterite soil, or arid soil. The sediment that the rivers carry down creates these soils. They also possess a variety of chemical traits. Mangrove wetlands in the Sundarbans have a lot of marshy soil. The organization of the various soil layers according to shared characteristics is what is referred to as stratification of soil. Natural soil deposits typically form in a layered fashion. It is believed that each layer in stratified soils is isotropic and homogeneous. Each layer has a different coefficient of permeability from the previous layers. In order to obtain the average permeability coefficient for the complete soil deposit for various types of soils [5].

Major Soil Deposits:

Alluvial deposits: In North India, alluvial deposits are typically found. Mostly the Ganga and Brahmaputra River flood plains. Layers can range in depth from a few meters to 100 meters. Peninsular India has alluvial deposits as well. Silt, sand, and clay are found in various thicknesses in alluvial soil. Alluvial soil is distinguished by the presence of these layers. The local topography and the type of floods that deposit the layers determine the layer thickness. Because of their low density, these deposits are vulnerable to liquefaction in earthquake-prone regions.

Black Cotton Soil: This earth is quite malleable. BC Soil covers a large section of central India and a small amount of south India. The leftover deposit of basalt or trap rocks is this soil. This soil type is referred to as "Black cotton soil" because it is favorable for the growth of cotton. Montmorillonite is a mineral that is found in significant amounts in soil. The fundamental characteristic of this soil is that it grows when there is moisture present and shrinks when there is none. The shrinkage qualities are therefore strong. Due of this characteristic, this soil is considered to be the most problematic from an engineering perspective. Because BC soil has such a poor bearing strength, building on it is more hazardous.

Lateritic Soils – This kind of soil is created through the breakdown of rock, the removal of silica and base, and the buildup of iron oxide and aluminum oxide. Iron oxide is the cause of the red color of soil. India's central, southern, and eastern regions all contain this soil. When wet, this particular form of soil is so pliable that it can be carved with a chisel. It gets harder over time. As we dig deeper and get closer to parent rock, the flexibility of lateritic soil decreases. The specific gravity of soils containing iron oxide is high.

Desert Soil – Large portions of Rajasthan and the neighboring states have soil with a fine gradation. Sand dunes are the name for these sand deposits. There are dry conditions and little rainfall in this region. Granular sand is what it is. Gradient is uniform, and it belongs in the category of sand according to classification. Higher density and very little plasticity characterize it. Due to the sand's lack of cohesion, densification is necessary to increase strength.

- Marine Deposits: The south west coast of India is a limited strip near the shore where marine soil deposits are primarily found. Above the sea sand layers are thick layers of sand. These marine deposits are classed as clay because they include very small particles.
- Additionally soft and highly plastic, soil is. It is very compressible and low in strength. Organic material is present since it is a marine deposit [6].

Soil Conservation: A technique called "soil conservation" is used to keep soil fertile, stop soil erosion, and restore deteriorated soil. By avoiding or reducing soil particle separation and its transport in air or water, farming operations and management measures known as soil conservation practices aim to mitigate soil erosion.

- Some of the corrective procedures used to decrease soil erosion include contour bonding, contour terracing, controlled grazing, controlled forestry, cover crops, mixed farming, and crop rotation.
- Planting trees helps to prevent soil erosion, and it's also crucial to stop the indiscriminate removal of trees.
- Floods and the issue of soil erosion go hand in hand. Floods typically happen during the wet season. Therefore, efforts for the storage of floodwater or the redirection of additional rains must be done. The Ganga-Kaveri connection Canal Project is one example of how rivers might be connected.
- Another step that must be taken to address the issue of soil erosion is the reclamation of ravines and gullies. In the Chambal ravines in Madhya Pradesh, a number of such programs that involve plugging gully mouths, building bunds across the slopes, levelling the gullies, and planting cover plants are being implemented.
- One of the primary causes of soil erosion in north-east India and the Western and Eastern Ghats is shifting cropping (slash and burn). Such farmers need to be encouraged to switch to terraced agriculture. In the seven states of northeast India, a plan has been launched to regulate shifting farming. This program is beneficiary-focused and strives to rehabilitate families who engage in shifting agriculture (Jhumming). Sedentary farming should take the place of this agricultural technique.

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CHAPTER - 9

DAMAGE CAUSED BY THE EXPANSIVE SOIL

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

Cracks can appear for a number of reasons, including chemical reactions in building materials, foundation motions and settling of structures, temperature and climate changes, environmental pressures such nearby train activity, earthquakes, etc. [1],[2]. Cracks can be produced by faulty and inefficient design, subpar materials, improper construction techniques, bad weather, and heavy wear and tear [3],[4]. Assume that it isn't because they happen so frequently, but that is incorrect. In fact, if you ask an expert this question, even he might find it challenging to respond right away. The explanation is straightforward: while some cracks are minor and simple to fix, others may indicate a significant flaw that could put the building in danger of collapse or necessitate costly repairs.

Buildings crack: It is a regular occurrence for different crack patterns to appear in a building during construction, after completion when it is put under extra strain, or during the building's service life. When a building component's tension surpasses its capacity, fractures begin to form. External forces, such as dead, live, wind, seismic loads, foundation settlement, etc., or internal forces, such as temperature movements, moisture change, elastic deformation, chemical changes, etc., may create stress in the building component. Building cracks can be broadly divided into structural and nonstructural cracks.

- **Structural Cracks:** These might jeopardize a building's safety because they result from poor design, shoddy construction, or overloading. Extensive cracking in an RCC beam, for instance.
- **Non-structural Cracks:** These are mostly caused by internally stress transfer in building materials and do not pose a threat to a building's safety, but they may be ugly, give the appearance that the work was poorly done, or give the building a sense of instability. Non-structural fissures may occasionally cause internal finishes to deteriorate, raising the cost of servicing, or they may cause reinforcement to corrode, which would be detrimental to the structure's long-term stability. An example would be a vertical crack caused by shrinkage or heat movement in a long compound wall.

Cracks may be the same width throughout or they may start out narrow before progressively getting wider. Cracks might be horizontal, vertical, diagonal, toothed, stepped, map-patterned, or random in shape. Cracks may only be seen at the material's surface or they may penetrate more than one layer. Cracks resulting from various sources have different features, and by carefully observing these features, one can identify the source of cracking and take the proper corrective action [5].

Principal Causes of Cracks: In order to prevent or minimize the development of non-structural cracks, it is important to comprehend the fundamental causes and mechanisms of cracking, as well as specific properties of building materials that may result in dimensional changes of the structural parts. Non-structural cracks in the structure are mostly caused by the following mechanisms:

- Foundation movement and soil settlement
- Moisture change
- Thermal movement
- Elastic deformation
- Creep
- Chemical reaction
- Vegetation growth

Buildings and other constructed objects are always in motion, although most of the time these movements are as minute as to be imperceptible. Defects, shifting ground conditions, foundation settlement, modifications to the structure of the building, and other factors can all contribute to this movement. However, cracking is likely to happen if the structure is insufficient to handle this movement. The emergence of fractures and other distortions brought on by building movement can be unsightly and unsettling for residents, and if left unchecked, they can compromise the structure's integrity, safety, and stability. Understanding the reasons behind the cracking is necessary before any treatment may be effective. Only after that can a plan be created for fixing the issue.

Rutting of Roads: The base and subbase layers of the pavements are its structural layers. They carry out the crucial task of dispersing traffic loads throughout the pavement's substructure. Their structural robustness depends on the thickness of these layers. The subgrade may fail and there may be significant pavement distortions, which are visible as rutting at the surface, if the structural layers are too thin. Under repeated traffic loading, particle movements inside the unbound structural layers are occasionally possible. The base layer thins as a result of the lateral motions away from the wheel path, and surface rutting also occurs. It has been demonstrated that the addition of Tensar geogrid increases the mechanical stability and strength of the unbound base layer. By preventing aggregate particle movement, the Tensar geogrid minimizes pavement deformations and keeps layer thickness constant. Additionally, it aids in dispersing and lowering the stress placed on the subgrade. As a result, the pavement life-design is increased, which lowers maintenance expenses. The strength of the subgrade has a significant impact on pavement design. The structural strength of the pavement is impaired and rutting may occur if the subgrade is less robust than anticipated in the design.

The most likely causes of this are either poor drainage, maybe as a result of malfunctioning or insufficient side drains, or an increase in moisture content caused by a broken pavement that allows surface infiltration of precipitation through it. With a maintenance schedule, prompt action, and resurfacing when needed, both problems can be resolved. The actual in-service power of the subgrade may be less than predicted for the design, which could be another cause of problems with weak subgrade layers. The most likely reason for this is if the subsoil was disturbed throughout construction: if construction traffic ruts the clay subgrade, remolding takes place, which lowers the subgrade strength. Low subgrade strength could have potentially been caused by an unusual subgrade situation at the time of the examination, like a protracted dry period. Inadequate site investigation before building would be a final, potential explanation. It is possible that the testing or the interpretation of the data was incorrect, but it is more likely that the testing was insufficient to detect subgrade variations throughout the entire site. When stabilizing the subbase with tenser geogrid, subgrade rutting can be avoided during construction. It has been demonstrated to be successful in minimizing the impact of fluctuating subgrade strength. Tenser matrix stabilizes and fortifies the subbase by being positioned at the subgrade/subbase contact. This increases the subbase's ultimate strength and rutting resistance, safeguarding the subgrade [6].

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CHAPTER - 10

CANAL LININGS

Mr. Dayalan J,
Assistant Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - dayalanj@presidencyuniversity.in

In order to stop water from flowing through the sides and bed of a canal, linings are created. These can be built from a variety of materials, including compacted earth, cement, concrete, polymers, rocks, and bricks, among others [1],[2]. The primary benefit of canal lining is that it prevents water loss due to seepage [3],[4]. To extend the life and increase the canal's capacity for discharge, an impermeable coating called "canal lining" is placed on the canal's bed and sides. Construction canal lining can prevent the loss of 60 to 80 percent of the water lost to seepage in an unlined canal.

Various Canal Linings: Based on the type of surface, canal linings are divided into two major categories, and they are as follows:

Earthen Type lining: Lings of the Earthen Type are once more divided into two sorts, and they are as follows:

Earth Lining Compacted: Earth Lining Compacted When the earth is present on-site or close to the construction site, compacted earth linings are preferred for canals. The expense of building a compacted earth lining increases if the earth is not readily available nearby. By moving air and water, compaction reduces the size of soil pores. The density, compressive strength, and shear strength of the soil all rise while permeability decreases as void size is reduced. This is accompanied by a decrease in volume and surface settlement. The durability and frost resistance (if necessary) must be increased, and erosion and seepage losses must be reduced, all of which depend on proper compaction.

Cement Soil Lining Sand: Cement Soil Lining Sand, cement, and water are combined to create soil-cement linings, which form into a substance resembling concrete. Cement should make up at least 2 to 8% of the soil's volume. Larger cement amounts are also employed, though. Two approaches are often employed for the production of soil-cement linings.

Dry-mix technique

Plastic-mixing technique

The layer of soil-cement may occasionally be topped with coarse soil to prevent erosion and provide extra reinforcement in large channels. It is advised that the soil-cement lining be covered with 50 mm or more of soil, straw, or hessian bags for seven days to protect it from the elements and promote good curing. Following installation, watering should continue for 28 days [5].

Long-lasting canal linings

It is further broken into 4 categories, which are

Cement Concrete Lining: Cement Concrete linings are frequently employed, and their advantages outweigh their comparatively high cost. They are hydraulically effective, robust, long-lasting, and reasonably impermeable. For both high and low flow velocities and small and large channels, concrete linings are appropriate. They serve every lining function. When employing cement concrete, there are various different lining techniques.

- A cast-in-place liner
- Lining with shortcrete
- Concrete precast lining
- Lining with cement mortar

Brick Lining: Clay lining In the event of a brick lining, cement mortar is used to lay bricks on the canal's sides and bed. After placing the bricks, cement mortar is used to give the surface a smooth finish.

Plastic Lining: Plastic Interior the recently developed method of plastic canal lining shows great promise. For the lining of canals, three different types of plastic membranes are employed, namely:

- Polyethylene with low density
- High density, high molecular polythene
- Vinyl chloride polymer

The use of plastic to line canals has many benefits, including its low weight, ease of handling, spreading, and transportation, resistance to chemical action, and quick construction. The plastic film is applied to the canal's subgrade once it has been prepared. There are 'V ditches available to anchor the membrane to the banks. The protective soil cover is then placed over the film.

Boulder Lining: lining a boulder Dressed stone blocks set in mortar are used to build this kind of lining. Stones that have been properly treated are not found in nature. Stone blocks that are not uniform are treated and chipped off as needed. When rough-dressed stones are used as lining, the surface becomes rough and may cause significant flow resistance. The percentage of rugosity will theoretically be higher. The percentage of rugosity will theoretically be higher. Therefore, the use of stone lining is restricted to circumstances in which head loss is not a major concern and in which stones are reasonably priced.

Advantages:

- The primary goal of canal lining is to minimize seepage losses. The leakage loss of water in untreated canals in some soils ranges from 25 to 50 percent of the total water provided. Although canal lining is expensive, its attempts to prevent most water losses from seepage make it justified. If seepage losses are very minimal, canal lining is not required.

- Water logging is brought on by the water table rising dramatically as a result of unchecked seepage in an unlined canal. The groundwater table in the area is affected by the seepage, making the land unsuitable for irrigation. Therefore, by properly lining the canal sides, this issue of water logging can be avoided.
- A controlled region is one that is ideal for irrigation. More land may be irrigated with lined canals since their water carrying capacity is substantially higher than that of an unlined canal.
- The capacity of a channel can also be increased via canal lining. Compared to an unlined channel, the surface of a lined canal is often smooth and permits rapid water flow. The capacity of a channel increases with flow velocity, hence adding lining will improve channel capacity. On the other hand, this increase in production also allows for a reduction in channel dimensions, preserving the unlined canal's original capacity while lowering project costs.
- Unlined canals require more maintenance than lined canals do. In unlined canals, a common concern is silting, which must be removed at great expense. However, in lined canals, the silt is easily removed by the water due to the high flow rate. There is a chance for flora to grow on the canal surface in the case of unlined canals, but not in the case of lined canals. The vegetation has an impact on the channel's ability to convey water and the flow rate. A lined canal also guards against insect or rodent damage to the surface.
- A lined canal always resists flooding, whereas an unlined canal may not, and there is also a potential of a breach, which could cause damage to the entire canal as well as to nearby fields or other regions. However, all masonry canal linings are effective against floods or fast-moving flows [6].

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CHAPTER - 11

PROPERTIES OF SOIL

Dr. Madhavi T,
Associate Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - madhavit@presidencyuniversity.in

When used as a substrate for plant growth, soil is a complex natural substance created by the weathering of rocks and the breakdown of organic components, which gives plants access to nutrients, moisture, and a place to root [1],[2]. Minerals, humus, organic material, air, and water are all components of soil. The perfect soil for plant growth has roughly 50% solids made up of minerals and organic matter [3],[4]. Remains from plants, animals, and other living things make up the organic part. The amount of water and air in the pore space among soil particles is approximately equal under ideal conditions for plant growth. The capacity of plants to absorb the soil's nutrients is hampered by soil compaction because it lowers pore space and the quantity of air and water that the soil can store.

Chemical Properties of Soils: The following elements make up the chemical properties of soils: inorganic soil components, organic soil components, colloidal characteristics of soil particles, soil reactions, and buffering effects in basic and acidic soils. Naturally, the chemical aspect of a soil is quite significant and concerns the proper nutrient balance in the soil. This is greatly influenced by the amount of organic matter and the proportion of humus; this is the "store house" of nutrients on any farm. Specific nutrients are released depending on how dominating a presence of minerals is or is not. While it's necessary to fill gaps in supplies, finding the correct balance is even more crucial. If the soil is properly balanced, it will only generate nutrients. Biological properties are influenced by chemical and physical qualities. Ideal biological characteristics and soil functions, such as nutrient and water cycling, will result from optimal chemical and physical features.

The concentrations of particular chemicals (such as phosphorus, nitrogen, carbon, major cations (calcium, magnesium, sodium, potassium), sulphur, and trace metals and elements) as well as pH, cation exchange capacity, base saturation, salinity, sodium adsorption ratio, enzyme activity, and electrical conductivity are all examples of soil chemical properties. Processes including nutrient cycling, biological activity, soil formation, contaminant destiny, and erosion are impacted by these characteristics. Chemical characteristics of the soil, how these processes are impacted by human activity, how storm water applications are discussed, and links to associated material on sampling, testing, and evaluations of the soil's health [5].

Properties of Soil

The top layer of the earth's surface, known as the soil, is what supports life and is abundant in minerals and microorganisms. It covers all of the land that is visible to us. The soil is where all living things, including plants, animal, and microorganisms, develop and live. Based on location, soil types can be distinguished by their colour, texture, and composition. Diverse types of soil are shown by the different types of flora seen in various locations. Different physical, chemical, and biological characteristics exist in soil.

These categories are used to divide soil into three types: sandy, clayey, and loamy based on characteristics like texture, colour, and water-holding ability. The soil type is also determined by a number of chemical factors, including pH, salinity, organic content, etc. The soil is home to a variety of microorganisms, including bacteria and earthworms, which are essential for boosting soil fertility. The soil encompasses the topsoil, subsoil, and various inner layers above its parent rocks. It is a complete component of nature. Rocks, which are its parent material, weather to make it.

The nature and characteristics of the soil vary depending on the climate it is exposed to, the type of topography it is found on, the plants and other organisms that are involved in the soil's growth as a whole, and the amount of time it takes for the soil to form. Scattered rocks and humus make up soil. Most of the mineral content in soils is made up of eight chemical components. The most abundant of these eight elements in terms of weight and volume is oxygen, which occurs as a negatively-charged ion (anion) in crystal formations. In decreasing order, the next most prevalent elements are silicon, aluminum, iron, magnesium, calcium, sodium, and potassium, which are all positively-charged ions (cations). These elements' ions mix in a variety of ratios to create various minerals. In soils and the crust of the earth, more than eighty other elements also exist, albeit in considerably lesser concentrations.

In comparison to the rocks and minerals from which they were formed, soils are genetically different in that they have a higher concentration of relatively insoluble elements like iron and aluminum and a lower concentration of the water-soluble weathering products calcium, magnesium, sodium, and potassium. Aluminum and iron oxides are typically found in high concentrations in old, severely worn soils. Although it typically makes up considerably less than 10% of the soil's total mass by weight, a soil's organic fraction has a significant impact on the chemical properties of the soil. The main elements that make up soil organic matter are carbon, hydrogen, oxygen, and nitrogen, with smaller amounts of Sulphur and other elements. The organic fraction improves soil aggregation and structure, boosts soil water retention and cation exchange capabilities, and acts as a storehouse for the nitrogen, phosphorus, and Sulphur that plants need to grow. Organic materials and colloidal clays make up the portion of soils that is most chemically active. Because colloidal particles are so minute (0.0002 mm), they float in water and have a very high surface area to weight ratio. Additionally, these materials typically have a high adsorptive capacity and net negative charge. In soils, silicate clay minerals come in a variety of forms, but they all have a layered structure. While kaolinite is a 1:1 clay mineral, montmorillonite, vermiculite, and micaceous clays are examples of 2:1 clays. 2:1 clays are defined as having two layers of silicon oxide (tetrahedral sheets) and an octahedral layer of aluminum oxide between them. 1:1 clays are defined as having one tetrahedral sheet bound to one octahedral sheet [6].

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CHAPTER - 12

CLASSIFICATION OF FLY ASH

Mr. Dayalan J,
Assistant Professor, Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India.
Email Id: - dayalanj@presidencyuniversity.in

Fly ash is a waste product that is collected from the gases coming from coal-fired furnaces, often of a thermal power plant [1],[2]. Fly ash closely resembles the volcanic ashes that were used as hydraulic cements in ancient times, which was one of the main uses of volcanic ashes. One of the finest pozzolans (binding agents) utilised globally was thought to be these ashes. These days, as urbanization and industry continue to rise, there is an exponential increase in the need for electricity supply [3],[4]. This expansion has therefore led to a rise in the number of thermal power stations that offer energy and burn coal as a fuel. Fly ash is the mineral residue that remains after coal is burned. These fly ashes are collected by the power plants' Electro Static Precipitator (ESP). The management for fly ash and its safe disposal are the two main problems associated with its production [5],[6].

Due to their complex features and dangerous nature, the wastes produced by enterprises must be disposed of safely and effectively in order to prevent disruption of the ecological system and potential disasters for both human life and the environment. Unless these industrial pollutants are processed before disposal or storage, environmental damage is inevitable. Fly ashes are microscopic particles mostly made of alumina, silica, and iron. Both amorphous and crystalline forces of nature of minerals are present in fly ash created, and their overall spherical shape makes it simple for them to combine and flow to create an appropriate concoction. Although its composition varies depending on the kind of coal burned, it mostly consists of non-plastic silt. Fly ash is a possible material that may be utilised for waste liners, and it can also be used as barrier material when combined with certain minerals (calcium and bentonite). In the existing situation, more fly ash (the waste material in the photo) is generated than is being used. To put it another way, we produce more fly ash than what we can use. The kind of soil that has to be stabilised, the needed strength of the stabilised layer, the quality of the stabilised layer, the intended use of the stabilised soil, financial considerations, and the durability of the stabilised layer all play a role in the decision-making process. The soil should exhibit enhanced qualities after stabilization, including increased volume stability, shear strength parameters, particle size distribution and longevity.

Generation and Disposal

It is normal practise to use coal in thermal power plants to produce steam. In the past, coal in the form of lumps was burned in the furnaces of the boilers to produce the evaporated content: steam. This approach was later shown to be inefficient in terms of energy utilisation. Thus, the thermal power plants started using pulverised coal mass as opposed to the aforementioned content in order to maximise the production of energy from coal mass. First, this pulverised coal is introduced into the combustion chamber, in which the fuel is instantly yet effectively burned. Fly ash is the term for the ash that resulted from this, and it includes molten minerals. The fly ash particle's spherical shape is a product of the steam that forms around this molten mass when the coal ash moves with the flue gases. The use of the economizer then re-covers the heat from either the fly ash or steam gases. This procedure causes the fly ash temperature to abruptly decrease in value. The fly ash substance will have an amorphous form if the temperature drop is quick.

Fly ash, on the other hand, takes on a more crystalline appearance if the temperature decrease that occurs during this freezing phase is moderate. This demonstrates how the economizer is used and how it enhances the reactivity process. Fly ash creates a 4.3% soluble matter and a 94% pozzolanic activity index when the economizer is not used in the process. In contrast, when fly ash is subjected to the expansion valve, its pozzolanic activity measures at 103% and it creates 8.8% soluble matter. In summary, a mechanical particle collector, also known as an electrostatic precipitator (ESP) or scrubbers, separates fly ashes from the flue gases. The chimney is used to release the remaining flue gases into the atmosphere after being cleared of fly ashes. The effectiveness of ESPs for the separation and finer and lighter fly ash particles is great, ranging between 90% and 98%. The fly ash typically comprises of four to six field-named hoppers. Therefore, the number of fields that may be used in an ESP is proportional to the fineness of the fly ash particles that are collected. As a result, the fly ashes that were already collected from the first hopper have an approximate specific surface area of 2800 cm2/gm, but the fly ashes that have been collected from the final hopper have a larger specific surface area, or 8200 cm2/gm. The resultant ash content that forms during the scorching of pulverized coal is either recovered as fly ash or bottom ash. The remaining 20%, which are typically coarser size, are collected at the bottom of both the furnace as bottom ash. Of the coal ashes that are removed from either the flue gases, 80% are recovered as fly ash. Bottom ash is removed from the bottom of the furnace in either dry form or as a collection from either a hopper filled with water. The transference may take place via water jets or water cascade to a disposal pond when there is enough bottom ash throughout the water-filled hopper, above which its destruction becomes imperative before going on to the next operation. Then, this trash is referred to as "pond ash.

Stabilization of Soil Using Alccofine

The impact of fly ash and alocofine on the compressive and flexural strengths of high performance concrete. The research came to the following conclusions: 1) the strength development during the first seven days was great; strength increase between 7 and 28 days was relatively smaller; nevertheless, strength rise between 28 and 56 days was high because of the presence with fly ash. The compressive strength after 28 days was 1% to 10% lower than the standard compressive strength. 2) Slump measurements for all combinations were more than 150 mm. 3) the compressive strength attained after 90 days was higher than the strength after 28 days. For M2 mix, the highest compressive strength obtained was 78.58 MPa, exceeding the desired strength. 4) All combinations achieved the required flexural strength. During the course of the investigation, M4mix's maximum flexural hardness of 7.05 MPa was attained.

It was noted through investigations of the literature that numerous attempts have been undertaken to investigate the potential use of various industrial wastes for stabilising expansive soil. Alcofine and fly ash were tested for their influence on HPC's strength qualities by Sunil Suthar et al (high performance concrete). The considerable benefits over binary blends and sometimes even greater increases in strength qualities over Portland cement are presented by a mixture of cementitious materials including fly ash, alccofine, and Portland cement. It has been discovered that adding alccofine as a mineral additive to hardened concrete together with fly ash increases the concrete's early age strength. Alcofine and fly ash were found to be superior to Portland cement in terms of the durability of concrete. It was discovered that the concrete's compressive strength made with 8% alccofine and diverse fly ash blends had more than 10% silica fumes. In comparison to all other silica-fume mixtures, a mixture of cementitious composites, including Portland cement, fly ash, as well as Alccofine, had the highest compressive strength. 20% fly ash and 8% alccofine may be used to create high strength concrete.

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